# C60 Breaker Management Relay

## UR Series Instruction Manual

**C60 Revision: 4.4x**

Manual P/N: 1601-0100-**J2** (GEK-112987A)

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LISTED
MEASURING EQUIP.
36GN

dnp level 2

ISO9001:2000 REGISTERED GE MULTILIN

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

# ADDENDUM

This Addendum contains information that relates to the C60 Breaker Management Relay relay, version 4.4x. This addendum lists a number of information items that appear in the instruction manual GEK-112987A (revision **J2**) but are not included in the current C60 operations.

The following functions/items are not yet available with the current version of the C60 relay:

• Signal Sources SRC 5 and SRC 6

Version 4.0x and higher releases of the C60 relay includes new hardware (CPU and CT/VT modules).

• The new CPU modules are specified with the following order codes: 9E, 9G, and 9H.

• The new CT/VT modules are specified with the following order codes: 8F, 8G, 8H, 8J.

The following table maps the relationship between the old CPU and CT/VT modules to the newer versions:

| MODULE | OLD | NEW | DESCRIPTION |
|--------|-----|-----|-------------|
| CPU | 9A | 9E | RS485 and RS485 (Modbus RTU, DNP) |
|  | 9C | 9G | RS485 and 10Base-F (MMS/UCA2, Modbus TCP/IP, DNP) |
|  | 9D | 9H | RS485 and Redundant 10Base-F (MMS/UCA2, Modbus TCP/IP, DNP) |
| CT/VT | 8A | 8F | Standard 4CT/4VT |
|  | 8B | 8G | Sensitive Ground 4CT/4VT |
|  | 8C | 8H | Standard 8CT |
|  | 8D | 8J | Sensitive Ground 8CT/8VT |

The new CT/VT modules can only be used with the new CPUs (9E, 9G, 9H), and the old CT/VT modules can only be used with the old CPU modules (9A, 9C, 9D). To prevent any hardware mismatches, the new CPU and CT/VT modules have blue labels and a warning sticker stating **"Attn.: Ensure CPU and DSP module label colors are the same!"**. In the event that there is a mismatch between the CPU and CT/VT module, the relay will not function and a **DSP ERROR** or **HARDWARE MISMATCH** error will be displayed.

All other input/output modules are compatible with the new hardware.

With respect to the firmware, firmware versions 4.0x and higher are only compatible with the new CPU and CT/VT modules. Previous versions of the firmware (3.4x and earlier) are only compatible with the older CPU and CT/VT modules.

# 6. ACTUAL VALUES

**7. COMMANDS AND TARGETS**

**A. FLEXANALOG PARAMETERS**

**B. MODBUS COMMUNICATIONS**

**C. IEC 60870-5-104 COMMUNICATIONS**

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

### 1.1.1 CAUTIONS AND WARNINGS

**WARNING**  **CAUTION**  **Before attempting to install or use the relay, it is imperative that all WARNINGS and CAU-TIONS in this manual are reviewed to help prevent personal injury, equipment damage, and/or downtime.**

### 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.

**C60** *Breaker Management Relay*

*GE Multilin*

Technical Support:
Tel: (905) 294-6222
Fax: (905) 201-2098

http://www.GEindustrial.com/multilin

**RATINGS:**
Control Power: 88-300V DC @ 35W / 77-265V AC @ 35VA
Contact Inputs: 300V DC Max 10mA
Contact Outputs: Standard Pilot Duty / 250V AC 7.5A
360V A Resistive / 125V DC Break
4A @ L/R = 40mS / 300W

Made in Canada

Model: C60H00HCHF8FH6AM6BP8GX7A
Mods: 000
Wiring Diagram: 834723
Inst. Manual: D
Serial Number: MAZB98000029
Firmware: D
Mfg. Date: 1998/01/05

- M A A 8 9 7 0 0 0 0 9 9 -

**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 website at http://www.GEindustrial.com/multilin.

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

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

GE Multilin
215 Anderson Avenue
Markham, Ontario
Canada   L6E 1B3

**TELEPHONE**:     (905) 294-6222,        1-800-547-8629 (North America only)
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**E-MAIL**:          gemultilin@indsys.ge.com
**HOME PAGE**:   http://www.GEindustrial.com/multilin

**1**

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 5 milliseconds. This has been established by the Electric Power Research Institute, a collective body of many American and Canadian power utilities, in their IEC 61850 project. In late 1998, some European utilities began to show an interest in this ongoing initiative.

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**

### 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.
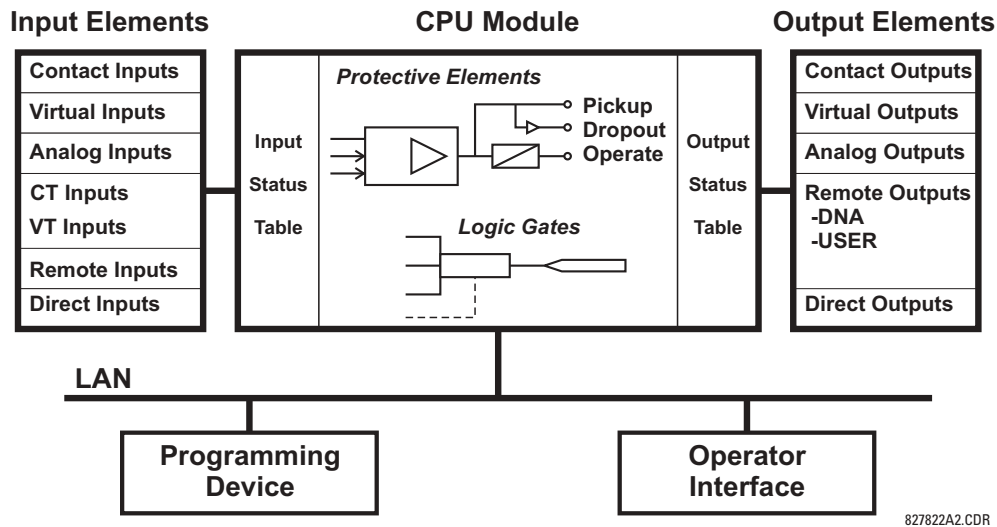


**Figure 1–2: UR CONCEPT BLOCK DIAGRAM**

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 messages and are of two assignment types: DNA standard functions and user-defined (UserSt) functions.

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.

**1**

### 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.
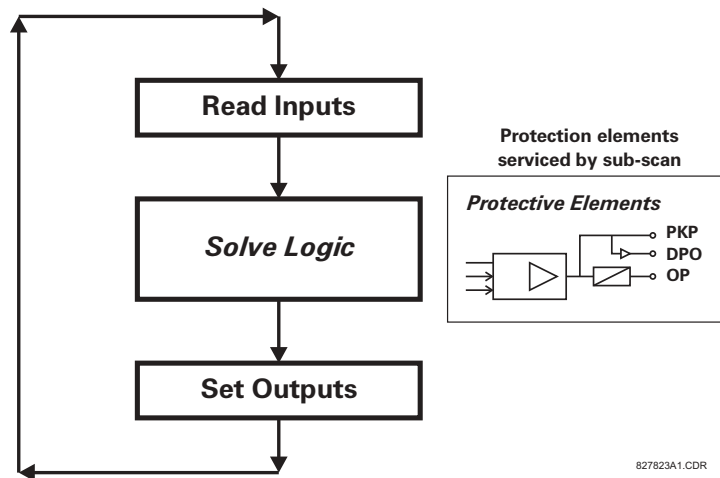


**Figure 1–3: UR-SERIES SCAN OPERATION**

### 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 Universal Relay achieves the same features as the hardware architecture: modularity, scalability, and flexibility. The application software for any Universal Relay (e.g. 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. An example of a simple element, and some of the organization of this manual, can be found in the *Digital Elements* section. 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**

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 C60 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

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 **Install Software** button and select the "C60 Breaker Management Relay" 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 **Check Now** button to list software items for the C60.
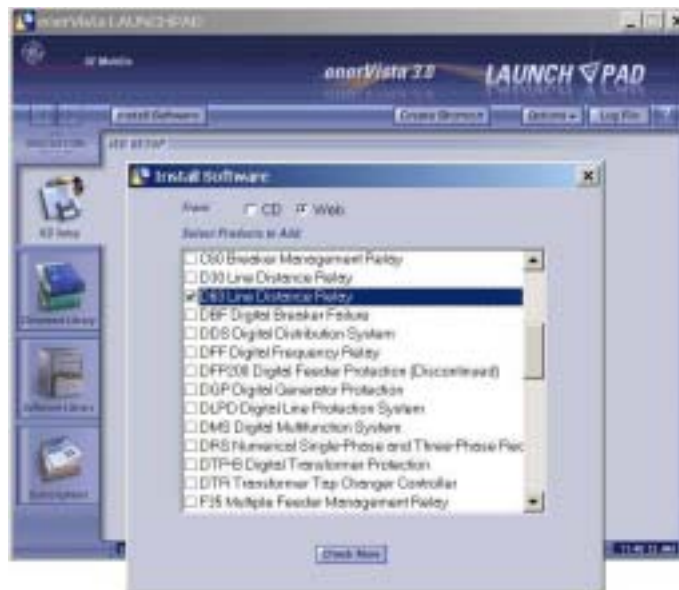


6.  Select the C60 software program and release notes (if desired) from the list and click the **Download Now** button to obtain the installation program.



7.  enerVista Launchpad will obtain the installation program from the Web or CD. Once the download is complete, double-click the installation program to install the enerVista UR Setup software.

8.  Select the complete path, including the new directory name, where the enerVista UR Setup will be installed.

9.  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.

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10. Click **Finish** to end the installation. The C60 device will be added to the list of installed IEDs in the enerVista Launch-pad window, as shown below.



**1.3.3 CONNECTING ENERVISTA UR SETUP WITH THE C60**

This section is intended as a quick start guide to using the enerVista UR Setup software. Please refer to the enerVista UR Setup Help File and Chapter 4 of this manual for more information.

**a) CONFIGURING AN ETHERNET CONNECTION**

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. Install and start the latest version of the enerVista UR Setup software (available from the GE enerVista CD or online from http://www.GEindustrial.com/multilin (see previous section for installation instructions).

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. Click the **OK** button when complete.

5. The new site will appear in the upper-left list in the enerVista UR Setup window. Click on the new site name and then click the **Device Setup** button 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.

   • Enter the relay IP address (from **SETTINGS** ⇨⇩ **PRODUCT SETUP** ⇨⇩ **COMMUNICATIONS** ⇨⇩ **NETWORK** ⇨ **IP ADDRESS**) in the "IP Address" field.

   • Enter the relay Modbus address (from the **PRODUCT SETUP** ⇨⇩ **COMMUNICATIONS** ⇨⇩ **MODBUS PROTOCOL** ⇨ **MOD-BUS SLAVE ADDRESS** setting) in the "Slave Address" field.

   • Enter the Modbus port address (from the **PRODUCT SETUP** ⇨⇩ **COMMUNICATIONS** ⇨⇩ **MODBUS PROTOCOL** ⇨⇩ **MODBUS TCP PORT NUMBER** setting) in the "Modbus Port" field.

9. Click the **Read Order Code** button to connect to the C60 device and upload the order code. If an communications error occurs, ensure that the three enerVista UR Setup values entered in the previous step correspond to the relay setting values.

**1**

10. 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 Section c) below to begin communications.

### b) CONFIGURING AN RS232 CONNECTION

Before starting, verify that the RS232 serial cable is properly connected to the RS232 port on the front panel of the relay.

1. Install and start the latest version of the enerVista UR Setup software (available from the GE enerVista CD or online from http://www.GEindustrial.com/multilin.

2. Select the **Device Setup** button to open the Device Setup window and click the **Add Site** button to define a new site.

3. 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. Click the **OK** button when complete.

4. The new site will appear in the upper-left list in the enerVista UR Setup window. Click on the new site name and then click the **Device Setup** button to re-open the Device Setup window.

5. Click the **Add Device** button to define the new device.

6. Enter the desired name in the "Device Name" field and a description (optional) of the site.

7. Select "Serial" from the **Interface** drop-down list. This will display a number of interface parameters that must be entered for proper serial communications.

   • Enter the relay slave address and COM port values (from the **SETTINGS** ⇨ **PRODUCT SETUP** ⇨⇩ **COMMUNICATIONS** ⇨⇩ **SERIAL PORTS** menu) in the "Slave Address" and "COM Port" fields.

   • Enter the physical communications parameters (baud rate and parity settings) in their respective fields.

8. Click the **Read Order Code** button to connect to the C60 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.

9. 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 Section c) Connecting to the Relay below to begin communications.

### c) CONNECTING TO THE RELAY

1. Open the Display Properties window through the Site List tree as shown below:
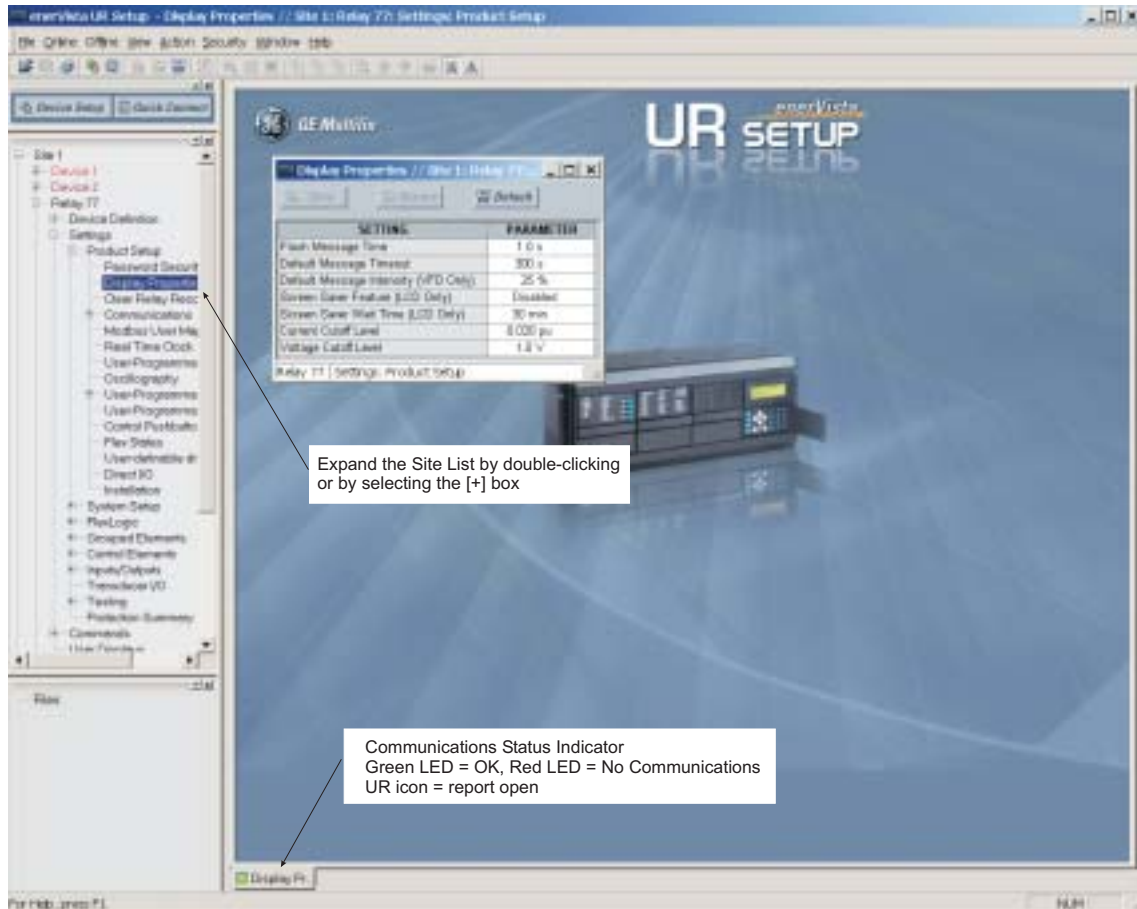
842743A1.CDR

2. The Display Properties window will open with a status indicator on the lower left of the enerVista UR Setup window.

3. If the status indicator is red, verify that the Ethernet network cable is properly connected to the Ethernet port on the back of the relay and that the relay has been properly setup for communications (steps A and B earlier).

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

4. The Display Properties settings can now be edited, printed, or changed according to user specifications.

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

**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.
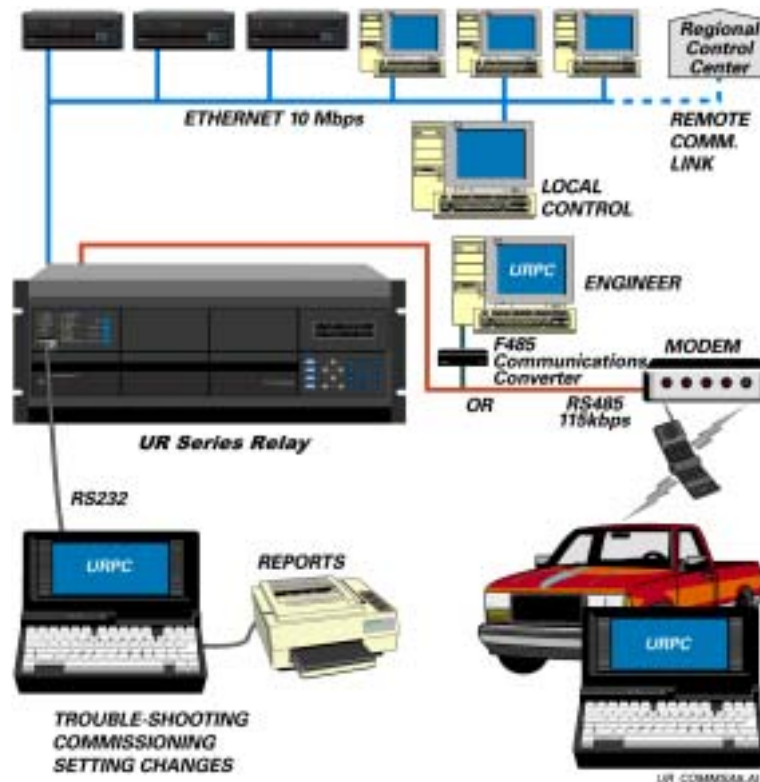


**Figure 1–4: RELAY COMMUNICATIONS OPTIONS**

To communicate through the C60 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 C60 rear communications port. The converter terminals (+, –, GND) are connected to the C60 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 (i.e. 120 Ω, 1 nF) as described in the Chapter 3.

**1.4.3 FACEPLATE DISPLAY**

All messages are displayed on a 2 × 20 character vacuum fluorescent display to make them visible under poor lighting conditions. An optional liquid crystal display (LCD) is also available. Messages are displayed in English and do 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 defined messages. Any high priority event driven message will automatically override the default message and appear on the display.

**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 ⎡·⎤ 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.

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 main heading pages as illustrated below.

| MENU | ⇨ | MENU | ⇨ | MENU | ⇨ | MENU |
|---|---|---|---|---|---|---|
| ACTUAL VALUES | | SETTINGS | | COMMANDS | | TARGETS |
| ⇩ | | ⇩ | | ⇩ | | ⇩ |
| ■■ ACTUAL VALUES ■■ STATUS | | ■■ SETTINGS ■■ PRODUCT SETUP | | ■■ COMMANDS ■■ VIRTUAL INPUTS | | No Active Targets |

⇨  MENU

USER DISPLAYS
(*when in use*)

⇩

User Display 1

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 ⬤ and ⬇ keys move within a group of headers, sub-headers, setting values, or actual values. Continually pressing the MESSAGE ▶ key from a header display displays specific information for the header category. Conversely, continually pressing the ◀ MESSAGE key from a setting value or actual value display returns to the header display.

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

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

⬤⬇

■■ SETTINGS
■■ SYSTEM SETUP

**1**

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.

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:

• operate breakers via faceplate keypad

• change state of virtual inputs

• clear event records

• clear oscillography records

• operate user-programmable pushbuttons

**2. SETTING**

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

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

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

**1**

Templated tables for charting all the required settings before entering them via the keypad are available from the GE Multilin website at http://www.GEindustrial.com/multilin.

The C60 requires a minimum amount of maintenance when it is commissioned into service. The C60 is a microprocessor-based relay and its characteristics do not change over time. As such no further functional tests are required.

Furthermore the C60 performs a number of ongoing self-tests and takes the necessary action in case of any major errors (see the *Relay Self-Test* section in Chapter 7 for details). However, it is recommended that maintenance on the C60 be scheduled with other system maintenance. This maintenance may involve the following.

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 setpoints 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 or one of its representatives for prompt service.

The C60 Breaker Management Relay is a microprocessor based relay designed for breaker monitoring, control and protection.

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

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™ equations) 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 (PC). 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 10BaseF 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 (C60 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 C60 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**

| DEVICE NUMBER | FUNCTION | DEVICE NUMBER | FUNCTION |
|---|---|---|---|
| 25 | Synchrocheck | 50P BF | Phase Instantaneous Overcurrent, Breaker Failure |
| 27P | Phase Undervoltage | 51G | Ground Time Overcurrent |
| 27X | Auxiliary Undervoltage | 51N | Neutral Time Overcurrent |
| 32 | Sensitive Directional Power | 51P | Phase Time Overcurrent |
| 50G | Ground Instantaneous Overcurrent | 52 | AC Circuit Breaker |
| 50N | Neutral Instantaneous Overcurrent | 59N | Neutral Overvoltage |
| 50N BF | Neutral Instantaneous Overcurrent, Breaker Failure | 59X | Auxiliary Overvoltage |
| 50P | Phase Instantaneous Overcurrent | 79 | Autoreclose |

**2**
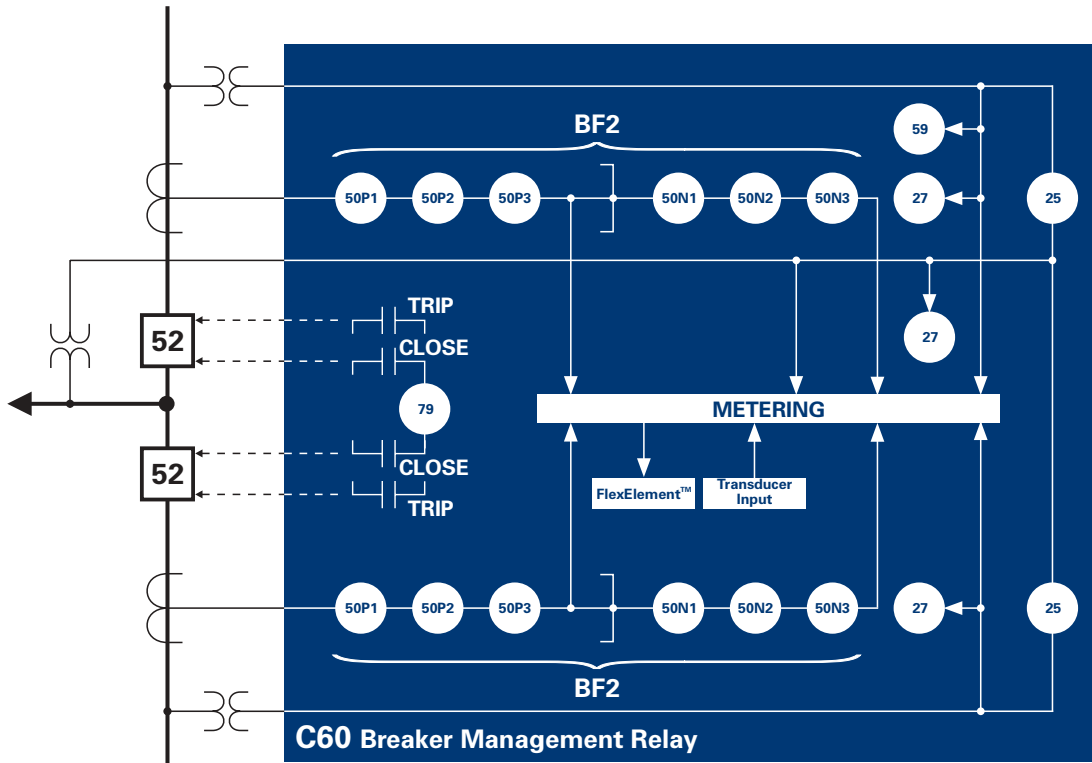


834710AB.CDR

**Figure 2–1: SINGLE LINE DIAGRAM**

**Table 2–2: OTHER DEVICE FUNCTIONS**

| FUNCTION | FUNCTION | FUNCTION |
|---|---|---|
| Breaker Arcing Current ($I^2t$) | Ethernet Global Data (EGD) Protocol | Non-Volatile Selector Switch |
| Breaker Control | Event Recorder | Oscillography |
| Contact Inputs (up to 96) | Fault Detector and Fault Report | Setting Groups (6) |
| Contact Outputs (up to 64) | FlexElements™ (8) | Time Synchronization over SNTP |
| Control Pushbuttons | FlexLogic™ Equations | Transducer Inputs/Outputs |
| Data Logger | IEC 61850 Communications | User Definable Displays |
| Demand | IEC 61850 Remote Inputs/Outputs (GSSE) | User Programmable LEDs |
| Digital Counters (8) | Metering: Current, Voltage, Power, Energy, Frequency | User Programmable Pushbuttons |
| Digital Elements (16) | | User Programmable Self-Tests |
| Direct Inputs/Outputs (32) | Modbus Communications | Virtual Inputs (32) |
| Disturbance Detection | Modbus User Map | Virtual Outputs (64) |
| DNP 3.0 or IEC 60870-5-104 Communications | Non-Volatile Latches | VT Fuse Failure |

**2.1.2 ORDERING**

The relay is available as a 19-inch rack horizontal mount unit or a reduced size (¾) vertical mount unit, and consists of the following modules: power supply, CPU, CT/VT, digital input/output, transducer input/output. 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 table (see Chapter 3 for full details of relay modules).

**2**

### Table 2–3: C60 ORDER CODES

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C60 | - * | 00 - H | * | * - F | ** | - H | ** | - M | ** | - P ** - U ** - W ** | Full Size Horizontal Mount |
| | C60 | - * | 00 - V | * | * - F | ** | - H | ** | - M | ** | - # ** | Reduced Size Vertical Mount (see note below for value of slot #) |
| **BASE UNIT** | C60 | | | | | | | | | | | Base Unit |
| **CPU** | | E | | | | | | | | | | RS485 + RS485 (ModBus RTU, DNP) |
| | | G | | | | | | | | | | RS485 + 10BaseF (IEC 61850, Modbus TCP/IP, DNP) |
| | | H | | | | | | | | | | RS485 + Redundant 10BaseF (IEC 61850, Modbus TCP/IP, DNP) |
| **SOFTWARE** | | | 00 | | | | | | | | | No Software Options |
| | | | 01 | | | | | | | | | Ethernet Global Data (EGD); only available with Type G and H CPUs |
| **MOUNT/ FACEPLATE** | | | | H C | | | | | | | | Horizontal (19" rack) mount |
| | | | | H P | | | | | | | | Horizontal (19" rack) mount with User-Programmable Pushbuttons |
| | | | | V F | | | | | | | | Reduced size vertical mount (3/4 rack) |
| **POWER SUPPLY** (redundant power supply only available in horizontal mount units) | | | | | H | | | | | | | 125 / 250 V AC/DC power supply |
| | | | | | H | | | | | | RH | 125 / 250 V AC/DC with redundant 125 / 250 V AC/DC power supply |
| | | | | | L | | | | | | | 24 to 48 V (DC only) power supply |
| | | | | | L | | | | | | RL | 24 to 48 V (DC only) with redundant 24 to 48 V DC power supply |
| **CT/VT MODULES** | | | | | | 8F | | 8F | | | | Standard 4CT/4VT |
| | | | | | | 8G | | 8G | | | | Sensitive Ground 4CT/4VT |
| | | | | | | 8H | | 8H | | | | Standard 8CT |
| | | | | | | 8J | | 8J | | | | Sensitive Ground 8CT |
| **DIGITAL INPUTS/OUTPUTS** | | | | | | XX | | XX | XX | | XX | No Module |
| | | | | | | 4A | | 4A | 4A | 4A | 4A | 4 Solid-State (No Monitoring) MOSFET Outputs |
| | | | | | | 4B | | 4B | 4B | 4B | 4B | 4 Solid-State (Voltage w/ opt Current) MOSFET Outputs |
| | | | | | | 4C | | 4C | 4C | 4C | 4C | 4 Solid-State (Current w/ opt Voltage) MOSFET Outputs |
| | | | | | | 4L | | 4L | 4L | 4L | 4L | 14 Form-A (No Monitoring) Latching Outputs |
| | | | | | | 67 | | 67 | 67 | 67 | 67 | 8 Form-A (No Monitoring) Outputs |
| | | | | | | 6A | | 6A | 6A | 6A | 6A | 2 Form-A (Volt w/ opt Curr) & 2 Form-C outputs, 8 Digital Inputs |
| | | | | | | 6B | | 6B | 6B | 6B | 6B | 2 Form-A (Volt w/ opt Curr) & 4 Form-C Outputs, 4 Digital Inputs |
| | | | | | | 6C | | 6C | 6C | 6C | 6C | 8 Form-C Outputs |
| | | | | | | 6D | | 6D | 6D | 6D | 6D | 16 Digital Inputs |
| | | | | | | 6E | | 6E | 6E | 6E | 6E | 4 Form-C Outputs, 8 Digital Inputs |
| | | | | | | 6F | | 6F | 6F | 6F | 6F | 8 Fast Form-C Outputs |
| | | | | | | 6G | | 6G | 6G | 6G | 6G | 4 Form-A (Voltage w/ opt Current) Outputs, 8 Digital Inputs |
| | | | | | | 6H | | 6H | 6H | 6H | 6H | 6 Form-A (Voltage w/ opt Current) Outputs, 4 Digital Inputs |
| | | | | | | 6K | | 6K | 6K | 6K | 6K | 4 Form-C & 4 Fast Form-C Outputs |
| | | | | | | 6L | | 6L | 6L | 6L | 6L | 2 Form-A (Curr w/ opt Volt) & 2 Form-C Outputs, 8 Digital Inputs |
| | | | | | | 6M | | 6M | 6M | 6M | 6M | 2 Form-A (Curr w/ opt Volt) & 4 Form-C Outputs, 4 Digital Inputs |
| | | | | | | 6N | | 6N | 6N | 6N | 6N | 4 Form-A (Current w/ opt Voltage) Outputs, 8 Digital Inputs |
| | | | | | | 6P | | 6P | 6P | 6P | 6P | 6 Form-A (Current w/ opt Voltage) Outputs, 4 Digital Inputs |
| | | | | | | 6R | | 6R | 6R | 6R | 6R | 2 Form-A (No Monitoring) & 2 Form-C Outputs, 8 Digital Inputs |
| | | | | | | 6S | | 6S | 6S | 6S | 6S | 2 Form-A (No Monitoring) & 4 Form-C Outputs, 4 Digital Inputs |
| | | | | | | 6T | | 6T | 6T | 6T | 6T | 4 Form-A (No Monitoring) Outputs, 8 Digital Inputs |
| | | | | | | 6U | | 6U | 6U | 6U | 6U | 6 Form-A (No Monitoring) Outputs, 4 Digital Inputs |
| **TRANSDUCER INPUTS/OUTPUTS** (select a maximum of 3 per unit) | | | | | | 5A | | 5A | 5A | 5A | 5A | 4 dcmA Inputs, 4 dcmA Outputs (only one 5A module is allowed) |
| | | | | | | 5C | | 5C | 5C | 5C | 5C | 8 RTD Inputs |
| | | | | | | 5D | | 5D | 5D | 5D | 5D | 4 RTD Inputs, 4 dcmA Outputs (only one 5D module is allowed) |
| | | | | | | 5E | | 5E | 5E | 5E | 5E | 4 RTD Inputs, 4 dcmA Inputs |
| | | | | | | 5F | | 5F | 5F | 5F | 5F | 8 dcmA Inputs |
| **INTER-RELAY COMMUNICATIONS** (select a maximum of 1 per unit) | | | | | | | | | | | 2A | C37.94SM, 1300nm single-mode, ELED, 1 channel single-mode |
| | | | | | | | | | | | 2B | C37.94SM, 1300nm single-mode, ELED, 2 channel single-mode |
| | | | | | | | | | | | 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 |

**NOTE** For vertical mounting units, # = slot P for digital and transducer input/output modules; # = slot R for inter-relay communications modules

**2**

The order codes for replacement modules to be ordered separately are shown in the following table. When ordering a replacement CPU module or faceplate, please provide the serial number of your existing unit.

**Table 2–4: ORDER CODES FOR REPLACEMENT MODULES**

| | UR - ** - | | |
|---|---|---|---|
| **POWER SUPPLY** (redundant power supply only available in horizontal mount units) | \| | 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 (IEC 61850, Modbus TCP/IP, DNP 3.0) |
| | \| | 9H \| | RS485 and Redundant 10Base-F (IEC 61850, ModBus TCP/IP, DNP 3.0) |
| **FACEPLATE** | \| | 3C \| | Horizontal faceplate with display and keypad |
| | \| | 3F \| | Vertical faceplate with display and keypad |
| | \| | 3P \| | Horizontal faceplate with display, keypad, and user-programmable pushbuttons |
| **DIGITAL INPUTS/OUTPUTS** | \| | 4A \| | 4 Solid-State (no monitoring) MOSFET Outputs |
| | \| | 4B \| | 4 Solid-State (voltage with optional current) MOSFET Outputs |
| | \| | 4C \| | 4 Solid-State (current with optional voltage) MOSFET Outputs |
| | \| | 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 & 4 Fast Form-C Outputs |
| | \| | 6L \| | 2 Form-A (current with optional voltage) and 2 Form-C Outputs, 8 Digital Inputs |
| | \| | 6M \| | 2 Form-A (current with optional voltage) and 4 Form-C Outputs, 4 Digital Inputs |
| | \| | 6N \| | 4 Form-A (current with optional voltage) Outputs, 8 Digital Inputs |
| | \| | 6P \| | 6 Form-A (current with optional voltage) Outputs, 4 Digital Inputs |
| | \| | 6R \| | 2 Form-A (no monitoring) and 2 Form-C Outputs, 8 Digital Inputs |
| | \| | 6S \| | 2 Form-A (no monitoring) and 4 Form-C Outputs, 4 Digital Inputs |
| | \| | 6T \| | 4 Form-A (no monitoring) Outputs, 8 Digital Inputs |
| | \| | 6U \| | 6 Form-A (no monitoring) Outputs, 4 Digital Inputs |
| **CT/VT MODULES** (NOT AVAILABLE FOR THE C30) | \| | 8F \| | Standard 4CT/4VT |
| | \| | 8G \| | Sensitive Ground 4CT/4VT |
| | \| | 8H \| | Standard 8CT |
| | \| | 8J \| | Sensitive Ground 8CT |
| **UR 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 |
| | \| | 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**

> **NOTE**
> The operating times below include the activation time of a trip rated Form-A output contact unless otherwise indicated. FlexLogic™ operands of a given element are 4 ms faster. This should be taken into account when using FlexLogic™ to interconnect with other protection or control elements of the relay, building FlexLogic™ equations, or interfacing with other IEDs or power system devices via communications or different output contacts.

### 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 ±1% of rated (whichever is greater) |
| for > 2.0 × CT: | ±1.5% of reading > 2.0 × CT rating |
| Curve shapes: | IEEE Moderately/Very/Extremely Inverse; IEC (and BS) A/B/C and Short Inverse; GE IAC Inverse, Short/Very/Extremely Inverse; $I^2t$; FlexCurves™ (programmable); Definite Time (0.01 s base curve) |
| Curve multiplier: | Time Dial = 0.00 to 600.00 in steps of 0.01 |
| Reset type: | Instantaneous/Timed (per IEEE) |
| Timing accuracy: | Operate at > 1.03 × actual Pickup ±3.5% of operate time or ±½ cycle (whichever is greater) |

### PHASE/NEUTRAL/GROUND IOC

| | |
|---|---|
| Pickup level: | 0.000 to 30.000 pu in steps of 0.001 |
| Dropout level: | 97 to 98% of pickup |
| Level accuracy: | |
| 0.1 to 2.0 × CT rating: | ±0.5% of reading or ±1% 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) |

### SENSITIVE DIRECTIONAL POWER

| | |
|---|---|
| Measured power: | 3-phase, true RMS |
| Number of stages: | 2 |
| Characteristic angle: | 0 to 359° in steps of 1 |
| Calibration angle: | 0.00 to 0.95° in steps of 0.05 |
| Minimum power: | –1.200 to 1.200 pu in steps of 0.001 |
| Pickup level accuracy: | ±1% or ±0.001 pu, whichever is greater |
| Hysteresis: | 2% or 0.001 pu, whichever is greater |
| Pickup delay: | 0 to 600.00 s in steps of 0.01 |
| Time accuracy: | ±3% or ±4 ms, whichever is greater |
| Operate time: | 50 ms |

### 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) |

### AUXILIARY UNDERVOLTAGE

| | |
|---|---|
| Pickup level: | 0.000 to 3.000 pu in steps of 0.001 |
| Dropout level: | 102 to 103% of pickup |
| Level accuracy: | ±0.5% of reading from 10 to 208 V |
| Curve shapes: | GE IAV Inverse, Definite Time |
| Curve multiplier: | Time Dial = 0 to 600.00 in steps of 0.01 |
| Timing accuracy: | ±3% of operate time or ±4 ms (whichever is greater) |

### NEUTRAL 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: | 0.00 to 600.00 s in steps of 0.01 |
| Reset delay: | 0.00 to 600.00 s in steps of 0.01 |
| Timing accuracy: | ±3% or ±4 ms (whichever is greater) |
| Operate time: | < 30 ms at 1.10 × Pickup at 60 Hz |

### AUXILIARY OVERVOLTAGE

| | |
|---|---|
| Pickup level: | 0.000 to 3.000 pu in steps of 0.001 |
| Dropout level: | 97 to 98% of Pickup |
| Level accuracy: | ±0.5% of reading from 10 to 208 V |
| Pickup delay: | 0 to 600.00 s in steps of 0.01 |
| Reset delay: | 0 to 600.00 s in steps of 0.01 |
| Timing accuracy: | ±3% of operate time or ±4 ms (whichever is greater) |
| Operate time: | < 30 ms at 1.10 × pickup at 60 Hz |

### BREAKER FAILURE

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

**2**

### BREAKER ARCING CURRENT

| | |
|---|---|
| Principle: | accumulates breaker duty ($I^2t$) and measures fault duration |
| Initiation: | programmable per phase from any Flex-Logic™ operand |

Compensation for auxiliary relays: 0 to 65.535 s in steps of 0.001

| | |
|---|---|
| Alarm threshold: | 0 to 50000 kA2-cycle in steps of 1 |
| Fault duration accuracy: | 0.25 of a power cycle |
| Availability: | 1 per CT bank with a minimum of 2 |

### BREAKER FLASHOVER

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

### SYNCHROCHECK

| | |
|---|---|
| Max voltage difference: | 0 to 100000 V in steps of 1 |
| Max angle difference: | 0 to 100° in steps of 1 |
| Max freq. difference: | 0.00 to 2.00 Hz in steps of 0.01 |
| Hysteresis for max. freq. diff.: | 0.00 to 0.10 Hz in steps of 0.01 |
| Dead source function: | None, LV1 & DV2, DV1 & LV2, DV1 or DV2, DV1 xor DV2, DV1 & DV2 (L = Live, D = Dead) |

### AUTORECLOSURE

Two breakers applications

Single- and three-pole tripping schemes

Up to 4 reclose attempts before lockout

Selectable reclosing mode and breaker sequence

### 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: | 8 |
| Operating signal: | any analog actual value, or two values in differential mode |
| Operating signal mode: | Signed or Absolute Value |
| Operating mode: | Level, Delta |
| Comparator direction: | Over, Under |
| Pickup Level: | –30.000 to 30.000 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 |

**2**

### 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 |
| Mode: | Self-Reset, Latched |
| Display message: | 2 lines of 20 characters each |

### 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 |

**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 |

### DATA LOGGER

| | |
|---|---|
| Number of channels: | 1 to 16 |
| Parameters: | Any available analog actual value |
| Sampling rate: | 1 sec.; 1, 5, 10, 15, 20, 30, 60 min. |
| Storage capacity: | (NN is dependent on memory) |
| 1-second rate: | 01 channel for NN days |
| | 16 channels for NN days |
| ↓ | ↓ |
| 60-minute rate: | 01 channel for NN days |
| | 16 channels for NN days |

### FAULT LOCATOR

| | |
|---|---|
| Method: | Single-ended |
| Maximum accuracy if: | Fault resistance is zero or fault currents from all line terminals are in phase |
| Relay accuracy: | ±1.5% (V > 10 V, I > 0.1 pu) |
| Worst-case accuracy: | |

$VT_{\%error}$ + (user data)
$CT_{\%error}$ + (user data)
$Z_{Line\%error}$ + (user data)
$METHOD_{\%error}$ + (Chapter 6)
$RELAY\ ACCURACY_{\%error}$ + (1.5%)

**2.2.4 METERING**

### RMS CURRENT: PHASE, NEUTRAL, AND GROUND

Accuracy at

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

### RMS VOLTAGE

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

### REAL POWER (WATTS)

| | |
|---|---|
| Accuracy: | ±1.0% of reading at −0.8 < PF ≤ −1.0 and 0.8 < PF ≤ 1.0 |

### REACTIVE POWER (VARS)

| | |
|---|---|
| Accuracy: | ±1.0% of reading at −0.2 ≤ PF ≤ 0.2 |

### APPARENT POWER (VA)

| | |
|---|---|
| Accuracy: | ±1.0% of reading |

### WATT-HOURS (POSITIVE AND NEGATIVE)

| | |
|---|---|
| Accuracy: | ±2.0% of reading |
| Range: | ±0 to 2 × 10⁹ MWh |
| Parameters: | 3-phase only |
| Update rate: | 50 ms |

### VAR-HOURS (POSITIVE AND NEGATIVE)

| | |
|---|---|
| Accuracy: | ±2.0% of reading |
| Range: | ±0 to 2 × 10⁹ Mvarh |
| Parameters: | 3-phase only |
| Update rate: | 50 ms |

### FREQUENCY

Accuracy at

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

**2**

**DEMAND**

| | |
|---|---|
| Measurements: | Phases A, B, and C present and maximum measured currents<br>3-Phase Power (P, Q, and S) present and maximum measured currents |
| Accuracy: | ±2.0% |

**AC CURRENT**

| | |
|---|---|
| CT rated primary: | 1 to 50000 A |
| CT rated secondary: | 1 A or 5 A by connection |
| Nominal frequency: | 20 to 65 Hz |
| Relay burden: | < 0.2 VA at rated secondary |
| Conversion range: | |
|   Standard CT: | 0.02 to 46 × CT rating RMS symmetrical |
|   Sensitive Ground module: | |
| | 0.002 to 4.6 × CT rating RMS symmetrical |
| Current withstand: | 20 ms at 250 times rated<br>1 sec. at 100 times rated<br>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<br>1 min./hr at 420 V to neutral |

**CONTACT INPUTS**

| | |
|---|---|
| Dry contacts: | 1000 Ω maximum |
| Wet contacts: | 300 V DC maximum |
| Selectable thresholds: | 17 V, 33 V, 84 V, 166 V |
| Tolerance: | ±10% |
| Recognition time: | < 1 ms |
| Debounce timer: | 0.0 to 16.0 ms in steps of 0.5 |

**DCMA INPUTS**

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

**RTD INPUTS**

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

**IRIG-B INPUT**

| | |
|---|---|
| Amplitude modulation: | 1 to 10 V pk-pk |
| DC shift: | TTL |
| Input impedance: | 22 kΩ |
| Isolation: | 2 kV |

**REMOTE INPUTS (MMS 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 |

**LOW RANGE**

| | |
|---|---|
| Nominal DC voltage: | 24 to 48 V at 3 A |
| Min/max DC voltage: | 20 / 60 V |

NOTE: Low range is DC only.

**HIGH RANGE**

| | |
|---|---|
| Nominal DC voltage: | 125 to 250 V at 0.7 A |
| Min/max DC voltage: | 88 / 300 V |
| Nominal AC voltage: | 100 to 240 V at 50/60 Hz, 0.7 A |
| Min/max AC voltage: | 88 / 265 V at 48 to 62 Hz |

**ALL RANGES**

| | |
|---|---|
| Volt withstand: | 2 × Highest Nominal Voltage for 10 ms |
| Voltage loss hold-up: | 50 ms duration at nominal |
| Power consumption: | Typical = 15 VA; Max. = 30 VA |

**INTERNAL FUSE**

RATINGS
>      Low range power supply: 7.5 A / 600 V
>      High range power supply: 5 A / 600 V

INTERRUPTING CAPACITY
>      AC:               100 000 A RMS symmetrical
>      DC:               10 000 A

**2**

## FORM-A 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. at 48 V
                            0.10 A DC max. at 125 V

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: 10 A

Carry continuous:            6 A

Break at L/R of 40 ms:      0.25 A DC max. at 48 V
                            0.10 A DC max. at 125 V

Operate time:               < 8 ms

Contact material:           Silver alloy

## FAST FORM-C RELAY

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

Minimum load impedance:

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

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

Operate time:               < 0.6 ms

Internal Limiting Resistor: 100 Ω, 2 W

## SOLID-STATE OUTPUT RELAY

Operate and release time: <100 μs

Maximum voltage:            265 V DC

Maximum continuous current: 5 A at 45°C; 4 A at 65°C

Make and carry for 0.2 s: as per ANSI C37.90

Breaking capacity:

| | IEC 647-5 / 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 | | |
| | 1.6 A L/R = 20 ms | 10 A L/R = 40 ms | 10 A L/R = 40 ms |
| | 0.8 A L/R = 40 ms | | |

## IRIG-B OUTPUT

Amplitude:                  10 V peak-peak RS485 level

Maximum load:               100 ohms

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

Isolation:                  2 kV

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

Capacity:                   100 mA DC at 48 V DC

Isolation:                  ±300 Vpk

## REMOTE OUTPUTS (IEC 61850 GSSE)

Standard output points:    32

User output points:        32

## DIRECT OUTPUTS

Output points:             32

## DCMA OUTPUTS

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

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

Accuracy:                  ±0.75% of full-scale for 0 to 1 mA range
                           ±0.5% of full-scale for –1 to 1 mA range
                           ±0.75% of full-scale for 0 to 20 mA range

99% Settling time to a step change: 100 ms

Isolation:                 1.5 kV

Driving signal:            any FlexAnalog quantity

Upper and lower limit for the driving signal: –90 to 90 pu in steps of 0.001

**2**

**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 PORT**

10Base-F:                      820 nm, multi-mode, supports half-duplex/full-duplex fiber optic with ST connector

Redundant 10Base-F:            820 nm, multi-mode, half-duplex/full-duplex fiber optic with ST connector

10Base-T:                      RJ45 connector

Power budget:                  10 db

Max optical input power:       –7.6 dBm

Max optical output power:      –20 dBm

Receiver sensitivity:          –30 dBm

Typical distance:              1.65 km

SNTP clock synchronization error: <10 ms (typical)

**SHIELDED TWISTED-PAIR INTERFACE OPTIONS**

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

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

**LINK POWER BUDGET**

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

> **NOTE** **These Power Budgets are calculated from the manufacturer's worst-case transmitter power and worst case receiver sensitivity.**

**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 | FIBER TYPE | CONNECTOR TYPE | TYPICAL DISTANCE |
|---|---|---|---|
| 820 nm LED | Multimode | ST | 1.65 km |
| 1300 nm LED | Multimode | ST | 3.8 km |
| 1300 nm ELED | Singlemode | ST | 11.4 km |
| 1300 nm Laser | Singlemode | ST | 64 km |
| 1550 nm Laser | Singlemode | ST | 105 km |

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

**CONNECTOR LOSSES (TOTAL OF BOTH ENDS)**

ST connector              2 dB

**FIBER LOSSES**

820 nm multimode          3 dB/km

1300 nm multimode         1 dB/km

1300 nm singlemode        0.35 dB/km

1550 nm singlemode        0.25 dB/km

Splice losses:            One splice every 2 km, at 0.05 dB loss per splice.

**SYSTEM MARGIN**

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

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

**2**

**OPERATING TEMPERATURES**

Cold:                         IEC 60028-2-1, 16 h at –40°C
Dry Heat:                     IEC 60028-2-2, 16 h at +85°C

**OTHER**

Humidity (noncondensing): IEC 60068-2-30, 95%, Variant 1, 6 days
Altitude:                     Up to 2000 m
Installation Category:        II

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/variations:
                             IEC 61000-4-11
                             IEC 60255-11
Power frequency magnetic field immunity:
                             IEC 61000-4-8
Vibration test (sinusoidal): IEC 60255-21-1
Shock and bump:              IEC 60255-21-2

> **NOTE**
> **Type test report available upon request.**

**THERMAL**

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

**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

**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.

The relay is available as a 19-inch rack horizontal mount unit or as a reduced size (¾) vertical mount unit, with a removable faceplate. 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 vertical and horizontal 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.

**3**
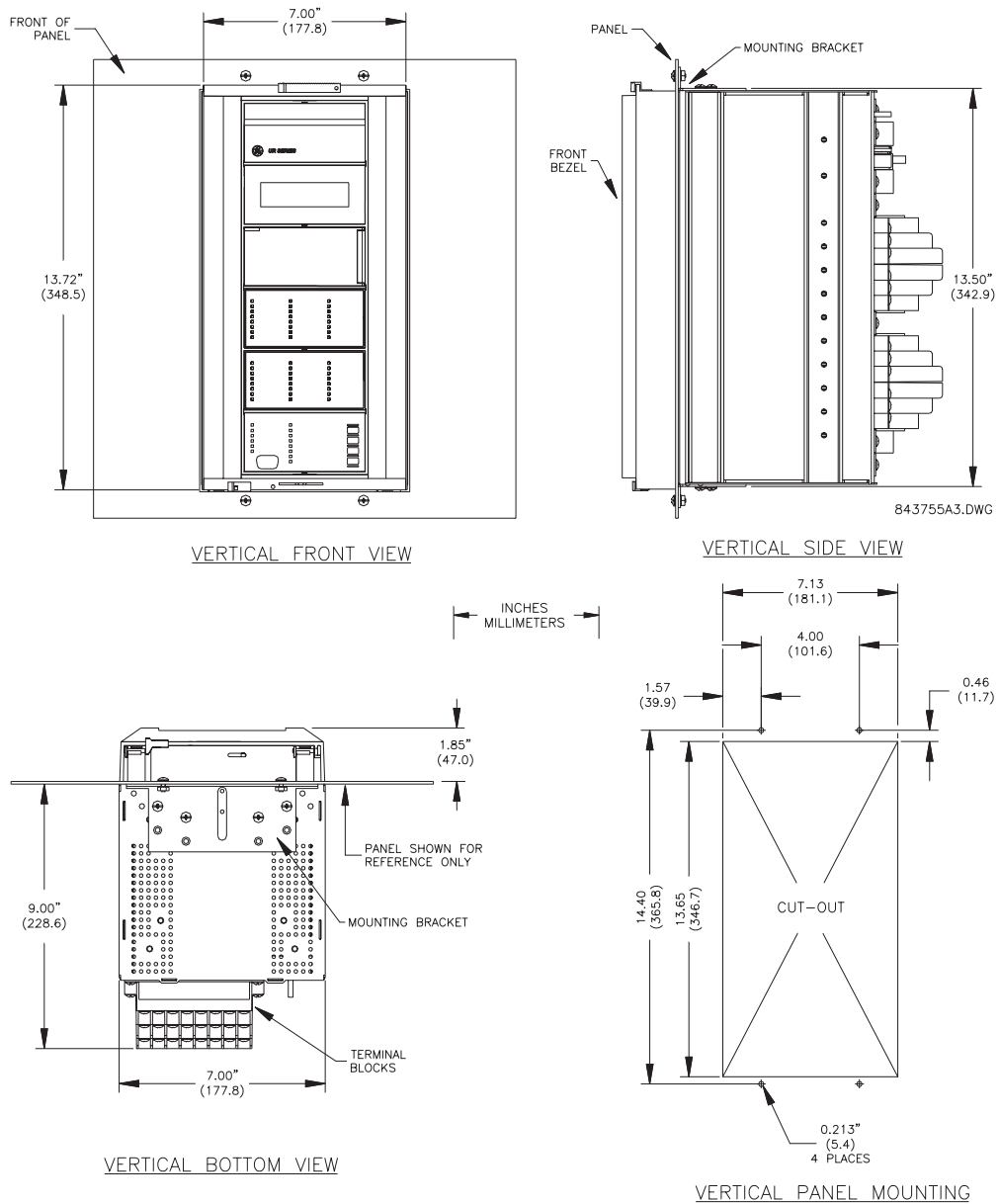


**Figure 3–1: C60 VERTICAL MOUNTING AND DIMENSIONS**

**3**
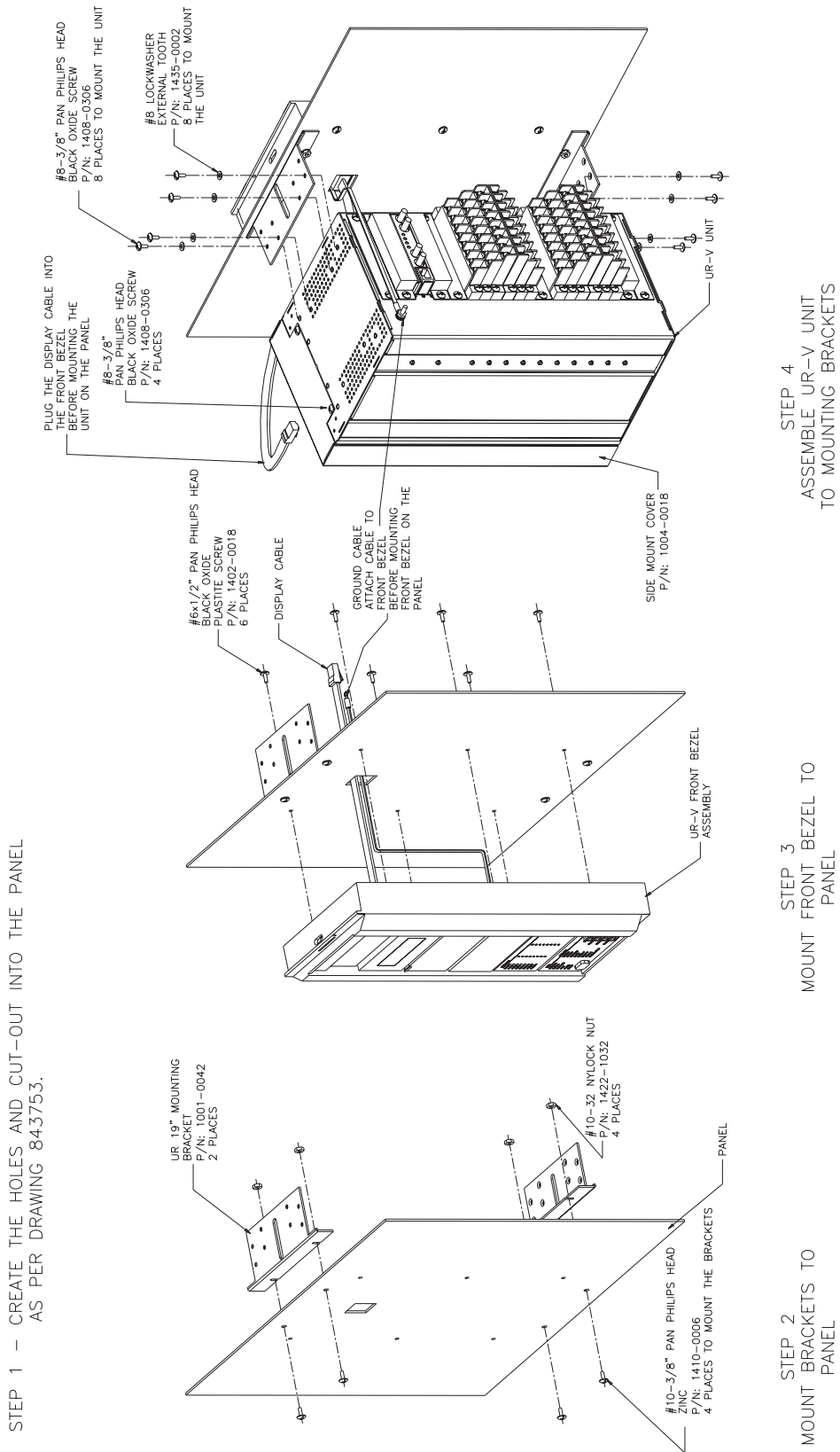


**Figure 3–2: C60 VERTICAL SIDE MOUNTING INSTALLATION**

**3**
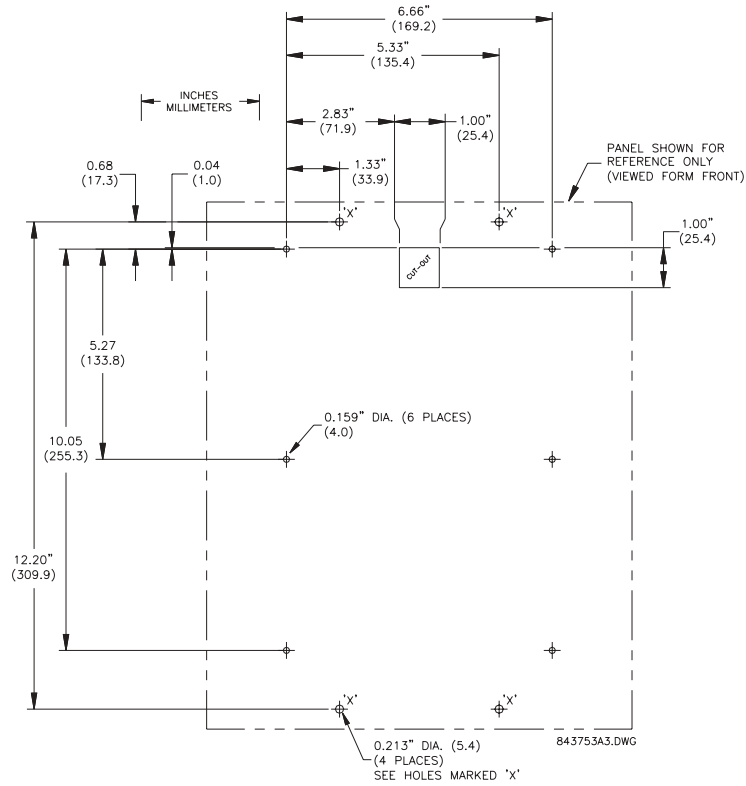


**Figure 3–3: C60 VERTICAL SIDE MOUNTING REAR DIMENSIONS**
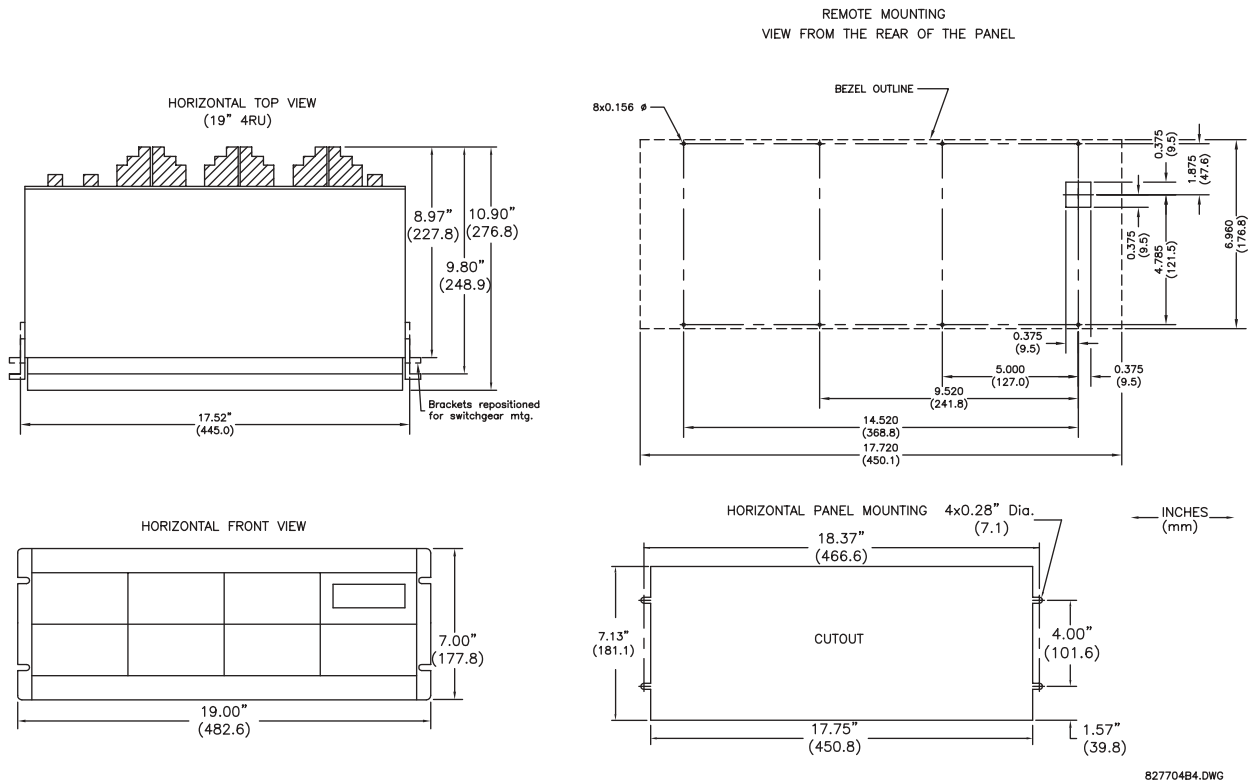


**Figure 3–4: C60 HORIZONTAL MOUNTING AND DIMENSIONS**

**3**

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

⚠️ **WARNING**  **Proper electrostatic discharge protection (i.e. 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 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.



**Figure 3–5: UR MODULE WITHDRAWAL/INSERTION**

- **MODULE WITHDRAWAL:** The ejector/inserter clips, located at the top and bottom of each module, must be pulled simultaneously to release the module for removal. 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.

- **MODULE INSERTION:** Ensure that the **correct** module type is inserted into the **correct** slot position. The ejector/inserter clips located at the top and at the bottom of each module must be in the disengaged position as the module is smoothly inserted into the slot. Once the clips have cleared the raised edge of the chassis, engage the clips simultaneously. When the clips have locked into position, the module will be fully inserted.

📝 **NOTE**  Type 9G and 9H CPU modules are equipped with 10Base-T and 10Base-F Ethernet connectors. These connectors must be individually disconnected from the module before the it can be removed from the chassis.

📝 **NOTE**  The version 4.0 release of the C60 relay includes new hardware (CPU and CT/VT modules). The new CPU modules are specified with the following order codes: 9E, 9G, and 9H. The new CT/VT modules are specified with the following order codes: 8F, 8G, 8H, 8J.

The new CT/VT modules (8F, 8G, 8H, 8J) can only be used with the new CPUs (9E, 9G, 9H); similarly, the old CT/VT modules (8A, 8B, 8C, 8D) can only be used with the old CPUs (9A, 9C, 9D). To prevent hardware mismatches, the new CPU and CT/VT modules have blue labels and a warning sticker stating **"Attn.: Ensure CPU and DSP module label colors are the same!"**. In the event that there is a mismatch between the CPU and CT/VT module, the relay will not function and a **DSP ERROR** or **HARDWARE MISMATCH** error will be displayed.

All other input/output modules are compatible with the new hardware. Firmware versions 4.0x and higher are only compatible with the new CPU and CT/VT modules. Previous versions of the firmware (3.4x and earlier) are only compatible with the older CPU and CT/VT modules.

834722A1.CDR

**Figure 3–6: REAR TERMINAL VIEW**

⚠ **WARNING**

**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.
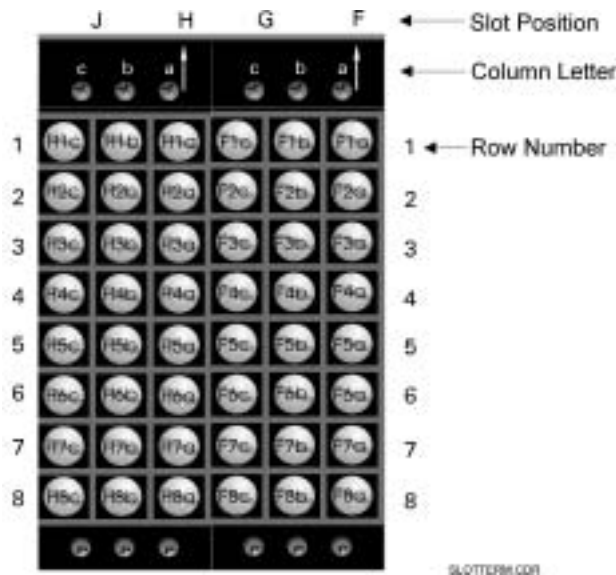


**Figure 3–7: EXAMPLE OF MODULES IN F AND H SLOTS**

**3**



**TYPICAL CONFIGURATION**
THE AC SIGNAL PATH IS CONFIGURABLE
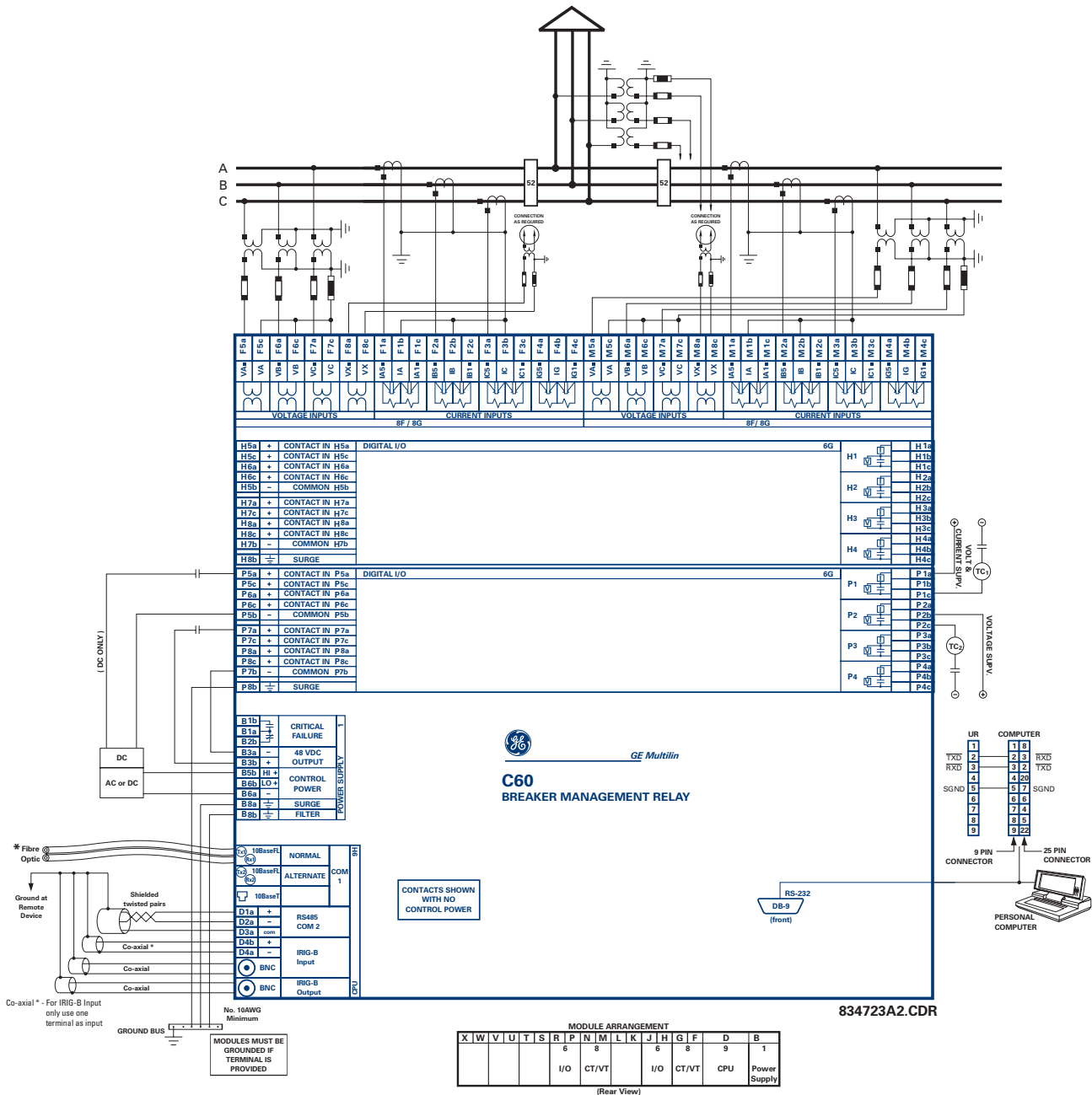
This diagram is based on the following order code: C60-E00-HCL-F8F-H6B-M6K-P5F.

The purpose of this diagram is to provide an example of how the relay is typically wired, not specifically how to wire your own relay. Please refer to the following pages for examples to help you wire your relay correctly based on your own relay configuration and order code.

**CAUTION**

**Figure 3–8: TYPICAL WIRING DIAGRAM**

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 (See Precaution 2) | 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 module hardware to prevent damage caused by high peak voltage transients, radio frequency interference (RFI) and electromagnetic interference (EMI). These protective components **can be damaged** by application of the ANSI/IEEE C37.90 specified test voltage for a period longer than the specified one minute.

### 3.2.3 CONTROL POWER

> ⚠ **CAUTION**
> **CONTROL POWER SUPPLIED TO THE RELAY MUST BE CONNECTED TO THE MATCHING POWER SUPPLY RANGE OF THE RELAY. IF THE VOLTAGE IS APPLIED TO THE WRONG TERMINALS, DAMAGE MAY OCCUR!**

> **NOTE**
> **The C60 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. Each range has a dedicated input connection for proper operation. The ranges are as shown below (see the Technical Specifications section for additional details):

- LO range: 24 to 48 V (DC only) nominal
- 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 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 table in Chapter 7) or control power is lost, the relay will de-energize.
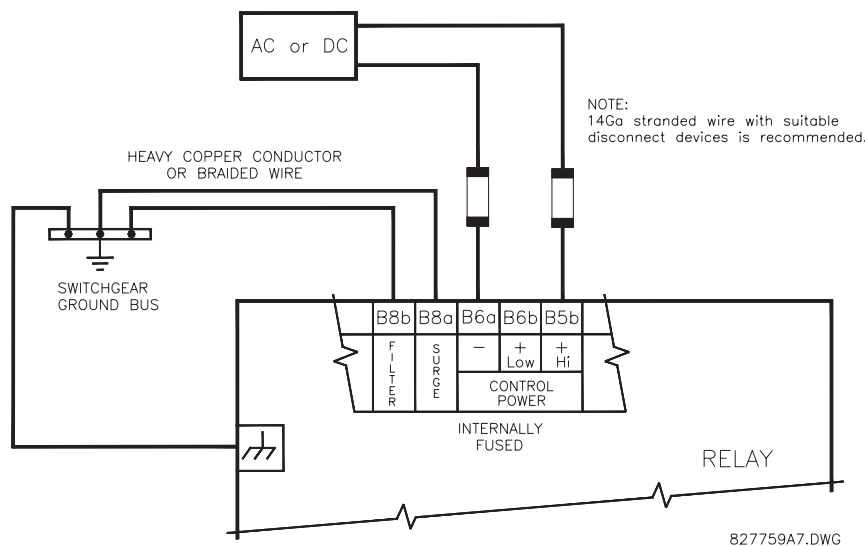


**Figure 3–9: CONTROL POWER CONNECTION**

### 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. Channels 2 and 6 are intended for connection to Phase B, and are labeled as such in the relay. Channels 3 and 7 are intended for connection to Phase C and are labeled as such in the relay. Channels 4 and 8 are intended for connection to a single phase source. If voltage, this channel is labelled the auxiliary voltage (VX). If current, this channel is intended for connection to a CT between a system neutral and ground, and is labelled the ground current (IG).

#### a) CT INPUTS

> ⚠ **CAUTION**
> **VERIFY THAT THE CONNECTION MADE TO THE RELAY NOMINAL CURRENT OF 1 A OR 5 A MATCHES THE SECONDARY RATING OF THE CONNECTED CTs. UNMATCHED CTs MAY RESULT IN EQUIPMENT DAMAGE OR INADEQUATE PROTECTION.**

The CT/VT module may be ordered with a standard ground current input that is the same as the phase current inputs (Type 8F) or with a sensitive ground input (Type 8G) which is 10 times more sensitive (see the Technical Specifications section for additional details). 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.

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 CT so that ground fault current will be detected is shown below. Twisted pair cabling on the zero-sequence CT is recommended.
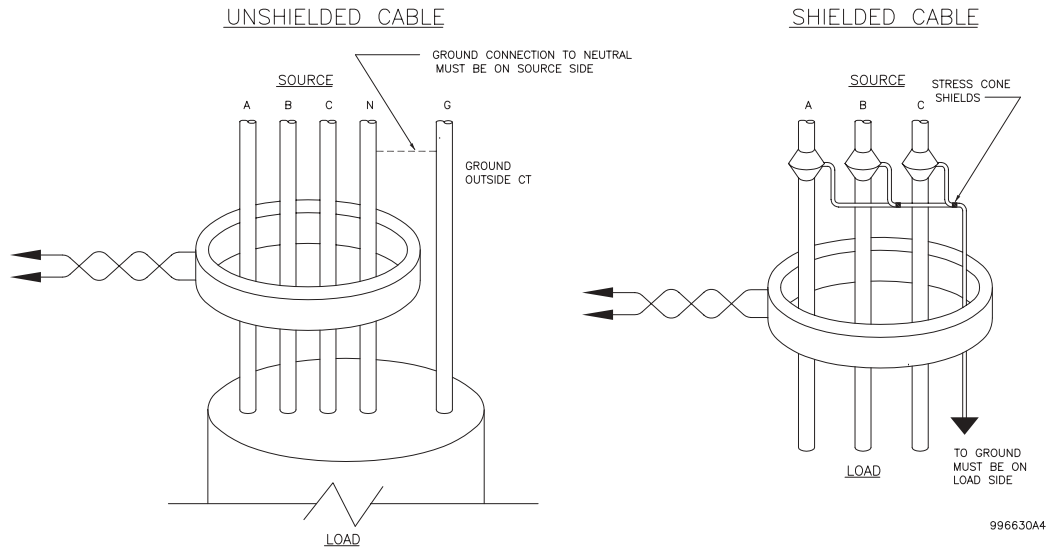


**Figure 3–10: ZERO-SEQUENCE CORE BALANCE CT INSTALLATION**

### b) VT INPUTS

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/Hertz features.
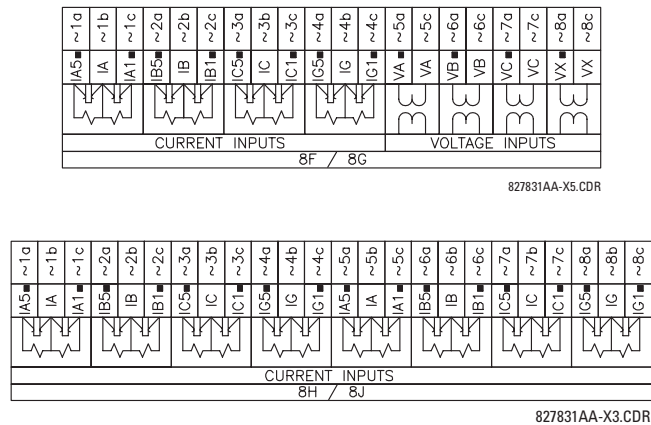


**Figure 3–11: CT/VT MODULE WIRING**

> **NOTE**
> Wherever a tilde "~" symbol appears, substitute with the Slot Position of the module.

**3**

Every digital input/output module has 24 terminal connections. They are arranged as 3 terminals per row, with 8 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. When a digital input/output module is ordered with contact inputs, they are arranged in groups of four and use two rows of three terminals. Ideally, each input would be totally isolated from any other input. However, this would require that every input have two dedicated terminals and limit the available number of contacts based on the available number of terminals. So, although each input is individually optically isolated, each group of four inputs uses a single common as a reasonable compromise. This allows each group of four outputs to be supplied by wet contacts from different voltage sources (if required) or a mix of wet and dry contacts.

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.

**UR-SERIES FORM-A / SOLID STATE (SSR) OUTPUT CONTACTS:**

Some Form-A/SSR 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. The block diagrams of the circuits are below above for the Form-A outputs with:

    a) optional voltage monitor
    b) optional current monitor
    c) with no monitoring
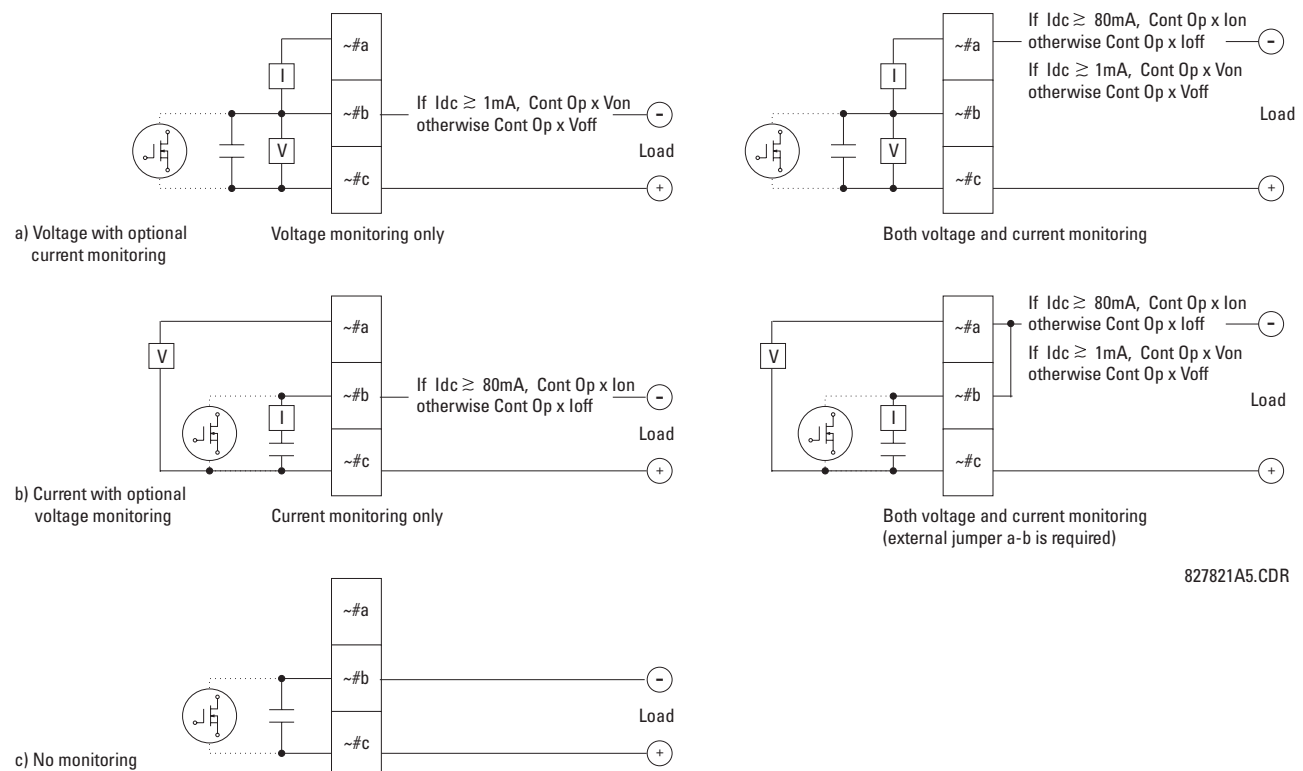
**Figure 3–12: FORM-A /SOLID STATE CONTACT FUNCTIONS**

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/SSR 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/SSR OUTPUTS IN HIGH IMPEDANCE CIRCUITS**
>
> For Form-A/SSR 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/SSR 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 I/O MODULE | |
|---|---|
| **TERMINAL ASSIGNMENT** | **OUTPUT OR INPUT** |
| ~1 | Form-A |
| ~2 | Form-A |
| ~3 | Form-C |
| ~4 | Form-C |
| ~5a, ~5c | 2 Inputs |
| ~6a, ~6c | 2 Inputs |
| ~7a, ~7c | 2 Inputs |
| ~8a, ~8c | 2 Inputs |

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

| ~6C I/O MODULE | |
|---|---|
| **TERMINAL ASSIGNMENT** | **OUTPUT** |
| ~1 | Form-C |
| ~2 | Form-C |
| ~3 | Form-C |
| ~4 | Form-C |
| ~5 | Form-C |
| ~6 | Form-C |
| ~7 | Form-C |
| ~8 | Form-C |

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

| ~6E I/O MODULE | |
|---|---|
| **TERMINAL ASSIGNMENT** | **OUTPUT OR INPUT** |
| ~1 | Form-C |
| ~2 | Form-C |
| ~3 | Form-C |
| ~4 | Form-C |
| ~5a, ~5c | 2 Inputs |
| ~6a, ~6c | 2 Inputs |
| ~7a, ~7c | 2 Inputs |
| ~8a, ~8c | 2 Inputs |

| ~6F I/O MODULE | |
|---|---|
| **TERMINAL ASSIGNMENT** | **OUTPUT** |
| ~1 | Fast Form-C |
| ~2 | Fast Form-C |
| ~3 | Fast Form-C |
| ~4 | Fast Form-C |
| ~5 | Fast Form-C |
| ~6 | Fast Form-C |
| ~7 | Fast Form-C |
| ~8 | Fast Form-C |

| ~6G I/O MODULE | |
|---|---|
| **TERMINAL ASSIGNMENT** | **OUTPUT OR INPUT** |
| ~1 | Form-A |
| ~2 | Form-A |
| ~3 | Form-A |
| ~4 | Form-A |
| ~5a, ~5c | 2 Inputs |
| ~6a, ~6c | 2 Inputs |
| ~7a, ~7c | 2 Inputs |
| ~8a, ~8c | 2 Inputs |

| ~6H I/O 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 |

**3**

| ~6K I/O MODULE | |
|---|---|
| TERMINAL ASSIGNMENT | OUTPUT |
| ~1 | Form-C |
| ~2 | Form-C |
| ~3 | Form-C |
| ~4 | Form-C |
| ~5 | Fast Form-C |
| ~6 | Fast Form-C |
| ~7 | Fast Form-C |
| ~8 | Fast Form-C |

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

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

| ~6N I/O MODULE | |
|---|---|
| TERMINAL ASSIGNMENT | OUTPUT OR INPUT |
| ~1 | Form-A |
| ~2 | Form-A |
| ~3 | Form-A |
| ~4 | Form-A |
| ~5a, ~5c | 2 Inputs |
| ~6a, ~6c | 2 Inputs |
| ~7a, ~7c | 2 Inputs |
| ~8a, ~8c | 2 Inputs |

| ~6P I/O MODULE | |
|---|---|
| TERMINAL ASSIGNMENT | OUTPUT OR INPUT |
| ~1 | Form-A |
| ~2 | Form-A |
| ~3 | Form-A |
| ~4 | Form-A |
| ~5 | Form-A |
| ~6 | Form-A |
| ~7a, ~7c | 2 Inputs |
| ~8a, ~8c | 2 Inputs |

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

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

| ~6T I/O MODULE | |
|---|---|
| TERMINAL ASSIGNMENT | OUTPUT OR INPUT |
| ~1 | Form-A |
| ~2 | Form-A |
| ~3 | Form-A |
| ~4 | Form-A |
| ~5a, ~5c | 2 Inputs |
| ~6a, ~6c | 2 Inputs |
| ~7a, ~7c | 2 Inputs |
| ~8a, ~8c | 2 Inputs |

| ~6U I/O 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 I/O 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 I/O 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 I/O 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 I/O 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 |

| ~4L I/O 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 |

**3**
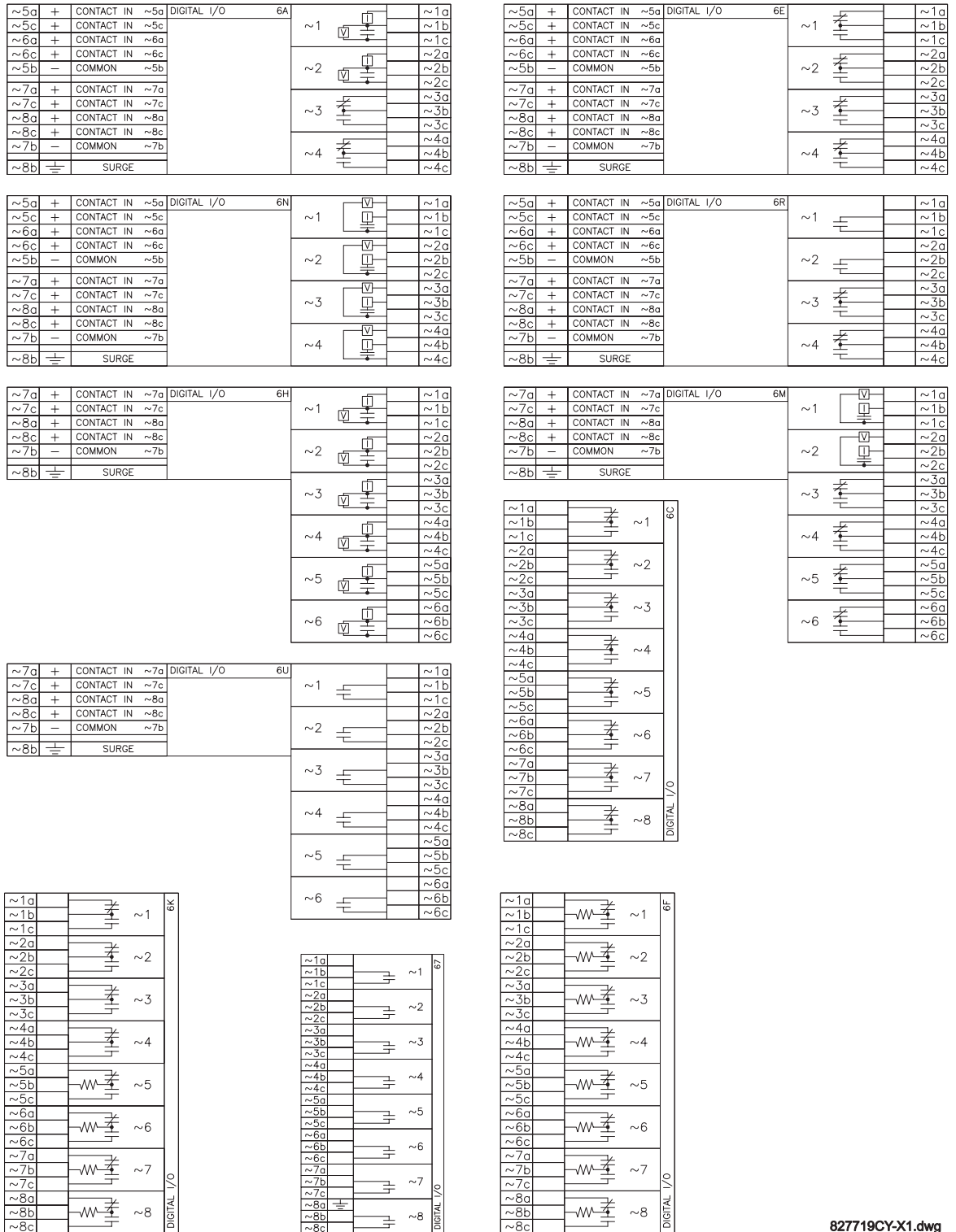
827719CY-X1.dwg

**Figure 3–13: DIGITAL INPUT/OUTPUT MODULE WIRING (1 of 2)**

**3**
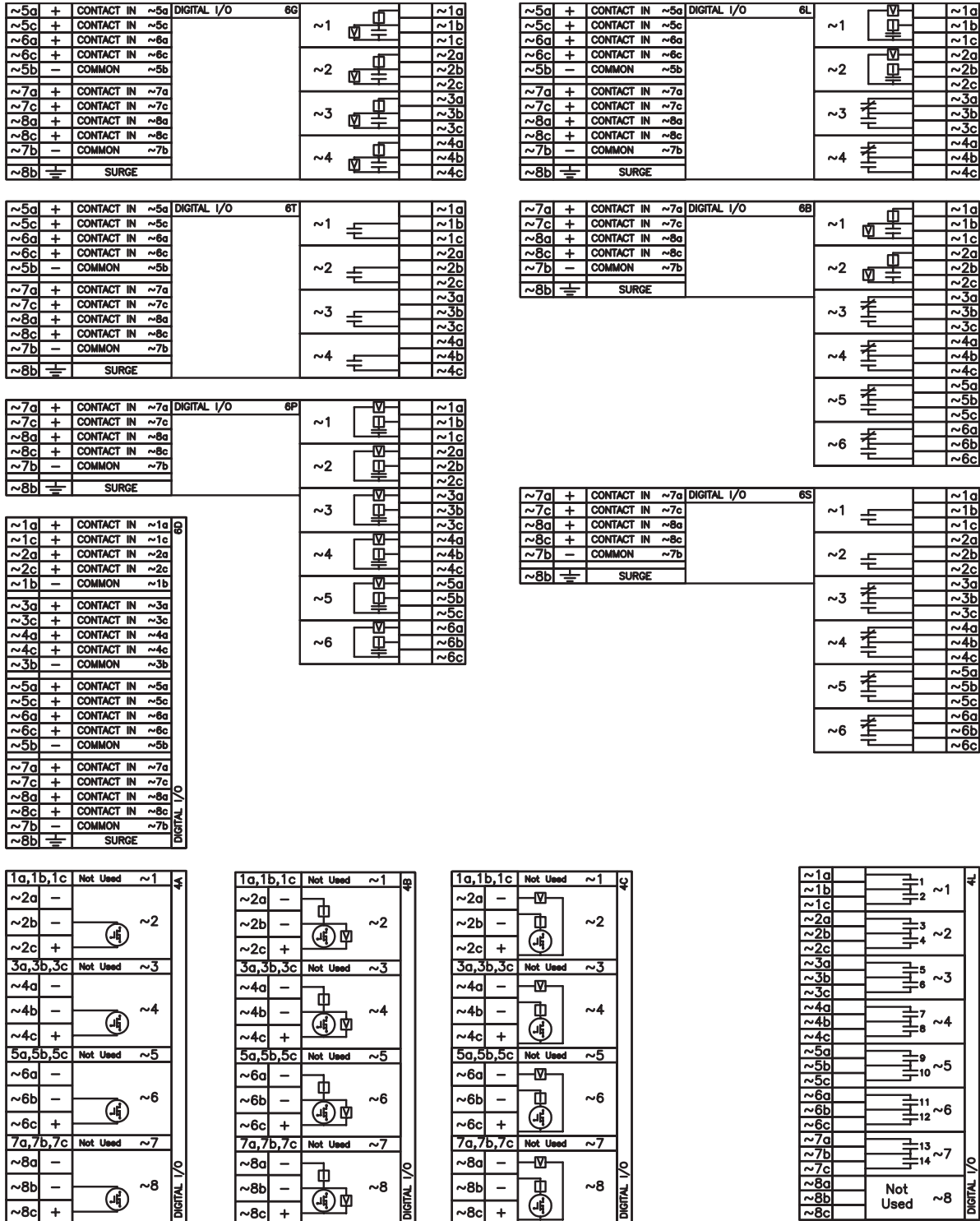


**Figure 3–14: DIGITAL INPUT/OUTPUT MODULE WIRING (2 of 2)**

827719CY-X2.dwg

⚠ **CAUTION**   **CORRECT POLARITY MUST BE OBSERVED FOR ALL CONTACT INPUT AND SOLID STATE OUTPUT CON-NECTIONS FOR PROPER FUNCTIONALITY.**

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. In addition, the negative side of the external source must be connected to the relay common (negative) terminal of each contact input group. The maximum external source voltage for this arrangement is 300 V DC.

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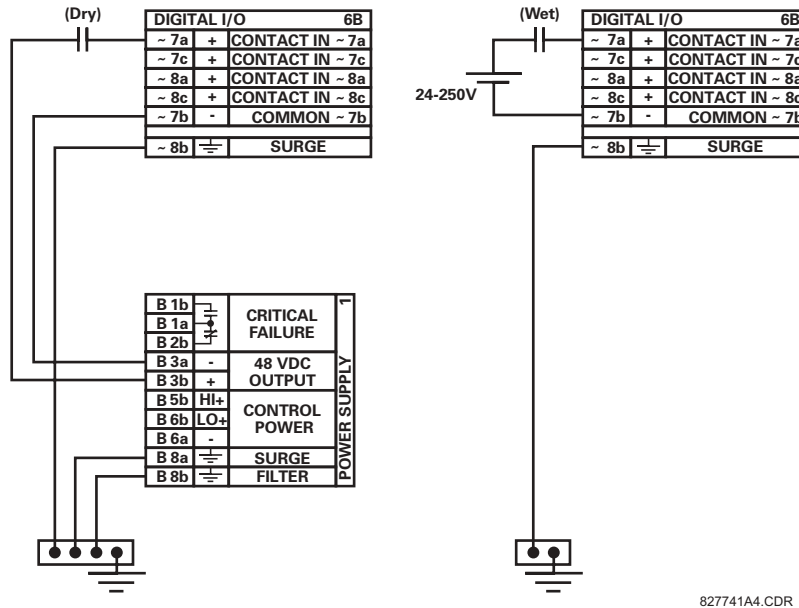


**Figure 3–15: DRY AND WET CONTACT INPUT CONNECTIONS**

> **NOTE**
> Wherever a tilde "~" symbol appears, substitute with the Slot Position of the module.

Contact outputs may be ordered as Form-A or Form-C. The Form A contacts may be connected for external circuit supervision. These contacts are provided with voltage and current monitoring circuits used to detect the loss of DC voltage in the circuit, and the presence of DC current flowing through the contacts when the Form-A contact closes. If enabled, the current monitoring can be used as a seal-in signal to ensure that the Form-A contact does not attempt to break the energized inductive coil circuit and weld the output contacts.

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

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

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

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

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

**NOTE**    **Wherever a tilde "~" symbol appears, substitute with the Slot Position of the module.**



827831AB-X1.CDR

**Figure 3–16: TRANSDUCER INPUT/OUTPUT MODULE WIRING**

**3.2.7 RS232 FACEPLATE PORT**

A 9-pin RS232C serial port is located on the relay's faceplate for programming with a portable (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**.

**NOTE**



```
Front panel 9 pin RS232 Program port

1:   N/A
2:   (TXD)
3:   (RXD)
4:   N/A
5:   (SGND) Signal Ground
6:   N/A
7:   N/A
8:   N/A
9:   N/A
```
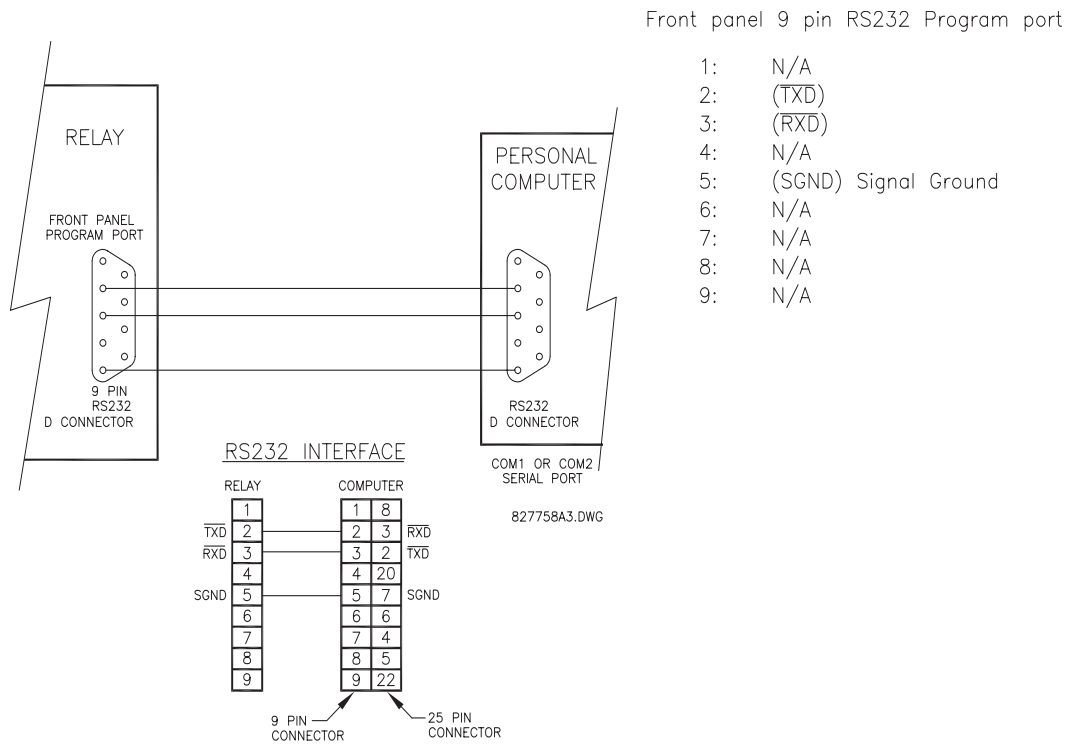
**Figure 3–17: RS232 FACEPLATE PORT CONNECTION**

### a) OPTIONS

In addition to the RS232 port on the faceplate, the relay provides the user with two additional communication port(s) depending on the CPU module installed.

**NOTE** The 9E, 9G, and 9H CPU modules do not require a surge ground connection.

| CPU TYPE | COM1 | COM2 |
|----------|------|------|
| 9E | RS485 | RS485 |
| 9G | 10Base-F and 10Base-T | RS485 |
| 9H | Redundant 10Base-F | RS485 |
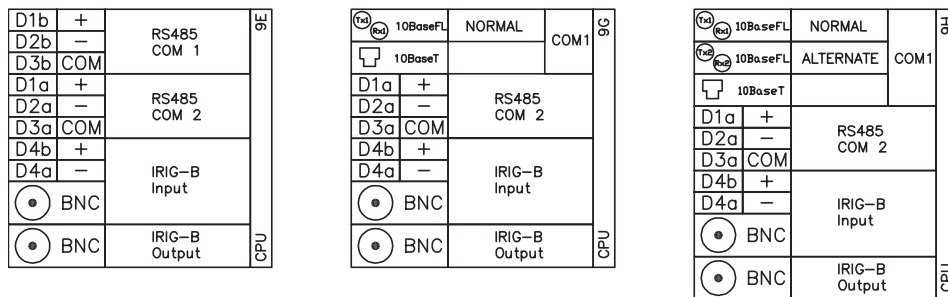


827831AB-X6.DWG

**Figure 3–18: 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 port(s), 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.

827757A7.DWG
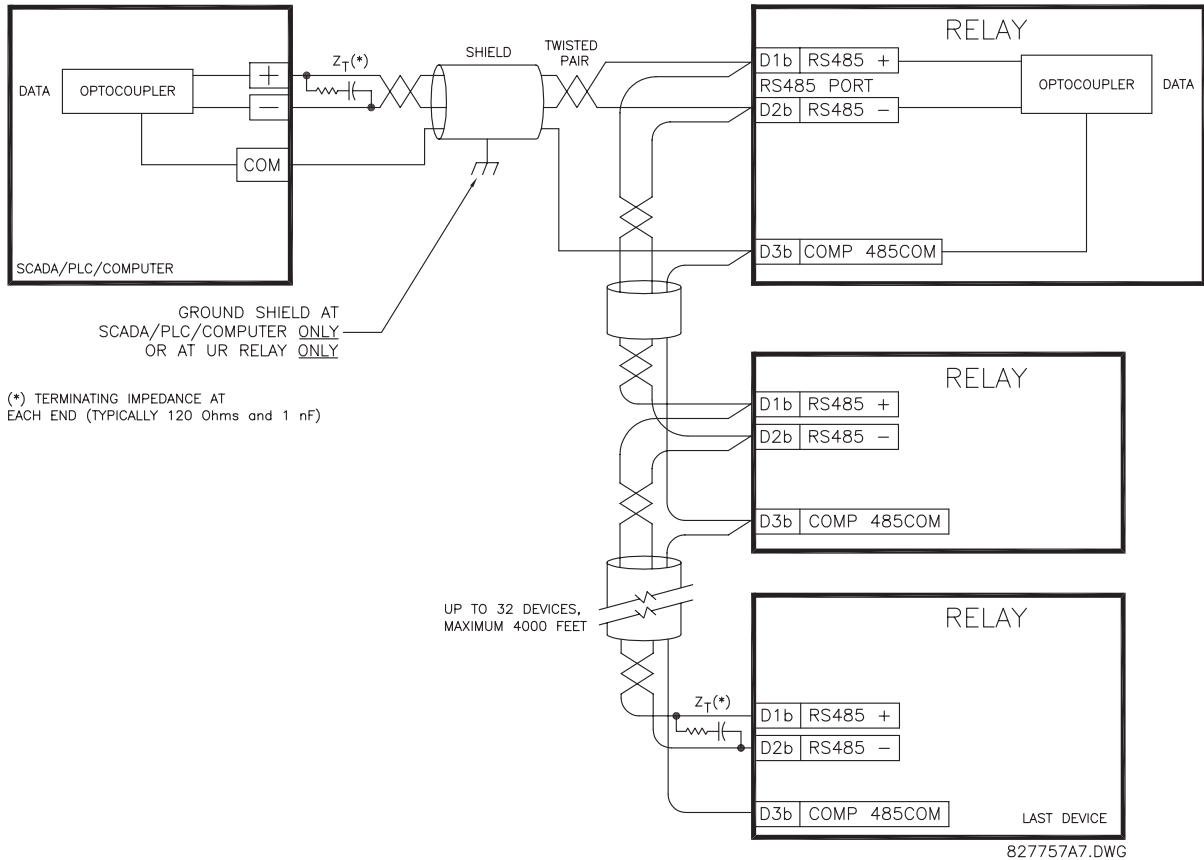
**Figure 3–19: RS485 SERIAL CONNECTION**

### c) 10BASE-F FIBER OPTIC PORT

> **CAUTION**
>
> **ENSURE THE DUST COVERS ARE INSTALLED WHEN THE FIBER IS NOT IN USE. DIRTY OR SCRATCHED CONNECTORS CAN LEAD TO HIGH LOSSES ON A FIBER LINK.**

> **CAUTION**
>
> **OBSERVING ANY FIBER TRANSMITTER OUTPUT MAY CAUSE INJURY TO THE EYE.**

The fiber optic communication ports allow for fast and efficient communications between relays at 10 Mbps. Optical fiber may be connected to the relay supporting a wavelength of 820 nanometers in multimode. Optical fiber is only available for CPU types 9G and 9H. The 9H CPU has a 10BaseF transmitter and receiver for optical fiber communications and a second pair of identical optical fiber transmitter and receiver for redundancy.

The optical fiber sizes supported include 50/125 µm, 62.5/125 µm and 100/140 µm. 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. For optical power budgeting, splices are required every 1 km for the transmitter/receiver pair (the ST type connector contributes for a connector loss of 0.2 dB). 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.

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.
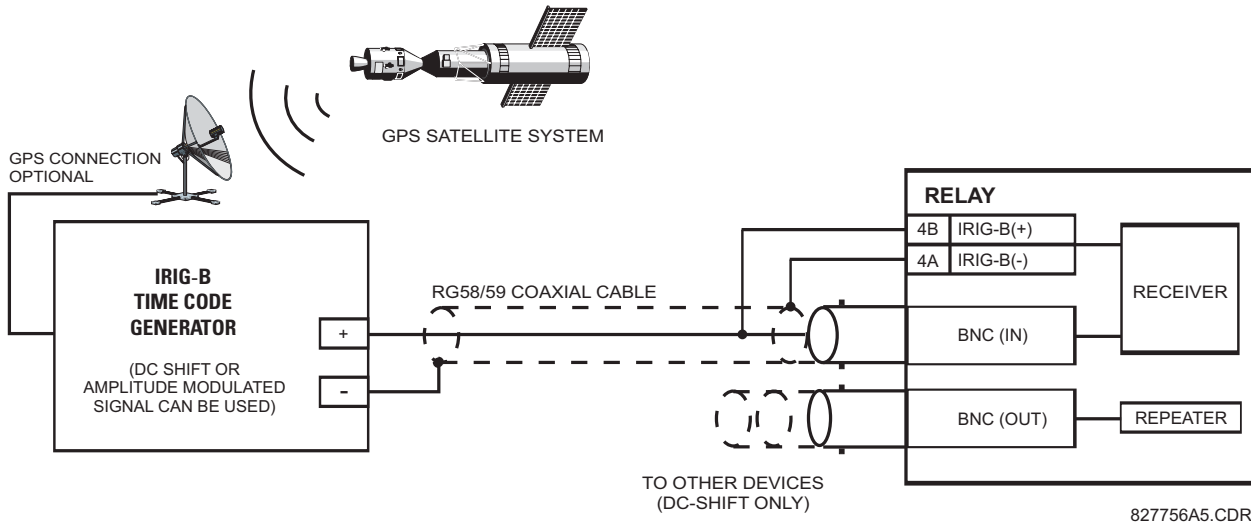


**Figure 3–20: IRIG-B CONNECTION**

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.
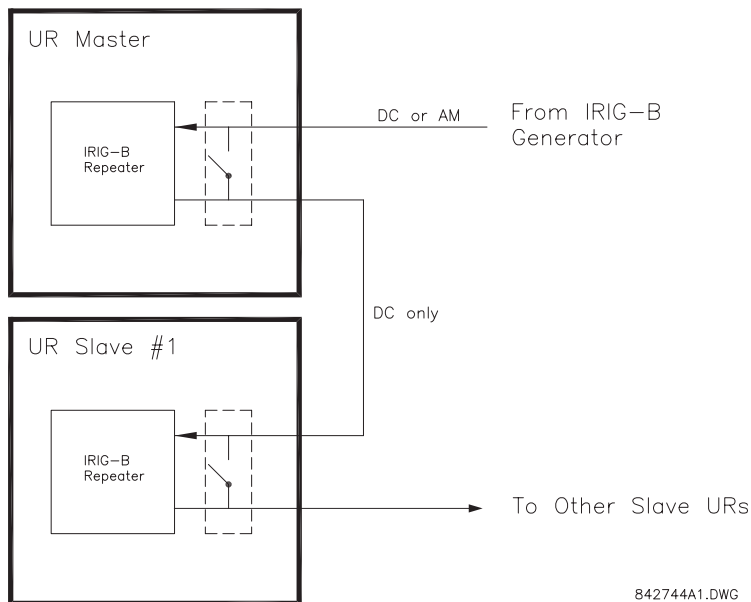


**Figure 3–21: IRIG-B REPEATER**

The C60 direct inputs/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/output feature uses the communications channel(s) 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 eight (8) UR-series relays can be connected in a single ring
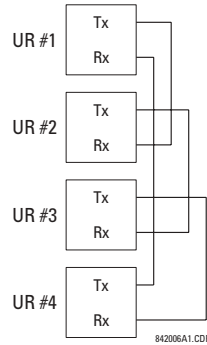


**Figure 3–22: DIRECT INPUT/OUTPUT SINGLE CHANNEL CONNECTION**

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 UR2-Rx2, UR2-Tx2 to UR3-Rx2, UR3-Tx2 to UR4-Rx2, and UR4-Tx2 to UR1-Rx2 for the second ring.
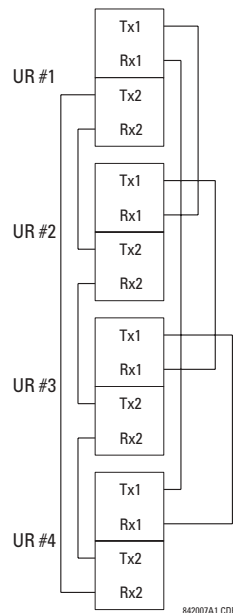


**Figure 3–23: DIRECT INPUT/OUTPUT DUAL CHANNEL CONNECTION**

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/output data to 'crossover' 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.
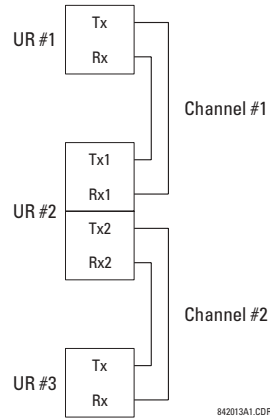
**Figure 3–24: DIRECT INPUT/OUTPUT SINGLE/DUAL CHANNEL COMBINATION CONNECTION**

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.

**Table 3–3: CHANNEL COMMUNICATION OPTIONS**

| MODULE | SPECIFICATION |
|--------|---------------|
| 2A | C37.94SM, 1300 nm, single-mode, ELED, 1 channel single-mode |
| 2B | C37.94SM, 1300 nm, single-mode, ELED, 2 channel single-mode |
| 7A | 820 nm, multi-mode, LED, 1 channel |
| 7B | 1300 nm, multi-mode, LED, 1 channel |
| 7C | 1300 nm, single-mode, ELED, 1 channel |
| 7D | 1300 nm, single-mode, LASER, 1 channel |
| 7E | Channel 1: G.703, Channel 2: 820 nm, multi-mode |
| 7F | Channel 1: G.703, Channel 2: 1300 nm, multi-mode |
| 7G | Channel 1: G.703, Channel 2: 1300 nm, single-mode ELED |
| 7H | 820 nm, multi-mode, LED, 2 channels |
| 7I | 1300 nm, multi-mode, LED, 2 channels |
| 7J | 1300 nm, single-mode, ELED, 2 channels |
| 7K | 1300 nm, single-mode, LASER, 2 channels |
| 7L | Channel 1: RS422, Channel: 820 nm, multi-mode, LED |
| 7M | Channel 1: RS422, Channel 2: 1300 nm, multi-mode, LED |
| 7N | Channel 1: RS422, Channel 2: 1300 nm, single-mode, ELED |
| 7P | Channel 1: RS422, Channel 2: 1300 nm, single-mode, LASER |
| 7Q | Channel 1: G.703, Channel 2: 1300 nm, single-mode, LASER |
| 7R | G.703, 1 channel |
| 7S | G.703, 2 channels |
| 7T | RS422, 1 channel |
| 7W | RS422, 2 channels |
| 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, multi-mode, LED, 1 channel |
| 77 | IEEE C37.94, 820 nm, multi-mode, LED, 2 channels |

⚠ **OBSERVING ANY FIBER TRANSMITTER OUTPUT MAY CAUSE INJURY TO THE EYE.**

CAUTION

**3.3.2 FIBER: LED AND ELED TRANSMITTERS**

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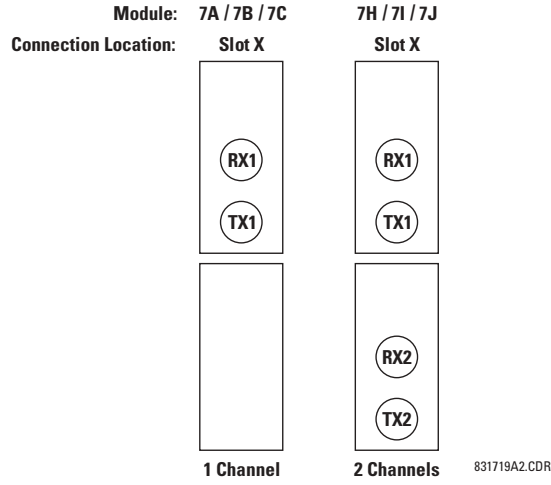


**Figure 3–25: LED AND ELED FIBER MODULES**

**3.3.3 FIBER-LASER TRANSMITTERS**

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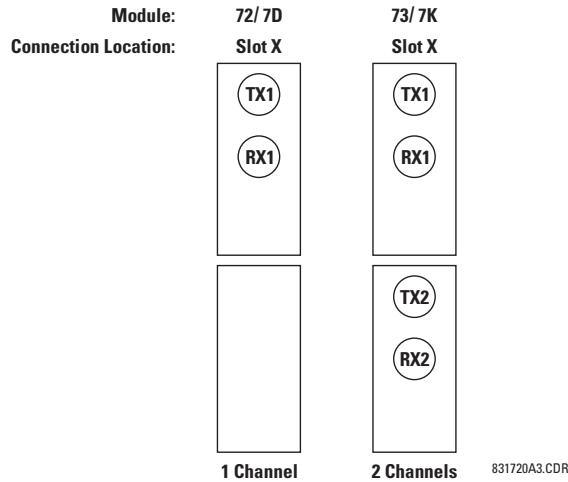


**Figure 3–26: LASER FIBER MODULES**

**WARNING**

**When using a LASER Interface, attenuators may be necessary to ensure that you do <u>not</u> exceed Maximum Optical Input Power to the receiver.**

**a) DESCRIPTION**

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

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

AWG 22 twisted shielded pair is recommended for external connections, with the shield grounded only at one end. Connecting the shield to Pin X1a or X6a grounds the shield since these pins are internally connected to ground. Thus, if Pin X1a or X6a is used, do not ground at the other end. This interface module is protected by surge suppression devices.



**Figure 3–27: G.703 INTERFACE CONFIGURATION**

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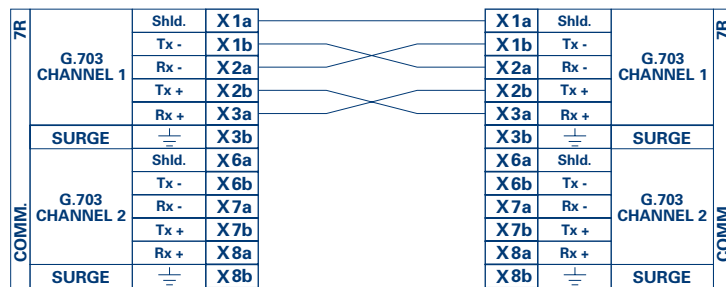


**Figure 3–28: TYPICAL PIN INTERCONNECTION BETWEEN TWO G.703 INTERFACES**

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

**b) G.703 SELECTION SWITCH PROCEDURES**

1.  Remove the G.703 module (7R or 7S):

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

2.  Remove the module cover screw.

3.  Remove the top cover by sliding it towards the rear and then lift it upwards.

4.  Set the Timing Selection Switches (Channel 1, Channel 2) to the desired timing modes.

5.  Replace the top cover and the cover screw.

6.  Re-insert the G.703 module Take care to ensure that the **correct** module type is inserted into the **correct** slot position. The ejector/inserter clips located at the top and at the bottom of each module must be in the disengaged position as the module is smoothly inserted into the slot. Once the clips have cleared the raised edge of the chassis, engage the clips simultaneously. When the clips have locked into position, the module will be fully inserted.
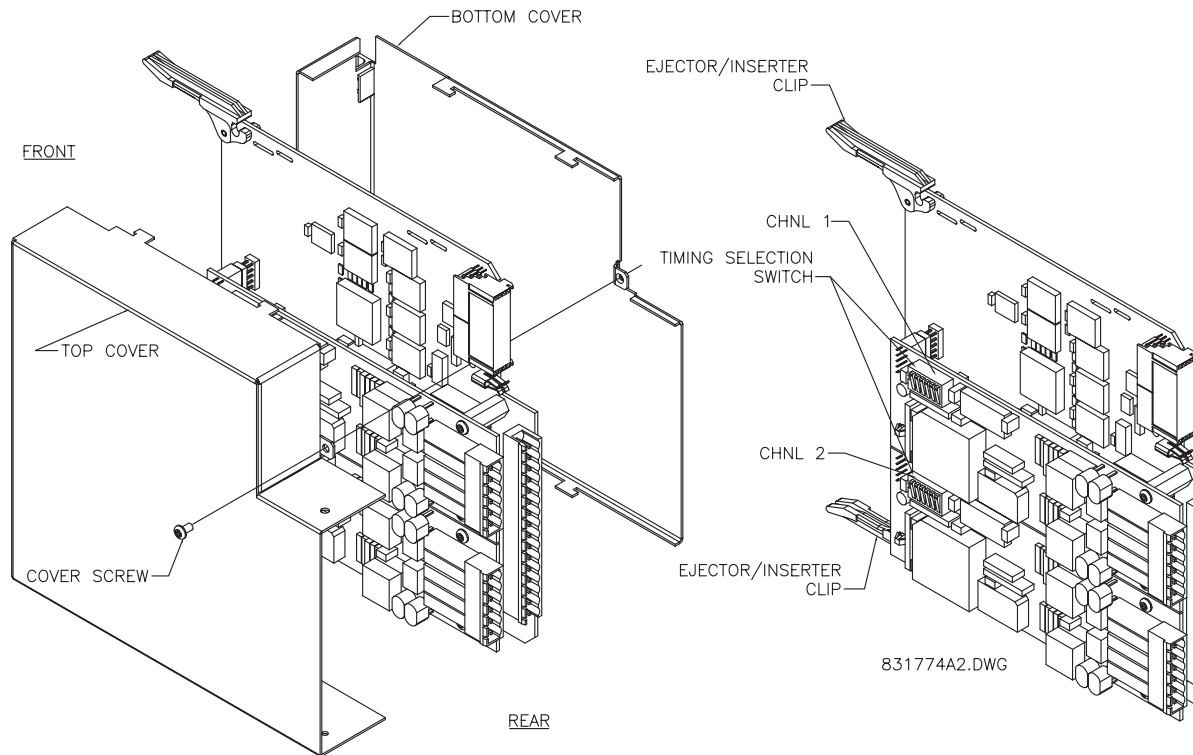


**Figure 3–29: G.703 TIMING SELECTION SWITCH SETTING**

**Table 3–4: G.703 TIMING SELECTIONS**

| SWITCHES | FUNCTION |
|---|---|
| S1 | OFF → Octet Timing Disabled<br>ON → Octet Timing 8 kHz |
| S5 and S6 | S5 = OFF and S6 = OFF → Loop Timing Mode<br>S5 = ON and S6 = OFF → Internal Timing Mode<br>S5 = OFF and S6 = ON → Minimum Remote Loopback Mode<br>S5 = ON and S6 = ON → Dual Loopback Mode |

**c) OCTET TIMING (SWITCH S1)**

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 C60s are connected back to back, Octet Timing should be disabled (OFF).

**d) TIMING MODES (SWITCHES S5 AND S6)**

•   **Internal Timing Mode:** The system clock 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 = 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 = Loop Timing (S5 = OFF and S6 = OFF).

**e) TEST MODES (SWITCHES S5 AND S6)**

**MINIMUM REMOTE LOOPBACK MODE:**

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.



DMR = Differential Manchester Receiver
DMX = Differential Manchester Transmitter
G7X = G.703 Transmitter
G7R = G.703 Receiver
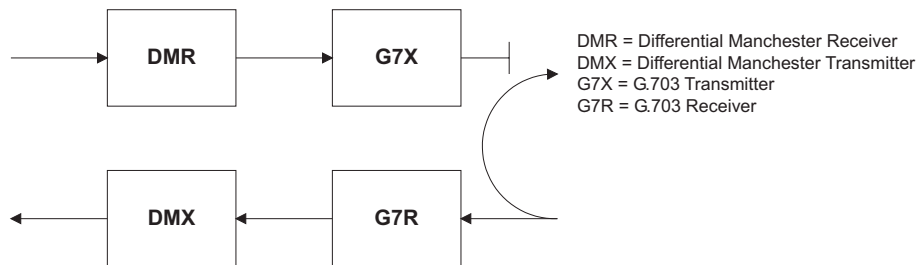
**DUAL LOOPBACK MODE:**

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.



DMR = Differential Manchester Receiver
DMX = Differential Manchester Transmitter
G7X = G.703 Transmitter
G7R = G.703 Receiver
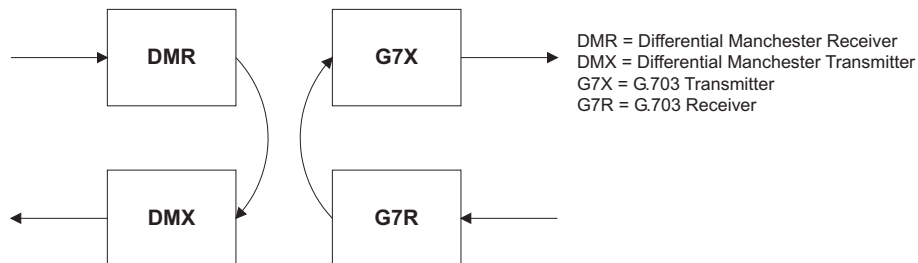
**a) DESCRIPTION**

The following figure shows the RS422 2-terminal interface configuration at 64 kbps. AWG 22 twisted shielded pair is recommended for external connections. This interface module is protected by surge suppression devices which optically isolated.

> **NOTE**
>
> The RS422 module is fixed at 64 kbps only. The SETTINGS ⇨ PRODUCT SETUP ⇨ ⇩ DIRECT I/O ⇨ ⇩ DIRECT I/O DATA RATE setting is not applicable to this module.

**SHIELD TERMINATION**

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 and/or 7b;   Site 2: Terminate shield to 'COM' pin 2b.

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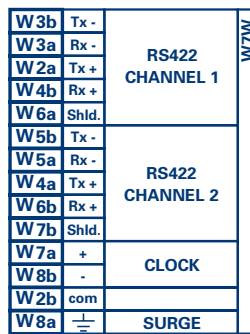


RS422.CDR
p/o 827831A6.CDR

**Figure 3–30: RS422 INTERFACE CONFIGURATION**

The following figure shows the typical pin interconnection between two RS422 interfaces. All pin interconnections are to be maintained for a connection to a multiplexer.
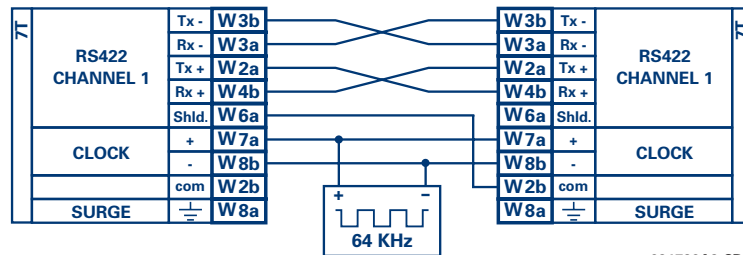


831728A3.CDR

**Figure 3–31: TYPICAL PIN INTERCONNECTION BETWEEN TWO RS422 INTERFACES**

**b) TWO CHANNEL APPLICATIONS VIA MULTIPLEXERS**

The RS422 Interface may be used for '1 channel' or '2 channel' applications over SONET/SDH and/or Multiplexed systems. When used in 1 channel applications, the RS422 interface links to higher order systems in a typical fashion observing Tx, Rx, and Send Timing connections. However, when used in 2 channel applications, certain criteria have to be followed due to the fact that there is 1 clock input for the two RS422 channels. The system will function correctly if the following connections are observed and your Data Module has a feature called Terminal Timing. 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, 2 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 in the following figure. 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.
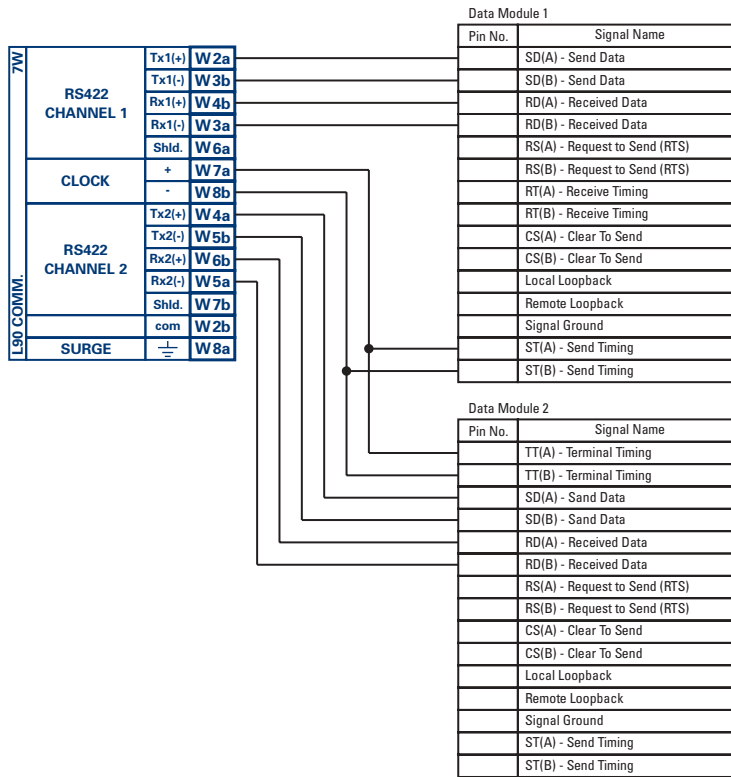


**Figure 3–32: TIMING CONFIGURATION FOR RS422 TWO-CHANNEL, 3-TERMINAL APPLICATION**

Data Module 1 provides timing to the C60 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) TRANSIT 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.
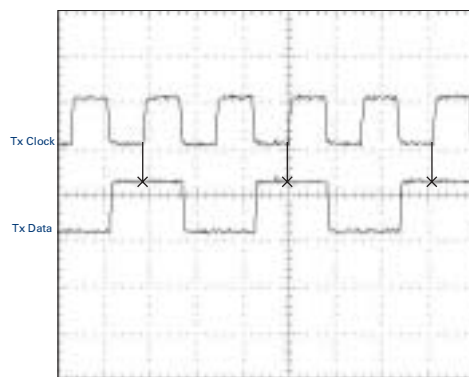


**Figure 3–33: CLOCK AND DATA TRANSITIONS**

**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 over-sampled 16X, and uses this clock along with the data-stream to generate a data clock that can be used as the SCC (Serial Communication Controller) receive clock.

**3.3.6 RS422 AND FIBER INTERFACE**

The following figure shows the combined RS422 plus Fiber interface configuration at 64K baud. The 7L, 7M, 7N, 7P, and 74 modules are used in 2-terminal with a redundant channel or 3-terminal configurations where Channel 1 is employed via the RS422 interface (possibly with a multiplexer) and Channel 2 via direct fiber.

AWG 22 twisted shielded pair is recommended for external RS422 connections and the shield should be grounded only at one end. For the direct fiber channel, power budget issues should be addressed properly.

⚠ **WARNING**     **When using a LASER Interface, attenuators may be necessary to ensure that you do not exceed Maximum Optical Input Power to the receiver.**
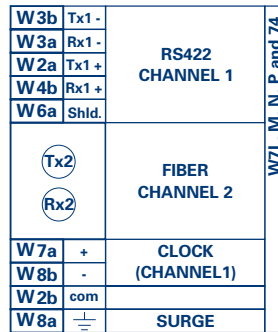


L907LMNP.CDR
P/O 827831A6.CDR

**Figure 3–34: RS422 AND FIBER INTERFACE CONNECTION**

Connections shown above are for multiplexers configured as DCE (Data Communications Equipment) units.

**3.3.7 G.703 AND FIBER INTERFACE**

The figure below shows the combined G.703 plus Fiber interface configuration at 64K baud. The 7E, 7F, 7G, 7Q, and 75 modules are used in configurations where Channel 1 is employed via the G.703 interface (possibly with a multiplexer) and Channel 2 via direct fiber. AWG 22 twisted shielded pair is recommended for external G.703 connections connecting the shield to Pin 1A at one end only. For the direct fiber channel, power budget issues should be addressed properly. See previous sections for more details on the G.703 and Fiber interfaces.

⚠ **WARNING**     **When using a LASER Interface, attenuators may be necessary to ensure that you do <u>not</u> exceed Maximum Optical Input Power to the receiver.**
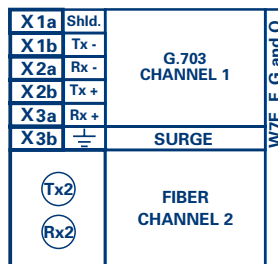


**Figure 3–35: G.703 AND FIBER INTERFACE CONNECTION**

The UR-series IEEE C37.94 communication modules (76 and 77) are designed to interface with IEEE C37.94 compliant digital multiplexers and/or an IEEE C37.94 compliant interface converter for use with direct input/output applications for firmware revisions 3.30 and higher. The IEEE C37.94 standard defines a point-to-point optical link for synchronous data between a multiplexer and a teleprotection device. This data is typically 64 kbps, but the standard provides for speeds up to 64*n* kbps, where *n* = 1, 2,…, 12. The UR-series C37.94 communication module is 64 kbps only with *n* fixed at 1. The frame is a valid International Telecommunications Union (ITU-T) recommended G.704 pattern from the standpoint of framing and data rate. The frame is 256 bits and is repeated at a frame rate of 8000 Hz, with a resultant bit rate of 2048 kbps.

The specifications for the module are as follows:

> IEEE standard: C37.94 for $1 \times 64$ kbps optical fiber interface
> 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.
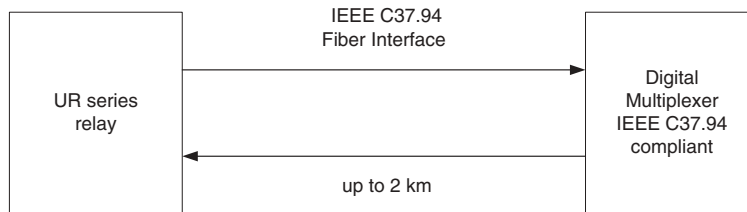


The UR-series C37.94 communication module can be connected to the electrical interface (G.703, RS422, or X.21) of a non-compliant digital multiplexer via an optical-to-electrical interface converter that supports the IEEE C37.94 standard, as shown below.
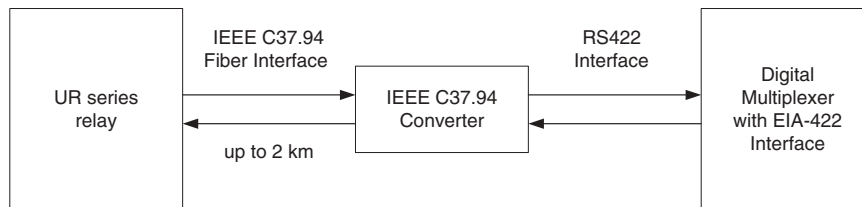


The UR-series C37.94 communication module has six (6) switches that are used to set the clock configuration. The functions of these control switches is shown below.
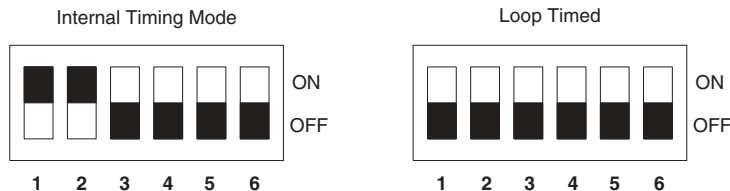


| Switch | Internal | Loop Timed |
|--------|----------|------------|
| 1 | ON | OFF |
| 2 | ON | OFF |
| 3 | OFF | OFF |
| 4 | OFF | OFF |
| 5 | OFF | OFF |
| 6 | OFF | OFF |

For the Internal Timing Mode, the system clock is generated internally. Therefore, the timing switch selection should be Internal Timing for Relay 1 and Loop Timed for Relay 2. There must be only one timing source configured.

For the Looped Timing Mode, the system clock is derived from the received line signal. Therefore, the timing selection should be in Loop Timing Mode for connections to higher order systems.

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

1.  Remove the C37.94 module (76 or 77):

    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 C37.94 module Take care to ensure that the **correct** module type is inserted into the **correct** slot position. The ejector/inserter clips located at the top and at the bottom of each module must be in the disengaged position as the module is smoothly inserted into the slot. Once the clips have cleared the raised edge of the chassis, engage the clips simultaneously. When the clips have locked into position, the module will be fully inserted.
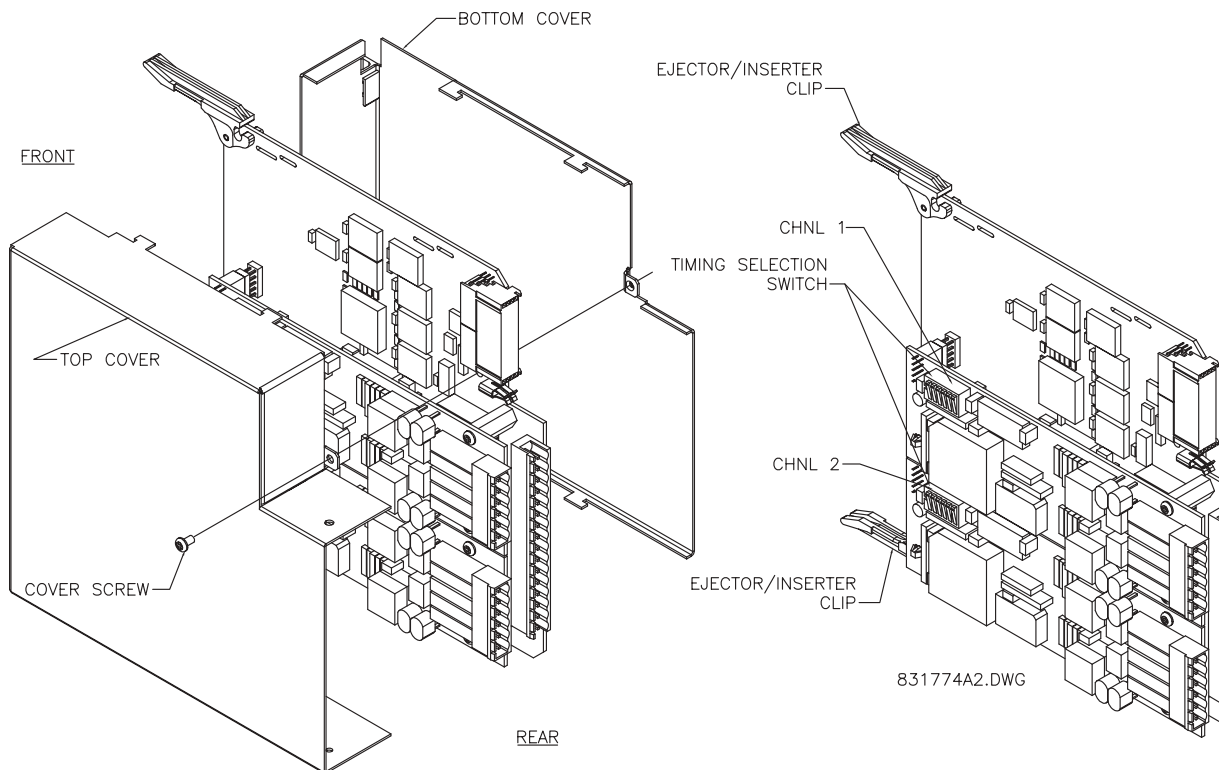


**Figure 3–36: C37.94 TIMING SELECTION SWITCH SETTING**

The enerVista UR Setup software provides a graphical user interface (GUI) as one of two human interfaces to a UR device. The alternate human interface is implemented via the device's faceplate keypad and display (see 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 (i.e. off-line) or connected (i.e. 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 C60 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 C60* section in Chapter 1 for details.

**4.1.3 ENERVISTA UR SETUP SOFTWARE OVERVIEW**

**a) ENGAGING A DEVICE**

The enerVista UR Setup software may be used in on-line mode (relay connected) to directly communicate with a UR relay. Communicating relays are organized and grouped by communication interfaces and into sites. Sites may contain any number of relays selected from the UR product series.

**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 FLEXLOGIC™ EQUATIONS**

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 C60 device can be upgraded, locally or remotely, via the enerVista UR Setup software. The corresponding instructions are provided by the enerVista UR Setup Help file under the topic "Upgrading Firmware".

> **NOTE**
>
> Modbus addresses assigned to firmware modules, features, settings, and corresponding data items (i.e. default values, minimum/maximum values, data type, and item size) may change slightly from version to version of firmware. The addresses are rearranged when new features are added or existing features are enhanced or modified. The **EEPROM DATA ERROR** message displayed after upgrading/downgrading the firmware is a resettable, self-test message intended to inform users that the Modbus addresses have changed with the upgraded firmware. This message does not signal any problems when appearing after firmware upgrades.

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

a.     Title bar which shows the pathname of the active data view

b.     Main window menu bar

c.     Main window tool bar

d.     Site List control bar window

e.     Settings List control bar window

f.     Device data view window(s), with common tool bar

g.     Settings File data view window(s), with common tool bar

h.     Workspace area with data view tabs

i.     Status bar
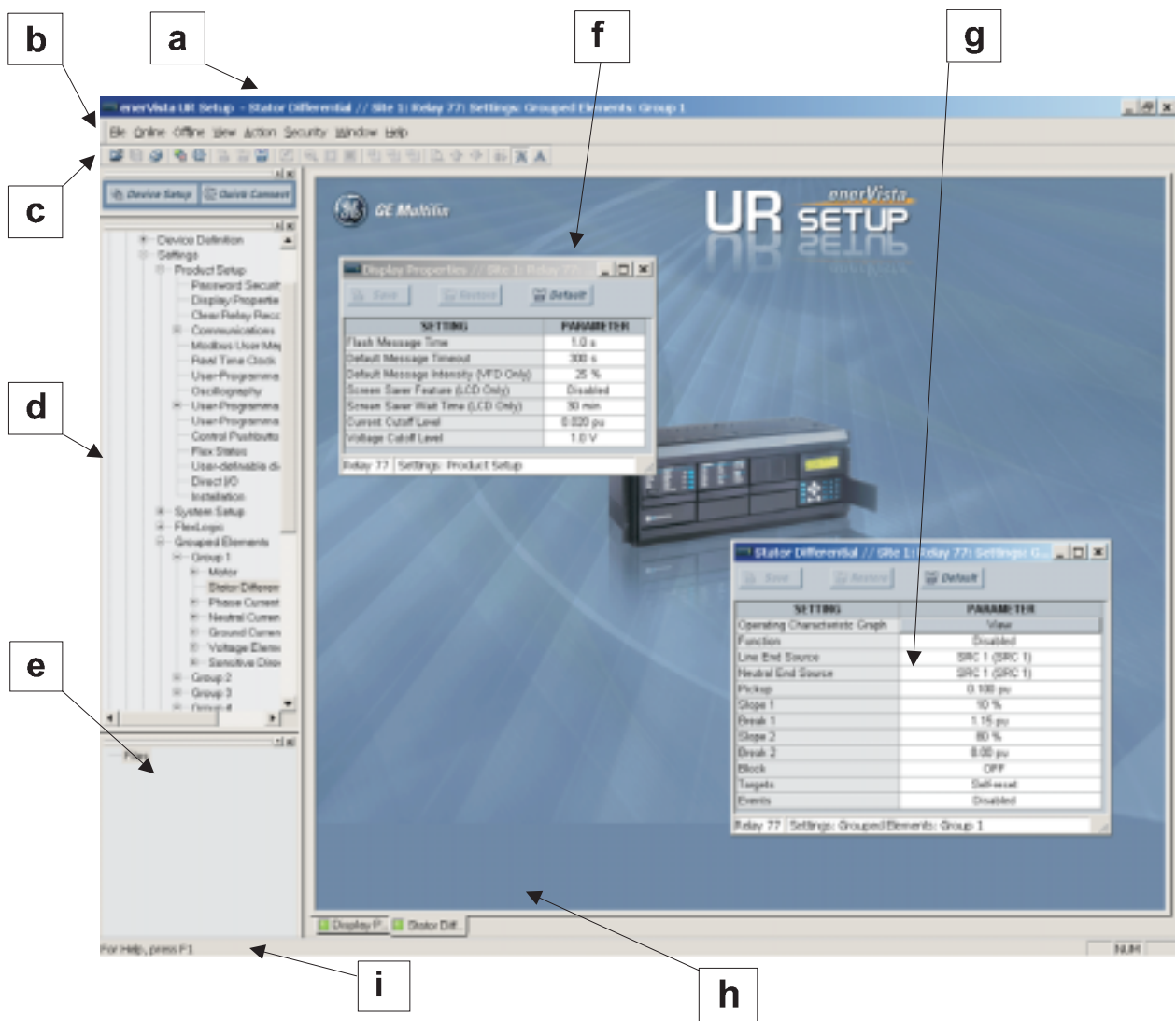


**Figure 4–1: ENERVISTA UR SETUP SOFTWARE MAIN WINDOW**

The keypad/display/LED interface is one of two alternate human interfaces supported. The other alternate human interface is implemented via the enerVista UR Setup software. The faceplate interface is available in two configurations: horizontal or vertical. The faceplate interface consists of several functional panels.

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 two figures show the horizontal and vertical arrangement of faceplate panels.
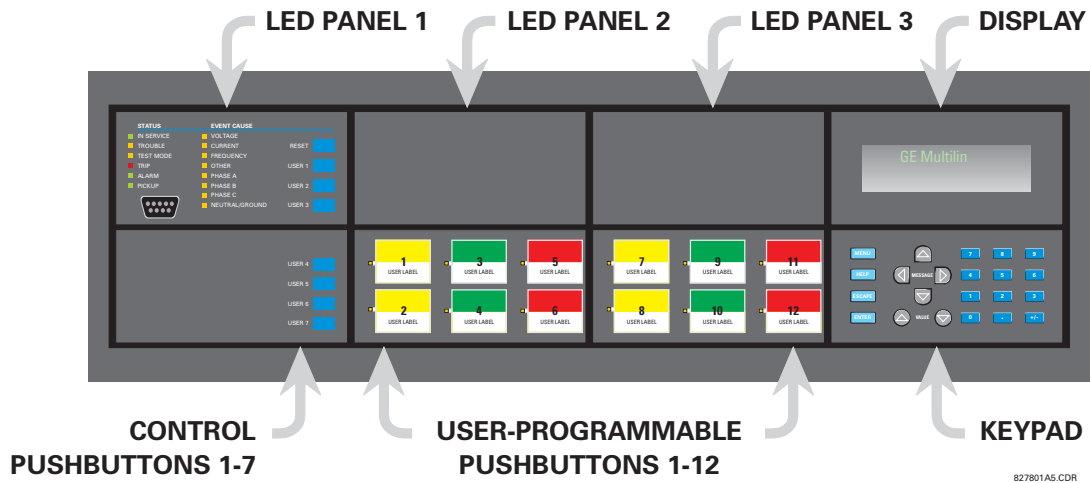
**Figure 4–2: UR-SERIES HORIZONTAL FACEPLATE PANELS**
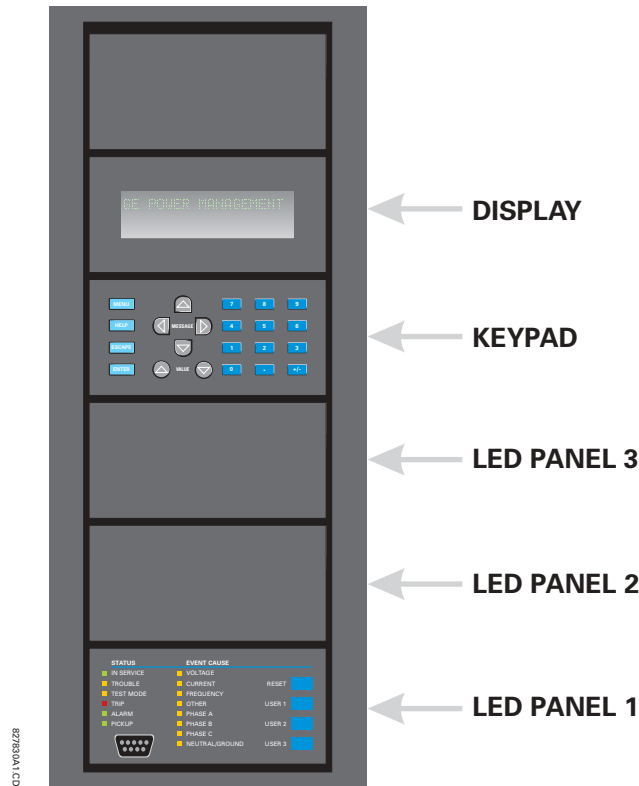
**Figure 4–3: UR-SERIES VERTICAL FACEPLATE PANELS**

### a) LED PANEL 1

This panel provides several LED indicators, several 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 USER keys are used by the Breaker Control feature. The RS232 port is intended for connection to a portable PC.
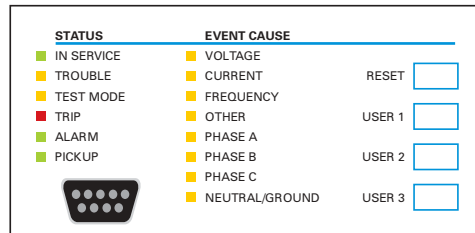


**Figure 4–4: LED PANEL 1**

**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 neutral or ground was involved.

**b) LED PANELS 2 AND 3**

These panels 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              USER-PROGRAMMABLE LEDS
 ■ (1)     ■ (9)     ■ (17)         ■ (25)    ■ (33)    ■ (41)
 ■ (2)     ■ (10)    ■ (18)         ■ (26)    ■ (34)    ■ (42)
 ■ (3)     ■ (11)    ■ (19)         ■ (27)    ■ (35)    ■ (43)
 ■ (4)     ■ (12)    ■ (20)         ■ (28)    ■ (36)    ■ (44)
 ■ (5)     ■ (13)    ■ (21)         ■ (29)    ■ (37)    ■ (45)
 ■ (6)     ■ (14)    ■ (22)         ■ (30)    ■ (38)    ■ (46)
 ■ (7)     ■ (15)    ■ (23)         ■ (31)    ■ (39)    ■ (47)
 ■ (8)     ■ (16)    ■ (24)         ■ (32)    ■ (40)    ■ (48)
```

**Figure 4–5: LED PANELS 2 AND 3 (INDEX TEMPLATE)**

**c) DEFAULT LABELS FOR LED PANEL 2**

The default labels are intended to represent:

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

- **BREAKER n OPEN**: The breaker is open.

- **BREAKER n CLOSED**: The breaker is closed.

- **BREAKER n TROUBLE**: A problem related to the breaker has been detected.

- **SYNCHROCHECK NO n IN-SYNCH**: Voltages have satisfied the synchrocheck element.

- **RECLOSE ENABLED**: The recloser is operational.

- **RECLOSE DISABLED**: The recloser is not operational.

- **RECLOSE IN PROGRESS**: A reclose operation is in progress.

- **RECLOSE LOCKED OUT**: The recloser is not operational and requires a reset.

> **NOTE**
> **Firmware revisions 2.9x and earlier support eight user setting groups; revisions 3.0x and higher support six setting groups. For convenience of users using earlier firmware revisions, the relay panel shows eight setting groups. Please note that the LEDs, despite their default labels, are fully user-programmable.**

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      BREAKER 1        SYNCHROCHECK
 ■ GROUP 1            ■ OPEN           ■ NO1 IN-SYNCH
 ■ GROUP 2            ■ CLOSED         ■ NO2 IN-SYNCH
 ■ GROUP 3            ■ TROUBLE
 ■ GROUP 4                             RECLOSE
 ■ GROUP 5            BREAKER 2        ■ ENABLED
 ■ GROUP 6            ■ OPEN           ■ DISABLED
 ■ GROUP 7            ■ CLOSED         ■ IN PROGRESS
 ■ GROUP 8            ■ TROUBLE        ■ LOCKED OUT
```

**Figure 4–6: LED PANEL 2 (DEFAULT LABELS)**

**d) CUSTOM LABELING OF LEDS**

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

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

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

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



Push in
and gently lift
up the cover.

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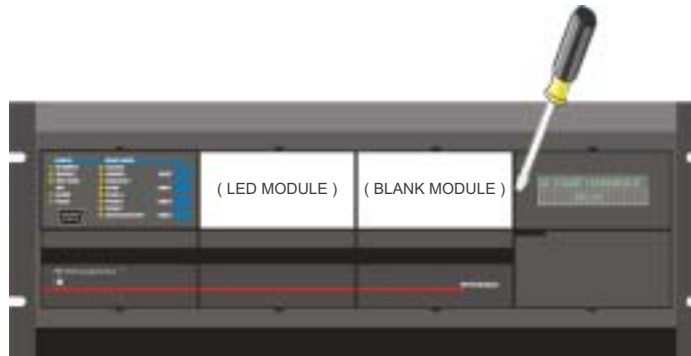


3.   Place the left side of the customized module back to the front panel frame, then snap back the right side.

4.   Put the clear Lexan Front Cover back into place.

**e) CUSTOMIZING THE LED DISPLAY**

The following items are required to customize the C60 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).

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.

All messages are displayed on a 2 × 20 character vacuum fluorescent display to make them visible under poor lighting conditions. An optional liquid crystal display (LCD) is also available. Messages are displayed in English and do 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 defined messages. Any high priority event driven message will automatically override the default message and appear on the display.

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 ▪▪ 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.

**a) INTRODUCTION**

The C60 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 No. 1.

For the following discussion it is assumed the **SETTINGS** ⇨⇩ **SYSTEM SETUP** ⇨⇩ **BREAKERS** ⇨ **BREAKER n** ⇨ **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 3-pole, a single input tracks the breaker open or closed position. If the mode is selected as 1-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 n** ⇨⇩ **BREAKER 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 symbol **(Name)** represents the user-programmed variable name.

For this application (setup shown below), the relay is connected and programmed for both breaker No. 1 and breaker No. 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```<br>```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```<br>```   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```<br>```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```<br>``` 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 No. 1. |

**(2)**

| | |
|---|---|
| ```     USER 3 OFF/ON```<br>``` 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 No. 1. |

**(3)**

| | |
|---|---|
| ```BKR2-(Name) SELECTED```<br>```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 No. 1 only. Operation for this application is identical to that described for two breakers.

**4.2.6 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 main heading pages as illustrated below.

| MENU | ⇨ | MENU | ⇨ | MENU | ⇨ | MENU |
|---|---|---|---|---|---|---|
| ```     ACTUAL VALUES``` | | ```       SETTINGS``` | | ```       COMMANDS``` | | ```        TARGETS``` |
| ⇩ | | ⇩ | | ⇩ | | ⇩ |
| ```■■ ACTUAL VALUES```<br>```■■ STATUS``` | | ```■■ SETTINGS```<br>```■■ PRODUCT SETUP``` | | ```■■ COMMANDS```<br>```■■ VIRTUAL INPUTS``` | | ```        No Active```<br>```         Targets``` |

⇨

| MENU |
|---|
| ```     USER DISPLAYS```<br>```     (when in use)``` |
| ⇩ |
| ```   User Display 1``` |
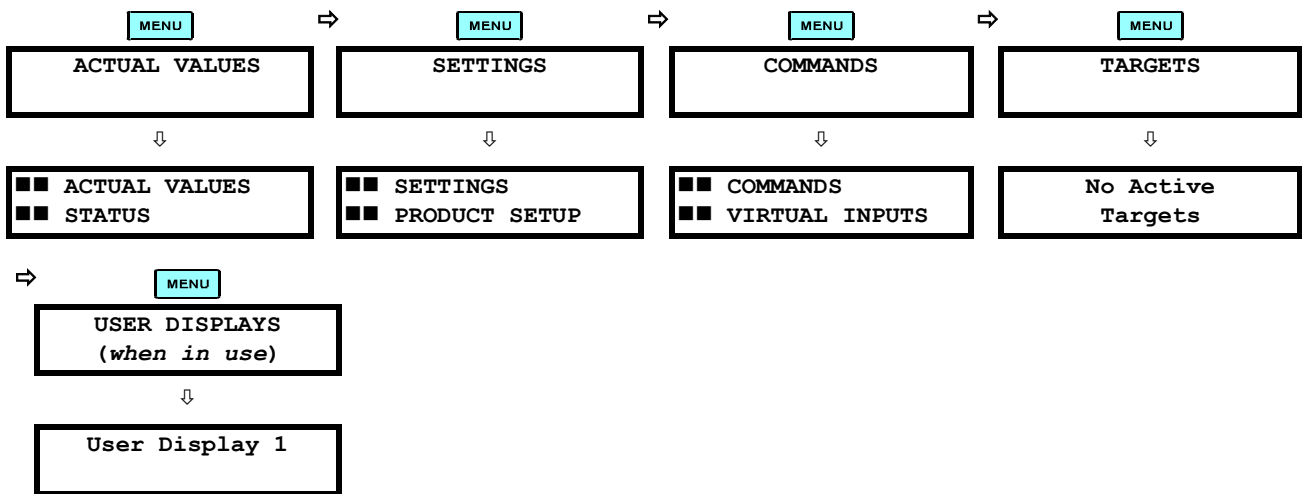
**b) HIERARCHY**

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 ⬆ and ⬇ keys move within a group of headers, sub-headers, setting values, or actual values. Continually pressing the MESSAGE ▶ key from a header display displays specific information for the header category. Conversely, continually pressing the ◀ MESSAGE key from a setting value or actual value display returns to the header display.

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

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

⬆⬇

```
■■ SETTINGS
■■ SYSTEM SETUP
```
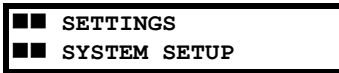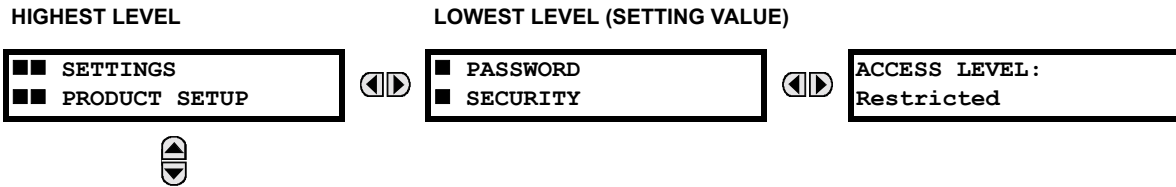
**c) EXAMPLE MENU NAVIGATION**

```
■■ ACTUAL VALUES
■■ STATUS
```
Press the MENU key until the header for the first Actual Values page appears. This page contains system and relay status information. Repeatedly press the ⬆ ◀ MESSAGE ▶ ⬇ keys to display the other actual value headers.

⇩

```
■■ SETTINGS
■■ PRODUCT SETUP
```
Press the MENU key until the header for the first page of Settings appears. This page contains settings to configure the relay.

⇩

```
■■ SETTINGS
■■ SYSTEM SETUP
```
Press the MESSAGE ⬇ key to move to the next Settings page. This page contains settings for System Setup. Repeatedly press the ⬆ MESSAGE ⬇ keys to display the other setting headers and then back to the first Settings page header.

⇩

```
■ PASSWORD
■ SECURITY
```
From the Settings page one header (Product Setup), press the MESSAGE ▶ key once to display the first sub-header (Password Security).

⇩

```
ACCESS LEVEL:
Restricted
```
Press the MESSAGE ▶ key once more and this will display the first setting for Password Security. Pressing the MESSAGE ⬇ key repeatedly will display the remaining setting messages for this sub-header.

⇩

```
■ PASSWORD
■ SECURITY
```
Press the MESSAGE ◀ key once to move back to the first sub-header message.

⇩

```
■ DISPLAY
■ PROPERTIES
```
Pressing the MESSAGE ⬇ key will display the second setting sub-header associated with the Product Setup header.

⇩

```
FLASH MESSAGE
TIME: 1.0 s
```
Press the MESSAGE ▶ key once more and this will display the first setting for Display Properties.

⇩

```
DEFAULT MESSAGE
INTENSITY: 25%
```
To view the remaining settings associated with the Display Properties subheader, repeatedly press the MESSAGE ⬇ key. The last message appears as shown.

#### 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
```
⇩
```
MINIMUM:   0.5
MAXIMUM:  10.0
```

For example, select the **SETTINGS** ⇨ **PRODUCT SETUP** ⇨⇩ **DISPLAY PROPERTIES** ⇨ **FLASH MESSAGE TIME** setting.

Press the 〔HELP〕 key to view the minimum and maximum values. Press the 〔HELP〕 key again to view the next context sensitive help message.

Two methods of editing and storing a numerical setting value are available.

- **0 to 9** and 〔．〕 (decimal point): The relay numeric keypad works the same as that of any electronic calculator. A number is entered one digit at a time. The leftmost digit is entered first and the rightmost digit is entered last. Pressing the MESSAGE ◀ key or pressing the ESCAPE key, returns the original value to the display.

- ▲ **VALUE** ▼: The VALUE ▲ key increments the displayed value by the step value, up to the maximum value allowed. While at the maximum value, pressing the VALUE ▲ key again will allow the setting selection to continue upward from the minimum value. The VALUE ▼ key decrements the displayed value by the step value, down to the minimum value. While at the minimum value, pressing the VALUE ▼ key again will allow the setting selection to continue downward from the maximum value.

```
FLASH MESSAGE
TIME:   2.5 s
```
⇩
```
NEW SETTING
HAS BEEN STORED
```

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.

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 ▲ key displays the next selection while the VALUE ▼ key displays the previous selection.

```
ACCESS LEVEL:
Setting
```
⇩
```
NEW SETTING
HAS BEEN STORED
```

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.

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 [··] to enter text edit mode.

2.  Press the VALUE keys until the character 'B' appears; press [··] 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 **SETTINGS PRODUCT SETUP** message appears on the display.

2.  Press the MESSAGE [▶] key until the **PASSWORD SECURITY** message appears on the display.

3.  Press the MESSAGE [▼] key until the **INSTALLATION** message appears on the display.

4.  Press the MESSAGE [▶] key until the **RELAY SETTINGS: Not Programmed** message is displayed.
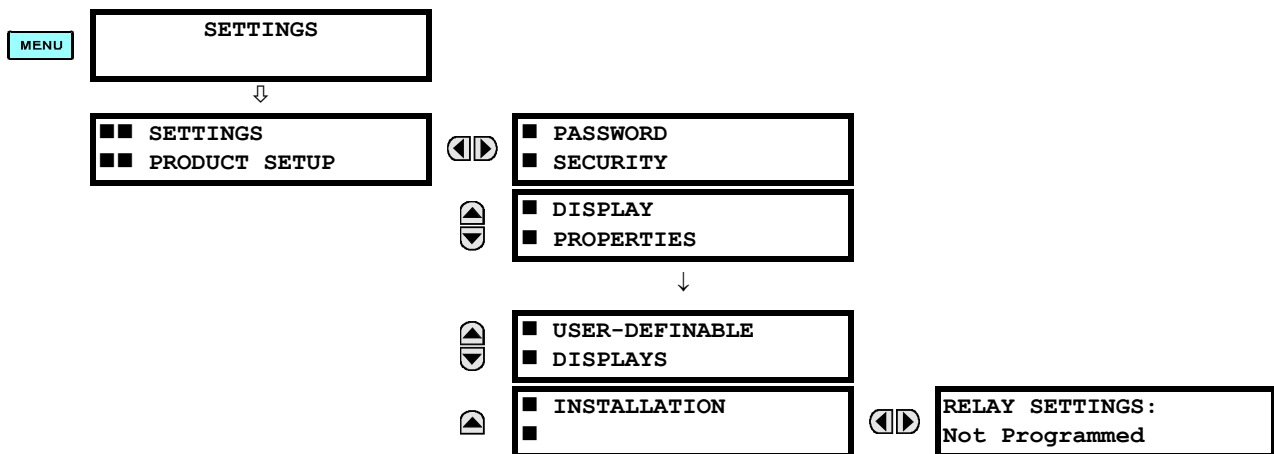


5.  After the **RELAY SETTINGS: Not Programmed** message appears on the display, press the VALUE keys change the selection to "Programmed".

6.  Press the [ENTER] key.
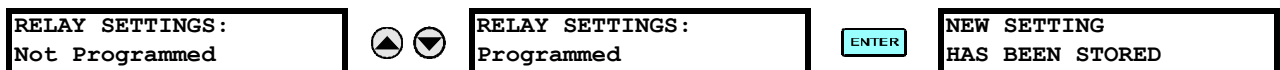


7.  When the "NEW SETTING HAS BEEN STORED" message appears, the relay will be in "Programmed" state and the In Service LED will turn on.

**e) ENTERING INITIAL PASSWORDS**

To enter the initial Setting (or Command) Password, proceed as follows:

1.  Press the MENU key until the **SETTINGS** header flashes momentarily and the **SETTINGS PRODUCT SETUP** message appears on the display.

2.  Press the MESSAGE ▶ key until the **ACCESS LEVEL** message appears on the display.

3.  Press the MESSAGE ▼ key until the **CHANGE SETTING** (or **COMMAND**) **PASSWORD** message appears on the display.

```
┌────────┐   ┌────────────────────────┐
│  MENU  │   │        SETTINGS        │
└────────┘   │                        │
             └────────────────────────┘
                      ⇩

┌────────────────────────┐        ┌────────────────────────┐        ┌────────────────────────────┐
│ ■■  SETTINGS           │  ◀▶    │ ■  PASSWORD            │  ◀▶    │ ACCESS LEVEL:              │
│ ■■  PRODUCT SETUP      │        │ ■  SECURITY           │        │ Restricted                 │
└────────────────────────┘        └────────────────────────┘        └────────────────────────────┘
                                                                    ▲
                                                                    ▼
                                                                    ┌────────────────────────────┐
                                                                    │ CHANGE COMMAND             │
                                                                    │ PASSWORD: No               │
                                                                    └────────────────────────────┘
                                                                    ▲
                                                                    ▼
                                                                    ┌────────────────────────────┐
                                                                    │ CHANGE SETTING             │
                                                                    │ PASSWORD: No               │
                                                                    └────────────────────────────┘
                                                                    ▲
                                                                    ▼
                                                                    ┌────────────────────────────┐
                                                                    │ ENCRYPTED COMMAND          │
                                                                    │ PASSWORD: ----------       │
                                                                    └────────────────────────────┘
                                                                    ▲
                                                                    ┌────────────────────────────┐
                                                                    │ ENCRYPTED SETTING          │
                                                                    │ PASSWORD: ----------       │
                                                                    └────────────────────────────┘
```
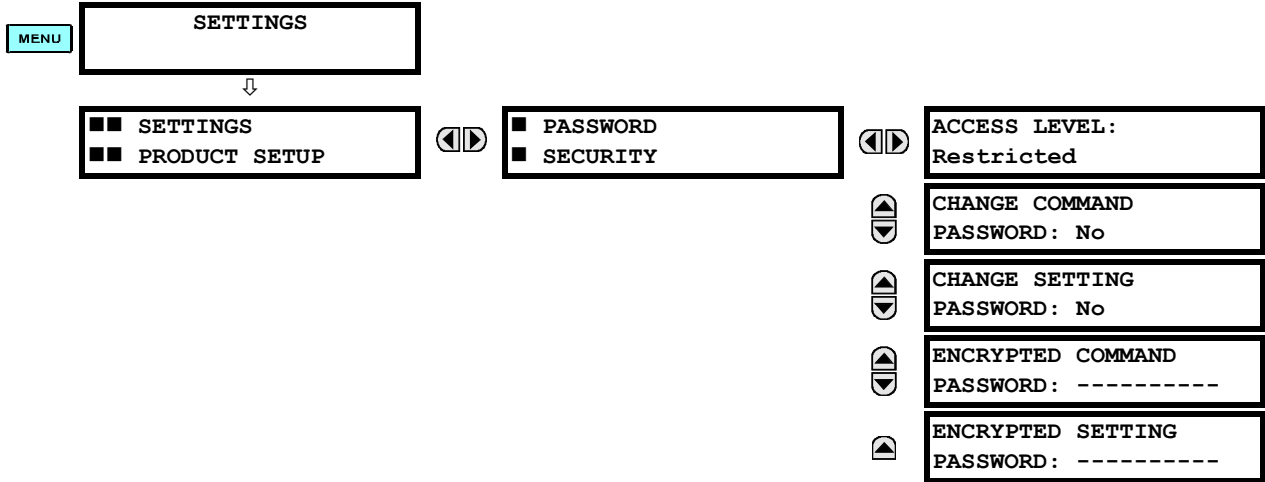
4.  After the **CHANGE...PASSWORD** message appears on the display, press the VALUE ▲ key or the VALUE ▼ key to change the selection to "Yes".

5.  Press the ENTER key and the display will prompt you to **ENTER NEW PASSWORD**.

6.  Type in a numerical password (up to 10 characters) and press the ENTER key.

7.  When the **VERIFY NEW PASSWORD** is displayed, re-type in the same password and press ENTER.

```
┌────────────────────────┐
│ CHANGE SETTING         │
│ PASSWORD: No           │
└────────────────────────┘
         ▼ ▲

┌────────────────────────┐   ┌───────┐   ┌────────────────────────────┐   ┌───────┐   ┌────────────────────────────┐
│ CHANGE SETTING         │   │ ENTER │   │ ENTER NEW                  │   │ ENTER │   │ VERIFY NEW                 │
│ PASSWORD: Yes          │   └───────┘   │ PASSWORD: ##########       │   └───────┘   │ PASSWORD: ##########       │
└────────────────────────┘              └────────────────────────────┘              └────────────────────────────┘
                                                                                              ┌───────┐
                                                                                              │ ENTER │
                                                                                              └───────┘
                                                                                     ┌────────────────────────────┐
                                                                                     │ NEW PASSWORD               │
                                                                                     │ HAS BEEN STORED            │
                                                                                     └────────────────────────────┘
```
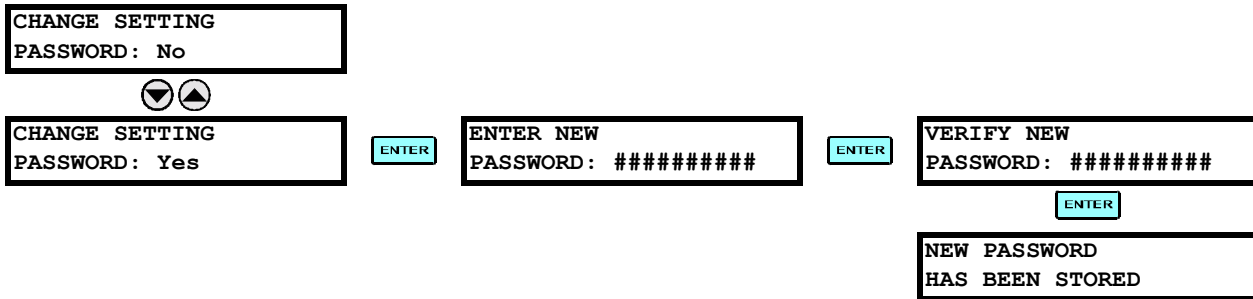
8.  When the **NEW PASSWORD HAS BEEN STORED** message appears, your new Setting (or Command) Password will be active.

**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.

**4**

| | | | |
|---|---|---|---|
| ■■ SETTINGS<br>■■ PRODUCT SETUP | ◁▷ | ■ PASSWORD<br>■ SECURITY | See page 5-7. |
| ▽ | ▲▽ | ■ DISPLAY<br>■ PROPERTIES | See page 5-8. |
| | ▲▽ | ■ CLEAR RELAY<br>■ RECORDS | See page 5-10. |
| | ▲▽ | ■ COMMUNICATIONS<br>■ | See page 5-11. |
| | ▲▽ | ■ MODBUS USER MAP<br>■ | See page 5-20. |
| | ▲▽ | ■ REAL TIME<br>■ CLOCK | See page 5-20. |
| | ▲▽ | ■ FAULT REPORTS<br>■ | See page 5-21. |
| | ▲▽ | ■ OSCILLOGRAPHY<br>■ | See page 5-22. |
| | ▲▽ | ■ DATA LOGGER<br>■ | See page 5-24. |
| | ▲▽ | ■ DEMAND<br>■ | See page 5-25. |
| | ▲▽ | ■ USER-PROGRAMMABLE<br>■ LEDS | See page 5-26. |
| | ▲▽ | ■ USER-PROGRAMMABLE<br>■ SELF TESTS | See page 5-29. |
| | ▲▽ | ■ CONTROL<br>■ PUSHBUTTONS | See page 5-29. |
| | ▲▽ | ■ USER-PROGRAMMABLE<br>■ PUSHBUTTONS | See page 5-31. |
| | ▲▽ | ■ FLEX STATE<br>■ PARAMETERS | See page 5-32. |
| | ▲▽ | ■ USER-DEFINABLE<br>■ DISPLAYS | See page 5-33. |
| | ▲▽ | ■ DIRECT I/O<br>■ | See page 5-35. |
| | ▲ | ■ INSTALLATION<br>■ | See page 5-40. |
| ▲<br>■■ SETTINGS<br>■■ SYSTEM SETUP | ◁▷ | ■ AC INPUTS<br>■ | See page 5-41. |
| ▽ | ▲▽ | ■ POWER SYSTEM<br>■ | See page 5-43. |
| | ▲▽ | ■ SIGNAL SOURCES<br>■ | See page 5-44. |

**5**

```
                                    ▉ BREAKERS
                              ⬘     ▉                         See page 5-46.
                              ⬗

                                    ▉ FLEXCURVES
                              ⬗     ▉                         See page 5-49.

        ⬗
  ▉▉ SETTINGS                       ▉ FLEXLOGIC
  ▉▉ FLEXLOGIC              ◄▉►     ▉ EQUATION EDITOR         See page 5-68.

                                    ▉ FLEXLOGIC
        ⬙                     ⬘     ▉ TIMERS                  See page 5-68.
                              ⬗

                                    ▉ FLEXELEMENTS
                              ⬘     ▉                         See page 5-69.
                              ⬗

                                    ▉ NON-VOLATILE
                              ⬗     ▉ LATCHES                 See page 5-73.

        ⬗
  ▉▉ SETTINGS                       ▉ SETTING GROUP 1
  ▉▉ GROUPED ELEMENTS       ◄▉►     ▉                         See page 5-74.

                                    ▉ SETTING GROUP 2
        ⬙                     ⬘     ▉
                              ⬗
                                              ↓

                                    ▉ SETTING GROUP 6
                              ⬗     ▉

        ⬗
  ▉▉ SETTINGS                       ▉ SETTING GROUPS
  ▉▉ CONTROL ELEMENTS       ◄▉►     ▉                         See page 5-107.

                                    ▉ SELECTOR SWITCH
        ⬙                     ⬘     ▉                         See page 5-108.
                              ⬗

                                    ▉ SYNCHROCHECK
                              ⬘     ▉                         See page 5-113.
                              ⬗

                                    ▉ AUTORECLOSE
                              ⬘     ▉                         See page 5-117.
                              ⬗

                                    ▉ DIGITAL ELEMENTS
                              ⬘     ▉                         See page 5-129.
                              ⬗

                                    ▉ DIGITAL COUNTERS
                              ⬘     ▉                         See page 5-132.
                              ⬗

                                    ▉ MONITORING
                              ⬗     ▉ ELEMENTS                See page 5-134.

        ⬗
  ▉▉ SETTINGS                       ▉ CONTACT INPUTS
  ▉▉ INPUTS / OUTPUTS       ◄▉►     ▉                         See page 5-141.

                                    ▉ VIRTUAL INPUTS
        ⬙                     ⬘     ▉                         See page 5-143.
                              ⬗

                                    ▉ CONTACT OUTPUTS
                              ⬘     ▉                         See page 5-144.
                              ⬗

                                    ▉ LATCHING OUTPUTS
                              ⬘     ▉                         See page 5-144.
                              ⬗
```

| | | |
|---|---|---|
| ▲▼ | ■ VIRTUAL OUTPUTS<br>■ | See page 5-146. |
| ▲▼ | ■ REMOTE DEVICES<br>■ | See page 5-147. |
| ▲▼ | ■ REMOTE INPUTS<br>■ | See page 5-148. |
| ▲▼ | ■ REMOTE OUTPUTS<br>■ DNA BIT PAIRS | See page 5-149. |
| ▲▼ | ■ REMOTE OUTPUTS<br>■ UserSt BIT PAIRS | See page 5-150. |
| ▲▼ | ■ RESETTING<br>■ | See page 5-150. |
| ▲▼ | ■ DIRECT INPUTS<br>■ | See page 5-150. |
| ▲ | ■ DIRECT OUTPUTS<br>■ | See page 5-150. |

▲

**■■ SETTINGS**
**■■ TRANSDUCER I/O**          ◄▐▶

▼

| | | |
|---|---|---|
| | ■ DCMA INPUTS<br>■ | See page 5-154. |
| ▲▼ | ■ RTD INPUTS<br>■ | See page 5-155. |
| ▲ | ■ DCMA OUTPUTS<br>■ | See page 5-155. |

▲

**■■ SETTINGS**
**■■ TESTING**          ◄▐▶

| | | |
|---|---|---|
| | TEST MODE<br>FUNCTION: Disabled | See page 5-159. |
| ▲▼ | TEST MODE INITIATE:<br>On | See page 5-159. |
| ▲▼ | ■ FORCE CONTACT<br>■ INPUTS | See page 5-159. |
| ▲ | ■ FORCE CONTACT<br>■ OUTPUTS | See page 5-160. |

**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, except the Digital Element which uses a logic state as the input, use analog parameter actual values as the input.

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 input(s), settings, fixed logic, and the output operands generated (abbreviations used on scheme logic diagrams are defined in Appendix F).

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

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

- For current elements, the 'base quantity' is the nominal secondary or primary current of the CT. Where the current source is the sum of two CTs with different ratios, the 'base quantity' will be the common secondary or primary current to which the sum is scaled (i.e. normalized to the larger of the 2 rated CT inputs). For example, if CT1 = 300 / 5 A and CT2 = 100 / 5 A, then in order to sum these, CT2 is scaled to the CT1 ratio. In this case, the 'base quantity' will be 5 A secondary or 300 A primary.

- For voltage elements the 'base quantity' is the nominal primary voltage of the protected system which corresponds (based on VT ratio and connection) to secondary VT voltage applied to the relay. For example, on a system with a 13.8 kV nominal primary voltage and with 14400:120 V Delta-connected VTs, the secondary nominal voltage (1 pu) would be:

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

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

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

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

- **FUNCTION setting:** This setting programs the element to be operational when selected as "Enabled". The factory default is "Disabled". Once programmed to "Enabled", any element associated with the Function becomes active and all options become available.

- **NAME setting:** This setting is used to uniquely identify the element.

- **SOURCE setting:** This setting is used to select the parameter or set of parameters to be monitored.

- **PICKUP setting:** For simple elements, this setting is used to program the level of the measured parameter above or below which the pickup state is established. In more complex elements, a set of settings may be provided to define the range of the measured parameters which will cause the element to pickup.

- **PICKUP DELAY setting:** This setting sets a time-delay-on-pickup, or on-delay, for the duration between the Pickup and Operate output states.

- **RESET DELAY setting:** This setting is used to set a time-delay-on-dropout, or off-delay, for the duration between the Operate output state and the return to logic 0 after the input transits outside the defined pickup range.

- **BLOCK setting:** The default output operand state of all comparators is a logic 0 or "flag not set". The comparator remains in this default state until a logic 1 is asserted at the RUN input, allowing the test to be performed. If the RUN input changes to logic 0 at any time, the comparator returns to the default state. The RUN input is used to supervise the comparator. The BLOCK input is used as one of the inputs to RUN control.

- **TARGET setting:** This setting is used to define the operation of an element target message. When set to Disabled, no target message or illumination of a faceplate LED indicator is issued upon operation of the element. When set to Self-Reset, the target message and LED indication follow the Operate state of the element, and self-resets once the operate element condition clears. When set to Latched, the target message and LED indication will remain visible after the element output returns to logic 0 - until a RESET command is received by the relay.

- **EVENTS setting:** This setting is used to control whether the Pickup, Dropout or Operate states are recorded by the event recorder. When set to Disabled, element pickup, dropout or operate are not recorded as events. When set to Enabled, events are created for:

        (Element) PKP (pickup)
        (Element) DPO (dropout)
        (Element) OP (operate)

The DPO event is created when the measure and decide comparator output transits from the pickup state (logic 1) to the dropout state (logic 0). This could happen when the element is in the operate state if the reset delay time is not '0'.

**a) BACKGROUND**

The C60 may be used on systems with breaker-and-a-half or ring bus configurations. In these applications, each of the two three-phase sets of individual phase currents (one associated with each breaker) can be used as an input to a breaker failure element. The sum of both breaker phase currents and 3I_0 residual currents may be required for the circuit relaying and metering functions. For a three-winding transformer application, it may be required to calculate watts and vars for each of three windings, using voltage from different sets of VTs. These requirements can be satisfied with a single UR, equipped with sufficient CT and VT input channels, by selecting the parameter to measure. A mechanism is provided to specify the AC parameter (or group of parameters) used as the input to protection/control comparators and some metering elements.

Selection of the parameter(s) to measure is partially performed by the design of a measuring element or protection/control comparator by identifying the type of parameter (fundamental frequency phasor, harmonic phasor, symmetrical component, total waveform RMS magnitude, phase-phase or phase-ground voltage, etc.) to measure. The user completes the process by selecting the instrument transformer input channels to use and some of the parameters calculated from these channels. The input parameters available include the summation of currents from multiple input channels. For the summed currents of phase, 3I_0, and ground current, current from CTs with different ratios are adjusted to a single ratio before summation.

A mechanism called a "Source" configures the routing of CT and VT input channels to measurement sub-systems. Sources, in the context of UR series relays, refer to the logical grouping of current and voltage signals such that one source contains all the signals required to measure the load or fault in a particular power apparatus. A given source may contain all or some of the following signals: three-phase currents, single-phase ground current, three-phase voltages and an auxiliary voltage from a single VT for checking for synchronism.

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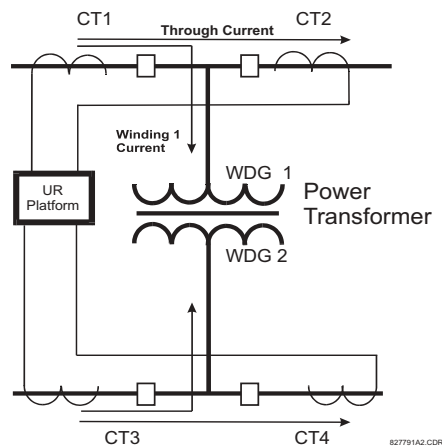


**Figure 5–1: BREAKER-AND-A-HALF SCHEME**

In conventional analog or electronic relays, the sum of the currents is obtained from an appropriate external connection of all CTs through which any portion of the current for the element being protected could flow. Auxiliary CTs are required to perform ratio matching if the ratios of the primary CTs to be summed are not identical. In the UR series of relays, provisions have been included for all the current signals to be brought to the UR device where grouping, ratio correction and summation are applied internally via configuration settings.

A major advantage of using internal summation is that the individual currents are available to the protection device; for example, as additional information to calculate a restraint current, or to allow the provision of additional protection features that operate on the individual currents such as breaker failure.

Given the flexibility of this approach, it becomes necessary to add configuration settings to the platform to allow the user to select which sets of CT inputs will be added to form the net current into the protected device.

The internal grouping of current and voltage signals forms an internal source. This source can be given a specific name through the settings, and becomes available to protection and metering elements in the UR platform. Individual names can be given to each source to help identify them more clearly for later use. For example, in the scheme shown in the above diagram, the 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 | 2 |
| CT Bank (3 phase channels, 1 ground channel) | 8 |
| VT Bank (3 phase channels, 1 auxiliary channel) | 4 |

### 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.

**PATH: SETTINGS ⇨ PRODUCT SETUP ⇨ PASSWORD SECURITY**

| | | |
|---|---|---|
| ■ PASSWORD<br>■ SECURITY | ◀▶ | **ACCESS LEVEL:**<br>**Restricted** |

*Range:* Restricted, Command, Setting,<br>Factory Service (for factory use only)

| | | |
|---|---|---|
| *MESSAGE* | ▲▼ | **CHANGE COMMAND**<br>**PASSWORD: No** |

*Range:* No, Yes

| | | |
|---|---|---|
| *MESSAGE* | ▲▼ | **CHANGE SETTING**<br>**PASSWORD: No** |

*Range:* No, Yes

| | | |
|---|---|---|
| *MESSAGE* | ▲▼ | **ENCRYPTED COMMAND**<br>**PASSWORD: ----------** |

*Range:* 0 to 9999999999<br>Note: ---------- indicates no password

| | | |
|---|---|---|
| *MESSAGE* | ▲ | **ENCRYPTED SETTING**<br>**PASSWORD: ----------** |

*Range:* 0 to 9999999999<br>Note: ---------- indicates no password

Two levels of password security are provided: **Command** and **Setting**. Operations under password supervision are:

- **COMMAND:** operating the breakers via faceplate keypad, changing the state of virtual inputs, clearing the event records, clearing the oscillography records, clearing fault reports, changing the date and time, clearing the breaker arcing amps, clearing energy records, clearing the data logger, user-programmable push-buttons

- **SETTING:** changing any setting, test mode operation

The Command and Setting passwords are defaulted to "Null" when the relay is shipped from the factory. When a password is set to "Null", the password security feature is disabled.

Programming a password code is required to enable each access level. A password consists of 1 to 10 numerical characters. When a **CHANGE … PASSWORD** setting is set to "Yes", 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, set **ACCESS LEVEL** 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. If no keys are pressed for longer than 30 minutes or control power is cycled, accessibility will automatically revert to the "Restricted" level.

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

The UR 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 these are required, the operand can be assigned to a digital element programmed with event logs and/or targets enabled.

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

**NOTE:** When enerVista UR Setup is used to access a particular level, the user will continue to have access to that level as long as there are open windows in the enerVista UR Setup software. To re-establish the Password Security feature, all windows must be closed for at least 30 minutes.

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨ ⇩ DISPLAY PROPERTIES

```
■ DISPLAY                    ◀▶    FLASH MESSAGE          Range:  0.5 to 10.0 s in steps of 0.1
■ PROPERTIES                       TIME:  1.0 s

                  MESSAGE    ▲     DEFAULT MESSAGE        Range:  10 to 900 s in steps of 1
                             ▼     TIMEOUT: 300 s

                  MESSAGE    ▲     DEFAULT MESSAGE        Range:  25%, 50%, 75%, 100%
                             ▼     INTENSITY: 25 %                Visible only if a VFD is installed

                  MESSAGE    ▲     SCREEN SAVER           Range:  Disabled, Enabled
                             ▼     FEATURE: Disabled              Visible only if an LCD is installed

                  MESSAGE    ▲     SCREEN SAVER           Range:  1 to 65535 min. in steps of 1
                             ▼     WAIT TIME: 30 min              Visible only if an LCD is installed

                  MESSAGE    ▲     CURRENT CUT-OFF        Range:  0.002 to 0.020 pu in steps of 0.001
                             ▼     LEVEL: 0.020 pu

                  MESSAGE    ▲     VOLTAGE CUT-OFF        Range:  0.1 to 1.0 V secondary in steps of 0.1
                                   LEVEL: 1.0 V
```

Some relay messaging characteristics can be modified to suit different situations using the display properties settings.

- **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 C60 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 C60 applies a cut-off value to the magnitudes and angles of the measured currents. If the magnitude is below the cut-off level, it is substituted with zero. This applies to phase and ground current phasors as well as true RMS values and symmetrical components. The cut-off operation applies to quantities used for metering, protection, and control, as well as those used by communications protocols. Note that the cut-off level for the sensitive ground input is 10 times lower that the **CURRENT CUT-OFF LEVEL** setting value. Raw current samples available via oscillography are not subject to cut-off.

- **VOLTAGE CUT-OFF LEVEL:** This setting modifies the voltage cut-off threshold. Very low secondary voltage measurements (at the fractional volt level) can be affected by noise. Some customers prefer these low voltages to be displayed as zero, while others prefer the voltage to be displayed even when the value reflects noise rather than the actual signal. The C60 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. This setting relates to the actual measured voltage at the VT secondary inputs. It can be converted to per-unit values (pu) by dividing by the **PHASE VT SECONDARY** setting value. For example, a **PHASE VT SECONDARY** setting of "66.4 V" and a **VOLTAGE CUT-OFF LEVEL** setting of "1.0 V" gives a cut-off value of 1.0 V / 66.4 V = 0.015 pu.

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 follows:

$$\text{power cut-off level} = \textbf{CURRENT CUT-OFF LEVEL} \times \textbf{VOLTAGE CUT-OFF LEVEL} \times 1.0 \text{ pu current} \times 1.0 \text{ pu voltage} \quad \textbf{(EQ 5.3)}$$

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".

We have:

1.0 pu current = CT primary = "100 A", and
1.0 pu voltage = **PHASE VT SECONDARY** x **PHASE VT RATIO** = 66.4 V x 208 = 13811.2 V

The power cut-off is therefore:

power cut-off = **CURRENT CUT-OFF LEVEL** $\times$ **VOLTAGE CUT-OFF LEVEL** $\times$ 1.0 pu current $\times$ 1.0 pu voltage
        = 0.02 pu $\times$ 0.015 pu $\times$ 100 A $\times$ 13811.2 V
        = 416 watts

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

> **NOTE**
>
> **Lower the VOLTAGE CUT-OFF LEVEL and CURRENT CUT-OFF LEVEL with care as the relay accepts lower signals as valid measurements. Unless dictated otherwise by a specific application, the default settings of "0.02 pu" for CURRENT CUT-OFF LEVEL and "1.0 V" for VOLTAGE CUT-OFF LEVEL are recommended.**

**5**

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ CLEAR RELAY RECORDS

| | | | |
|---|---|---|---|
| ■ CLEAR RELAY<br>■ RECORDS | ◁▷ | CLEAR FAULT REPORTS:<br>Off | *Range: FlexLogic™ operand* |
| MESSAGE | ⬆⬇ | CLEAR EVENT RECORDS:<br>Off | *Range: FlexLogic™ operand* |
| MESSAGE | ⬆⬇ | CLEAR OSCILLOGRAPHY?<br>No | *Range: FlexLogic™ operand* |
| MESSAGE | ⬆⬇ | CLEAR DATA LOGGER:<br>Off | *Range: FlexLogic™ operand* |
| MESSAGE | ⬆⬇ | CLEAR ARC AMPS 1:<br>Off | *Range: FlexLogic™ operand* |
| MESSAGE | ⬆⬇ | CLEAR ARC AMPS 2:<br>Off | *Range: FlexLogic™ operand* |
| MESSAGE | ⬆⬇ | CLEAR DEMAND:<br>Off | *Range: FlexLogic™ operand* |
| MESSAGE | ⬆⬇ | CLEAR ENERGY:<br>Off | *Range: FlexLogic™ operand* |
| MESSAGE | ⬆⬇ | RESET UNAUTH ACCESS:<br>Off | *Range: FlexLogic™ operand* |
| MESSAGE | ⬆ | CLEAR DIR I/O STATS:<br>Off | *Range: FlexLogic™ operand.*<br>*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 C60 responds to rising edges of the configured FlexLogic™ operands, they must be asserted for at least 50 ms to take effect.

Clearing records with user-programmable operands is not protected by the command password. However, user-programmable pushbuttons are protected by the command password. Thus, if they are used to clear records, the user-programmable pushbuttons can provide extra security if required.

For example, to assign User-Programmable Pushbutton 1 to clear demand records, the following settings should be applied.

1.  Assign the clear demand function to Pushbutton 1 by making the following change in the **SETTINGS** ⇨ **PRODUCT SETUP** ⇨⇩ **CLEAR RELAY RECORDS** menu:

    **CLEAR DEMAND:** "PUSHBUTTON 1 ON"

2.  Set the properties for User-Programmable Pushbutton 1 by making the following changes in the **SETTINGS** ⇨ **PRODUCT SETUP** ⇨⇩ **USER-PROGRAMMABLE PUSHBUTTONS** ⇨ **USER PUSHBUTTON 1** menu:

    **PUSHBUTTON 1 FUNCTION:** "Self-reset"
    **PUSHBTN 1 DROP-OUT TIME:** "0.20 s"

**a) MAIN MENU**

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS

| ■ COMMUNICATIONS ■ | ◄�Ⅰ▶ | ■ SERIAL PORTS ■ | See below. |
|---|---|---|---|
| *MESSAGE* ⬆⬇ | | ■ NETWORK ■ | See page 5-12. |
| *MESSAGE* ⬆⬇ | | ■ MODBUS PROTOCOL ■ | See page 5-12. |
| *MESSAGE* ⬆⬇ | | ■ DNP PROTOCOL ■ | See page 5-13. |
| *MESSAGE* ⬆⬇ | | ■ IEC 61850 PROTOCOL ■ | See page 5-15. |
| *MESSAGE* ⬆⬇ | | ■ WEB SERVER ■ HTTP PROTOCOL | See page 5-16. |
| *MESSAGE* ⬆⬇ | | ■ TFTP PROTOCOL ■ | See page 5-16. |
| *MESSAGE* ⬆⬇ | | ■ IEC 60870-5-104 ■ PROTOCOL | See page 5-17. |
| *MESSAGE* ⬆⬇ | | ■ SNTP PROTOCOL ■ | See page 5-18. |
| *MESSAGE* ⬆ | | ■ EGD PROTOCOL ■ | See page 5-18. |

**b) SERIAL PORTS**

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

| ■ SERIAL PORTS ■ | ◄Ⅰ▶ | RS485 COM1 BAUD RATE: 19200 | *Range:* | *300, 1200, 2400, 4800, 9600, 14400, 19200, 28800, 33600, 38400, 57600, 115200. Only active if CPU 9E is ordered.* |
|---|---|---|---|---|
| *MESSAGE* ⬆⬇ | | RS485 COM1 PARITY: None | *Range:* | *None, Odd, Even Only active if CPU Type 9E is ordered* |
| *MESSAGE* ⬆⬇ | | RS485 COM1 RESPONSE MIN TIME:    0 ms | *Range:* | *0 to 1000 ms in steps of 10 Only active if CPU Type 9E 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 C60 is equipped with up to 3 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.

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

### c) NETWORK

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

| | | |
|---|---|---|
| ■ NETWORK<br>■ | | *Range:* Standard IP address format<br>Only active if CPU Type 9G or 9H is ordered. |
| | IP ADDRESS:<br>0.0.0.0 | |
| *MESSAGE* | SUBNET IP MASK:<br>0.0.0.0 | *Range:* Standard IP address format<br>Only active if CPU Type 9G or 9H is ordered. |
| *MESSAGE* | GATEWAY IP ADDRESS:<br>0.0.0.0 | *Range:* Standard IP address format<br>Only active if CPU Type 9G or 9H is ordered. |
| *MESSAGE* | ■ OSI NETWORK<br>■ ADDRESS (NSAP) | *Range:* Press the MESSAGE ⇨ key to enter the **OSI NETWORK ADDRESS**. Only active if CPU Type 9G or 9H is ordered. |
| *MESSAGE* | ETHERNET OPERATION<br>MODE: Full-Duplex | *Range:* Half-Duplex, Full-Duplex<br>Only active if CPU Type 9G or 9H is ordered. |

These messages appear only if the C60 is ordered with an Ethernet card.

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

> **NOTE**
>
> When the NSAP address, any TCP/UDP Port Number, or any User Map setting (when used with DNP) is changed, it will not become active until power to the relay has been cycled (OFF/ON).

> **WARNING**
>
> **Do not set more than one protocol to use 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

| | | |
|---|---|---|
| ■ MODBUS PROTOCOL<br>■ | MODBUS SLAVE<br>ADDRESS: 254 | *Range:* 1 to 254 in steps of 1 |
| *MESSAGE* | MODBUS TCP PORT<br>NUMBER:  502 | *Range:* 1 to 65535 in steps of 1 |

The serial communication ports utilize the Modbus protocol, unless configured for DNP operation (see the DNP Protocol description 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 C60 will respond regardless of the **MODBUS SLAVE ADDRESS** programmed. For the RS485 ports each C60 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.

**e) DNP PROTOCOL**

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

| ■ DNP PROTOCOL ■ | ◀▶ | DNP PORT: NONE | *Range: NONE, COM1 - RS485, COM2 - RS485, FRONT PANEL - RS232, NETWORK* |
|---|---|---|---|
| MESSAGE | ▲▼ | DNP ADDRESS: 255 | *Range: 0 to 65519 in steps of 1* |
| MESSAGE | ▲▼ | ■ DNP NETWORK ■ CLIENT ADDRESSES | *Range: Press the MESSAGE ⇨ key to enter the DNP NETWORK CLIENT ADDRESSES* |
| 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 | ▲▼ | USER MAP FOR DNP ANALOGS: Disabled | *Range: Enabled, Disabled* |
| MESSAGE | ▲▼ | NUMBER OF SOURCES IN ANALOG LIST: 1 | *Range: 1 to 4 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 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 65535 in steps of 1* |
| MESSAGE | ▲▼ | DNP VOLTAGE DEFAULT DEADBAND: 30000 | *Range: 0 to 65535 in steps of 1* |
| MESSAGE | ▲▼ | DNP POWER DEFAULT DEADBAND: 30000 | *Range: 0 to 65535 in steps of 1* |
| MESSAGE | ▲▼ | DNP ENERGY DEFAULT DEADBAND: 30000 | *Range: 0 to 65535 in steps of 1* |
| MESSAGE | ▲▼ | DNP OTHER DEFAULT DEADBAND: 30000 | *Range: 0 to 65535 in steps of 1* |
| MESSAGE | ▲▼ | DNP TIME SYNC IIN PERIOD: 1440 min | *Range: 1 to 10080 min. in steps of 1* |

**5**

**5**

MESSAGE ⬆⬇
```
DNP MESSAGE FRAGMENT
SIZE: 240
```
*Range:  30 to 2048 in steps of 1*

MESSAGE ⬆⬇
```
■ DNP BINARY INPUTS
■ USER MAP
```

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*

The C60 supports the Distributed Network Protocol (DNP) version 3.0. The C60 can be used as a DNP slave device connected to a single DNP master (usually an RTU or a SCADA master station). Since the C60 maintains one set of DNP data change buffers and connection information, only one DNP master should actively communicate with the C60 at one time. The **DNP PORT** setting selects the communications port assigned to the DNP protocol; only a single port can be assigned. 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", the DNP protocol can be used over either TCP/IP or UDP/IP. Refer to Appendix E for more information on the DNP protocol. The **DNP ADDRESS** setting is the DNP slave address. This number identifies the C60 on a DNP communications link. Each DNP slave should be assigned a unique address. The **DNP NETWORK CLIENT ADDRESS** setting can force the C60 to respond to a maximum of five specific DNP masters.

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 C60 waits for a DNP master to confirm an unsolicited response. The **DNP UNSOL RESPONSE MAX RETRIES** setting determines the number of times the C60 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 C60 from the current TCP connection or the most recent UDP message.

The **USER MAP FOR DNP ANALOGS** setting allows the large pre-defined Analog Inputs points list to be replaced by the much smaller Modbus User Map. This can be useful for users wishing to read only selected Analog Input points from the C60. See Appendix E for more information.

The **NUMBER OF SOURCES IN ANALOG LIST** setting allows the selection of the number of current/voltage source values that are included in the Analog Inputs points list. This allows the list to be customized to contain data for only the sources that are configured. This setting is relevant only when the User Map is not used.

The **DNP SCALE FACTOR** settings are numbers used to scale Analog Input point values. These settings group the C60 Analog Input data into types: current, voltage, power, energy, 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 a value of 1000, all DNP Analog Input points that are voltages will be returned with values 1000 times smaller (e.g. a value of 72000 V on the C60 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 (i.e. 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 C60 Analog Input data into types: current, voltage, power, energy, 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 C60

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 C60, the default deadbands will be in effect.

The **DNP TIME SYNC IIN PERIOD** setting determines how often the Need Time Internal Indication (IIN) bit is set by the C60. 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.

The **DNP BINARY INPUTS USER MAP** setting allows for the creation of a custom DNP Binary Inputs points list. The default DNP Binary Inputs list contains 928 points representing various binary states (contact inputs and outputs, virtual inputs and outputs, protection element states, etc.). If not all of these points are required in the DNP master, a custom Binary Inputs points list can be created by selecting up to 58 blocks of 16 points. Each block represents 16 binary input points. Block 1 represents binary input points 0 to 15, block 2 represents binary input points 16 to 31, block 3 represents binary input points 32 to 47, etc. The minimum number of binary input points that can be selected is 16 (1 block). If all of the **BIN INPUT BLOCK X** settings are set to "Not Used", the standard list of 928 points will be in effect. The C60 will form the binary inputs points list from the **BIN INPUT BLOCK X** settings up to the first occurrence of a setting value of "Not Used".

> **NOTE** When using the User Maps for DNP data points (analog inputs and/or binary inputs) for relays with ethernet installed, check the "DNP Points Lists" C60 web page to ensure the desired points lists are created. This web page can be viewed using a web browser by entering the C60 IP address to access the C60 "Main Menu", then by selecting the "Device Information Menu" > "DNP Points Lists" menu item.

The **DNP OBJECT *N* 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.

### f) IEC 61850 PROTOCOL

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

| | | |
|---|---|---|
| ■ IEC 61850 PROTOCOL ■ | ◄I► | *Range: 1 to 60 s in steps of 1. See UserSt Bit Pairs in the Remote Outputs section of this Chapter.* |
| *MESSAGE* ⬆⬇ | DEFAULT GSSE UPDATE TIME: 60 s | |
| *MESSAGE* ⬆⬇ | LOGICAL DEVICE NAME: IECDevice | *Range: Up to 16 alphanumeric characters representing the name of the IEC 61850 logical device.* |
| *MESSAGE* ⬆⬇ | IEC/MMS TCP PORT NUMBER: 102 | *Range: 1 to 65535 in steps of 1* |
| *MESSAGE* ⬆ | GSSE FUNCTION: Enabled | *Range: Disabled, Enabled* |

The C60 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 C60 operates as an IEC 61850 server. The *Remote Inputs/Outputs* section in this chapter describe the peer-to-peer GSSE message scheme.

The **LOGICAL DEVICE NAME** setting represents the MMS domain name (IEC 61850 logical device) where all IEC/MMS objects are located. The **GSSE FUNCTION** setting allows for the blocking of GSSE messages from the C60. This can be used during testing or to prevent the relay from sending GSSE messages during normal operation.

> **NOTE** Since GSSE messages are multicast ethernet by specification, router networks must not be used for IEC/MMS.

### g) WEB SERVER HTTP PROTOCOL

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

```
■ WEB SERVER              ◀▮▶    HTTP TCP PORT
■ HTTP PROTOCOL                  NUMBER:    80
```
*Range:  1 to 65535 in steps of 1*

The C60 contains an embedded web server and is capable of transferring web pages to a web browser such as Microsoft Internet Explorer or Netscape Navigator. This feature is available only if the C60 has the ethernet option installed. The web pages are organized as a series of menus that can be accessed starting at the C60 "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 C60 into the "Address" box on the web browser.

### h) TFTP PROTOCOL

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

```
■ TFTP PROTOCOL           ◀▮▶    TFTP MAIN UDP PORT
■                                NUMBER:    69
```
*Range:  1 to 65535 in steps of 1*

*MESSAGE*  ▲▼
```
TFTP DATA UDP PORT 1
NUMBER:     0
```
*Range:  0 to 65535 in steps of 1*

*MESSAGE*  ▲
```
TFTP DATA UDP PORT 2
NUMBER:     0
```
*Range:  0 to 65535 in steps of 1*

The Trivial File Transfer Protocol (TFTP) can be used to transfer files from the UR over a network. The C60 operates as a TFTP server. TFTP client software is available from various sources, including Microsoft Windows NT. The `dir.txt` file obtained from the C60 contains a list and description of all available files (event records, oscillography, etc.).

### i) IEC 60870-5-104 PROTOCOL

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

| | | |
|---|---|---|
| ■ IEC 60870-5-104 <br> ■ PROTOCOL | ◀�B▶ | IEC 60870-5-104 <br> FUNCTION: Disabled | *Range: Enabled, Disabled* |
| MESSAGE | ▲▼ | IEC TCP PORT <br> NUMBER: 2404 | *Range: 1 to 65535 in steps of 1* |
| MESSAGE | ▲▼ | ■ IEC NETWORK <br> ■ CLIENT ADDRESSES | |
| MESSAGE | ▲▼ | IEC COMMON ADDRESS <br> OF ASDU:     0 | *Range: 0 to 65535 in steps of 1* |
| MESSAGE | ▲▼ | IEC CYCLIC DATA <br> PERIOD:     60 s | *Range: 1 to 65535 s in steps of 1* |
| MESSAGE | ▲▼ | NUMBER OF SOURCES <br> IN MMENC1 LIST: 1 | *Range: 1 to 4 in steps of 1* |
| MESSAGE | ▲▼ | IEC CURRENT DEFAULT <br> THRESHOLD: 30000 | *Range: 0 to 65535 in steps of 1* |
| MESSAGE | ▲▼ | IEC VOLTAGE DEFAULT <br> THRESHOLD: 30000 | *Range: 0 to 65535 in steps of 1* |
| MESSAGE | ▲▼ | IEC POWER DEFAULT <br> THRESHOLD: 30000 | *Range: 0 to 65535 in steps of 1* |
| MESSAGE | ▲▼ | IEC ENERGY DEFAULT <br> THRESHOLD: 30000 | *Range: 0 to 65535 in steps of 1* |
| MESSAGE | ▲ | IEC OTHER DEFAULT <br> THRESHOLD: 30000 | *Range: 0 to 65535 in steps of 1* |

The C60 supports the IEC 60870-5-104 protocol. The C60 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 C60 maintains two sets of IEC 60870-5-104 data change buffers, no more than two masters should actively communicate with the C60 at one time.

The **NUMBER OF SOURCES IN MMENC1 LIST** setting allows the selection of the number of current/voltage source values that are included in the M_ME_NC_1 (measured value, short floating point) Analog points list. This allows the list to be customized to contain data for only the sources that are configured.

The **IEC ------- DEFAULT THRESHOLD** settings are the values used by the UR to determine when to trigger spontaneous responses containing M_ME_NC_1 analog data. These settings group the UR 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, in order to trigger spontaneous responses from the UR 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 UR, the default thresholds will be in effect.

> ▽ **NOTE** **The IEC 60870-5-104 and DNP protocols can not be used at the same time. When the IEC 60870-5-104 FUNC-TION 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/On).**

**j) SNTP PROTOCOL**

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

| ■ SNTP PROTOCOL ■ | ◀▶ | SNTP FUNCTION: Disabled | *Range:* *Enabled, Disabled* |
|---|---|---|---|
| | MESSAGE ▲▼ | SNTP SERVER IP ADDR: 0.0.0.0 | *Range:* *Standard IP address format* |
| | MESSAGE ▲ | SNTP UDP PORT NUMBER: 123 | *Range:* *0 to 65535 in steps of 1* |

The C60 supports the Simple Network Time Protocol specified in RFC-2030. With SNTP, the C60 can obtain clock time over an Ethernet network. The C60 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 C60 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 C60 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 C60 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 C60 clock is closely synchronized with the SNTP/NTP server. It may take up to one minute for the C60 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 C60 then listens to SNTP messages sent to the "all ones" broadcast address for the subnet. The C60 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.

**k) EGD PROTOCOL**

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

| ■ EGD PROTOCOL ■ | ◀▶ | ■ FAST PROD EXCH 1 ■ CONFIGURATION |
|---|---|---|
| | MESSAGE ▲▼ | ■ SLOW PROD EXCH 1 ■ CONFIGURATION |
| | MESSAGE ▲ | ■ SLOW PROD EXCH 2 ■ CONFIGURATION |

**NOTE:** The Ethernet Global Data (EGD) protocol settings are only available if CPU Type 9G or 9H is ordered.

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

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

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

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

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

```
■ FAST PROD EXCH 1     ◁▷    EXCH 1 FUNCTION:          Range:  Disable, Enable
■ CONFIGURATION              Disable

              MESSAGE  ▲     EXCH 1 DESTINATION:       Range:  standard IP address
                       ▼     0.0.0.0

              MESSAGE  ▲     EXCH 1 DATA RATE:         Range:  50 to 1000 ms in steps of 1
                       ▼      1000 ms

              MESSAGE  ▲     EXCH 1 DATA ITEM 1:       Range:  0 to 65535 in steps of 1
                       ▼     0                                 (Modbus register address range)

                             ↓

              MESSAGE  ▲     EXCH 1 DATA ITEM 20:      Range:  0 to 65535 in steps of 1
                             0                                 (Modbus register address range)
```

Fast exchanges (50 to 1000 ms) are generally used in control schemes. The C60 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**

```
■ SLOW PROD EXCH 1     ◁▷    EXCH 1 FUNCTION:          Range:  Disable, Enable
■ CONFIGURATION              Disable

              MESSAGE  ▲     EXCH 1 DESTINATION:       Range:  standard IP address
                       ▼     0.0.0.0

              MESSAGE  ▲     EXCH 1 DATA RATE:         Range:  500 to 1000 ms in steps of 1
                       ▼      1000 ms

              MESSAGE  ▲     EXCH 1 DATA ITEM 1:       Range:  0 to 65535 in steps of 1
                       ▼     0                                 (Modbus register address range in decimal)

                             ↓

              MESSAGE  ▲     EXCH 1 DATA ITEM 50:      Range:  0 to 65535 in steps of 1
                             0                                 (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 C60 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 (e.g. 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.

**PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ MODBUS USER MAP**

```
■ MODBUS  USER MAP
■
```
◀❚▶
```
ADDRESS    1:      0
VALUE:      0
```
*Range:  0 to 65535 in steps of 1*

↓

MESSAGE ▲
```
ADDRESS 256:      0
VALUE:      0
```
*Range:  0 to 65535 in steps of 1*

The Modbus User Map provides read-only access for up to 256 registers. To obtain a memory map value, enter the desired address in the **ADDRESS** line (this value must be converted from hex to decimal format). The corresponding value is displayed in the **VALUE** line. A value of "0" in subsequent register **ADDRESS** lines automatically returns values for the previous **ADDRESS** lines incremented by "1". An address value of "0" in the initial register means "none" and values of "0" will be displayed for all registers. Different **ADDRESS** values can be entered as required in any of the register positions.

> **These settings can also be used with the DNP protocol. See the DNP Analog Input Points section in Appendix E for details.**
> NOTE

**PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ REAL TIME CLOCK**

```
■ REAL TIME
■ CLOCK
```
◀❚▶
```
IRIG-B SIGNAL TYPE:
None
```
*Range:  None, DC Shift, Amplitude Modulated*

MESSAGE ▲
```
REAL TIME CLOCK
EVENTS: Disabled
```
*Range:  Disabled, Enabled*

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

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

**PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ FAULT REPORTS ⇨ FAULT REPORT 1**

| ■ FAULT REPORT 1 ■ | ◀▮▶ | FAULT REPORT 1 SOURCE: SRC 1 | *Range:* SRC 1, SRC 2, SRC 3, SRC 4 |
|---|---|---|---|
| *MESSAGE* | ▲▼ | FAULT REPORT 1 TRIG: Off | *Range:* FlexLogic™ operand |
| *MESSAGE* | ▲▼ | FAULT REPORT 1 Z1 MAG: 3.00 Ω | *Range:* 0.01 to 250.00 Ω in steps of 0.01 |
| *MESSAGE* | ▲▼ | FAULT REPORT 1 Z1 ANGLE: 75° | *Range:* 25 to 90° in steps of 1 |
| *MESSAGE* | ▲▼ | FAULT REPORT 1 Z0 MAG: 9.00 Ω | *Range:* 0.01 to 650.00 Ω in steps of 0.01 |
| *MESSAGE* | ▲▼ | FAULT REPORT 1 Z0 ANGLE: 75° | *Range:* 25 to 90° in steps of 1 |
| *MESSAGE* | ▲▼ | FAULT REPORT 1 LINE LENGTH UNITS: km | *Range:* km, miles |
| *MESSAGE* | ▲ | FAULT REP 1 LENGTH (km ): 100.0 | *Range:* 0.0 to 2000.0 in steps of 0.1 |

The C60 relay supports one fault report and an associated fault locator. The signal source and trigger condition, as well as the characteristics of the line or feeder, are entered in this menu.

The fault report stores data, in non-volatile memory, pertinent to an event when triggered. The captured data contained in the `FaultReport.txt` file includes:

- Fault report number
- Name of the relay, programmed by the user
- Firmware revision of the relay
- Date and time of trigger
- Name of trigger (specific operand)
- Line/Feeder ID via the name of a configured signal source
- Active setting group at the time of trigger
- Pre-fault current and voltage phasors (one-quarter cycle before the trigger)
- Fault current and voltage phasors (three-quarter cycle after the trigger)
- Elements operated at the time of triggering
- Events: 9 before trigger and 7 after trigger (only available via the relay webpage)
- Fault duration times for each breaker (created by the Breaker Arcing Current feature)

The captured data also includes the fault type and the distance to the fault location, as well as the reclose shot number (when applicable) The Fault Locator does not report fault type or location if the source VTs are connected in the Delta configuration. To include fault duration times in the fault report, the user must enable and configure Breaker Arcing Current feature for each of the breakers. Fault duration is reported on a per-phase basis.

The trigger can be any FlexLogic™ operand, but in most applications it is expected to be the same operand, usually a virtual output, that is used to drive an output relay to trip a breaker. To prevent the overwriting of fault events, the disturbance detector should not be used to trigger a fault report. A FAULT RPT TRIG event is automatically created when the report is triggered.

If a number of protection elements are ORed to create a fault report trigger, the first operation of any element causing the OR gate output to become high triggers a fault report. However, If other elements operate during the fault and the first operated element has not been reset (the OR gate output is still high), the fault report is not triggered again. Considering the reset time of protection elements, there is very little chance that fault report can be triggered twice in this manner. As the fault report must capture a usable amount of pre and post-fault data, it can not be triggered faster than every 20 ms.

Each fault report is stored as a file; the relay capacity is fifteen (15) files. An sixteenth (16th) trigger overwrites the oldest file.

The enerVista UR Setup software is required to view all captured data. The relay faceplate display can be used to view the date and time of trigger, the fault type, the distance location of the fault, and the reclose shot number.

The **FAULT REPORT 1 SOURCE** setting selects the source for input currents and voltages and disturbance detection. The **FAULT 1 REPORT TRIG** setting assigns the FlexLogic™ operand representing the protection element/elements requiring operational fault location calculations. The distance to fault calculations are initiated by this signal. The **FAULT REPORT 1 Z1 MAG** and **FAULT REPORT 1 Z0 MAG** impedances are entered in secondary ohms.

See the **ACTUAL VALUES** ⇨ ⇩ **RECORDS** ⇨ **FAULT REPORTS** menu for additional details.

### 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 CT/VT 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 (e.g. 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 (i.e. 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, i.e. 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.**
WARNING

**b) DIGITAL CHANNELS**

**PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ OSCILLOGRAPHY ⇨⇩ DIGITAL CHANNELS**

```
■ DIGITAL CHANNELS          ◁▷      DIGITAL CHANNEL  1:       Range:  FlexLogic™ operand
■                                   Off
                                        ↓
          MESSAGE        ▲      DIGITAL CHANNEL 63:       Range:  FlexLogic™ operand
                                   Off
```
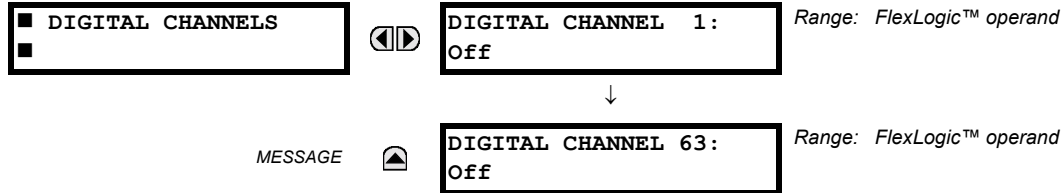
A **DIGITAL CHANNEL** setting selects the FlexLogic™ operand state recorded in an oscillography trace. The length of each oscillography trace depends in part on the number of parameters selected here. Parameters set to "Off" are ignored. Upon startup, the relay will automatically prepare the parameter list.

**c) ANALOG CHANNELS**

**PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ OSCILLOGRAPHY ⇨⇩ ANALOG CHANNELS**

```
■ ANALOG CHANNELS           ◁▷      ANALOG CHANNEL 1:         Range:  Off, any FlexAnalog parameter
■                                   Off                               See Appendix A for complete list.
                                        ↓
          MESSAGE        ▲      ANALOG CHANNEL 16:        Range:  Off, any FlexAnalog parameter
                                   Off                               See Appendix A for complete list.
```
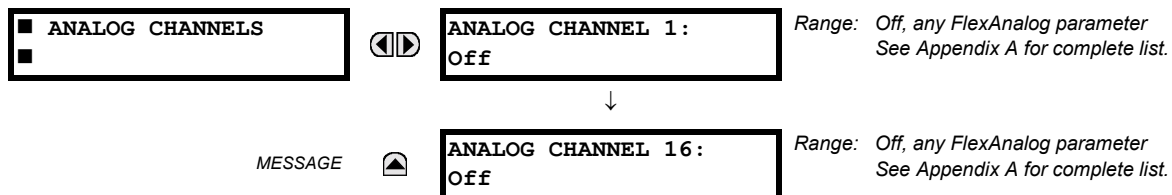
An **ANALOG CHANNEL** setting selects the metering actual value recorded in an oscillography trace. The length of each oscillography trace depends in part on the number of parameters selected here. Parameters set to "Off" are ignored. The parameters available in a given relay are dependent on: (a) the type of relay, (b) the type and number of CT/VT hardware modules installed, and (c) 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/display - entering this number via the relay keypad will cause the corresponding parameter to be displayed.

All eight CT/VT module channels are stored in the oscillography file. The CT/VT module channels are named as follows:

*<slot_letter><terminal_number>—<I* or *V><phase A*, *B*, or *C*, or *4th input>*

The fourth current input in a bank is called IG, and the fourth voltage input in a bank is called VX. For example, F2-IB designates the IB signal on Terminal 2 of the CT/VT module in slot F. If there are no CT/VT modules and Analog Input modules, no analog traces will appear in the file; only the digital traces will appear.

### 5.2.9 DATA LOGGER

**PATH: SETTINGS** ⇨⇩ **PRODUCT SETUP** ⇨⇩ **DATA LOGGER**

| | | |
|---|---|---|
| ■ **DATA LOGGER**<br>■ | ◀▷ | **DATA LOGGER RATE:**<br>**1 min** |
| *MESSAGE* | ▲▼ | **DATA LOGGER CHNL  1:**<br>**Off** |
| *MESSAGE* | ▲▼ | **DATA LOGGER CHNL  2:**<br>**Off** |
| | ↓ | |
| *MESSAGE* | ▲▼ | **DATA LOGGER CHNL 16:**<br>**Off** |
| *MESSAGE* | ▲ | **DATA LOGGER CONFIG:**<br>** 0 CHNL x    0.0 DAYS** |

*Range: 1 sec; 1 min, 5 min, 10 min, 15 min, 20 min, 30 min, 60 min*

*Range: Off, any FlexAnalog parameter. See Appendix A: FlexAnalog Parameters for complete list.*

*Range: Off, any FlexAnalog parameter. See Appendix A: FlexAnalog Parameters for complete list.*

*Range: Off, any FlexAnalog parameter. See Appendix A: FlexAnalog Parameters for complete list.*

*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 the enerVista UR Setup software 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.

**NOTE**

**Changing any setting affecting Data Logger operation will clear any data that is currently in the log.**

- **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.

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨ ⇩ DEMAND

| ■ DEMAND<br>■ | ◄||► | CRNT DEMAND METHOD:<br>Thermal Exponential | *Range:* *Thermal Exponential, Block Interval,*<br>*Rolling Demand* |
|---|---|---|---|
| *MESSAGE* | ▲▼ | POWER DEMAND METHOD:<br>Thermal Exponential | *Range:* *Thermal Exponential, Block Interval,*<br>*Rolling Demand* |
| *MESSAGE* | ▲▼ | DEMAND INTERVAL:<br>15 MIN | *Range:* *5, 10, 15, 20, 30, 60 minutes* |
| *MESSAGE* | ▲ | DEMAND TRIGGER:<br>Off | *Range:* *FlexLogic™ operand*<br>*Note: for calculation using Method 2a* |

The relay measures current demand on each phase, and three-phase demand for real, reactive, and apparent power. Current and Power methods can be chosen separately for the convenience of the user. Settings are provided to allow the user to emulate some common electrical utility demand measuring techniques, for statistical or control purposes. If the **CRNT DEMAND METHOD** is set to "Block Interval" and the **DEMAND TRIGGER** is set to "Off", Method 2 is used (see below). If **DEMAND TRIGGER** is assigned to any other FlexLogic™ operand, Method 2a is used (see below).

The relay can be set to calculate demand by any of three methods as described below:

**CALCULATION METHOD 1: THERMAL EXPONENTIAL**

This method emulates the action of an analog peak recording thermal demand meter. The relay measures the quantity (RMS current, real power, reactive power, or apparent power) on each phase every second, and assumes the circuit quantity remains at this value until updated by the next measurement. It calculates the 'thermal demand equivalent' based on the following equation:

$$d(t) = D(1 - e^{-kt})$$ **(EQ 5.4)**

where: $d$ = demand value after applying input quantity for time $t$ (in minutes)
$D$ = input quantity (constant), and $k$ = 2.3 / thermal 90% response time.

The 90% thermal response time characteristic of 15 minutes is illustrated below. A setpoint establishes the time to reach 90% of a steady-state value, just as the response time of an analog instrument. A steady state value applied for twice the response time will indicate 99% of the value.
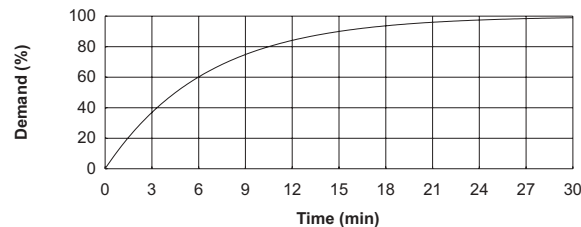


**Figure 5–2: THERMAL DEMAND CHARACTERISTIC**

**CALCULATION METHOD 2: BLOCK INTERVAL**

This method calculates a linear average of the quantity (RMS current, real power, reactive power, or apparent power) over the programmed demand time interval, starting daily at 00:00:00 (i.e. 12:00 am). The 1440 minutes per day is divided into the number of blocks as set by the programmed time interval. Each new value of demand becomes available at the end of each time interval.

**CALCULATION METHOD 2a: BLOCK INTERVAL (with Start Demand Interval Logic Trigger)**

This method calculates a linear average of the quantity (RMS current, real power, reactive power, or apparent power) over the interval between successive Start Demand Interval logic input pulses. Each new value of demand becomes available at the end of each pulse. Assign a FlexLogic™ operand to the **DEMAND TRIGGER** setting to program the input for the new demand interval pulses.

**NOTE**

If no trigger is assigned in the **DEMAND TRIGGER** setting and the **CRNT DEMAND METHOD** is "Block Interval", use cal-culating method #2. If a trigger is assigned, the maximum allowed time between 2 trigger signals is 60 minutes. If no trigger signal appears within 60 minutes, demand calculations are performed and available and the algorithm resets and starts the new cycle of calculations. The minimum required time for trigger contact closure is 20 μs.

**CALCULATION METHOD 3: ROLLING DEMAND**

This method calculates a linear average of the quantity (RMS current, real power, reactive power, or apparent power) over the programmed demand time interval, in the same way as Block Interval. The value is updated every minute and indicates the demand over the time interval just preceding the time of update.

**5.2.11 USER-PROGRAMMABLE LEDS**

**a) MAIN MENU**

**PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ USER-PROGRAMMABLE LEDS**

```
■ USER-PROGRAMMABLE           ◀▮▶      ■ LED TEST                 See below
■ LEDS                                 ■

                                       ■ TRIP & ALARM LEDS        See page 5-28.
                     MESSAGE   ▲▼       ■

                                       ■ USER-PROGRAMMABLE        See page 5-28.
                     MESSAGE   ▲▼       ■ LED 1

                                       ■ USER-PROGRAMMABLE
                     MESSAGE   ▲▼       ■ LED 2

                                              ↓

                                       ■ USER-PROGRAMMABLE
                     MESSAGE   ▲        ■ LED 48
```
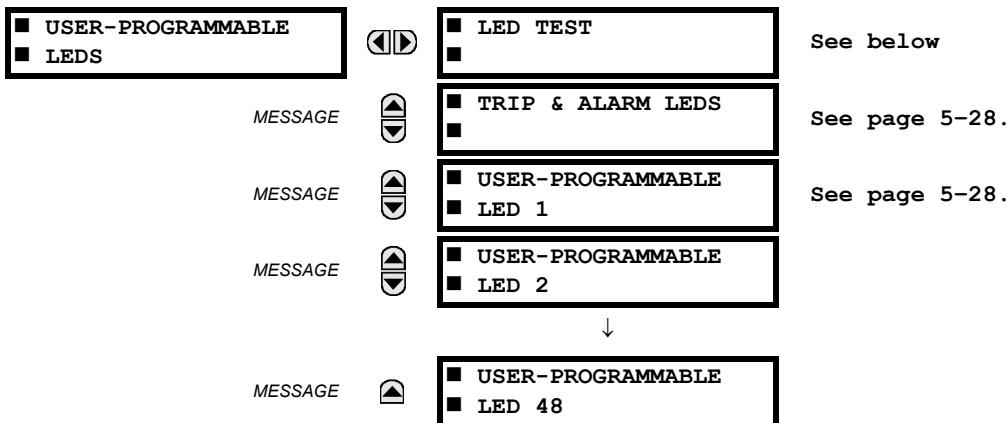
**b) LED TEST**

**PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ USER-PROGRAMMABLE LEDS ⇨ LED TEST**

```
■ LED TEST            ◀▮▶      LED TEST FUNCTION:        Range:  Disabled, Enabled.
■                             Disabled

                             LED TEST CONTROL:          Range:  FlexLogic™ operand
             MESSAGE   ▲      Off
```
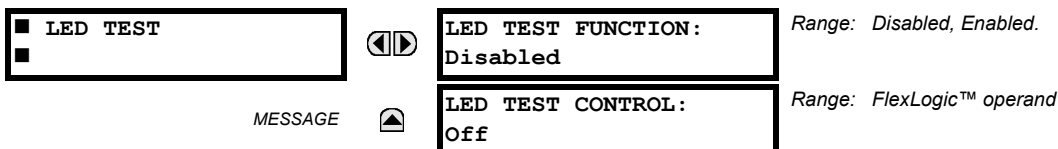
When enabled, the LED Test can be initiated from any digital input or user-programmable condition such as user-program-mable pushbutton. The control operand is configured under the **LED TEST CONTROL** setting. The test covers all LEDs, including the LEDs of the optional user-programmable pushbuttons.

The test consists of three stages.

**Stage 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.

**Stage 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.

**Stage 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 monitor-ing features. However, the LED control mechanism accepts all the changes to LED states generated by the relay and stores the actual LED states (On or Off) in memory. When the test completes, the LEDs reflect the actual state resulting from relay response during testing. The Reset pushbutton will not clear any targets when the LED Test is in progress.

A dedicated FlexLogic™ operand, LED TEST IN PROGRESS, is set for the duration of the test. When the test sequence is initiated, the LED Test Initiated event is stored in the Event Recorder.

The entire test procedure is user-controlled. In particular, Stage 1 can last as long as necessary, and Stages 2 and 3 can be interrupted. The test responds to the position and rising edges of the control input defined by the **LED TEST CONTROL** setting. The control pulses must last at least 250 ms to take effect. The following diagram explains how the test is executed.
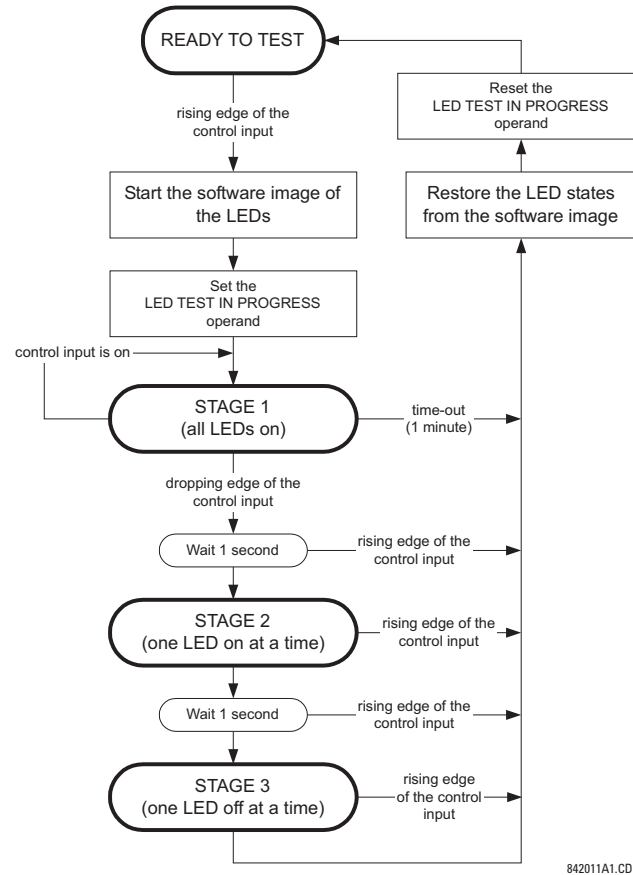


**Figure 5–3: LED TEST SEQUENCE**

**Application Example 1:**

Assume one needs to check if any of the LEDs is "burned" through User-Programmable Pushbutton 1. The following settings should be applied. Configure User-Programmable Pushbutton 1 by making the following entries in the **SETTINGS ⇨ PRODUCT SETUP ⇨ ⇩ USER-PROGRAMMABLE PUSHBUTTONS ⇨ USER PUSHBUTTON 1** menu:

> **PUSHBUTTON 1 FUNCTION:** "Self-reset"
> **PUSHBTN 1 DROP-OUT TIME:** "0.10 s"

Configure the LED test to recognize User-Programmable Pushbutton 1 by making the following entries in the **SETTINGS ⇨ PRODUCT SETUP ⇨ ⇩ USER-PROGRAMMABLE LEDS ⇨ LED TEST** menu:

> **LED TEST FUNCTION:** "Enabled"
> **LED TEST CONTROL:** "PUSHBUTTON 1 ON"

The test will be initiated when the User-Programmable Pushbutton 1 is pressed. The pushbutton should remain pressed for as long as the LEDs are being visually inspected. When finished, the pushbutton should be released. The relay will then automatically start Stage 2. At this point forward, test may be aborted by pressing the pushbutton.

**Application Example 2:**

Assume one needs to check if any LEDs are "burned" as well as exercise one LED at a time to check for other failures. This is to be performed via User-Programmable Pushbutton 1.

After applying the settings in Application Example 1, hold down the pushbutton as long as necessary to test all LEDs. Next, release the pushbutton to automatically start Stage 2. Once Stage 2 has started, the pushbutton can be released. When Stage 2 is completed, Stage 3 will automatically start. The test may be aborted at any time by pressing the pushbutton.

### c) TRIP AND ALARM LEDS

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

```
■ TRIP & ALARM LEDS          ◀▶    TRIP LED INPUT:          Range:  FlexLogic™ operand
■                                  Off

                   MESSAGE   ▲     ALARM LED INPUT:         Range:  FlexLogic™ operand
                                   Off
```

The Trip and Alarm LEDs are on LED Panel 1. Each indicator can be programmed to become illuminated when the selected FlexLogic™ operand is in the Logic 1 state.

### d) USER-PROGRAMMABLE LED 1(48)

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ USER-PROGRAMMABLE LEDS ⇨⇩ USER-PROGRAMMABLE LED 1(48)

```
■ USER-PROGRAMMABLE          ◀▶    LED 1 OPERAND:           Range:  FlexLogic™ operand
■ LED 1                            Off

                   MESSAGE   ▲     LED 1 TYPE:              Range:  Self-Reset, Latched
                                   Self-Reset
```

There are 48 amber LEDs across the relay faceplate LED panels. Each of these indicators can be programmed to illuminate when the selected FlexLogic™ operand is in the Logic 1 state.

• LEDs 1 through 24 inclusive are on LED Panel 2; LEDs 25 through 48 inclusive are on LED Panel 3.

Refer to the LED Indicators section in Chapter 4 for the locations of these indexed LEDs. This menu selects the operands to control these LEDs. Support for applying user-customized labels to these LEDs is provided. If the **LED X TYPE** setting is "Self-Reset" (default setting), the LED illumination will track the state of the selected LED operand. If the **LED X 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 5–2: RECOMMENDED SETTINGS FOR LED PANEL 2 LABELS**

| SETTING | PARAMETER | SETTING | PARAMETER |
|---------|-----------|---------|-----------|
| LED 1 Operand | SETTING GROUP ACT 1 | LED 13 Operand | Off |
| LED 2 Operand | SETTING GROUP ACT 2 | LED 14 Operand | BREAKER 2 OPEN |
| LED 3 Operand | SETTING GROUP ACT 3 | LED 15 Operand | BREAKER 2 CLOSED |
| LED 4 Operand | SETTING GROUP ACT 4 | LED 16 Operand | BREAKER 2 TROUBLE |
| LED 5 Operand | SETTING GROUP ACT 5 | LED 17 Operand | SYNC 1 SYNC OP |
| LED 6 Operand | SETTING GROUP ACT 6 | LED 18 Operand | SYNC 2 SYNC OP |
| LED 7 Operand | Off | LED 19 Operand | Off |
| LED 8 Operand | Off | LED 20 Operand | Off |
| LED 9 Operand | BREAKER 1 OPEN | LED 21 Operand | AR ENABLED |
| LED 10 Operand | BREAKER 1 CLOSED | LED 22 Operand | AR DISABLED |
| LED 11 Operand | BREAKER 1 TROUBLE | LED 23 Operand | AR RIP |
| LED 12 Operand | Off | LED 24 Operand | AR LO |

Refer to the *Control of Setting Groups* example in the *Control Elements* section of this chapter for group activation.

**5.2.12 USER-PROGRAMMABLE SELF TESTS**

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

| ■ USER-PROGRAMMABLE<br>■ SELF TESTS | ◀▶ | DIRECT RING BREAK<br>FUNCTION: Enabled | *Range:* *Disabled, Enabled.*<br>*Valid for units equipped with Direct I/O Module.* |
| --- | --- | --- | --- |
| *MESSAGE* | ▲▼ | DIRECT DEVICE OFF<br>FUNCTION: Enabled | *Range:* *Disabled, Enabled.*<br>*Valid for units equipped with Direct I/O Module.* |
| *MESSAGE* | ▲▼ | REMOTE DEVICE OFF<br>FUNCTION: Enabled | *Range:* *Disabled, Enabled.*<br>*Valid for units equipped with CPU Type C or D.* |
| *MESSAGE* | ▲▼ | PRI. ETHERNET FAIL<br>FUNCTION: Disabled | *Range:* *Disabled, Enabled.*<br>*Valid for units equipped with CPU Type C or D.* |
| *MESSAGE* | ▲▼ | SEC. ETHERNET FAIL<br>FUNCTION: Disabled | *Range:* *Disabled, Enabled.*<br>*Valid for units equipped with CPU Type D.* |
| *MESSAGE* | ▲▼ | BATTERY FAIL<br>FUNCTION: Enabled | *Range:* *Disabled, Enabled.* |
| *MESSAGE* | ▲▼ | SNTP FAIL<br>FUNCTION: Enabled | *Range:* *Disabled, Enabled.*<br>*Valid for units equipped with CPU Type C or D.* |
| *MESSAGE* | ▲ | IRIG-B FAIL<br>FUNCTION: Enabled | *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, 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.

**5.2.13 CONTROL PUSHBUTTONS**

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ CONTROL PUSHBUTTONS ⇨ CONTROL PUSHBUTTON 1(7)

| ■ CONTROL<br>■ PUSHBUTTON 1 | ◀▶ | CONTROL PUSHBUTTON 1<br>FUNCTION: Disabled | *Range:* *Disabled, Enabled* |
| --- | --- | --- | --- |
| *MESSAGE* | ▲ | CONTROL PUSHBUTTON 1<br>EVENTS: Disabled | *Range:* *Disabled, Enabled* |

The three standard pushbuttons located on the top left panel of the faceplate are user-programmable and can be used for various applications such as performing an LED test, switching setting groups, and invoking and scrolling though user-programmable displays, etc. Firmware revisions 3.2x and older use these three pushbuttons for manual breaker control. This functionality has been retained – if the Breaker Control feature is configured to use the three pushbuttons, they cannot be used as user-programmable control pushbuttons. The location of the control pushbuttons in the following figure.

An additonal four control pushbuttons are included when the C60 is ordered with twelve user programmable pushbuttons.
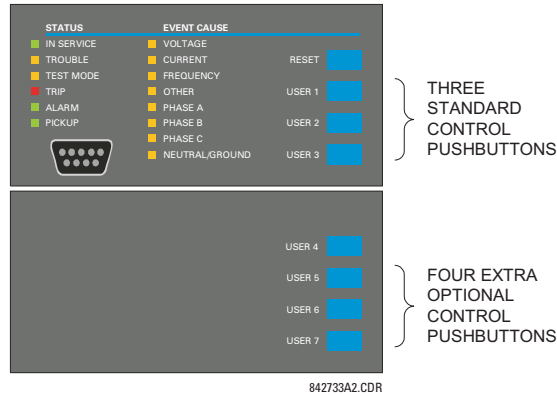
**Figure 5–4: CONTROL PUSHBUTTONS**

The control pushbuttons are typically not used for critical operations. As such, they are not protected by the control password. However, by supervising their output operands, the user can dynamically enable or disable the control pushbuttons for security reasons.

Each control pushbutton asserts its own FlexLogic™ operand, CONTROL PUSHBTN 1(7) ON. These operands should be configured appropriately to perform the desired function. The operand remains asserted as long as the pushbutton is pressed and resets when the pushbutton is released. A dropout delay of 100 ms is incorporated to ensure fast pushbutton manipulation will be recognized by various features that may use control pushbuttons as inputs.

An event is logged in the Event Record (as per user setting) when a control pushbutton is pressed; no event is logged when the pushbutton is released. The faceplate keys (including control keys) cannot be operated simultaneously – a given key must be released before the next one can be pressed.

The control pushbuttons become user-programmable only if the Breaker Control feature is not configured for manual control via the User 1 through User 7 pushbuttons as shown below. If configured for manual control, the Breaker Control feature typically uses the larger, optional user-programmable pushbuttons, making the control pushbuttons available for other user applications.
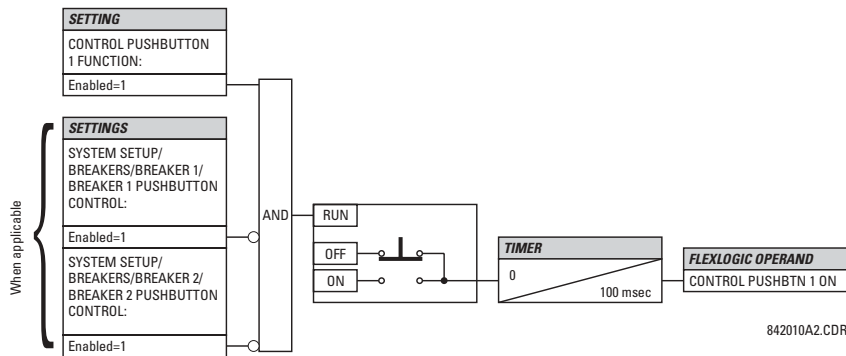


**Figure 5–5: CONTROL PUSHBUTTON LOGIC**

**PATH: SETTINGS ⇨ PRODUCT SETUP ⇨ ⇩ USER-PROGRAMMABLE PUSHBUTTONS ⇨ USER PUSHBUTTON 1(12)**

| | | |
|---|---|---|
| ■ 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 DROP-OUT TIME: 0.00 s | *Range:  0 to 60.00 s in steps of 0.01* |
| MESSAGE | PUSHBUTTON 1 TARGETS: Disabled | *Range:  Self-Reset, Latched, Disabled* |
| MESSAGE | PUSHBUTTON 1 EVENTS: Disabled | *Range:  Disabled, Enabled* |

The C60 has 12 optional user-programmable pushbuttons available, each configured via 12 identical menus. The pushbuttons provide an easy and error-free method of manually entering digital information (On, Off) into FlexLogic™ equations as well as protection and control elements. Typical applications include breaker control, autorecloser blocking, ground protection blocking, and setting groups changes.

The user-configurable pushbuttons are shown below. They can be custom labeled with a factory-provided template, available online at http://www.GEindustrial.com/multilin.



**Figure 5–6: USER-PROGRAMMABLE PUSHBUTTONS**

Each pushbutton asserts its own On and Off FlexLogic™ operands, respectively. FlexLogic™ operands should be used to program desired pushbutton actions. The operand names are PUSHBUTTON 1 ON and PUSHBUTTON 1 OFF.

A pushbutton may be programmed to latch or self-reset. An indicating LED next to each pushbutton signals the present status of the corresponding "On" FlexLogic™ operand. When set to "Latched", the state of each pushbutton is stored in non-volatile memory which is maintained during any supply power loss.

Pushbuttons states can be logged by the Event Recorder and displayed as target messages. User-defined messages can also be associated with each pushbutton and displayed when the pushbutton is ON.

• **PUSHBUTTON 1 FUNCTION:** This setting selects the characteristic of the pushbutton. If set to "Disabled", the pushbutton is deactivated and the corresponding FlexLogic™ operands (both "On" and "Off") are de-asserted. If set to "Self-reset", the control logic of the pushbutton asserts the "On" corresponding FlexLogic™ operand as long as the pushbutton is being pressed. As soon as the pushbutton is released, the FlexLogic™ operand is de-asserted. The "Off" operand is asserted/de-asserted accordingly.

If set to "Latched", the control logic alternates the state of the corresponding FlexLogic™ operand between "On" and "Off" on each push of the button. When operating in "Latched" mode, FlexLogic™ operand states are stored in non-volatile memory. Should power be lost, the correct pushbutton state 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. All user text messaging durations for the pushbuttons are configured with the **PRODUCT SETUP ⇨ ⇩ DISPLAY PROPERTIES ⇨ FLASH MESSAGE TIME** setting.

- **PUSHBTN 1 DROP-OUT TIME:** This setting specifies a drop-out time delay for a pushbutton in the self-reset mode. A typical applications for this setting is providing a select-before-operate functionality. The selecting pushbutton should have the drop-out time set to a desired value. The operating pushbutton should be logically ANDed with the selecting pushbutton in FlexLogic™. The selecting pushbutton LED remains on for the duration of the drop-out time, signaling the time window for the intended operation.

For example, consider a relay with the following settings: **PUSHBTN 1 ID TEXT**: "AUTORECLOSER", **PUSHBTN 1 ON TEXT**: "DISABLED - CALL 2199", and **PUSHBTN 1 OFF TEXT**: "ENABLED". When Pushbutton 1 changes its state to the "On" position, the following **AUTOCLOSER DISABLED – Call 2199** message is displayed: When Pushbutton 1 changes its state to the "Off" position, the message will change to **AUTORECLOSER ENABLED**.

> **NOTE:** User-programmable pushbuttons require a type HP relay faceplate. If an HP-type faceplate was ordered separately, the relay order code must be changed to indicate the HP faceplate option. This can be done via enerVista UR Setup with the **Maintenance > Enable Pushbutton** command.

### 5.2.15 FLEX STATE PARAMETERS

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨ ⇩ FLEX STATE PARAMETERS

```
■ FLEX STATE               PARAMETER    1:        Range: FlexLogic™ Operand
■ PARAMETERS               Off

                           PARAMETER    2:        Range: FlexLogic™ Operand
        MESSAGE            Off

                            ↓

                           PARAMETER 256:         Range: FlexLogic™ Operand
        MESSAGE            Off
```
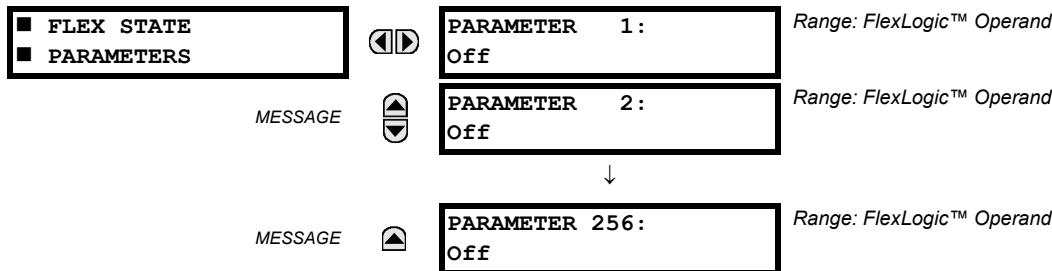
This feature provides a mechanism where any of 256 selected FlexLogic™ operand states can be used for efficient monitoring. The feature allows user-customized access to the FlexLogic™ operand states in the relay. The state bits are packed so that 16 states may be read out in a single Modbus register. 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 900 hex. 16 states are packed into each register, with the lowest-numbered state in the lowest-order bit. There are 16 registers in total to accommodate the 256 state bits.

**a) MAIN MENU**

**PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ USER-DEFINABLE DISPLAYS**

```
■ USER-DEFINABLE        ◄I►      INVOKE AND SCROLL:       Range:  FlexLogic™ operand
■ DISPLAYS                       Off
```

```
        MESSAGE  ⬆⬇      ■ USER DISPLAY 1         Range:  up to 20 alphanumeric characters
                                 ■
```

↓

```
        MESSAGE  ⬆        ■ USER DISPLAY 16        Range:  up to 20 alphanumeric characters
                                 ■
```
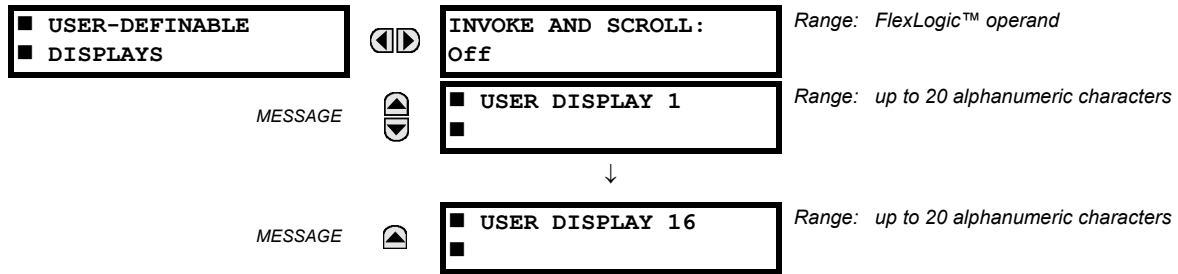
This menu provides a mechanism for manually creating up to 16 user-defined information displays in a convenient viewing sequence in the **USER DISPLAYS** menu (between the **TARGETS** and **ACTUAL VALUES** top-level menus). The sub-menus facilitate text entry and Modbus Register data pointer options for defining the User Display content.

Once programmed, the user-definable displays can be viewed in two ways.

- **KEYPAD**: Use the Menu key to select the **USER DISPLAYS** menu item to access the first user-definable display (note that only the programmed screens are displayed). The screens can be scrolled using the Up and Down keys. The display disappears after the default message time-out period specified by the **PRODUCT SETUP ⇨⇩ DISPLAY PROPERTIES ⇨⇩ DEFAULT MESSAGE TIMEOUT** setting.

- **USER-PROGRAMMABLE CONTROL INPUT**: The user-definable displays also respond to the **INVOKE AND SCROLL** setting. Any FlexLogic™ operand (in particular, the user-programmable pushbutton operands), can be used to navigate the programmed displays.

  On the rising edge of the configured operand (such as when the pushbutton is pressed), the displays are invoked by showing the last user-definable display shown during the previous activity. From this moment onward, the operand acts exactly as the Down key and allows scrolling through the configured displays. The last display wraps up to the first one. The **INVOKE AND SCROLL** input and the Down keypad key operate concurrently.

  When the default timer expires (set by the **DEFAULT MESSAGE TIMEOUT** setting), the relay will start to cycle through the user displays. The next activity of the **INVOKE AND SCROLL** input stops the cycling at the currently displayed user display, not at the first user-defined display. The **INVOKE AND SCROLL** pulses must last for at least 250 ms to take effect.

**b) USER DISPLAY 1(16)**

**PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ USER-DEFINABLE DISPLAYS ⇨ USER DISPLAY 1(16)**

```
■ USER DISPLAY 1        ◄I►      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            Range:  0 to 65535 in steps of 1
                                     0
```

```
        MESSAGE  ⬆⬇      DISP 1 ITEM 2            Range:  0 to 65535 in steps of 1
                                     0
```

```
        MESSAGE  ⬆⬇      DISP 1 ITEM 3            Range:  0 to 65535 in steps of 1
                                     0
```

```
        MESSAGE  ⬆⬇      DISP 1 ITEM 4            Range:  0 to 65535 in steps of 1
                                     0
```

```
        MESSAGE  ⬆        DISP 1 ITEM 5:          Range:  0 to 65535 in steps of 1
                                     0
```

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/or 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 5 separate data fields (**ITEM 1(5)**) 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 ▣ 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 ▣ 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 5 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:
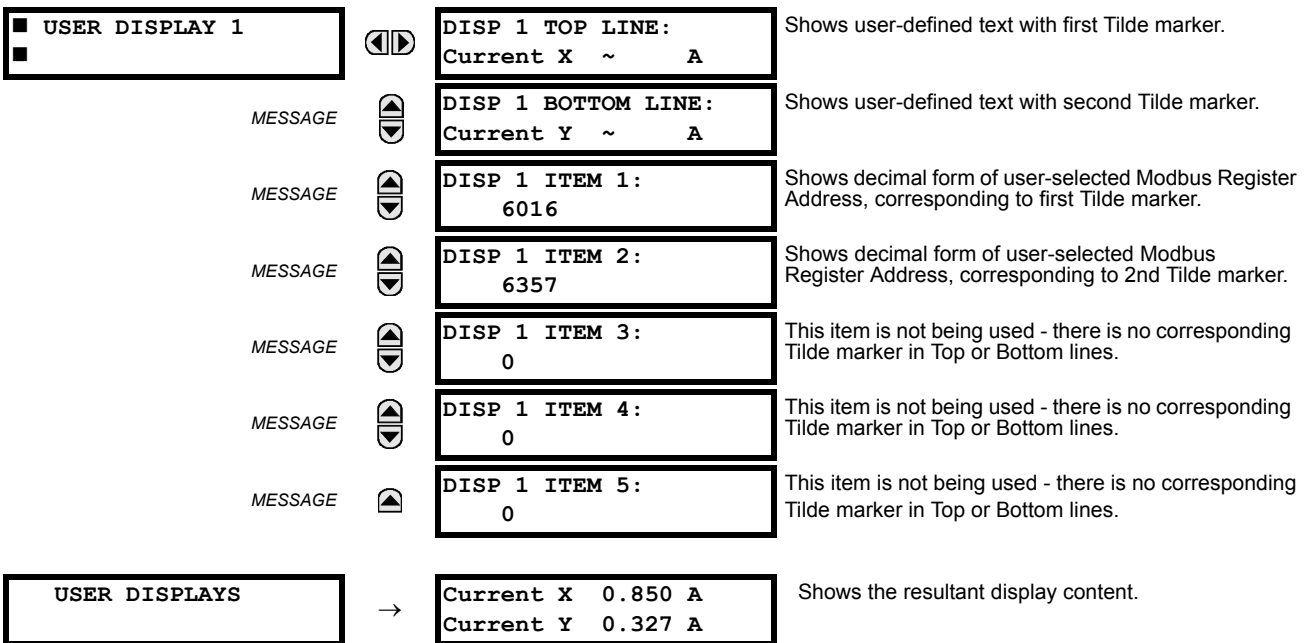
### a) MAIN MENU

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

| | | |
|---|---|---|
| ■ DIRECT I/O<br>■ | DIRECT OUTPUT<br>DEVICE ID: 1 | *Range: 1 to 16* |
| *MESSAGE* | DIRECT I/O CH1 RING<br>CONFIGURATION: Yes | *Range: Yes, No* |
| *MESSAGE* | DIRECT I/O CH2 RING<br>CONFIGURATION: Yes | *Range: Yes, No* |
| *MESSAGE* | DIRECT I/O DATA<br>RATE: 64 kbps | *Range: 64 kbps, 128 kbps* |
| *MESSAGE* | DIRECT I/O CHANNEL<br>CROSSOVER: Disabled | *Range: Disabled, Enabled* |
| *MESSAGE* | ■ CRC ALARM CH1<br>■ | See page 5–39. |
| *MESSAGE* | ■ CRC ALARM CH2<br>■ | See page 5–39. |
| *MESSAGE* | ■ UNRETURNED<br>■ MESSAGES ALARM CH1 | See page 5–40. |
| *MESSAGE* | ■ UNRETURNED<br>■ MESSAGES ALARM CH2 | See page 5–40. |

Direct inputs/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(16) OFF (direct device offline). This FlexLogic™ operand indicates that direct output messages from at least one direct device are not being received.

Direct input/output settings are similar to remote input/output settings. The equivalent of the remote device name strings for direct inputs/outputs is the **DIRECT OUTPUT DEVICE ID**. The **DIRECT OUTPUT DEVICE ID** 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/output message.

If the direct input/output scheme is configured to operate in a ring (**DIRECT I/O RING CONFIGURATION**: "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. Back-to-back connections of the local relays configured with the 7A, 7B, 7C, 7D, 7H, 7I, 7J, 7K, 72 and 73 fiber optic communication cards may be set to 128 kbps. For local relays configured with all other communication cards (i.e. 7E, 7F, 7G, 7L, 7M, 7N, 7P, 7R, 7S, 7T, 7W, 74, 75, 76 and 77), the baud rate will be set to 64 kbps. All IEDs communicating over direct inputs/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/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'.

> **NOTE**
>
> **The G.703 and RS422 modules are fixed at 64 kbps only. The** SETTINGS $\Rightarrow$ PRODUCT SETUP $\Rightarrow \Downarrow$ DIRECT I/O $\Rightarrow \Downarrow$ DIRECT I/O DATA RATE **setting is not applicable to these modules.**

The **DIRECT I/O CHANNEL CROSSOVER** setting applies to C60s 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/output network regardless of the physical media of the two communication channels.

The following application examples illustrate the basic concepts for direct input/output configuration. Please refer to the *Inputs/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 and/or output contacts and/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/output and programmable logic requirements. The two IEDs are connected via single-channel digital communication cards as shown in the figure below.
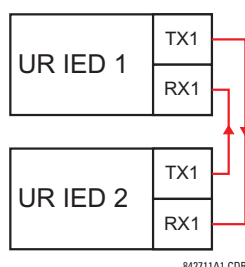


**Figure 5–7: INPUT/OUTPUT EXTENSION VIA DIRECT I/OS**

In the above application, the following settings should be applied:

UR IED 1:     **DIRECT OUTPUT DEVICE ID:** "1"
               **DIRECT I/O RING CONFIGURATION:** "Yes"
               **DIRECT I/O DATA RATE:** "128 kbps"

UR IED 2:     **DIRECT OUTPUT DEVICE ID:** "2"
               **DIRECT I/O 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); i.e., 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 (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.
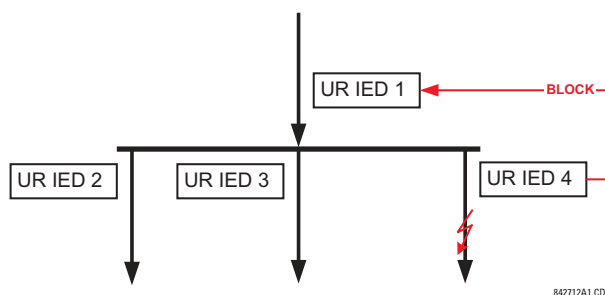


**Figure 5–8: SAMPLE INTERLOCKING BUSBAR PROTECTION SCHEME**

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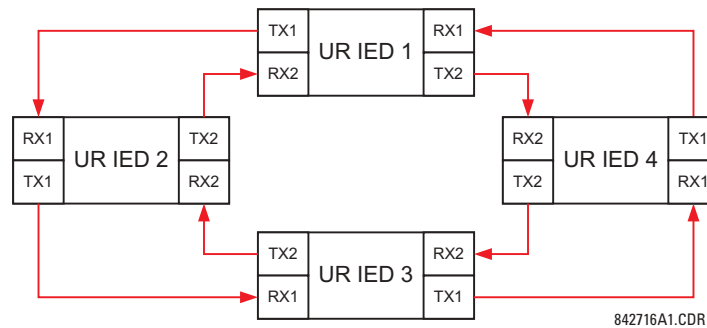


**Figure 5–9: INTERLOCKING BUS PROTECTION SCHEME VIA DIRECT I/OS**

In the above application, the following settings should be applied:

UR IED 1: **DIRECT OUTPUT DEVICE ID:** "1"
**DIRECT I/O RING CONFIGURATION:** "Yes"

UR IED 2: **DIRECT OUTPUT DEVICE ID:** "2"
**DIRECT I/O RING CONFIGURATION:** "Yes"

UR IED 3: **DIRECT OUTPUT DEVICE ID:** "3"
**DIRECT I/O RING CONFIGURATION:** "Yes"

UR IED 4: **DIRECT OUTPUT DEVICE ID:** "4"
**DIRECT I/O 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 power system cycle). Upon detecting a broken ring, the coordination time should be adaptively increased to 0.6 of 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/outputs feature would be primarily used to address these concerns.

**Example 3: Pilot-Aided Schemes**

Consider the three-terminal line protection application shown below:
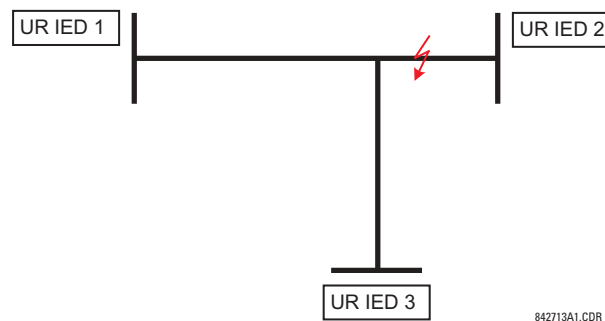


**Figure 5–10: THREE-TERMINAL LINE APPLICATION**

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):
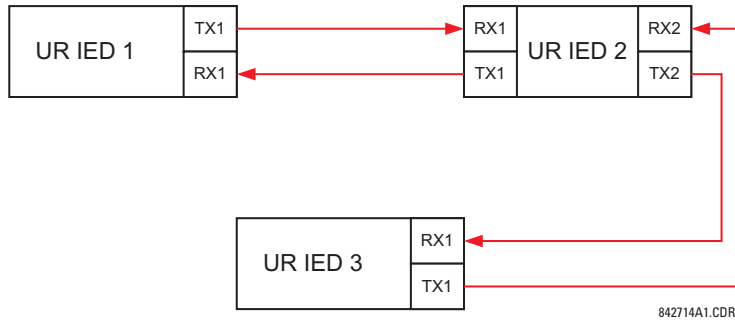
**Figure 5–11: SINGLE-CHANNEL OPEN LOOP CONFIGURATION**

In the above application, the following settings should be applied:

UR IED 1:   **DIRECT OUTPUT DEVICE ID**: "1"          UR IED 2:   **DIRECT OUTPUT DEVICE ID**: "2"
            **DIRECT I/O RING CONFIGURATION**: "Yes"              **DIRECT I/O RING CONFIGURATION**: "Yes"

UR IED 3:   **DIRECT OUTPUT DEVICE ID**: "3"
            **DIRECT I/O 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/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.
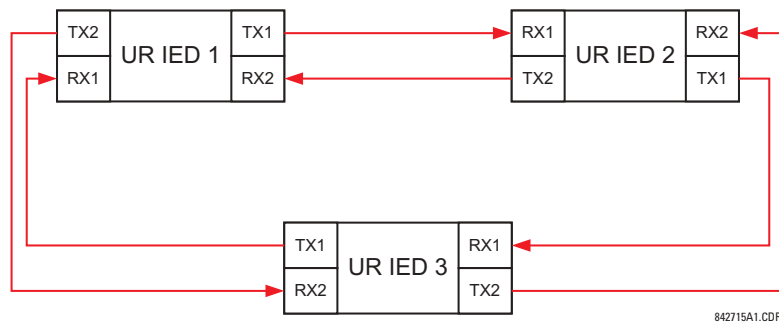


**Figure 5–12: DUAL-CHANNEL CLOSED LOOP (DUAL-RING) CONFIGURATION**

In the above application, the following settings should be applied:

UR IED 1:   **DIRECT OUTPUT DEVICE ID**: "1"          UR IED 2:   **DIRECT OUTPUT DEVICE ID**: "2"
            **DIRECT I/O RING CONFIGURATION**: "Yes"              **DIRECT I/O RING CONFIGURATION**: "Yes"

UR IED 3:   **DIRECT OUTPUT DEVICE ID**: "3"
            **DIRECT I/O RING CONFIGURATION**: "Yes"

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

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

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

**b) CRC ALARM CH1(2)**

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

| | | |
|---|---|---|
| ■ CRC ALARM CH1<br>■ | ◁▷ | CRC ALARM CH1<br>FUNCTION: Disabled | *Range:  Enabled, Disabled* |
| *MESSAGE* | ▲▼ | CRC ALARM CH1<br>MESSAGE COUNT: 600 | *Range:  100 to 10000 in steps of 1* |
| *MESSAGE* | ▲▼ | CRC ALARM CH1<br>THRESHOLD: 10 | *Range:  1 to 1000 in steps of 1* |
| *MESSAGE* | ▲ | CRC ALARM CH1<br>EVENTS: Disabled | *Range:  Enabled, Disabled* |

The C60 checks integrity of the incoming direct input/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/output messages that failed the CRC check is available as the **ACTUAL VALUES ⇨ STATUS ⇨⇩ DIRECT INPUTS ⇨⇩ CRC FAIL COUNT CH1(2)** 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/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 10,000 bits sent/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 $10^{-4}$.

**5**

**c) UNRETURNED MESSAGES ALARM CH1(2)**

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

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

The C60 checks integrity of the direct input/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/output messages is available as the **ACTUAL VALUES** ⇨ **STATUS** ⇨⇩ **DIRECT INPUTS** ⇨⇩ **UNRETURNED MSG COUNT CH1(2)** actual value.

**5.2.18 INSTALLATION**

**PATH: SETTINGS** ⇨ **PRODUCT SETUP** ⇨⇩ **INSTALLATION**

| ■ INSTALLATION<br>■ | ◀▷ | RELAY SETTINGS:<br>Not Programmed | *Range:  Not Programmed, Programmed* |
|---|---|---|---|
| MESSAGE | ▲ | RELAY NAME:<br>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.

**a) CURRENT BANKS**

**PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨ AC INPUTS ⇨ CURRENT BANK F1(M5)**

```
■ CURRENT BANK F1          ◁▷    PHASE CT F1          Range:  1 to 65000 A in steps of 1
■                                PRIMARY:     1 A

              MESSAGE      ⬆⬇    PHASE CT F1          Range:  1 A, 5 A
                                 SECONDARY: 1 A

              MESSAGE      ⬆⬇    GROUND CT F1         Range:  1 to 65000 A in steps of 1
                                 PRIMARY:     1 A

              MESSAGE       ⬆    GROUND CT F1         Range:  1 A, 5 A
                                 SECONDARY: 1 A
```

**NOTE**

**Because energy parameters are accumulated, these values should be recorded and then reset immediately prior to changing CT characteristics.**

Four banks of phase/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**} and *a* = {**1**, **5**}.

See the *Introduction to AC Sources* section at the beginning of this chapter for additional details.

These settings are critical for all features that have settings dependent on current measurements. When the relay is ordered, the CT module must be specified to include a standard or sensitive ground input. As the phase CTs are connected in Wye (star), the calculated phasor sum of the three phase currents (IA + IB + IC = Neutral Current = 3Io) is used as the input for the neutral overcurrent elements. In addition, a zero-sequence (core balance) CT which senses current in all of the circuit primary conductors, or a CT in a neutral grounding conductor may also be used. For this configuration, the ground CT primary rating must be entered. To detect low level ground fault currents, the sensitive ground input may be used. In this case, the sensitive ground CT primary rating must be entered. Refer to Chapter 3 for more details on CT connections.

Enter the rated CT primary current values. For both 1000:5 and 1000:1 CTs, the entry would be 1000. For correct operation, the CT secondary rating must match the setting (which must also correspond to the specific CT connections used).

The following example illustrates how multiple CT inputs (current banks) are summed as one source current. Given If the following current banks:

> F1: CT bank with 500:1 ratio; F5: CT bank with 1000: ratio; M1: CT bank with 800:1 ratio

The following rule applies:

$$SRC\ 1\ =\ F1 + F5 + M1 \tag{EQ 5.5}$$

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(M5)**

| | | |
|---|---|---|
| ■ VOLTAGE BANK F5<br>■ | ◀▶ | PHASE VT F5<br>CONNECTION: Wye | *Range: Wye, Delta* |
| MESSAGE ▲▼ | PHASE VT F5<br>SECONDARY: 66.4 V | *Range: 50.0 to 240.0 V in steps of 0.1* |
| MESSAGE ▲▼ | PHASE VT F5<br>RATIO: 1.00 :1 | *Range: 1.00 to 24000.00 in steps of 0.01* |
| MESSAGE ▲▼ | AUXILIARY VT F5<br>CONNECTION: Vag | *Range: Vn, Vag, Vbg, Vcg, Vab, Vbc, Vca* |
| MESSAGE ▲▼ | AUXILIARY VT F5<br>SECONDARY: 66.4 V | *Range: 50.0 to 240.0 V in steps of 0.1* |
| MESSAGE ▲ | AUXILIARY VT F5<br>RATIO: 1.00 :1 | *Range: 1.00 to 24000.00 in steps of 0.01* |

⚠ **CAUTION**

**Because energy parameters are accumulated, these values should be recorded and then reset immediately prior to changing VT characteristics.**

Two banks of phase/auxiliary VTs can be set, where voltage banks are denoted in the following format (*X* represents the module slot position letter):

> *Xa*, where *X* = {**F**, **M**} 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 CON-NECTION** made to the system as "Wye" or "Delta". An open-delta source VT connection would be entered as "Delta". See the *Typical Wiring Diagram* in Chapter 3 for details.

**NOTE**

The nominal **PHASE VT F5 SECONDARY** voltage setting is the voltage across the relay input terminals when nominal voltage is applied to the VT primary.

For example, on a system with a 13.8 kV nominal primary voltage and with a 14400:120 volt VT in a Delta connection, the secondary voltage would be 115, i.e. (13800 / 14400) × 120. For a Wye connection, the voltage value entered must be the phase to neutral voltage which would be 115 / $\sqrt{3}$ = 66.4.

On a 14.4 kV system with a Delta connection and a VT primary to secondary turns ratio of 14400:120, the voltage value entered would be 120, i.e. 14400 / 120.

**5**

**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* |
| MESSAGE | ▲ | FREQUENCY TRACKING: **Enabled** | *Range:* *Disabled, Enabled* |

The power system **NOMINAL FREQUENCY** value is used as a default to set the digital sampling rate if the system frequency cannot be measured from available signals. This may happen if the signals are not present or are heavily distorted. Before reverting to the nominal frequency, the frequency tracking algorithm holds the last valid frequency measurement for a safe period of time while waiting for the signals to reappear or for the distortions to decay.

The phase sequence of the power system is required to properly calculate sequence components and power parameters. The **PHASE ROTATION** setting matches the power system phase sequence. Note that this setting informs the relay of the actual system phase sequence, either ABC or ACB. CT and VT inputs on the relay, labeled as A, B, and C, must be connected to system phases A, B, and C for correct operation.

The **FREQUENCY AND PHASE REFERENCE** setting determines which signal source is used (and hence which AC signal) for phase angle reference. The AC signal used is prioritized based on the AC inputs that are configured for the signal source: phase voltages takes precedence, followed by auxiliary voltage, then phase currents, and finally ground current.

For three phase selection, phase A is used for angle referencing ($V_{\text{ANGLE REF}} = V_A$), while Clarke transformation of the phase signals is used for frequency metering and tracking ($V_{\text{FREQUENCY}} = (2V_A - V_B - V_C)/3$) for better performance during fault, open pole, and VT and CT fail conditions.

The phase reference and frequency tracking AC signals are selected based upon the Source configuration, regardless of whether or not a particular signal is actually applied to the relay.

Phase angle of the reference signal will always display zero degrees and all other phase angles will be relative to this signal. If the pre-selected reference signal is not measurable at a given time, the phase angles are not referenced.

The phase angle referencing is done via a phase locked loop, which can synchronize independent UR-series relays if they have the same AC signal reference. These results in very precise correlation of time tagging in the event recorder between different UR-series relays provided the relays have an IRIG-B connection.

**NOTE**

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

**PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ SIGNAL SOURCES ⇨ SOURCE 1(4)**

| ■ SOURCE 1<br>■ | | SOURCE 1 NAME:<br>SRC 1 | Range: | up to 6 alphanumeric characters |
|---|---|---|---|---|
| | MESSAGE ▲▼ | SOURCE 1 PHASE CT:<br>None | Range: | None, F1, F5, F1+F5,... up to a combination of any 5 CTs. Only Phase CT inputs are displayed. |
| | MESSAGE ▲▼ | SOURCE 1 GROUND CT:<br>None | Range: | None, F1, F5, F1+F5,... up to a combination of any 5 CTs. Only Ground CT inputs are displayed. |
| | MESSAGE ▲▼ | SOURCE 1 PHASE VT:<br>None | Range: | None, F1, F5, M1, M5<br>Only phase voltage inputs will be displayed. |
| | MESSAGE ▲ | SOURCE 1 AUX VT:<br>None | Range: | None, F1, F5, M1, M5<br>Only auxiliary voltage inputs will be displayed. |

Four identical source menus are available. The "SRC 1" text can be replaced by with a user-defined name appropriate for the associated source.

"F" and "M" represent the module slot position. The number directly following these letters 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 up to five (5) CTs. 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.

**Example Use of Sources:**

An example of the use of sources, with a relay with two CT/VT modules, is shown in the diagram below. A relay could have the following hardware configuration:

| INCREASING SLOT POSITION LETTER --> | | |
|---|---|---|
| **CT/VT MODULE 1** | **CT/VT MODULE 2** | **CT/VT MODULE 3** |
| CTs | VTs | not applicable |

This configuration could be used on a two winding transformer, with one winding connected into a breaker-and-a-half system. The following figure shows the arrangement of sources used to provide the functions required in this application, and the CT/VT inputs that are used to provide the data.
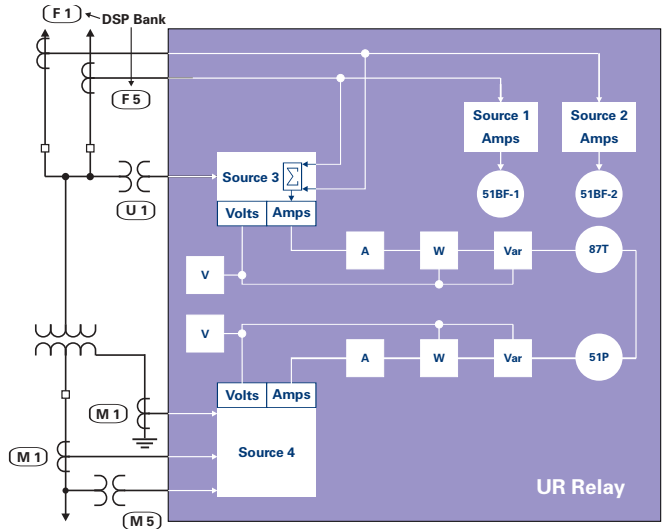
**Figure 5–13: EXAMPLE USE OF SOURCES**

**PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ BREAKERS ⇨ BREAKER 1(2)**

| ■ BREAKER 1 | | BREAKER 1<br>FUNCTION: Disabled | *Range: Disabled, Enabled* |
|---|---|---|---|
| | MESSAGE | BREAKER1 PUSH BUTTON<br>CONTROL: Disabled | *Range: Disabled, Enabled* |
| | MESSAGE | BREAKER 1 NAME:<br>Bkr 1 | *Range: up to 6 alphanumeric characters* |
| | MESSAGE | BREAKER 1 MODE:<br>3-Pole | *Range: 3-Pole, 1-Pole* |
| | MESSAGE | BREAKER 1 OPEN:<br>Off | *Range: FlexLogic™ operand* |
| | MESSAGE | BREAKER 1 CLOSE:<br>Off | *Range: FlexLogic™ operand* |
| | MESSAGE | BREAKER 1 φA/3-POLE:<br>Off | *Range: FlexLogic™ operand* |
| | MESSAGE | BREAKER 1 φB:<br>Off | *Range: FlexLogic™ operand* |
| | MESSAGE | BREAKER 1 φC:<br>Off | *Range: FlexLogic™ operand* |
| | MESSAGE | BREAKER 1 EXT ALARM:<br>Off | *Range: FlexLogic™ operand* |
| | MESSAGE | BREAKER 1 ALARM<br>DELAY:      0.000 s | *Range: 0.000 to 1 000 000.000 s in steps of 0.001* |
| | MESSAGE | MANUAL CLOSE RECAL1<br>TIME:      0.000 s | *Range: 0.000 to 1 000 000.000 s in steps of 0.001* |
| | MESSAGE | BREAKER 1 OUT OF SV:<br>Off | *Range: FlexLogic™ operand* |
| | MESSAGE | XCBR ST.LOC OPERAND:<br>Off | *Range: FlexLogic™ operand* |

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 breakers; a user may use only those portions of the design relevant to a single breaker, which must be Breaker 1.

• **BREAKER 1(2) FUNCTION:** Set to "Enable" to allow the operation of any breaker control feature.

• **BREAKER1(2) PUSH BUTTON CONTROL:** Set to "Enable" to allow faceplate push button operations.

• **BREAKER 1(2) NAME:** Assign a user-defined name (up to 6 characters) to the breaker. This name will be used in flash messages related to Breaker 1.

• **BREAKER 1(2) MODE:** Selects "3-pole" mode, where all breaker poles are operated simultaneously, or "1-pole" mode where all breaker poles are operated either independently or simultaneously.

• **BREAKER 1(2) OPEN:** Selects an operand that creates a programmable signal to operate an output relay to open Breaker No. 1.

• **BREAKER 1(2) CLOSE:** Selects an operand that creates a programmable signal to operate an output relay to close Breaker No. 1.

• **BREAKER 1(2) ΦA/3-POLE:** Selects an operand, usually a contact input connected to a breaker auxiliary position tracking mechanism. This input can be either a 52/a or 52/b contact, or a combination the 52/a and 52/b contacts, that

must be programmed to create a logic 0 when the breaker is open. If **BREAKER 1 MODE** 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 settings **BREAKER 1 ΦB** and **BREAKER 1 ΦC** select operands to track phases B and C, respectively.

•    **BREAKER 1(2) FB:** If the mode is selected as 3-pole, this setting has no function. If the mode is selected as 1-pole, this input is used to track phase B as above for phase A.

•    **BREAKER 1(2) FC:** If the mode is selected as 3-pole, this setting has no function. If the mode is selected as 1-pole, this input is used to track phase C as above for phase A.

•    **BREAKER 1(2) EXT ALARM:** Selects an operand, usually an external contact input, connected to a breaker alarm reporting contact.

•    **BREAKER 1(2) ALARM DELAY:** Sets the delay interval during which a disagreement of status among the three pole position tracking operands will not declare a pole disagreement, to allow for non-simultaneous operation of the poles.

•    **MANUAL CLOSE RECAL1 TIME:** Sets 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(2) OUT OF SV:** Selects an operand indicating that Breaker 1(2) is out-of-service.

•    **XCBR ST.LOC OPERAND:** Selects a FlexLogic™ operand to provide a value for the IEC 61850 XCBR1(2) St.Loc data item.

**5**
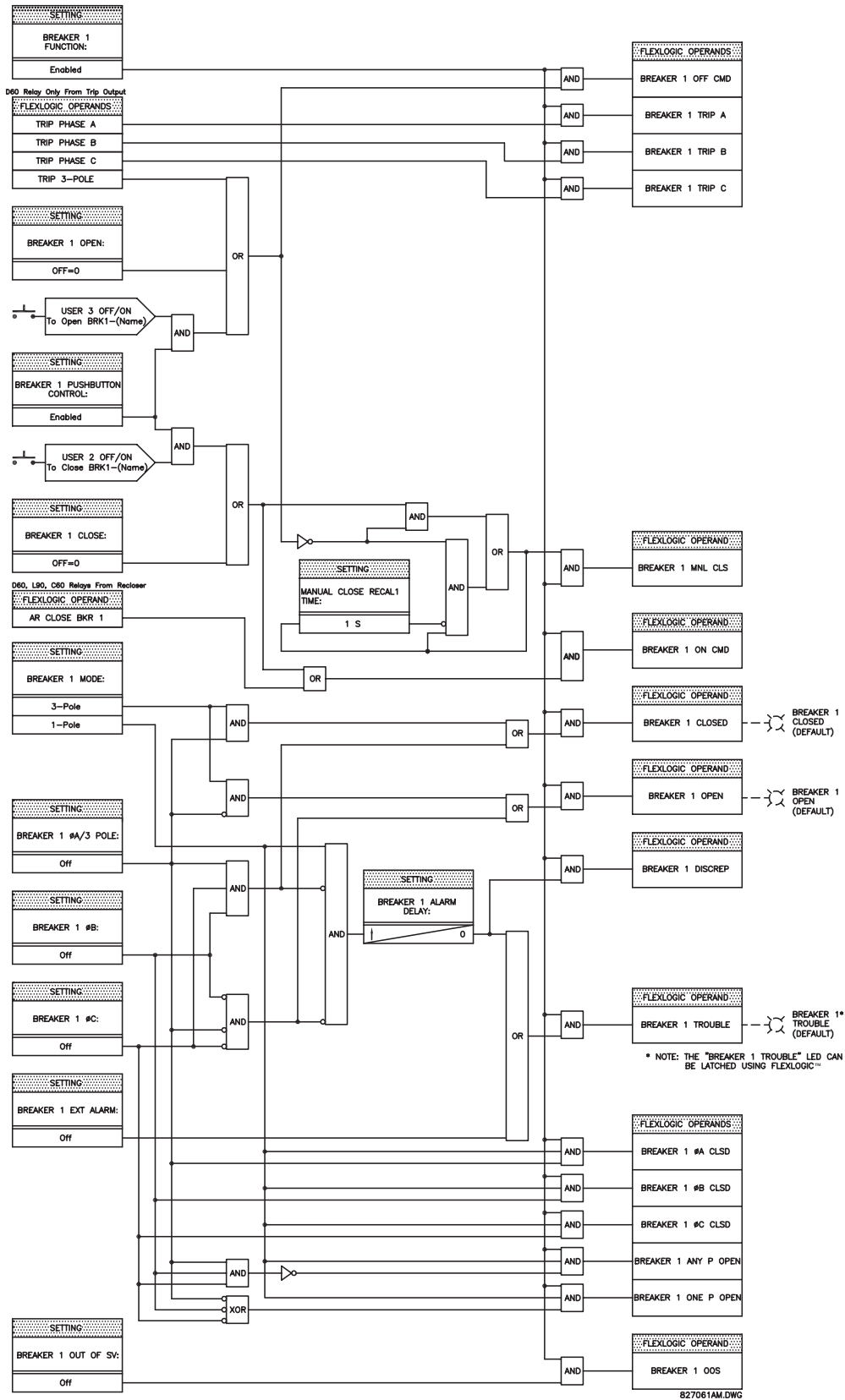
**Figure 5–14: DUAL BREAKER CONTROL SCHEME LOGIC**

**a) SETTINGS**

**PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ FLEXCURVES ⇨ FLEXCURVE A(D)**

| ■ FLEXCURVE A<br>■ | ◀▮▶ | FLEXCURVE A TIME AT<br>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/Operate at the following pickup levels: 0.00 to 0.98 / 1.03 to 20.00. This data is converted into 2 continuous curves by linear interpolation between data points. To enter a custom FlexCurve™, enter the Reset/Operate time (using the ▲ VALUE ▼ keys) for each selected pickup point (using the ▲ MESSAGE ▼ keys) for the desired protection curve (A, B, C, or D).

**Table 5–3: FLEXCURVE™ TABLE**

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

**NOTE**  **The relay using a given FlexCurve™ applies linear approximation for times between the user-entered points. Special care must be applied when setting the two points that are close to the multiple of pickup of 1, i.e. 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.



**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.

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**Figure 5–15: RECLOSER CURVE INITIALIZATION**

**NOTE**

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 8 times pickup with an operating time of 30 ms. At approximately 4 times pickup, the curve operating time is equal to the MRT and from then onwards the operating time remains at 200 ms (see below).
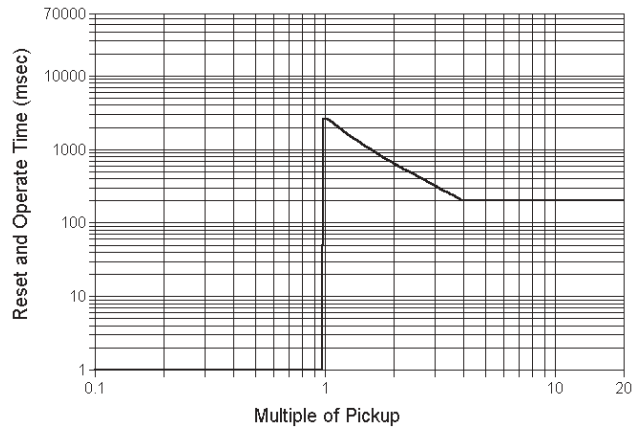


**Figure 5–16: COMPOSITE RECLOSER CURVE WITH HCT DISABLED**

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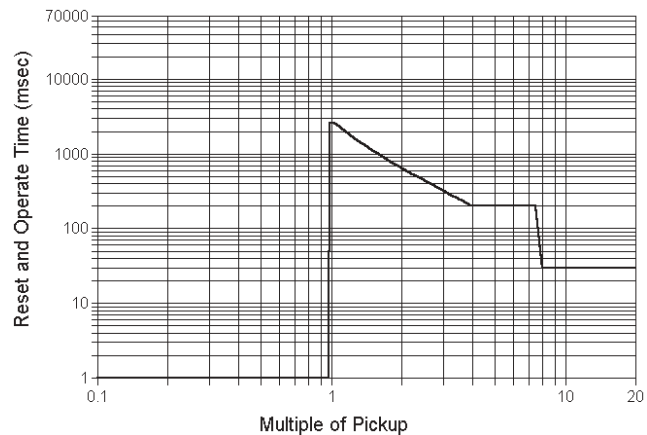


**Figure 5–17: COMPOSITE RECLOSER CURVE WITH HCT ENABLED**

**NOTE** Configuring a composite curve with an increase in operating time at increased pickup multiples is not allowed. If this is attempted, the enerVista UR Setup software generates an error message and discards the proposed changes.

**e) STANDARD RECLOSER CURVES**

The standard Recloser curves available for the C60 are displayed in the following graphs.
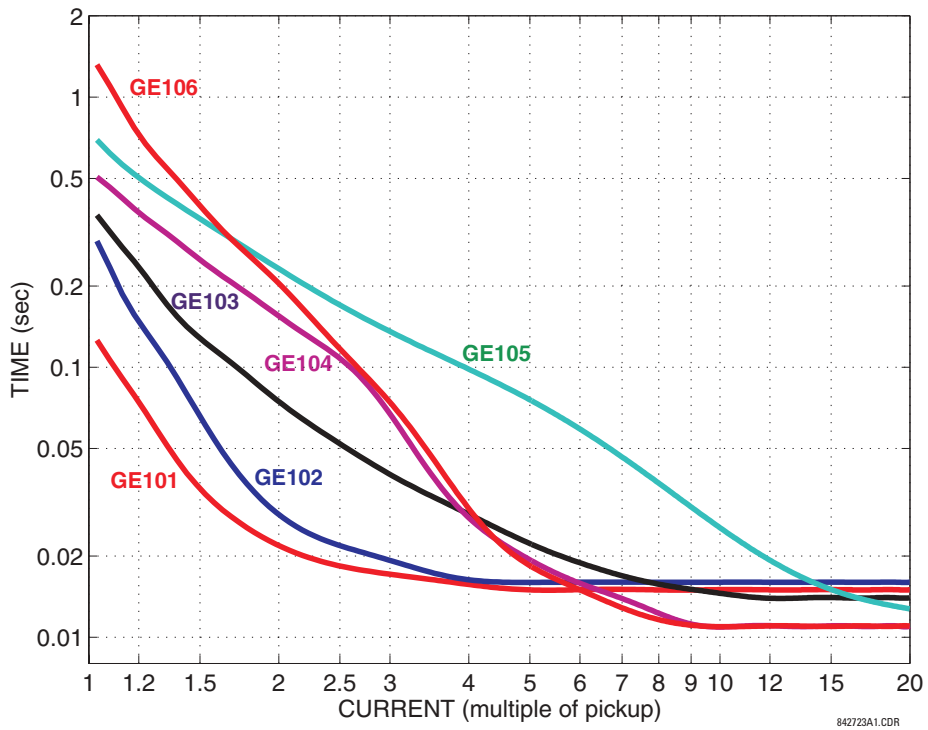
**Figure 5–18: RECLOSER CURVES GE101 TO GE106**
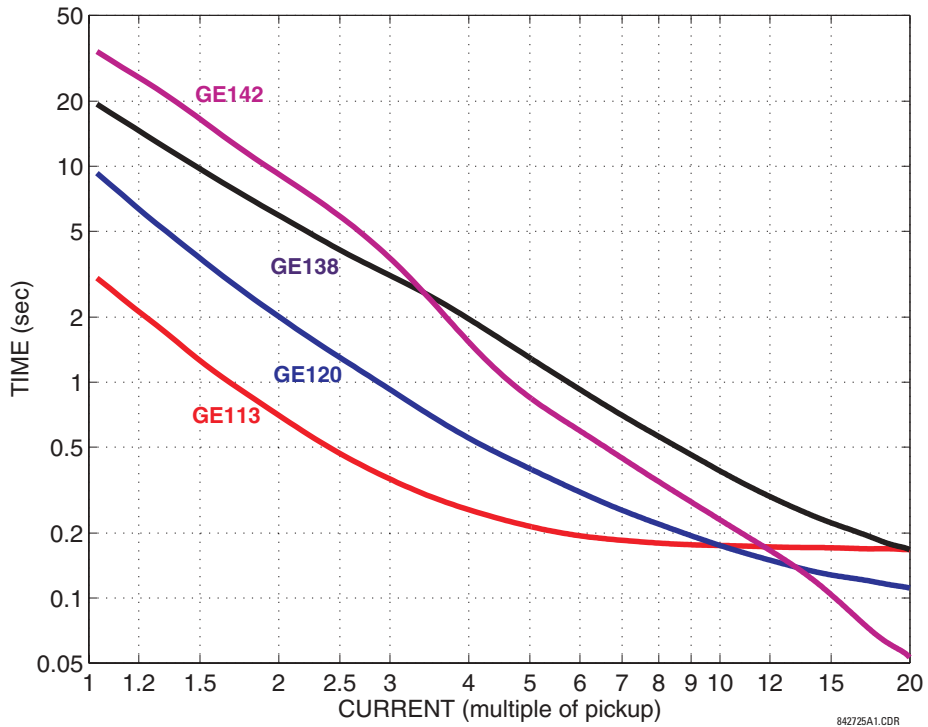


**Figure 5–19: RECLOSER CURVES GE113, GE120, GE138 AND GE142**
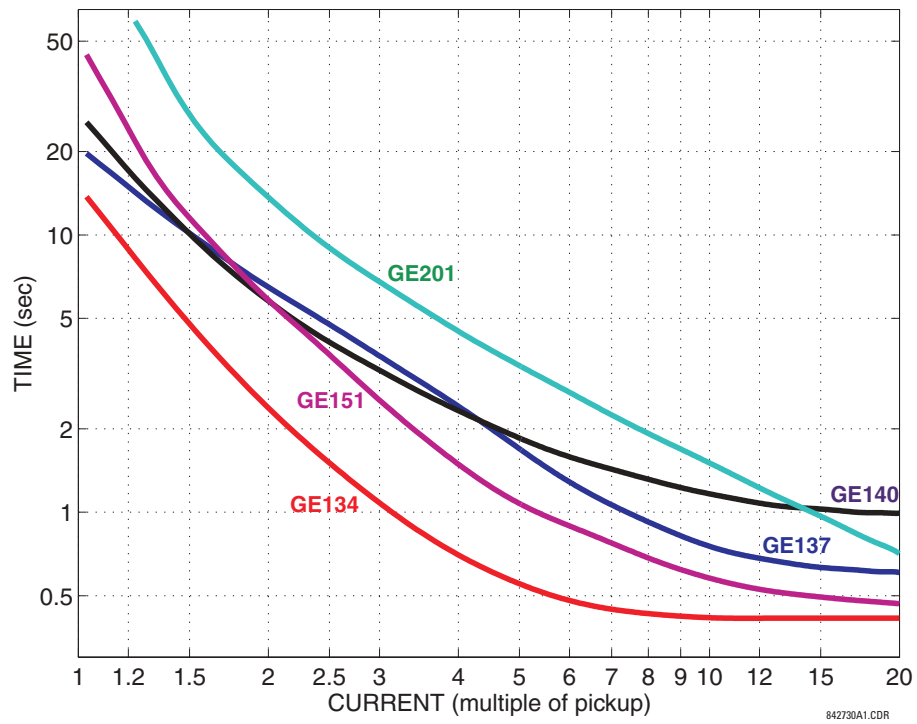
**Figure 5–20: RECLOSER CURVES GE134, GE137, GE140, GE151 AND GE201**
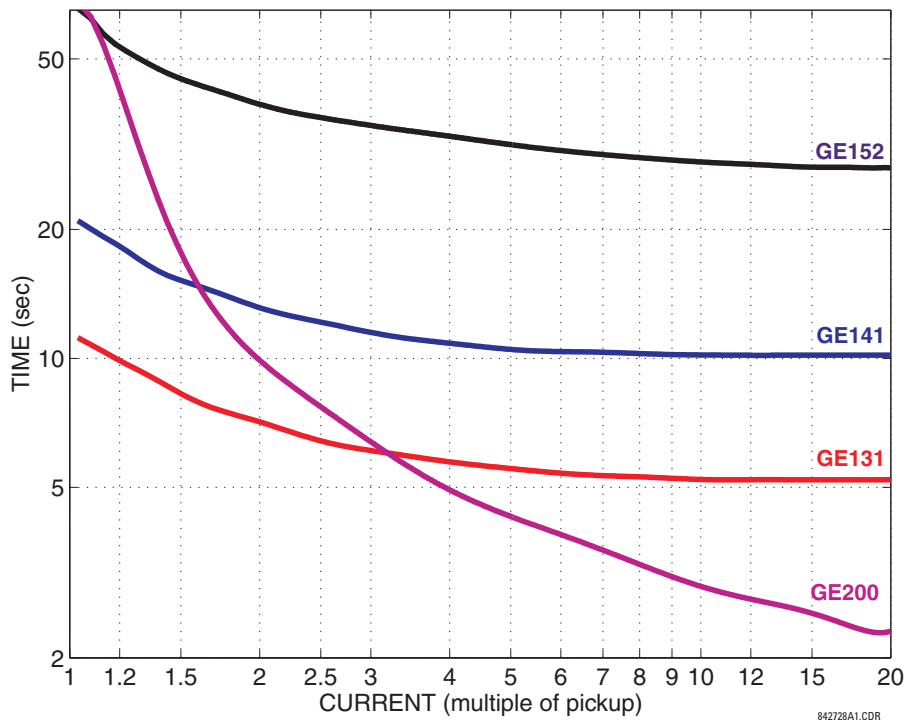


**Figure 5–21: RECLOSER CURVES GE131, GE141, GE152, AND GE200**
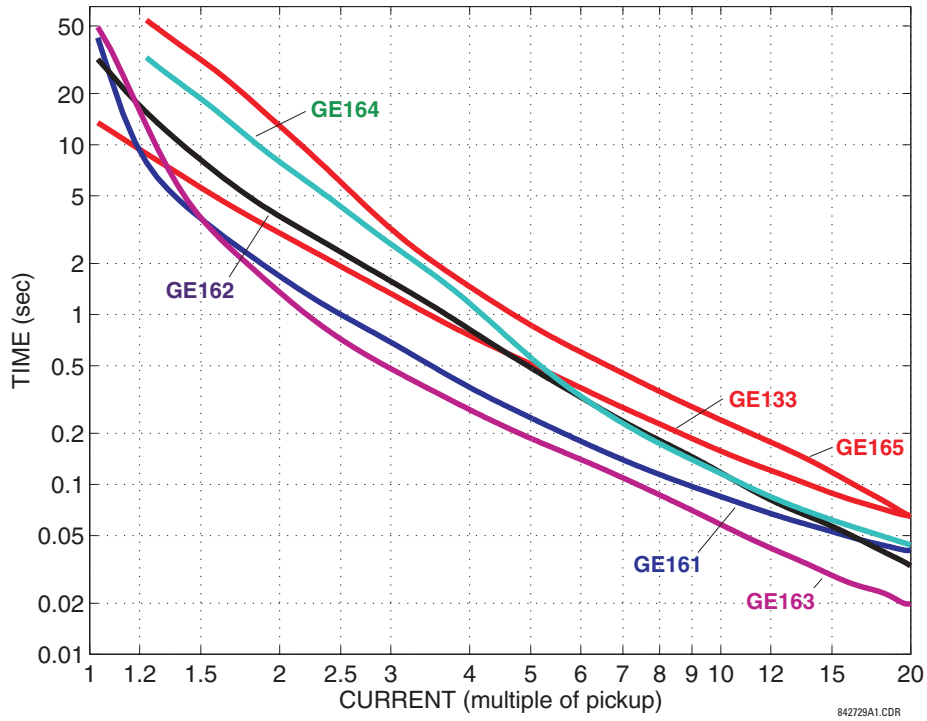
**Figure 5–22: RECLOSER CURVES GE133, GE161, GE162, GE163, GE164 AND GE165**
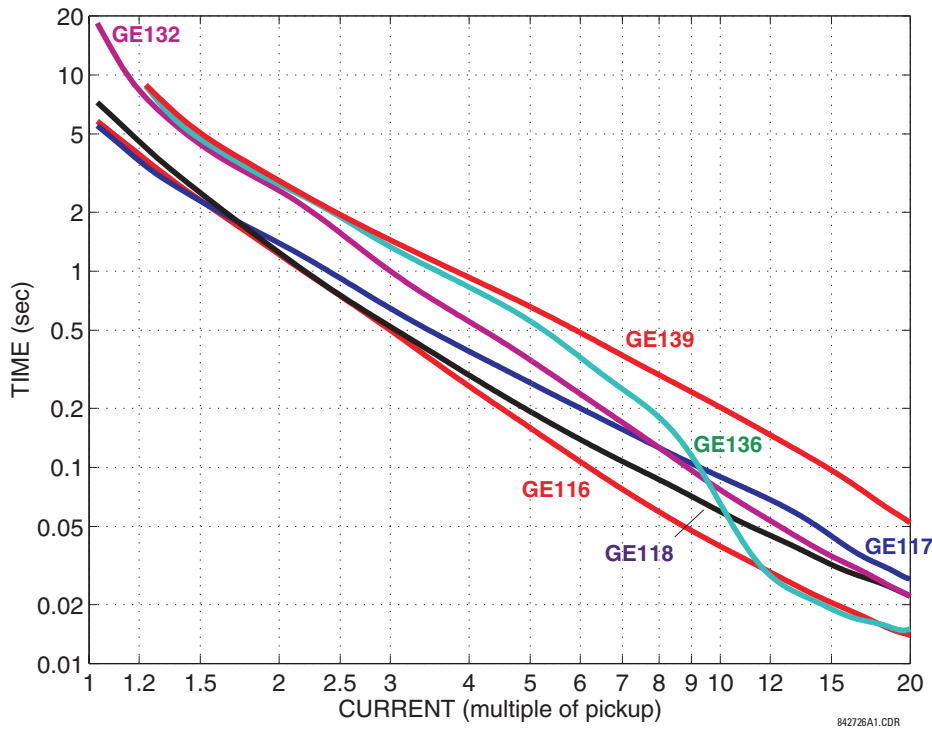


**Figure 5–23: RECLOSER CURVES GE116, GE117, GE118, GE132, GE136, AND GE139**
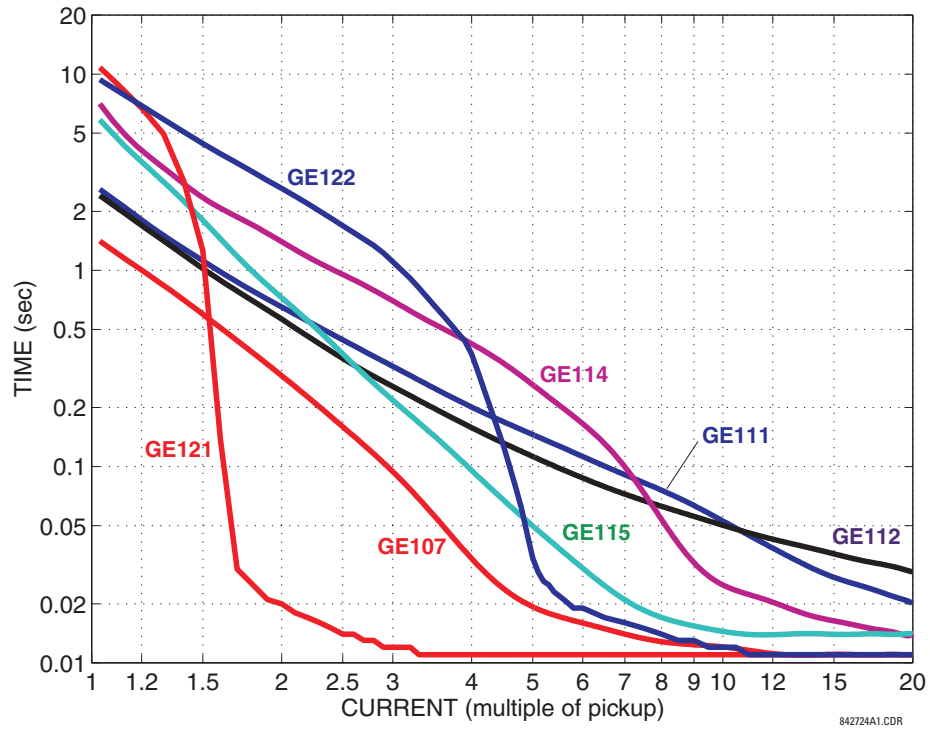
**Figure 5–24: RECLOSER CURVES GE107, GE111, GE112, GE114, GE115, GE121, AND GE122**
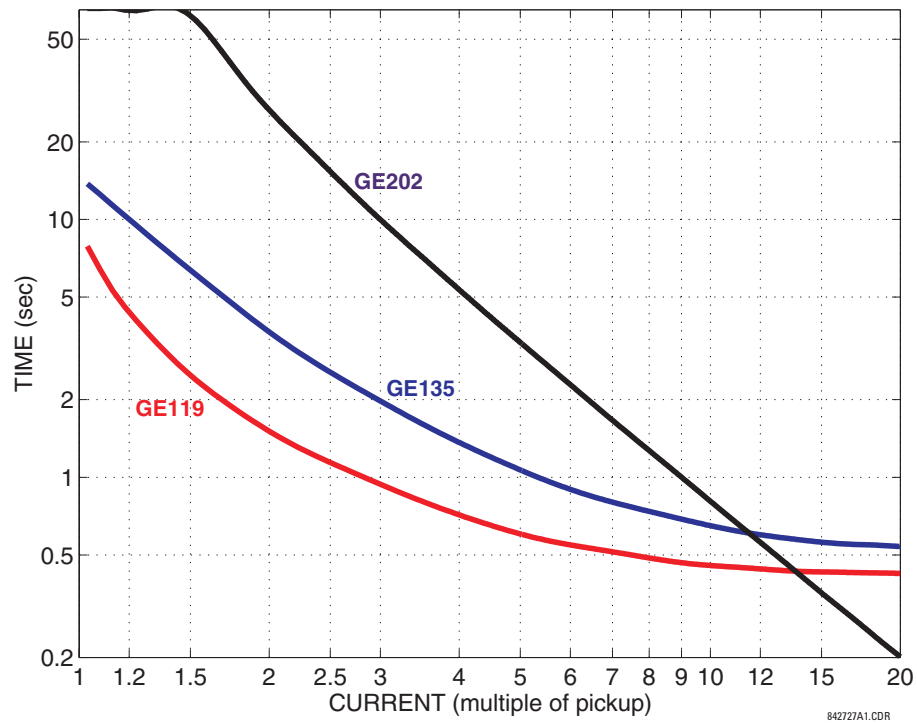


**Figure 5–25: RECLOSER CURVES GE119, GE135, AND GE202**

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.
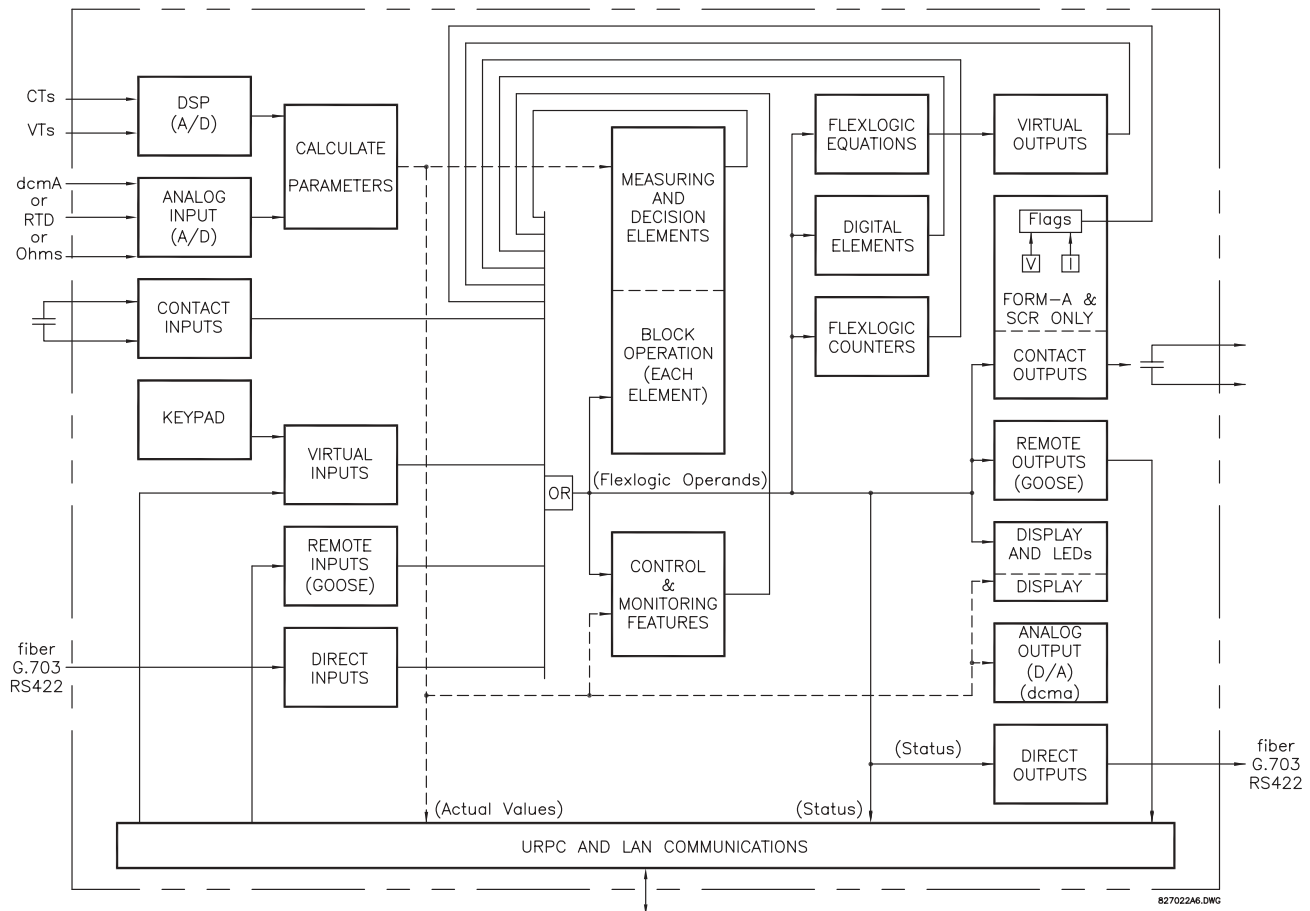


**Figure 5–26: UR ARCHITECTURE OVERVIEW**

The states of all digital signals used in the C60 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 <u>operators</u> and <u>operands</u>. 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 <u>virtual out-put</u>. 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 parame-ters 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 oper-ands 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 5–4: C60 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 exists across the contact. |
| | Current On | Cont Op 1 IOn | Current is flowing through the contact. |
| | Current Off | Cont Op 1 IOff | 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 | PH DIR1 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 5–5: C60 FLEXLOGIC™ OPERANDS (Sheet 1 of 5)**

| OPERAND TYPE | OPERAND SYNTAX | OPERAND DESCRIPTION |
|---|---|---|
| CONTROL PUSHBUTTONS | CONTROL PUSHBTN n ON | Control Pushbutton *n* (*n* = 1 to 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(2) CRC ALARM  DIR IO CRC ALARM  DIR IO CH1(2) UNRET ALM  DIR IO UNRET ALM | The rate of Direct Input messages received on Channel 1(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(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: Autoreclose (1P/3P) | AR ENABLED AR DISABLED AR RIP AR 1-P RIP AR 3-P/1 RIP AR 3-P/2 RIP AR 3-P/3 RIP AR 3-P/4 RIP AR LO AR BKR1 BLK AR BKR2 BLK AR CLOSE BKR1 AR CLOSE BKR2 AR FORCE 3-P TRIP AR SHOT CNT > 0 AR SHOT CNT = 1 AR SHOT CNT = 2 AR SHOT CNT = 3 AR SHOT CNT = 4 AR ZONE 1 EXTENT AR INCOMPLETE SEQ AR RESET | Autoreclosure is enabled and ready to perform Autoreclosure is disabled Autoreclosure is in "Reclose in Progress" state A single-pole reclosure is in progress A three-pole reclosure is in progress, via Dead Time 1 A three-pole reclosure is in progress, via Dead Time 2 A three-pole reclosure is in progress, via Dead Time 3 A three-pole reclosure is in progress, via Dead Time 4 Autoreclosure is in lockout state Reclosure of Breaker 1 is blocked Reclosure of Breaker 2 is blocked Reclose Breaker 1 signal Reclose Breaker 2 signal Force any trip to a three-phase trip The first 'CLOSE BKR X' signal has been issued Shot count is equal to 1 Shot count is equal to 2 Shot count is equal to 3 Shot count is equal to 4 The Zone 1 Distance function must be set to the extended overreach value The incomplete sequence timer timed out AR has been reset either manually or by the reset timer |
| 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 |
| ELEMENT: Auxiliary Undervoltage | AUX UV1 PKP AUX UV1 DPO AUX UV1 OP | Auxiliary Undervoltage element has picked up Auxiliary Undervoltage element has dropped out Auxiliary Undervoltage element has operated |
| ELEMENT: Breaker Arcing | BKR ARC 1 OP BKR ARC 2 OP | Breaker Arcing Current 1 has operated Breaker Arcing Current 2 has operated |
| ELEMENT Breaker Failure | BKR FAIL 1 RETRIPA BKR FAIL 1 RETRIPB BKR FAIL 1 RETRIPC BKR FAIL 1 RETRIP BKR FAIL 1 T1 OP BKR FAIL 1 T2 OP BKR FAIL 1 T3 OP BKR FAIL 1 TRIP OP | Breaker Failure 1 re-trip phase A (only for 1-pole schemes) Breaker Failure 1 re-trip phase B (only for 1-pole schemes) Breaker Failure 1 re-trip phase C (only for 1-pole schemes) Breaker Failure 1 re-trip 3-phase Breaker Failure 1 Timer 1 is operated Breaker Failure 1 Timer 2 is operated Breaker Failure 1 Timer 3 is operated Breaker Failure 1 trip is operated |
| | BKR FAIL 2 | Same set of operands as shown for BKR FAIL 1 |
| 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 |

**Table 5–5: C60 FLEXLOGIC™ OPERANDS (Sheet 2 of 5)**

| OPERAND TYPE | OPERAND SYNTAX | OPERAND DESCRIPTION |
|---|---|---|
| ELEMENT: Breaker Control | BREAKER 1 OFF CMD<br>BREAKER 1 ON CMD<br>BREAKER 1 φA CLSD<br>BREAKER 1 φB CLSD<br>BREAKER 1 φC CLSD<br>BREAKER 1 CLOSED<br>BREAKER 1 OPEN<br>BREAKER 1 DISCREP<br>BREAKER 1 TROUBLE<br>BREAKER 1 MNL CLS<br>BREAKER 1 TRIP A<br>BREAKER 1 TRIP B<br>BREAKER 1 TRIP C<br>BREAKER 1 ANY P OPEN<br>BREAKER 1 ONE P OPEN<br>BREAKER 1 OOS | Breaker 1 OFF command<br>Breaker 1 ON command<br>Breaker 1 phase A is closed<br>Breaker 1 phase B is closed<br>Breaker 1 phase C is closed<br>Breaker 1 is closed<br>Breaker 1 is open<br>Breaker 1 has discrepancy<br>Breaker 1 trouble alarm<br>Breaker 1 manual close<br>Breaker 1 trip phase A command<br>Breaker 1 trip phase B command<br>Breaker 1 trip phase C command<br>At least one pole of Breaker 1 is open<br>Only one pole of Breaker 1 is open<br>Breaker 1 is out of service |
| | BREAKER 2 | Same set of operands as shown for BREAKER 1 |
| ELEMENT: Digital Counters | Counter 1 HI<br>Counter 1 EQL<br>Counter 1 LO<br>↓<br>Counter 8 HI<br>Counter 8 EQL<br>Counter 8 LO | Digital Counter 1 output is 'more than' comparison value<br>Digital Counter 1 output is 'equal to' comparison value<br>Digital Counter 1 output is 'less than' comparison value<br>↓<br>Digital Counter 8 output is 'more than' comparison value<br>Digital Counter 8 output is 'equal to' comparison value<br>Digital Counter 8 output is 'less than' comparison value |
| ELEMENT: Digital Elements | Dig Element 1 PKP<br>Dig Element 1 OP<br>Dig Element 1 DPO<br>↓<br>Dig Element 16 PKP<br>Dig Element 16 OP<br>Dig Element 16 DPO | Digital Element 1 is picked up<br>Digital Element 1 is operated<br>Digital Element 1 is dropped out<br>↓<br>Digital Element 16 is picked up<br>Digital Element 16 is operated<br>Digital Element 16 is dropped out |
| ELEMENT: Sensitive Directional Power | DIR POWER 1 STG1 PKP<br>DIR POWER 1 STG2 PKP<br>DIR POWER 1 STG1 DPO<br>DIR POWER 1 STG2 DPO<br>DIR POWER 1 STG1 OP<br>DIR POWER 1 STG2 OP<br>DIR POWER 1 PKP<br>DIR POWER 1 DPO<br>DIR POWER 1 OP | Stage 1 of the Directional Power element 1 has picked up<br>Stage 2 of the Directional Power element 1 has picked up<br>Stage 1 of the Directional Power element 1 has dropped out<br>Stage 2 of the Directional Power element 1 has dropped out<br>Stage 1 of the Directional Power element 1 has operated<br>Stage 2 of the Directional Power element 1 has operated<br>The Directional Power element has picked up<br>The Directional Power element has dropped out<br>The Directional Power element has operated |
| | DIR POWER 2 | Same set of operands as DIR POWER 1 |
| ELEMENT: FlexElements™ | FxE 1 PKP<br>FxE 1 OP<br>FxE 1 DPO<br>↓<br>FxE 8 PKP<br>FxE 8 OP<br>FxE 8 DPO | FlexElement™ 1 has picked up<br>FlexElement™ 1 has operated<br>FlexElement™ 1 has dropped out<br>↓<br>FlexElement™ 8 has picked up<br>FlexElement™ 8 has operated<br>FlexElement™ 8 has dropped out |
| ELEMENT: Ground Instantaneous Overcurrent | GROUND IOC1 PKP<br>GROUND IOC1 OP<br>GROUND IOC1 DPO | Ground Instantaneous Overcurrent 1 has picked up<br>Ground Instantaneous Overcurrent 1 has operated<br>Ground Instantaneous Overcurrent 1 has dropped out |
| | GROUND IOC2 | Same set of operands as shown for GROUND IOC 1 |
| ELEMENT: Ground Time Overcurrent | GROUND TOC1 PKP<br>GROUND TOC1 OP<br>GROUND TOC1 DPO | Ground Time Overcurrent 1 has picked up<br>Ground Time Overcurrent 1 has operated<br>Ground Time Overcurrent 1 has dropped out |
| | GROUND TOC2 | Same set of operands as shown for GROUND TOC1 |
| ELEMENT Non-Volatile Latches | LATCH 1 ON<br>LATCH 1 OFF<br>↓<br>LATCH 16 ON<br>LATCH 16 OFF | Non-Volatile Latch 1 is ON (Logic = 1)<br>Non-Voltage Latch 1 is OFF (Logic = 0)<br>↓<br>Non-Volatile Latch 16 is ON (Logic = 1)<br>Non-Voltage Latch 16 is OFF (Logic = 0) |
| ELEMENT: Neutral Instantaneous Overcurrent | NEUTRAL IOC1 PKP<br>NEUTRAL IOC1 OP<br>NEUTRAL IOC1 DPO | Neutral Instantaneous Overcurrent 1 has picked up<br>Neutral Instantaneous Overcurrent 1 has operated<br>Neutral Instantaneous Overcurrent 1 has dropped out |
| | NEUTRAL IOC2 | Same set of operands as shown for NEUTRAL IOC1 |
| ELEMENT: Neutral Overvoltage | NEUTRAL OV1 PKP<br>NEUTRAL OV1 DPO<br>NEUTRAL OV1 OP | Neutral Overvoltage element has picked up<br>Neutral Overvoltage element has dropped out<br>Neutral Overvoltage element has operated |

**5**

**Table 5–5: C60 FLEXLOGIC™ OPERANDS (Sheet 3 of 5)**

| OPERAND TYPE | OPERAND SYNTAX | OPERAND DESCRIPTION |
|---|---|---|
| ELEMENT:<br>Neutral Time<br>Overcurrent | NEUTRAL TOC1 PKP<br>NEUTRAL TOC1 OP<br>NEUTRAL TOC1 DPO | Neutral Time Overcurrent 1 has picked up<br>Neutral Time Overcurrent 1 has operated<br>Neutral Time Overcurrent 1 has dropped out |
| | NEUTRAL TOC2 | Same set of operands as shown for NEUTRAL TOC1 |
| ELEMENT:<br>Phase<br>Instantaneous<br>Overcurrent | PHASE IOC1 PKP<br>PHASE IOC1 OP<br>PHASE IOC1 DPO<br>PHASE IOC1 PKP A<br>PHASE IOC1 PKP B<br>PHASE IOC1 PKP C<br>PHASE IOC1 OP A<br>PHASE IOC1 OP B<br>PHASE IOC1 OP C<br>PHASE IOC1 DPO A<br>PHASE IOC1 DPO B<br>PHASE IOC1 DPO C | At least one phase of PHASE IOC1 has picked up<br>At least one phase of PHASE IOC1 has operated<br>At least one phase of PHASE IOC1 has dropped out<br>Phase A of PHASE IOC1 has picked up<br>Phase B of PHASE IOC1 has picked up<br>Phase C of PHASE IOC1 has picked up<br>Phase A of PHASE IOC1 has operated<br>Phase B of PHASE IOC1 has operated<br>Phase C of PHASE IOC1 has operated<br>Phase A of PHASE IOC1 has dropped out<br>Phase B of PHASE IOC1 has dropped out<br>Phase C of PHASE IOC1 has dropped out |
| | PHASE IOC2 | Same set of operands as shown for PHASE IOC1 |
| ELEMENT:<br>Phase Time<br>Overcurrent | PHASE TOC1 PKP<br>PHASE TOC1 OP<br>PHASE TOC1 DPO<br>PHASE TOC1 PKP A<br>PHASE TOC1 PKP B<br>PHASE TOC1 PKP C<br>PHASE TOC1 OP A<br>PHASE TOC1 OP B<br>PHASE TOC1 OP C<br>PHASE TOC1 DPO A<br>PHASE TOC1 DPO B<br>PHASE TOC1 DPO C | At least one phase of PHASE TOC1 has picked up<br>At least one phase of PHASE TOC1 has operated<br>At least one phase of PHASE TOC1 has dropped out<br>Phase A of PHASE TOC1 has picked up<br>Phase B of PHASE TOC1 has picked up<br>Phase C of PHASE TOC1 has picked up<br>Phase A of PHASE TOC1 has operated<br>Phase B of PHASE TOC1 has operated<br>Phase C of PHASE TOC1 has operated<br>Phase A of PHASE TOC1 has dropped out<br>Phase B of PHASE TOC1 has dropped out<br>Phase C of PHASE TOC1 has dropped out |
| | PHASE TOC2 | Same set of operands as shown for PHASE TOC1 |
| ELEMENT:<br>Phase Undervoltage | PHASE UV1 PKP<br>PHASE UV1 OP<br>PHASE UV1 DPO<br>PHASE UV1 PKP A<br>PHASE UV1 PKP B<br>PHASE UV1 PKP C<br>PHASE UV1 OP A<br>PHASE UV1 OP B<br>PHASE UV1 OP C<br>PHASE UV1 DPO A<br>PHASE UV1 DPO B<br>PHASE UV1 DPO C | At least one phase of UV1 has picked up<br>At least one phase of UV1 has operated<br>At least one phase of UV1 has dropped out<br>Phase A of UV1 has picked up<br>Phase B of UV1 has picked up<br>Phase C of UV1 has picked up<br>Phase A of UV1 has operated<br>Phase B of UV1 has operated<br>Phase C of UV1 has operated<br>Phase A of UV1 has dropped out<br>Phase B of UV1 has dropped out<br>Phase C of UV1 has dropped out |
| | PHASE UV2 | Same set of operands as shown for PHASE UV1 |
| ELEMENT:<br>Selector Switch | SELECTOR 1 POS Y<br>SELECTOR 1 BIT 0<br>SELECTOR 1 BIT 1<br>SELECTOR 1 BIT 2<br>SELECTOR 1 STP ALARM<br><br>SELECTOR 1 BIT ALARM<br><br>SELECTOR 1 ALARM<br>SELECTOR 1 PWR ALARM | Selector Switch 1 is in Position Y (mutually exclusive operands).<br>First bit of the 3-bit word encoding position of Selector 1.<br>Second bit of the 3-bit word encoding position of Selector 1.<br>Third bit of the 3-bit word encoding position of Selector 1.<br>Position of Selector 1 has been pre-selected with the stepping up control input but not acknowledged.<br>Position of Selector 1 has been pre-selected with the 3-bit control input but not acknowledged.<br>Position of Selector 1 has been pre-selected but not acknowledged.<br>Position of Selector Switch 1 is undetermined when the relay powers up and synchronizes to the 3-bit input. |
| | SELECTOR 2 | Same set of operands as shown above for SELECTOR 1 |
| ELEMENT:<br>Setting Group | SETTING GROUP ACT 1<br>↓<br>SETTING GROUP ACT 6 | Setting Group 1 is active<br>↓<br>Setting Group 6 is active |
| ELEMENT:<br>Disturbance<br>Detector | SRCx 50DD OP | Source x Disturbance Detector has operated |
| ELEMENT:<br>VTFF (Voltage<br>Transformer Fuse<br>Failure) | SRCx VT FUSE FAIL OP<br>SRCx VT FUSE FAIL DPO<br>SRCx VT FUSE FAIL VOL LOSS | Source x VT Fuse Failure detector has operated<br>Source x VT Fuse Failure detector has dropped out<br>Source x has lost voltage signals (V2 above 25% or V1 below 70% of nominal) |

**Table 5–5: C60 FLEXLOGIC™ OPERANDS (Sheet 4 of 5)**

| OPERAND TYPE | OPERAND SYNTAX | OPERAND DESCRIPTION |
|---|---|---|
| ELEMENT: Synchrocheck | SYNC 1 DEAD S OP<br>SYNC 1 DEAD S DPO<br>SYNC 1 SYNC OP<br>SYNC 1 SYNC DPO<br>SYNC 1 CLS OP<br>SYNC 1 CLS DPO<br>SYNC 1 V1 ABOVE MIN<br>SYNC 1 V1 BELOW MAX<br>SYNC 1 V2 ABOVE MIN<br>SYNC 1 V2 BELOW MAX | Synchrocheck 1 dead source has operated<br>Synchrocheck 1 dead source has dropped out<br>Synchrocheck 1 in synchronization has operated<br>Synchrocheck 1 in synchronization has dropped out<br>Synchrocheck 1 close has operated<br>Synchrocheck 1 close has dropped out<br>Synchrocheck 1 V1 is above the minimum live voltage<br>Synchrocheck 1 V1 is below the maximum dead voltage<br>Synchrocheck 1 V2 is above the minimum live voltage<br>Synchrocheck 1 V2 is below the maximum dead voltage |
| | SYNC 2 | Same set of operands as shown for SYNC 1 |
| FIXED OPERANDS | Off | Logic = 0. Does nothing and may be used as a delimiter in an equation list; used as 'Disable' by other features. |
| | On | Logic = 1. Can be used as a test setting. |
| INPUTS/OUTPUTS: Contact Inputs | Cont Ip 1    On<br>Cont Ip 2    On<br>↓<br>Cont Ip 1    Off<br>Cont Ip 2    Off<br>↓ | (will not appear unless ordered)<br>(will not appear unless ordered)<br>↓<br>(will not appear unless ordered)<br>(will not appear unless ordered)<br>↓ |
| INPUTS/OUTPUTS: Contact Outputs, Current (from detector on Form-A output only) | Cont Op 1    IOn<br>Cont Op 2    IOn<br>↓<br>Cont Op 1    IOff<br>Cont Op 2    IOff<br>↓ | (will not appear unless ordered)<br>(will not appear unless ordered)<br>↓<br>(will not appear unless ordered)<br>(will not appear unless ordered)<br>↓ |
| INPUTS/OUTPUTS: Contact Outputs, Voltage (from detector on Form-A output only) | Cont Op 1    VOn<br>Cont Op 2    VOn<br>↓<br>Cont Op 1    VOff<br>Cont Op 2    VOff<br>↓ | (will not appear unless ordered)<br>(will not appear unless ordered)<br>↓<br>(will not appear unless ordered)<br>(will not appear unless ordered)<br>↓ |
| INPUTS/OUTPUTS Direct Inputs | DIRECT INPUT 1 On<br>↓<br>DIRECT INPUT 32 On | Flag is set, logic=1<br>↓<br>Flag is set, logic=1 |
| INPUTS/OUTPUTS: Remote Inputs | REMOTE INPUT  1 On<br>↓<br>REMOTE INPUT 32 On | Flag is set, logic=1<br>↓<br>Flag is set, logic=1 |
| INPUTS/OUTPUTS: Virtual Inputs | Virt Ip 1    On<br>↓<br>Virt Ip 32   On | Flag is set, logic=1<br>↓<br>Flag is set, logic=1 |
| INPUTS/OUTPUTS: Virtual Outputs | Virt Op 1    On<br>↓<br>Virt Op 64    On | Flag is set, logic=1<br>↓<br>Flag is set, logic=1 |
| LED TEST | LED TEST IN PROGRESS | An LED test has been initiated and has not finished. |
| REMOTE DEVICES | REMOTE DEVICE  1 On<br>↓<br>REMOTE DEVICE 16 On | Flag is set, logic=1<br>↓<br>Flag is set, logic=1 |
| | REMOTE DEVICE  1 Off<br>↓<br>REMOTE DEVICE 16 Off | Flag is set, logic=1<br>↓<br>Flag is set, logic=1 |
| RESETTING | RESET OP<br>RESET OP (COMMS)<br>RESET OP (OPERAND)<br><br>RESET OP (PUSHBUTTON) | Reset command is operated (set by all 3 operands below)<br>Communications source of the reset command<br>Operand (assigned in the **INPUTS/OUTPUTS ⇨⇩ RESETTING** menu) source of the reset command<br>Reset key (pushbutton) source of the reset command |

**5**

**Table 5–5: C60 FLEXLOGIC™ OPERANDS (Sheet 5 of 5)**

| OPERAND TYPE | OPERAND SYNTAX | OPERAND DESCRIPTION |
|---|---|---|
| SELF-DIAGNOSTICS | ANY MAJOR ERROR<br>ANY MINOR ERROR<br>ANY SELF-TEST<br>BATTERY FAIL<br>DIRECT DEVICE OFF<br>DIRECT RING BREAK<br>DSP ERROR<br>EEPROM DATA ERROR<br>EQUIPMENT MISMATCH<br>FLEXLOGIC ERR TOKEN<br>IRIG-B FAILURE<br>LATCHING OUT ERROR<br>LOW ON MEMORY<br>NO DSP INTERRUPTS<br>PRI ETHERNET FAIL<br>PROGRAM MEMORY<br>PROTOTYPE FIRMWARE<br>REMOTE DEVICE OFF<br>SEC ETHERNET FAIL<br>SNTP FAILURE<br>SYSTEM EXCEPTION<br>UNIT NOT CALIBRATED<br>UNIT NOT PROGRAMMED<br>WATCHDOG ERROR | Any of the major self-test errors generated (major error)<br>Any of the minor self-test errors generated (minor error)<br>Any self-test errors generated (generic, any error)<br>See description in Chapter 7: Commands and Targets.<br>See description in Chapter 7: Commands and Targets.<br>See description in Chapter 7: Commands and Targets.<br>See description in Chapter 7: Commands and Targets.<br>See description in Chapter 7: Commands and Targets.<br>See description in Chapter 7: Commands and Targets.<br>See description in Chapter 7: Commands and Targets.<br>See description in Chapter 7: Commands and Targets.<br>See description in Chapter 7: Commands and Targets.<br>See description in Chapter 7: Commands and Targets.<br>See description in Chapter 7: Commands and Targets.<br>See description in Chapter 7: Commands and Targets.<br>See description in Chapter 7: Commands and Targets.<br>See description in Chapter 7: Commands and Targets.<br>See description in Chapter 7: Commands and Targets.<br>See description in Chapter 7: Commands and Targets.<br>See description in Chapter 7: Commands and Targets.<br>See description in Chapter 7: Commands and Targets.<br>See description in Chapter 7: Commands and Targets.<br>See description in Chapter 7: Commands and Targets.<br>See description in Chapter 7: Commands and Targets. |
| UNAUTHORIZED ACCESS ALARM | UNAUTHORIZED ACCESS | Asserted when a password entry fails while accessing a password-protected level of the relay. |
| USER-PROGRAMMABLE PUSHBUTTONS | PUSHBUTTON x ON<br>PUSHBUTTON x OFF | Pushbutton Number x is in the 'On' position<br>Pushbutton Number x is in the 'Off' position |

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/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 5–6: 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 5–7: 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 32 'one shots'. |
| | NEGATIVE ONE SHOT | One shot that responds to a negative going edge. | |
| | DUAL ONE SHOT | One shot that responds to both the positive and negative going edges. | |
| Logic Gate | NOT | Logical Not | Operates on the previous parameter. |
| | OR(2) ↓ OR(16) | 2 input OR gate ↓ 16 input OR gate | Operates on the 2 previous parameters. ↓ Operates on the 16 previous parameters. |
| | AND(2) ↓ AND(16) | 2 input AND gate ↓ 16 input AND gate | Operates on the 2 previous parameters. ↓ Operates on the 16 previous parameters. |
| | NOR(2) ↓ NOR(16) | 2 input NOR gate ↓ 16 input NOR gate | Operates on the 2 previous parameters. ↓ Operates on the 16 previous parameters. |
| | NAND(2) ↓ NAND(16) | 2 input NAND gate ↓ 16 input NAND gate | Operates on the 2 previous parameters. ↓ Operates on the 16 previous parameters. |
| | XOR(2) | 2 input Exclusive OR gate | Operates on the 2 previous parameters. |
| | LATCH (S,R) | Latch (Set, Reset) - reset-dominant | The parameter preceding LATCH(S,R) is the Reset input. The parameter preceding the Reset input is the Set input. |
| Timer | TIMER 1 ↓ TIMER 32 | Timer set with FlexLogic™ Timer 1 settings. ↓ Timer set with FlexLogic™ Timer 32 settings. | The timer is started by the preceding parameter. The output of the timer is TIMER #. |
| Assign Virtual Output | = Virt Op 1 ↓ = Virt Op 64 | Assigns previous FlexLogic™ parameter to Virtual Output 1. ↓ Assigns previous FlexLogic™ parameter to Virtual Output 64. | The virtual output is set by the preceding parameter |

**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 (e.g. "TIMER 1") or virtual output assignment (e.g. " = 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.

⚠ **CAUTION**

**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*; i.e. 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.**

This section provides an example of implementing logic for a typical application. The sequence of the steps is quite impor-
tant 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 64) can only be properly assigned once.
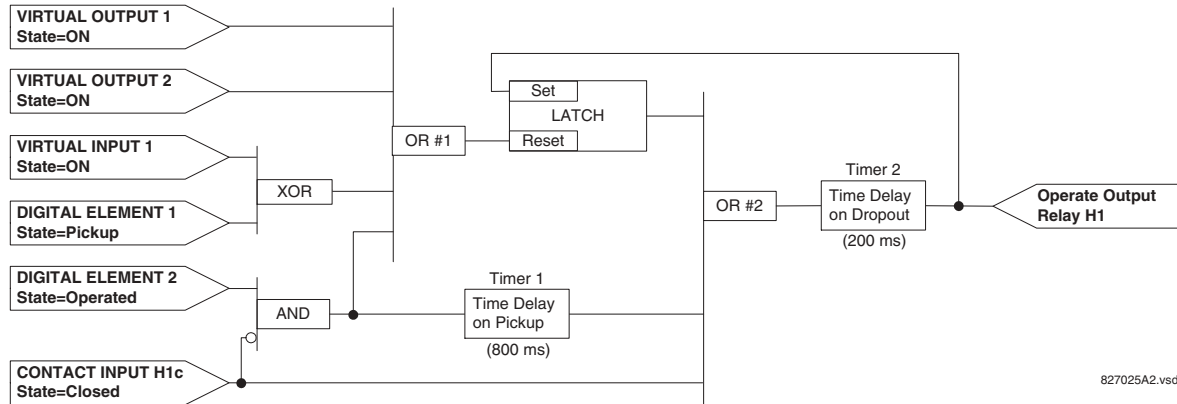


**Figure 5–27: EXAMPLE LOGIC SCHEME**

1.  Inspect the example logic diagram to determine if the required logic can be implemented with the FlexLogic™ opera-
    tors. 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 (i.e. Output Contact 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.
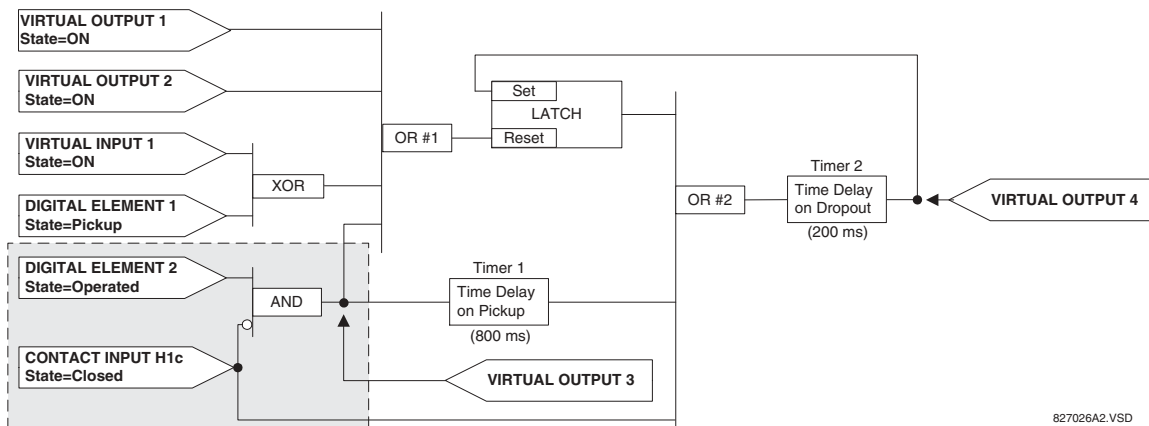


**Figure 5–28: LOGIC EXAMPLE WITH VIRTUAL OUTPUTS**

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.
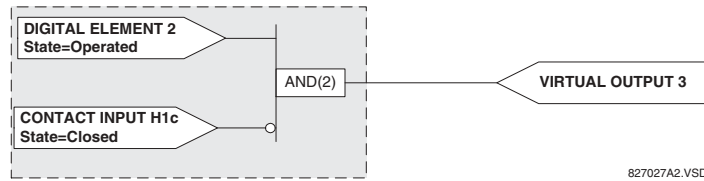


**Figure 5–29: LOGIC FOR VIRTUAL OUTPUT 3**

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.
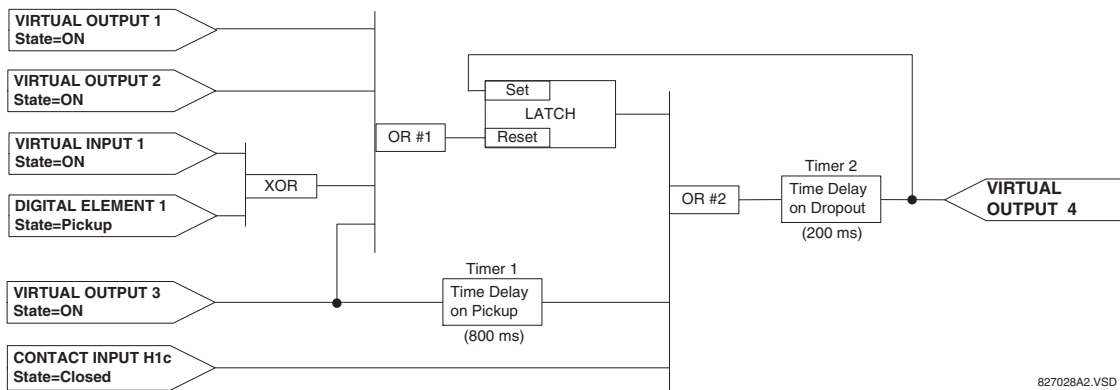


**Figure 5–30: LOGIC FOR VIRTUAL OUTPUT 4**

4.   Program the FlexLogic™ equation for Virtual Output 3 by translating the logic into available FlexLogic™ parameters. The equation is formed one parameter at a time until the required logic is complete. It is generally easier to start at the output end of the equation and work back towards the input, as shown in the following steps. It is also recommended to list operator inputs from bottom to top. For demonstration, the final output will be arbitrarily identified as parameter 99, and each preceding parameter decremented by one in turn. Until accustomed to using FlexLogic™, it is suggested that a worksheet with a series of cells marked with the arbitrary parameter numbers be prepared, as shown below.
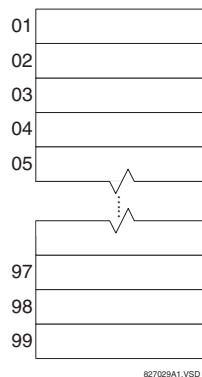


**Figure 5–31: FLEXLOGIC™ WORKSHEET**

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.
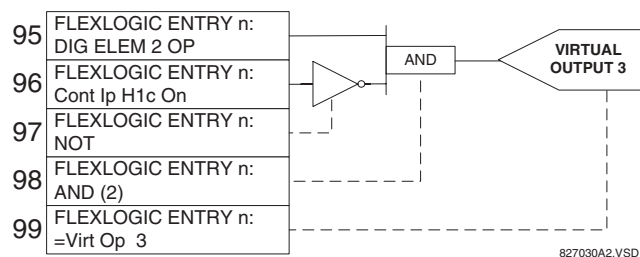


**Figure 5–32: FLEXLOGIC™ EQUATION FOR VIRTUAL OUTPUT 3**

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.
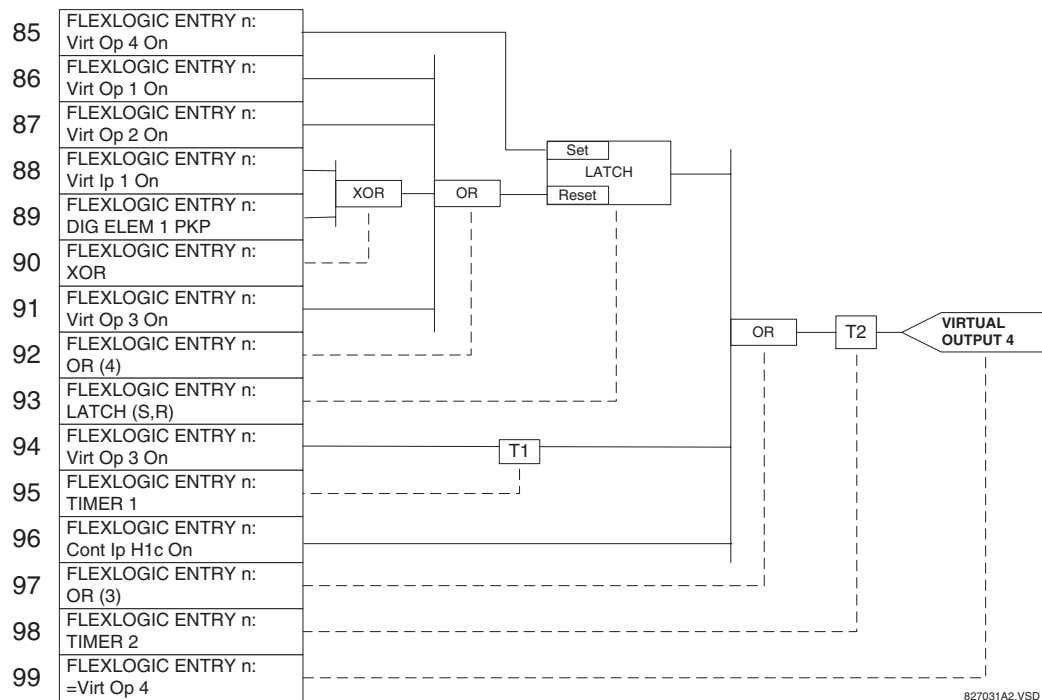


**Figure 5–33: FLEXLOGIC™ EQUATION FOR VIRTUAL OUTPUT 4**

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 4 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 4-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**

| ■ FLEXLOGIC<br>■ EQUATION EDITOR | ◀▶ | FLEXLOGIC ENTRY    1:<br>END | *Range: FlexLogic™ parameters* |
| --- | --- | --- | --- |
| | | ↓ | |
| MESSAGE ⬆ | | FLEXLOGIC ENTRY 512:<br>END | *Range: FlexLogic™ parameters* |
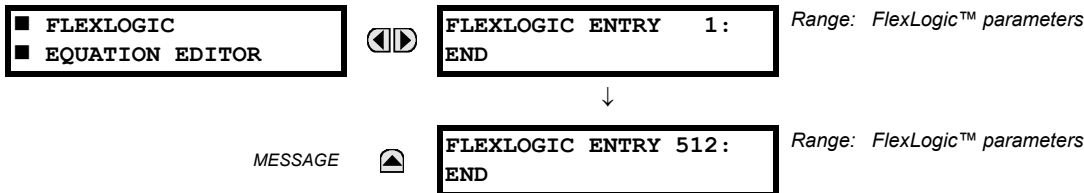
There are 512 FlexLogic™ entries available, numbered from 1 to 512, with default 'END' entry settings. If a "Disabled" Element is selected as a FlexLogic™ entry, the associated state flag will never be set to '1'. The '+/–' key may be used when editing FlexLogic™ equations from the keypad to quickly scan through the major parameter types.

### 5.4.6 FLEXLOGIC™ TIMERS

**PATH: SETTINGS ⇨⇩ FLEXLOGIC ⇨⇩ FLEXLOGIC TIMERS ⇨ FLEXLOGIC TIMER 1(32)**

| ■ FLEXLOGIC<br>■ TIMER  1 | ◀▶ | TIMER  1<br>TYPE: millisecond | *Range: millisecond, second, minute* |
| --- | --- | --- | --- |
| MESSAGE ⬆⬇ | | TIMER  1 PICKUP<br>DELAY:    0 | *Range: 0 to 60000 in steps of 1* |
| MESSAGE ⬆ | | TIMER  1 DROPOUT<br>DELAY:    0 | *Range: 0 to 60000 in steps of 1* |
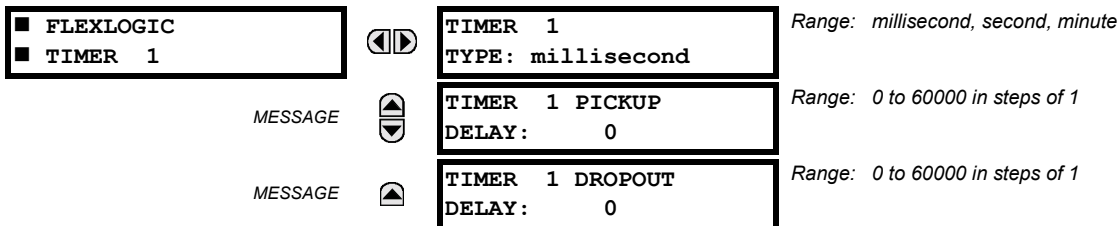
There are 32 identical FlexLogic™ timers available. These timers can be used as operators for FlexLogic™ equations.

• **TIMER  1 TYPE:** This setting is used to select the time measuring unit.

• **TIMER  1 PICKUP DELAY:** Sets the time delay to pickup. If a pickup delay is not required, set this function to "0".

• **TIMER  1 DROPOUT DELAY:** Sets the time delay to dropout. If a dropout delay is not required, set this function to "0".

**PATH: SETTING ⇨⇩ FLEXLOGIC ⇨⇩ FLEXELEMENTS ⇨ FLEXELEMENT 1(8)**

| | | Range: |
|---|---|---|
| ■ FLEXELEMENT 1 ■ ◀▮▶ | FLEXELEMENT 1 FUNCTION: Disabled | *Range: Disabled, Enabled* |
| MESSAGE | FLEXELEMENT 1 NAME: FxE1 | *Range: up to 6 alphanumeric characters* |
| MESSAGE | FLEXELEMENT 1 +IN: Off | *Range: Off, any analog actual value parameter* |
| MESSAGE | FLEXELEMENT 1 -IN: Off | *Range: Off, any analog actual value parameter* |
| MESSAGE | FLEXELEMENT 1 INPUT MODE: Signed | *Range: Signed, Absolute* |
| MESSAGE | FLEXELEMENT 1 COMP MODE: Level | *Range: Level, Delta* |
| MESSAGE | FLEXELEMENT 1 DIRECTION: Over | *Range: Over, Under* |
| MESSAGE | FLEXELEMENT 1 PICKUP: 1.000 pu | *Range: −90.000 to 90.000 pu in steps of 0.001* |
| MESSAGE | FLEXELEMENT 1 HYSTERESIS: 3.0% | *Range: 0.1 to 50.0% in steps of 0.1* |
| MESSAGE | FLEXELEMENT 1 dt UNIT: milliseconds | *Range: milliseconds, seconds, minutes* |
| MESSAGE | FLEXELEMENT 1 dt: 20 | *Range: 20 to 86400 in steps of 1* |
| MESSAGE | FLEXELEMENT 1 PKP DELAY: 0.000 s | *Range: 0.000 to 65.535 s in steps of 0.001* |
| MESSAGE | FLEXELEMENT 1 RST DELAY: 0.000 s | *Range: 0.000 to 65.535 s in steps of 0.001* |
| MESSAGE | FLEXELEMENT 1 BLK: Off | *Range: FlexLogic™ operand* |
| MESSAGE | FLEXELEMENT 1 TARGET: Self-reset | *Range: Self-reset, Latched, Disabled* |
| MESSAGE | FLEXELEMENT 1 EVENTS: Disabled | *Range: Disabled, Enabled* |

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

The element can be programmed to respond either to a signal level or to a rate-of-change (delta) over a pre-defined period of time. The output operand is asserted when the operating signal is higher than a threshold or lower than a threshold as per user's choice.
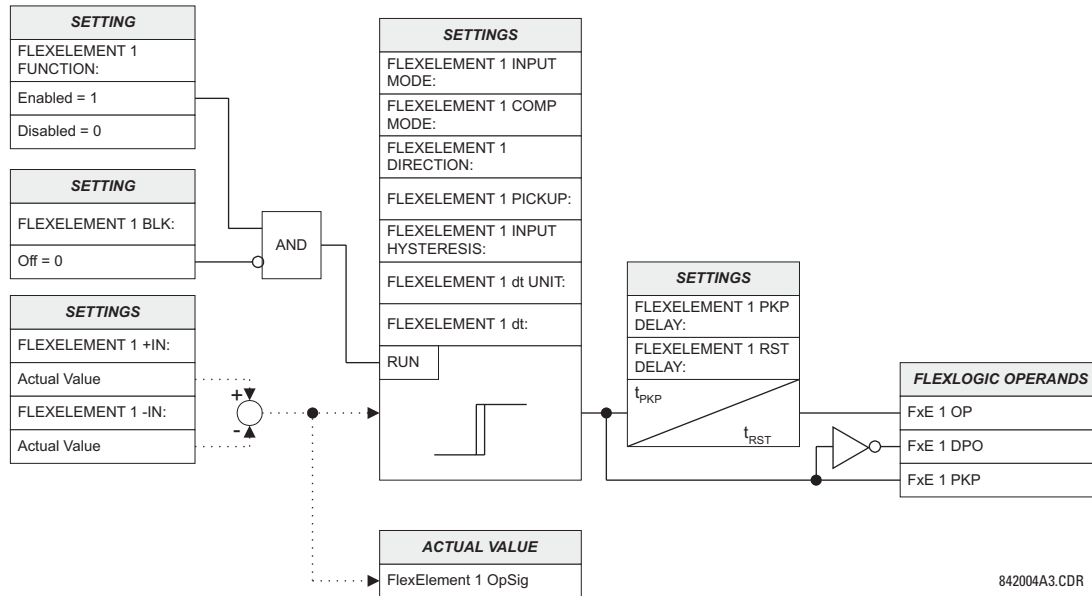
**Figure 5–34: FLEXELEMENT™ SCHEME LOGIC**

The **FLEXELEMENT 1 +IN** setting specifies the first (non-inverted) input to the FlexElement™. Zero is assumed as the input if this setting is set to "Off". For proper operation of the element at least one input must be selected. Otherwise, the element will not assert its output operands.

This **FLEXELEMENT 1 –IN** setting specifies the second (inverted) input to the FlexElement™. Zero is assumed as the input if this setting is set to "Off". For proper operation of the element at least one input must be selected. Otherwise, the element will not assert its output operands. This input should be used to invert the signal if needed for convenience, or to make the element respond to a differential signal such as for a top-bottom oil temperature differential alarm. The element will not operate if the two input signals are of different types, for example if one tries to use active power and phase angle to build the effective operating signal.

The element responds directly to the differential signal if the **FLEXELEMENT 1 INPUT MODE** setting is set to "Signed". The element responds to the absolute value of the differential signal if this setting is set to "Absolute". Sample applications for the "Absolute" setting include monitoring the angular difference between two phasors with a symmetrical limit angle in both directions; monitoring power regardless of its direction, or monitoring a trend regardless of whether the signal increases of decreases.

The element responds directly to its operating signal – as defined by the **FLEXELEMENT 1 +IN**, **FLEXELEMENT 1 –IN** and **FLEXELEMENT 1 INPUT MODE** settings – if the **FLEXELEMENT 1 COMP MODE** setting is set to "Threshold". 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.
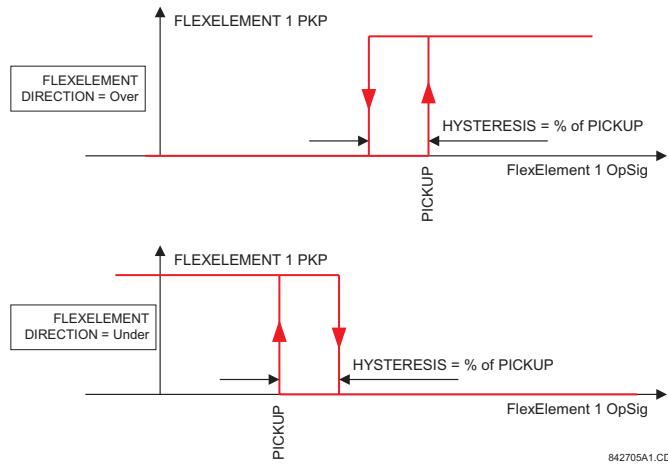
**Figure 5–35: FLEXELEMENT™ DIRECTION, PICKUP, AND HYSTERESIS**

In conjunction with the **FLEXELEMENT 1 INPUT MODE** setting the element could be programmed to provide two extra characteristics as shown in the figure below.
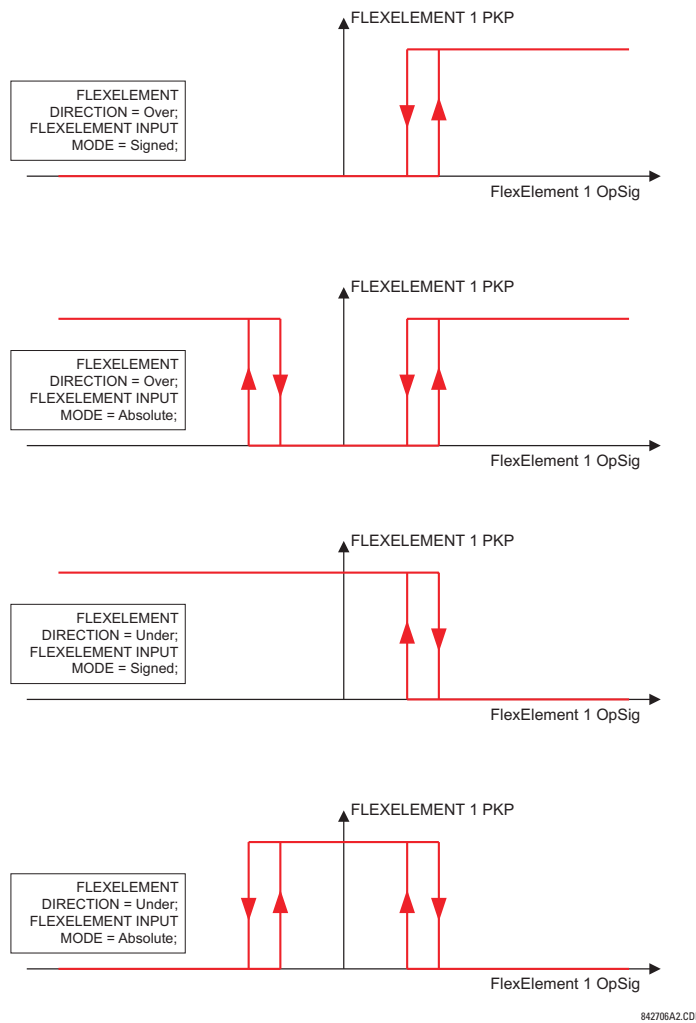


**Figure 5–36: FLEXELEMENT™ INPUT MODE SETTING**

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 5–8: FLEXELEMENT™ BASE UNITS**

| | |
|---|---|
| BREAKER ARCING AMPS<br>(Brk X Arc Amp A, B, and C) | BASE = 2000 $kA^2 \times$ cycle |
| dcmA | BASE = maximum value of the **DCMA INPUT MAX** setting for the two transducers configured under the +IN and –IN inputs. |
| FREQUENCY | $f_{BASE}$ = 1 Hz |
| PHASE ANGLE | $\varphi_{BASE}$ = 360 degrees (see the UR angle referencing convention) |
| POWER FACTOR | $PF_{BASE}$ = 1.00 |
| RTDs | BASE = 100°C |
| SOURCE CURRENT | $I_{BASE}$ = maximum nominal primary RMS value of the +IN and –IN inputs |
| SOURCE ENERGY<br>(Positive and Negative Watthours,<br>Positive and Negative Varhours) | $E_{BASE}$ = 10000 MWh or MVAh, respectively |
| SOURCE POWER | $P_{BASE}$ = maximum value of $V_{BASE} \times I_{BASE}$ for the +IN and –IN inputs |
| SOURCE VOLTAGE | $V_{BASE}$ = maximum nominal primary RMS value of the +IN and –IN inputs |
| SYNCHROCHECK<br>(Max Delta Volts) | $V_{BASE}$ = maximum primary RMS value of all the sources related to the +IN and –IN inputs |

The **FLEXELEMENT 1 HYSTERESIS** setting defines the pickup–dropout relation of the element by specifying the width of the hysteresis loop as a percentage of the pickup value as shown in the FlexElement™ Direction, Pickup, and Hysteresis diagram.

The **FLEXELEMENT 1 DT UNIT** setting specifies the time unit for the setting **FLEXELEMENT 1 dt**. This setting is applicable only if **FLEXELEMENT 1 COMP MODE** is set to "Delta". The **FLEXELEMENT 1 DT** setting specifies duration of the time interval for the rate of change mode of operation. This setting is applicable only if **FLEXELEMENT 1 COMP MODE** is set to "Delta".

This **FLEXELEMENT 1 PKP DELAY** setting specifies the pickup delay of the element. The **FLEXELEMENT 1 RST DELAY** setting specifies the reset delay of the element.

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



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 HMI action resets the latch. The settings, logic, and element operation are described below:

- **LATCH 1 TYPE**: This setting characterizes Latch 1 to be Set- or Reset-dominant.

- **LATCH 1 SET**: If asserted, the specified FlexLogic™ operands 'sets' Latch 1.

- **LATCH 1 RESET**: If asserted, the specified FlexLogic™ operand 'resets' Latch 1.

| LATCH N TYPE | LATCH N SET | LATCH N RESET | LATCH N ON | LATCH N OFF |
|---|---|---|---|---|
| Reset Dominant | ON | OFF | ON | OFF |
| | OFF | OFF | Previous State | Previous State |
| | ON | ON | OFF | ON |
| | OFF | ON | OFF | ON |
| Set Dominant | ON | OFF | ON | OFF |
| | ON | ON | ON | OFF |
| | OFF | OFF | Previous State | Previous State |
| | OFF | ON | OFF | ON |
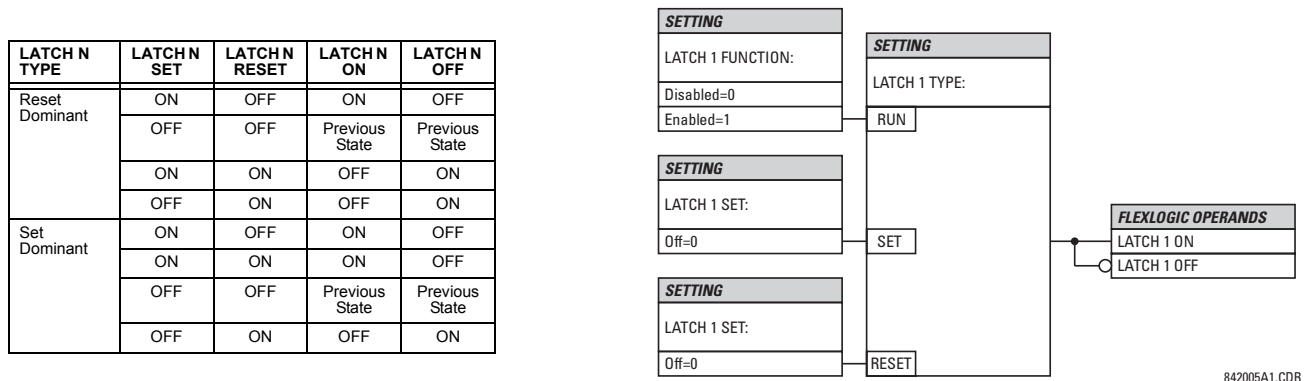


**Figure 5–37: NON-VOLATILE LATCH OPERATION TABLE (N=1 to 16) AND LOGIC**

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 (e.g. altered power system configuration, season of the year). 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 5-75. |
| | | | |
| MESSAGE ▲▼ | | ■ PHASE CURRENT ■ | See page 5-84. |
| MESSAGE ▲▼ | | ■ NEUTRAL CURRENT ■ | See page 5-93. |
| MESSAGE ▲▼ | | ■ GROUND CURRENT ■ | See page 5-96. |
| MESSAGE ▲▼ | | ■ VOLTAGE ELEMENTS ■ | See page 5-99. |
| MESSAGE ▲ | | ■ SENSITIVE ■ DIRECTIONAL POWER | See page 5-104. |

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).

**PATH: SETTINGS** ⇨⇩ **GROUPED ELEMENTS** ⇨ **SETTING GROUP 1(6)** ⇨⇩ **BREAKER FAILURE** ⇨ **BREAKER FAILURE 1(2)**

| ■ 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 |
| MESSAGE | | BF1 USE AMP SUPV: Yes | Range: Yes, No |
| MESSAGE | | BF1 USE SEAL-IN: Yes | Range: Yes, No |
| MESSAGE | | BF1 3-POLE INITIATE: Off | Range: FlexLogic™ operand |
| MESSAGE | | BF1 BLOCK: Off | Range: FlexLogic™ operand |
| MESSAGE | | BF1 PH AMP SUPV PICKUP: 1.050 pu | Range: 0.001 to 30.000 pu in steps of 0.001 |
| MESSAGE | | BF1 N AMP SUPV PICKUP: 1.050 pu | Range: 0.001 to 30.000 pu in steps of 0.001 |
| MESSAGE | | BF1 USE TIMER 1: Yes | Range: Yes, No |
| MESSAGE | | BF1 TIMER 1 PICKUP DELAY: 0.000 s | Range: 0.000 to 65.535 s in steps of 0.001 |
| MESSAGE | | BF1 USE TIMER 2: Yes | Range: Yes, No |
| MESSAGE | | BF1 TIMER 2 PICKUP DELAY: 0.000 s | Range: 0.000 to 65.535 s in steps of 0.001 |
| MESSAGE | | BF1 USE TIMER 3: Yes | Range: Yes, No |
| MESSAGE | | BF1 TIMER 3 PICKUP DELAY: 0.000 s | Range: 0.000 to 65.535 s in steps of 0.001 |
| MESSAGE | | BF1 BKR POS1 φA/3P: Off | Range: FlexLogic™ operand |
| MESSAGE | | BF1 BKR POS2 φA/3P: Off | Range: FlexLogic™ operand |
| MESSAGE | | BF1 BREAKER TEST ON: Off | Range: FlexLogic™ operand |
| MESSAGE | | BF1 PH AMP HISET PICKUP: 1.050 pu | Range: 0.001 to 30.000 pu in steps of 0.001 |
| MESSAGE | | BF1 N AMP HISET PICKUP: 1.050 pu | Range: 0.001 to 30.000 pu in steps of 0.001 |
| MESSAGE | | BF1 PH AMP LOSET PICKUP: 1.050 pu | Range: 0.001 to 30.000 pu in steps of 0.001 |

**5**

| | | | |
|---|---|---|---|
| MESSAGE | ⬆⬇ | BF1 N AMP LOSET<br>PICKUP: 1.050 pu | Range: 0.001 to 30.000 pu in steps of 0.001 |
| MESSAGE | ⬆⬇ | BF1 LOSET TIME<br>DELAY:   0.000 s | Range: 0.000 to 65.535 s in steps of 0.001 |
| MESSAGE | ⬆⬇ | BF1 TRIP DROPOUT<br>DELAY:   0.000 s | Range: 0.000 to 65.535 s in steps of 0.001 |
| MESSAGE | ⬆⬇ | BF1 TARGET<br>Self-Reset | Range: Self-reset, Latched, Disabled |
| MESSAGE | ⬆⬇ | BF1 EVENTS<br>Disabled | Range: Disabled, Enabled |
| MESSAGE | ⬆⬇ | BF1 PH A INITIATE:<br>Off | Range: FlexLogic™ operand<br>Valid only for 1-Pole breaker failure schemes. |
| MESSAGE | ⬆⬇ | BF1 PH B INITIATE:<br>Off | Range: FlexLogic™ operand<br>Valid only for 1-Pole breaker failure schemes. |
| MESSAGE | ⬆⬇ | BF1 PH C INITIATE:<br>Off | Range: FlexLogic™ operand<br>Valid only for 1-Pole breaker failure schemes. |
| MESSAGE | ⬆⬇ | BF1 BKR POS1 φB<br>Off | Range: FlexLogic™ operand<br>Valid only for 1-Pole breaker failure schemes. |
| MESSAGE | ⬆⬇ | BF1 BKR POS1 φC<br>Off | Range: FlexLogic™ operand<br>Valid only for 1-Pole breaker failure schemes. |
| MESSAGE | ⬆⬇ | BF1 BKR POS2 φB<br>Off | Range: FlexLogic™ operand<br>Valid only for 1-Pole breaker failure schemes. |
| MESSAGE | ⬆ | BF1 BKR POS2 φC<br>Off | Range: FlexLogic™ operand<br>Valid only for 1-Pole breaker failure schemes. |

There are 2 identical Breaker Failure menus available, numbered 1 and 2.

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, Hi-set and Lo-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 Hi-set detector is enabled after timeout of Timer 1 or 2, along with a timer that will enable the Lo-set detector after its delay interval. The delay interval between Hi-set and Lo-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/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:**
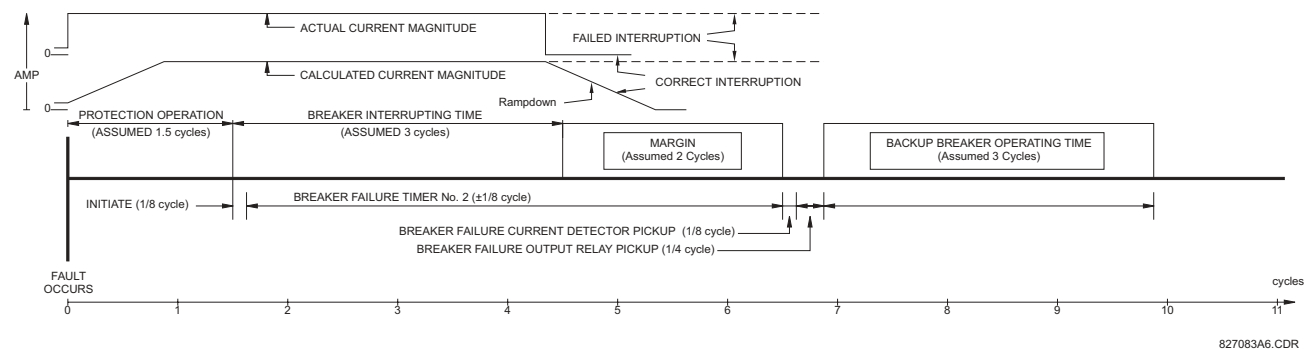


**Figure 5–38: BREAKER FAILURE MAIN PATH SEQUENCE**

**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 3-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) - Hiset and Loset 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 C60 relays, which use a Fourier transform, the calculated current magnitude will ramp-down to zero one power frequency cycle after the current is interrupted, and this lag should be included in the overall margin duration, as it occurs after current interruption. The Breaker Failure Main Path Sequence diagram below shows a margin of two cycles; this interval is considered the minimum appropriate for most applications.

  Note that in bulk oil circuit breakers, the interrupting time for currents less than 25% of the interrupting rating can be significantly longer than the normal interrupting time.

- **BF1 USE TIMER 3:** If set to "Yes", the Slow Path is operational.

- **BF1 TIMER 3 PICKUP DELAY:** Timer 3 is set to the same interval as Timer 2, plus an increased safety margin. Because this path is intended to operate only for low level faults, the delay can be in the order of 300 to 500 ms.

- **BF1 BKR POS1 ϕA/3P:** This setting selects the FlexLogic™ operand that represents the protected breaker early-type auxiliary switch contact (52/a). When using 1-Pole breaker failure scheme, this operand represents the protected breaker early-type auxiliary switch contact on pole A. This is normally a non-multiplied Form-A contact. The contact may even be adjusted to have the shortest possible operating time.

- **BF1 BKR POS2 ϕA/3P:** This setting selects the FlexLogic™ operand that represents the breaker normal-type auxiliary switch contact (52/a). When using 1-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 3-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 3-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 1-pole breaker failure schemes*.

- **BF1 BKR POS1 $\phi$B / BF1 BKR POS 1 $\phi$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 1-pole breaker failure schemes*.

- **BF1 BKR POS2 $\phi$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 1-pole breaker failure schemes*.

- **BF1 BKR POS2 $\phi$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 1-pole breaker failure schemes*.

  Upon operation of the breaker failure element for a single pole trip command, a 3-pole trip command should be given via output operand BKR FAIL 1 TRIP OP.

**5**
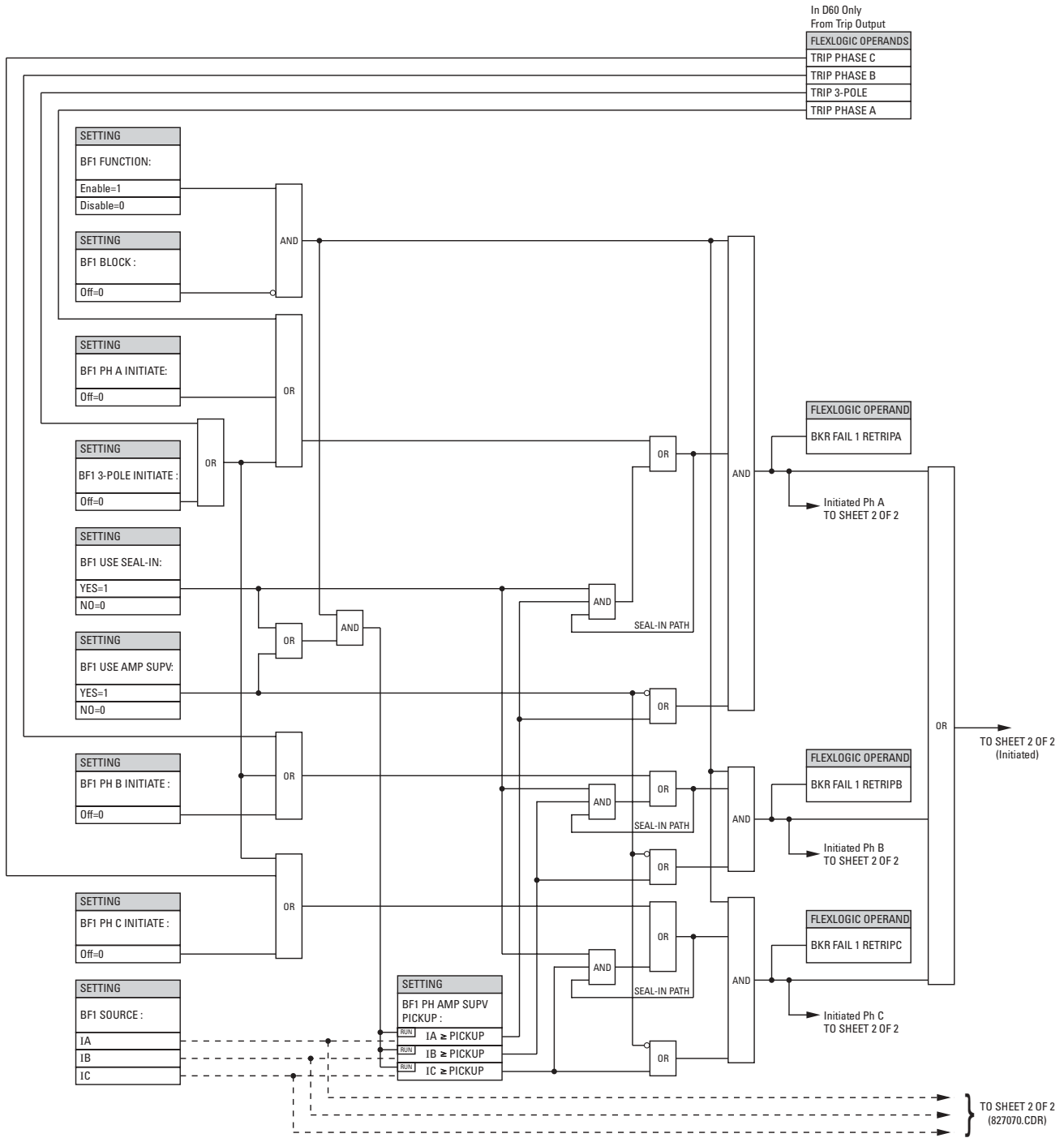
**Figure 5–39: BREAKER FAILURE 1-POLE [INITIATE] (Sheet 1 of 2)**
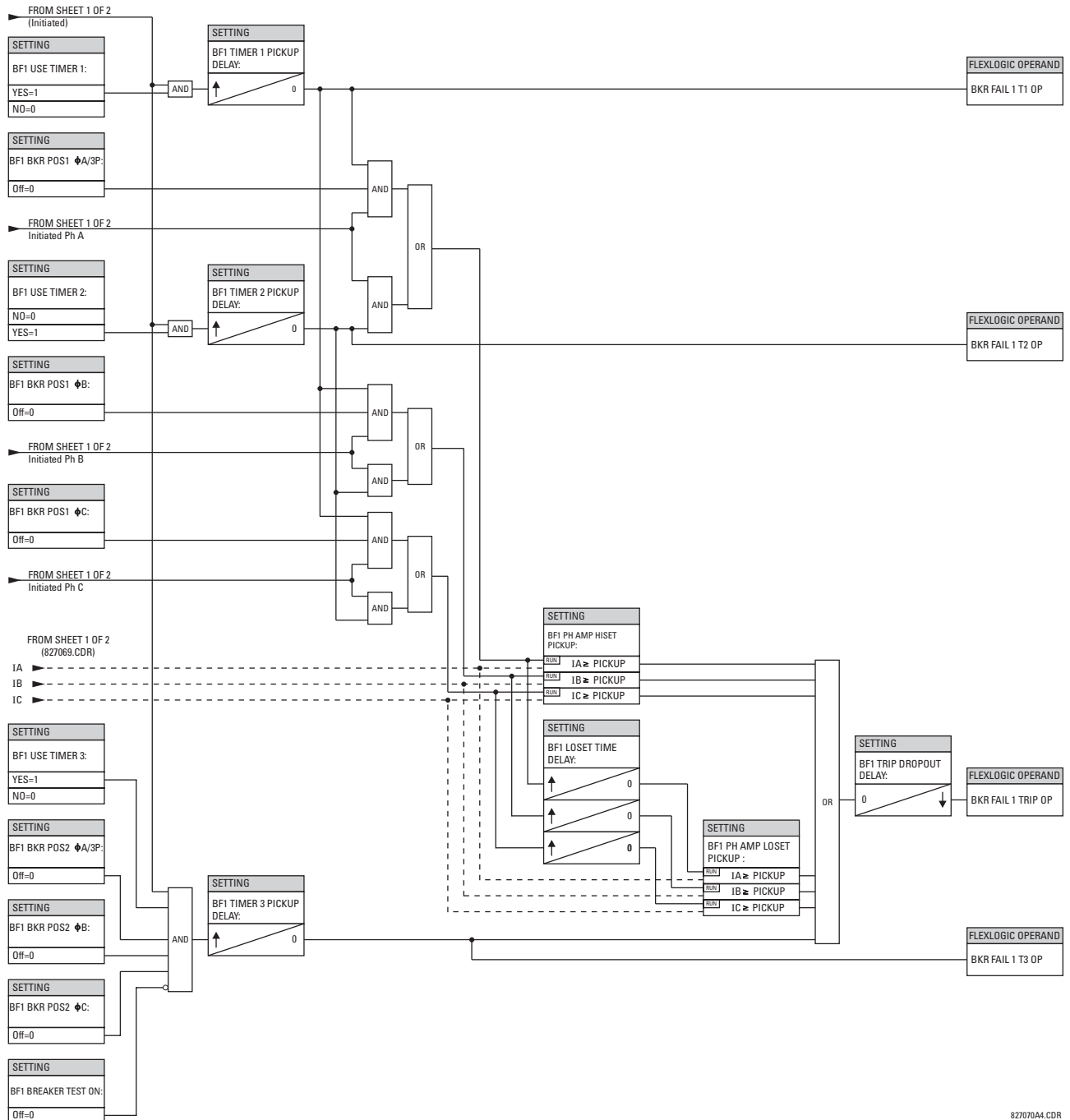
**Figure 5–40: BREAKER FAILURE 1-POLE [TIMERS] (Sheet 2 of 2)**

**5**
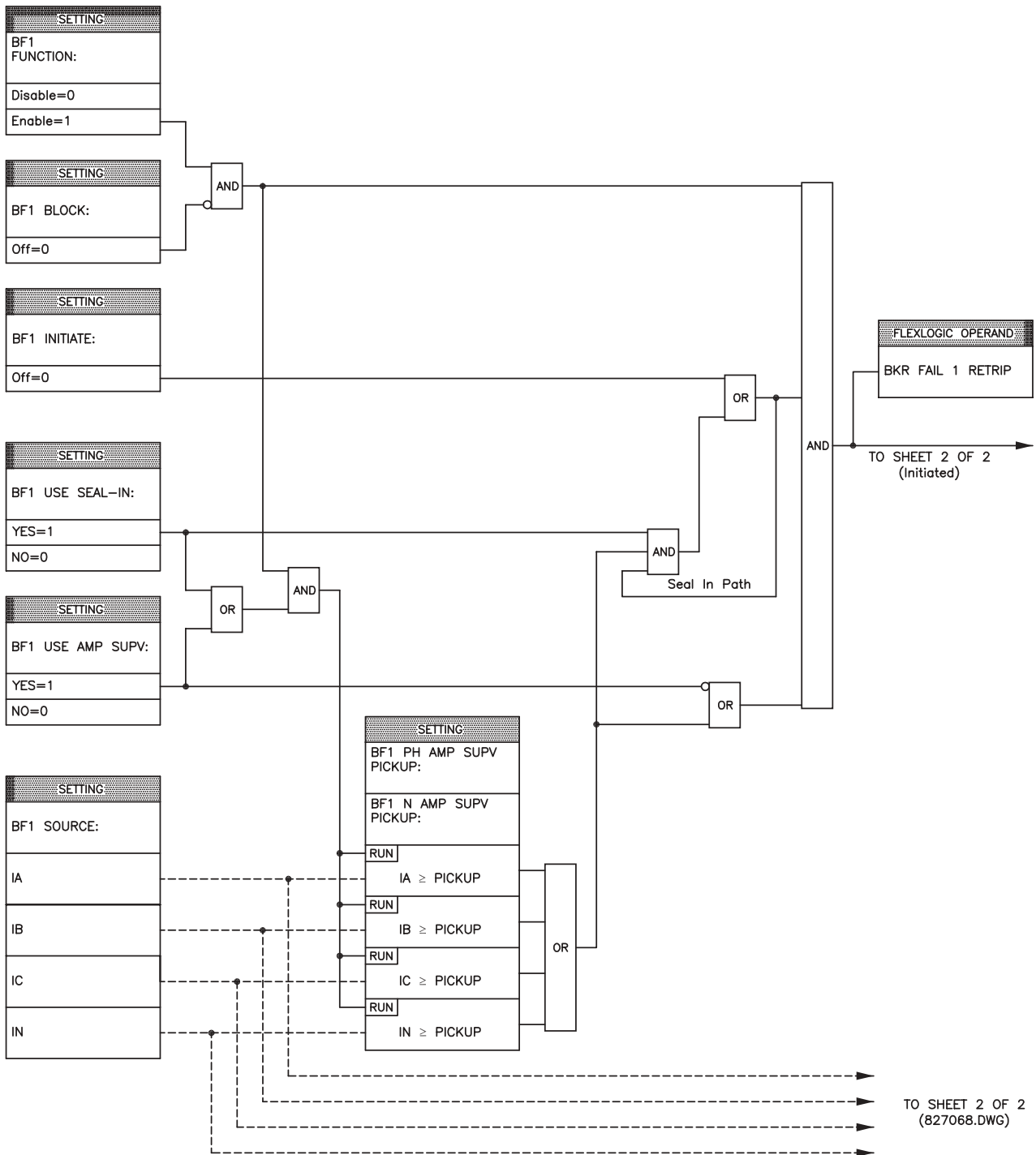


**Figure 5–41: BREAKER FAILURE 3-POLE [INITIATE] (Sheet 1 of 2)**
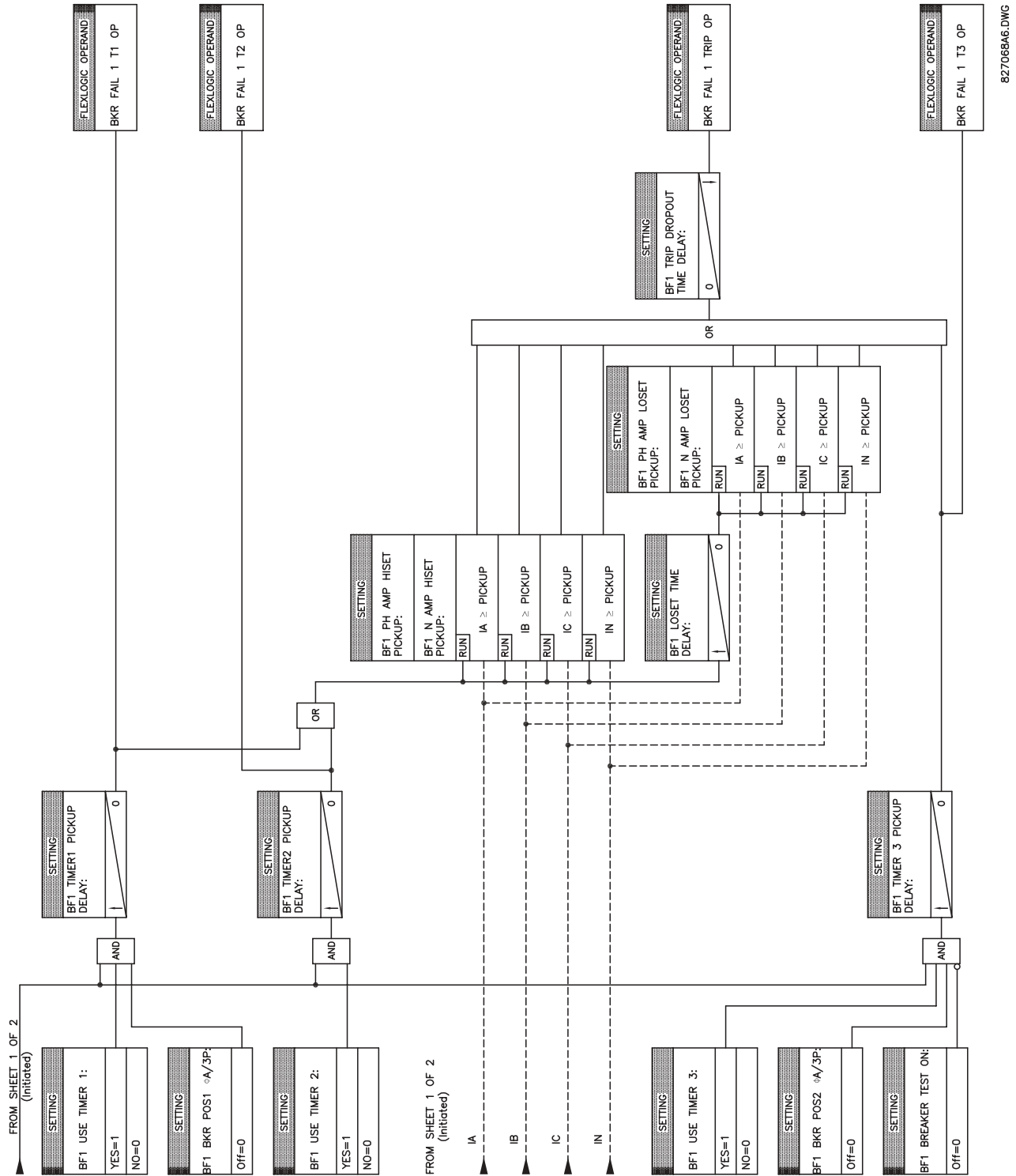
Figure 5–42: BREAKER FAILURE 3-POLE [TIMERS] (Sheet 2 of 2)

**a) MAIN MENU**

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

| ■ PHASE CURRENT<br>■ | ◀▶ | ■ PHASE TOC1<br>■ | **See page 5-90.** |
|---|---|---|---|

| | MESSAGE | ▲▼ | ■ PHASE TOC2<br>■ | |

| | MESSAGE | ▲▼ | ■ PHASE TOC3<br>■ | |

| | MESSAGE | ▲▼ | ■ PHASE TOC4<br>■ | |

| | MESSAGE | ▲▼ | ■ PHASE TOC5<br>■ | *Note:* *Seen only if slot F or slot M has an 8H or 8J CT module installed.* |

| | MESSAGE | ▲▼ | ■ PHASE TOC6<br>■ | *Note:* *Seen only if slot F or slot M has an 8H or 8J CT module installed.* |

| | MESSAGE | ▲▼ | ■ PHASE IOC1<br>■ | **See page 5-92.** |

| | MESSAGE | ▲▼ | ■ PHASE IOC2<br>■ | |

| | MESSAGE | ▲▼ | ■ PHASE IOC3<br>■ | |

| | MESSAGE | ▲▼ | ■ PHASE IOC4<br>■ | |

| | MESSAGE | ▲▼ | ■ PHASE IOC5<br>■ | *Note:* *Seen only if slot F or slot M has an 8H or 8J CT module installed.* |

| | MESSAGE | ▲▼ | ■ PHASE IOC6<br>■ | *Note:* *Seen only if slot F or slot M has an 8H or 8J CT module installed.* |

| | MESSAGE | ▲▼ | ■ PHASE IOC7<br>■ | *Note:* *Seen only if slot F and slot M have 8H or 8J CT modules installed.* |

| | MESSAGE | ▲ | ■ PHASE IOC8<br>■ | *Note:* *Seen only if slot F and slot M have 8H or 8J CT modules installed.* |

The C60 contains protection elements for phase time overcurrent (ANSI device 51P) and phase instantaneous overcurrent (ANSI device 50P). A maximum of six phase time overcurrent and eight phase instantaneous overcurrent elements are available, dependent on the CT/VT modules ordered with the relay. See the following table for details

| CT/VT MODULES | | NUMBER OF ELEMENTS | |
|---|---|---|---|
| **SLOT F** | **SLOT M** | **PHASE TOC** | **PHASE IOC** |
| 8F/8G | 8H/8J | 4 | 4 |
| 8F/8G | 8H/8J | 6 | 6 |
| 8H/8J | 8F/8G | 6 | 6 |
| 8H/8J | 8H/8J | 6 | 8 |

### b) INVERSE TOC CURVE CHARACTERISTICS

The inverse time overcurrent curves used by the time overcurrent elements are the IEEE, IEC, GE Type IAC, and $I^2$t standard curve shapes. This allows for simplified coordination with downstream devices. If however, 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 5–9: OVERCURRENT CURVE TYPES**

| IEEE | IEC | GE TYPE IAC | OTHER |
|------|-----|-------------|-------|
| IEEE Extremely Inv. | IEC Curve A (BS142) | IAC Extremely Inv. | $I^2$t |
| IEEE Very Inverse | IEC Curve B (BS142) | IAC Very Inverse | FlexCurves™ A, B, C, and D |
| IEEE Moderately Inv. | 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.

**NOTE**  **Graphs of standard time-current curves on 11" × 17" log-log graph paper are available upon request from the GE Multilin literature department. The original files are also available in PDF format on the enerVista CD and the GE Multilin website at http://www.GEindustrial.com/multilin.**

**5**

**IEEE CURVES:**

The IEEE time overcurrent curve shapes conform to industry standards and the IEEE C37.112-1996 curve classifications for extremely, very, and moderately inverse. The IEEE curves are derived from the formulae:

$$T = TDM \times \left[ \frac{A}{\left( \frac{I}{I_{pickup}} \right)^p - 1} + B \right], \quad T_{RESET} = TDM \times \left[ \frac{t_r}{\left( \frac{I}{I_{pickup}} \right)^2 - 1} \right] \qquad \textbf{(EQ 5.6)}$$

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 5–10: 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 5–11: 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:

$$T = TDM \times \left[ \frac{K}{(I/I_{pickup})^E - 1} \right], \quad T_{RESET} = TDM \times \left[ \frac{t_r}{(I/I_{pickup})^2 - 1} \right] \qquad \textbf{(EQ 5.7)}$$

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 5–12: 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 5–13: IEC CURVE TRIP TIMES (IN SECONDS)**

| MULTIPLIER (TDM) | CURRENT ( $I/I_{pickup}$) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
|  | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 |
| **IEC CURVE A** | | | | | | | | | | |
| 0.05 | 0.860 | 0.501 | 0.315 | 0.249 | 0.214 | 0.192 | 0.176 | 0.165 | 0.156 | 0.149 |
| 0.10 | 1.719 | 1.003 | 0.630 | 0.498 | 0.428 | 0.384 | 0.353 | 0.330 | 0.312 | 0.297 |
| 0.20 | 3.439 | 2.006 | 1.260 | 0.996 | 0.856 | 0.767 | 0.706 | 0.659 | 0.623 | 0.594 |
| 0.40 | 6.878 | 4.012 | 2.521 | 1.992 | 1.712 | 1.535 | 1.411 | 1.319 | 1.247 | 1.188 |
| 0.60 | 10.317 | 6.017 | 3.781 | 2.988 | 2.568 | 2.302 | 2.117 | 1.978 | 1.870 | 1.782 |
| 0.80 | 13.755 | 8.023 | 5.042 | 3.984 | 3.424 | 3.070 | 2.822 | 2.637 | 2.493 | 2.376 |
| 1.00 | 17.194 | 10.029 | 6.302 | 4.980 | 4.280 | 3.837 | 3.528 | 3.297 | 3.116 | 2.971 |
| **IEC CURVE B** | | | | | | | | | | |
| 0.05 | 1.350 | 0.675 | 0.338 | 0.225 | 0.169 | 0.135 | 0.113 | 0.096 | 0.084 | 0.075 |
| 0.10 | 2.700 | 1.350 | 0.675 | 0.450 | 0.338 | 0.270 | 0.225 | 0.193 | 0.169 | 0.150 |
| 0.20 | 5.400 | 2.700 | 1.350 | 0.900 | 0.675 | 0.540 | 0.450 | 0.386 | 0.338 | 0.300 |
| 0.40 | 10.800 | 5.400 | 2.700 | 1.800 | 1.350 | 1.080 | 0.900 | 0.771 | 0.675 | 0.600 |
| 0.60 | 16.200 | 8.100 | 4.050 | 2.700 | 2.025 | 1.620 | 1.350 | 1.157 | 1.013 | 0.900 |
| 0.80 | 21.600 | 10.800 | 5.400 | 3.600 | 2.700 | 2.160 | 1.800 | 1.543 | 1.350 | 1.200 |
| 1.00 | 27.000 | 13.500 | 6.750 | 4.500 | 3.375 | 2.700 | 2.250 | 1.929 | 1.688 | 1.500 |
| **IEC CURVE C** | | | | | | | | | | |
| 0.05 | 3.200 | 1.333 | 0.500 | 0.267 | 0.167 | 0.114 | 0.083 | 0.063 | 0.050 | 0.040 |
| 0.10 | 6.400 | 2.667 | 1.000 | 0.533 | 0.333 | 0.229 | 0.167 | 0.127 | 0.100 | 0.081 |
| 0.20 | 12.800 | 5.333 | 2.000 | 1.067 | 0.667 | 0.457 | 0.333 | 0.254 | 0.200 | 0.162 |
| 0.40 | 25.600 | 10.667 | 4.000 | 2.133 | 1.333 | 0.914 | 0.667 | 0.508 | 0.400 | 0.323 |
| 0.60 | 38.400 | 16.000 | 6.000 | 3.200 | 2.000 | 1.371 | 1.000 | 0.762 | 0.600 | 0.485 |
| 0.80 | 51.200 | 21.333 | 8.000 | 4.267 | 2.667 | 1.829 | 1.333 | 1.016 | 0.800 | 0.646 |
| 1.00 | 64.000 | 26.667 | 10.000 | 5.333 | 3.333 | 2.286 | 1.667 | 1.270 | 1.000 | 0.808 |
| **IEC SHORT TIME** | | | | | | | | | | |
| 0.05 | 0.153 | 0.089 | 0.056 | 0.044 | 0.038 | 0.034 | 0.031 | 0.029 | 0.027 | 0.026 |
| 0.10 | 0.306 | 0.178 | 0.111 | 0.088 | 0.075 | 0.067 | 0.062 | 0.058 | 0.054 | 0.052 |
| 0.20 | 0.612 | 0.356 | 0.223 | 0.175 | 0.150 | 0.135 | 0.124 | 0.115 | 0.109 | 0.104 |
| 0.40 | 1.223 | 0.711 | 0.445 | 0.351 | 0.301 | 0.269 | 0.247 | 0.231 | 0.218 | 0.207 |
| 0.60 | 1.835 | 1.067 | 0.668 | 0.526 | 0.451 | 0.404 | 0.371 | 0.346 | 0.327 | 0.311 |
| 0.80 | 2.446 | 1.423 | 0.890 | 0.702 | 0.602 | 0.538 | 0.494 | 0.461 | 0.435 | 0.415 |
| 1.00 | 3.058 | 1.778 | 1.113 | 0.877 | 0.752 | 0.673 | 0.618 | 0.576 | 0.544 | 0.518 |

**IAC CURVES:**

The curves for the General Electric type IAC relay family are derived from the formulae:

$$T = \text{TDM} \times \left( A + \frac{B}{(I/I_{pkp}) - C} + \frac{D}{((I/I_{pkp}) - C)^2} + \frac{E}{((I/I_{pkp}) - C)^3} \right), \ T_{RESET} = \text{TDM} \times \left[ \frac{t_r}{(I/I_{pkp})^2 - 1} \right] \quad \textbf{(EQ 5.8)}$$

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 5–14: 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 5–15: IAC CURVE TRIP TIMES**

| MULTIPLIER (TDM) | CURRENT ( $I / I_{pickup}$ ) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 |
| **IAC EXTREMELY INVERSE** | | | | | | | | | | |
| 0.5 | 1.699 | 0.749 | 0.303 | 0.178 | 0.123 | 0.093 | 0.074 | 0.062 | 0.053 | 0.046 |
| 1.0 | 3.398 | 1.498 | 0.606 | 0.356 | 0.246 | 0.186 | 0.149 | 0.124 | 0.106 | 0.093 |
| 2.0 | 6.796 | 2.997 | 1.212 | 0.711 | 0.491 | 0.372 | 0.298 | 0.248 | 0.212 | 0.185 |
| 4.0 | 13.591 | 5.993 | 2.423 | 1.422 | 0.983 | 0.744 | 0.595 | 0.495 | 0.424 | 0.370 |
| 6.0 | 20.387 | 8.990 | 3.635 | 2.133 | 1.474 | 1.115 | 0.893 | 0.743 | 0.636 | 0.556 |
| 8.0 | 27.183 | 11.987 | 4.846 | 2.844 | 1.966 | 1.487 | 1.191 | 0.991 | 0.848 | 0.741 |
| 10.0 | 33.979 | 14.983 | 6.058 | 3.555 | 2.457 | 1.859 | 1.488 | 1.239 | 1.060 | 0.926 |
| **IAC VERY INVERSE** | | | | | | | | | | |
| 0.5 | 1.451 | 0.656 | 0.269 | 0.172 | 0.133 | 0.113 | 0.101 | 0.093 | 0.087 | 0.083 |
| 1.0 | 2.901 | 1.312 | 0.537 | 0.343 | 0.266 | 0.227 | 0.202 | 0.186 | 0.174 | 0.165 |
| 2.0 | 5.802 | 2.624 | 1.075 | 0.687 | 0.533 | 0.453 | 0.405 | 0.372 | 0.349 | 0.331 |
| 4.0 | 11.605 | 5.248 | 2.150 | 1.374 | 1.065 | 0.906 | 0.810 | 0.745 | 0.698 | 0.662 |
| 6.0 | 17.407 | 7.872 | 3.225 | 2.061 | 1.598 | 1.359 | 1.215 | 1.117 | 1.046 | 0.992 |
| 8.0 | 23.209 | 10.497 | 4.299 | 2.747 | 2.131 | 1.813 | 1.620 | 1.490 | 1.395 | 1.323 |
| 10.0 | 29.012 | 13.121 | 5.374 | 3.434 | 2.663 | 2.266 | 2.025 | 1.862 | 1.744 | 1.654 |
| **IAC INVERSE** | | | | | | | | | | |
| 0.5 | 0.578 | 0.375 | 0.266 | 0.221 | 0.196 | 0.180 | 0.168 | 0.160 | 0.154 | 0.148 |
| 1.0 | 1.155 | 0.749 | 0.532 | 0.443 | 0.392 | 0.360 | 0.337 | 0.320 | 0.307 | 0.297 |
| 2.0 | 2.310 | 1.499 | 1.064 | 0.885 | 0.784 | 0.719 | 0.674 | 0.640 | 0.614 | 0.594 |
| 4.0 | 4.621 | 2.997 | 2.128 | 1.770 | 1.569 | 1.439 | 1.348 | 1.280 | 1.229 | 1.188 |
| 6.0 | 6.931 | 4.496 | 3.192 | 2.656 | 2.353 | 2.158 | 2.022 | 1.921 | 1.843 | 1.781 |
| 8.0 | 9.242 | 5.995 | 4.256 | 3.541 | 3.138 | 2.878 | 2.695 | 2.561 | 2.457 | 2.375 |
| 10.0 | 11.552 | 7.494 | 5.320 | 4.426 | 3.922 | 3.597 | 3.369 | 3.201 | 3.072 | 2.969 |
| **IAC SHORT INVERSE** | | | | | | | | | | |
| 0.5 | 0.072 | 0.047 | 0.035 | 0.031 | 0.028 | 0.027 | 0.026 | 0.026 | 0.025 | 0.025 |
| 1.0 | 0.143 | 0.095 | 0.070 | 0.061 | 0.057 | 0.054 | 0.052 | 0.051 | 0.050 | 0.049 |
| 2.0 | 0.286 | 0.190 | 0.140 | 0.123 | 0.114 | 0.108 | 0.105 | 0.102 | 0.100 | 0.099 |
| 4.0 | 0.573 | 0.379 | 0.279 | 0.245 | 0.228 | 0.217 | 0.210 | 0.204 | 0.200 | 0.197 |
| 6.0 | 0.859 | 0.569 | 0.419 | 0.368 | 0.341 | 0.325 | 0.314 | 0.307 | 0.301 | 0.296 |
| 8.0 | 1.145 | 0.759 | 0.559 | 0.490 | 0.455 | 0.434 | 0.419 | 0.409 | 0.401 | 0.394 |
| 10.0 | 1.431 | 0.948 | 0.699 | 0.613 | 0.569 | 0.542 | 0.524 | 0.511 | 0.501 | 0.493 |

**I2t CURVES:**

The curves for the I$^2$t are derived from the formulae:

$$T = \text{TDM} \times \left[ \frac{100}{\left( \frac{I}{I_{pickup}} \right)^2} \right], \ T_{RESET} = \text{TDM} \times \left[ \frac{100}{\left( \frac{I}{I_{pickup}} \right)^{-2}} \right]$$     **(EQ 5.9)**

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 5–16: I$^2$T 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:

$$T = \text{TDM} \times \left[ \text{FlexCurve Time at} \left( \frac{I}{I_{pickup}} \right) \right] \quad \text{when} \left( \frac{I}{I_{pickup}} \right) \geq 1.00$$     **(EQ 5.10)**

$$T_{RESET} = \text{TDM} \times \left[ \text{FlexCurve Time at} \left( \frac{I}{I_{pickup}} \right) \right] \quad \text{when} \left( \frac{I}{I_{pickup}} \right) \leq 0.98$$     **(EQ 5.11)**

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.

$$T = \text{TDM} \text{ in seconds, when } I > I_{pickup}$$     **(EQ 5.12)**

$$T_{RESET} = -\text{TDM} \text{ in seconds}$$     **(EQ 5.13)**

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 C60 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**<br>**FUNCTION: Disabled** — *Range: Disabled, Enabled* |

| | | |
|---|---|---|
| MESSAGE | ▲▼ | **PHASE TOC1 SIGNAL**<br>**SOURCE: SRC 1** — *Range: SRC 1, SRC 2, SRC 3, SRC 4* |
| MESSAGE | ▲▼ | **PHASE TOC1**<br>**INPUT: Phasor** — *Range: Phasor, RMS* |
| MESSAGE | ▲▼ | **PHASE TOC1**<br>**PICKUP: 1.000 pu** — *Range: 0.000 to 30.000 pu in steps of 0.001* |
| MESSAGE | ▲▼ | **PHASE TOC1**<br>**CURVE: IEEE Mod Inv** — *Range: See Overcurrent Curve Types table* |
| MESSAGE | ▲▼ | **PHASE TOC1**<br>**TD MULTIPLIER: 1.00** — *Range: 0.00 to 600.00 in steps of 0.01* |
| MESSAGE | ▲▼ | **PHASE TOC1**<br>**RESET: Instantaneous** — *Range: Instantaneous, Timed* |
| MESSAGE | ▲▼ | **PHASE TOC1 VOLTAGE**<br>**RESTRAINT: Disabled** — *Range: Disabled, Enabled* |
| MESSAGE | ▲▼ | **PHASE TOC1 BLOCK A:**<br>**Off** — *Range: FlexLogic™ operand* |
| MESSAGE | ▲▼ | **PHASE TOC1 BLOCK B:**<br>**Off** — *Range: FlexLogic™ operand* |
| MESSAGE | ▲▼ | **PHASE TOC1 BLOCK C:**<br>**Off** — *Range: FlexLogic™ operand* |
| MESSAGE | ▲▼ | **PHASE TOC1**<br>**TARGET: Self-reset** — *Range: Self-reset, Latched, Disabled* |
| MESSAGE | ▲ | **PHASE TOC1**<br>**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 *TOC 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.
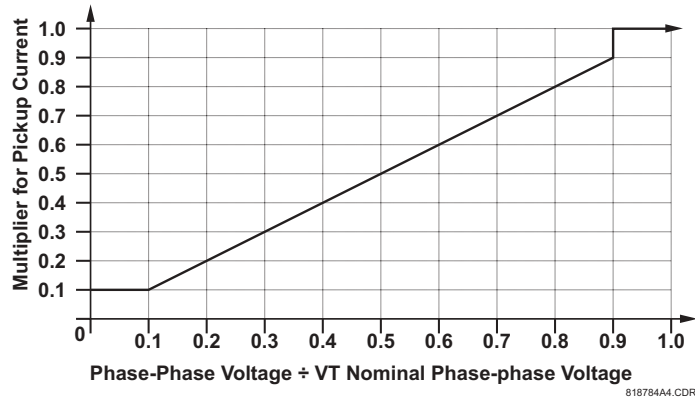
**Figure 5–43: PHASE TOC VOLTAGE RESTRAINT CHARACTERISTIC**
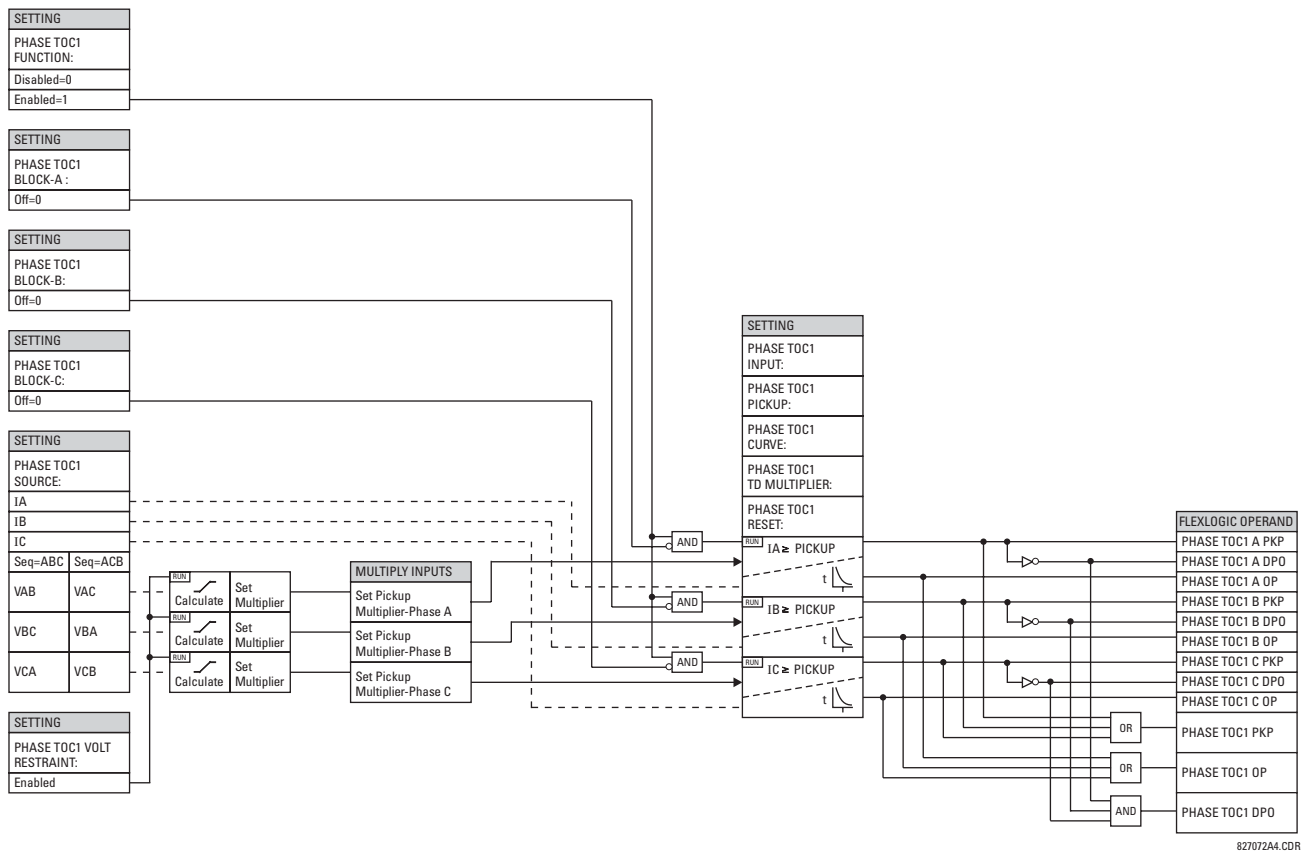


**Figure 5–44: PHASE TOC1 SCHEME LOGIC**

### d) PHASE INSTANTANEOUS OVERCURRENT (ANSI 50P)

**PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨ PHASE CURRENT ⇨ PHASE IOC 1(8)**

| ■ PHASE IOC1<br>■ | ◀▷ | PHASE IOC1<br>FUNCTION: Disabled | *Range: Disabled, Enabled* |
|---|---|---|---|
| | MESSAGE | PHASE IOC1 SIGNAL<br>SOURCE: SRC 1 | *Range: SRC 1, SRC 2, SRC 3, SRC 4* |
| | MESSAGE | PHASE IOC1<br>PICKUP: 1.000 pu | *Range: 0.000 to 30.000 pu in steps of 0.001* |
| | MESSAGE | PHASE IOC1 PICKUP<br>DELAY: 0.00 s | *Range: 0.00 to 600.00 s in steps of 0.01* |
| | MESSAGE | PHASE IOC1 RESET<br>DELAY: 0.00 s | *Range: 0.00 to 600.00 s in steps of 0.01* |
| | MESSAGE | PHASE IOC1 BLOCK A:<br>Off | *Range: FlexLogic™ operand* |
| | MESSAGE | PHASE IOC1 BLOCK B:<br>Off | *Range: FlexLogic™ operand* |
| | MESSAGE | PHASE IOC1 BLOCK C:<br>Off | *Range: FlexLogic™ operand* |
| | MESSAGE | PHASE IOC1<br>TARGET: Self-reset | *Range: Self-reset, Latched, Disabled* |
| | MESSAGE | PHASE IOC1<br>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.
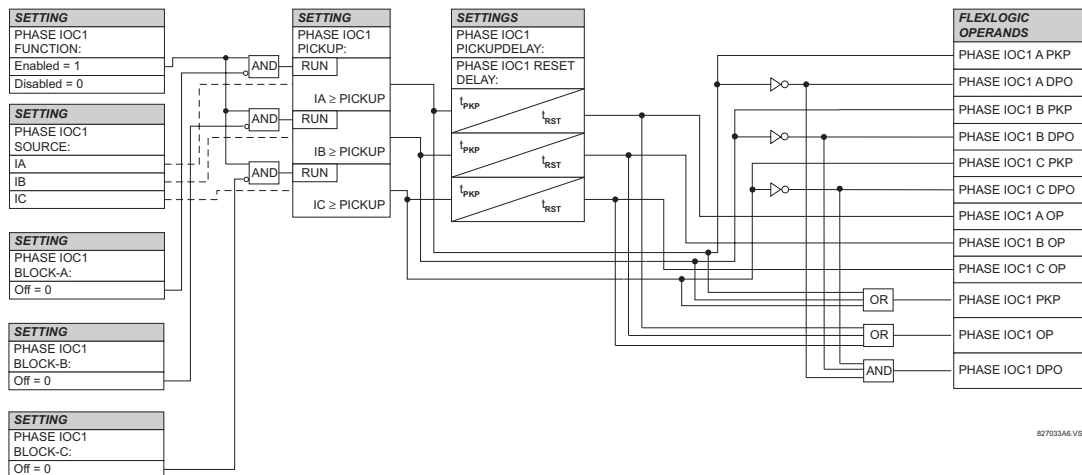


**Figure 5–45: PHASE IOC1 SCHEME LOGIC**

**a) MAIN MENU**

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

| | | | |
|---|---|---|---|
| ■ NEUTRAL CURRENT ■ | ◀▯▶ | ■ NEUTRAL TOC1 ■ | See page 5–94. |
| MESSAGE ▲▼ | | ■ NEUTRAL TOC2 ■ | |
| MESSAGE ▲▼ | | ■ NEUTRAL TOC3 ■ | |
| MESSAGE ▲▼ | | ■ NEUTRAL TOC4 ■ | |
| MESSAGE ▲▼ | | ■ NEUTRAL TOC5 ■ | *Note:* *Seen only if slot F or slot M has an 8H or 8J CT module installed.* |
| MESSAGE ▲▼ | | ■ NEUTRAL TOC6 ■ | *Note:* *Seen only if slot F or slot M has an 8H or 8J CT module installed.* |
| MESSAGE ▲▼ | | ■ NEUTRAL IOC1 ■ | See page 5–95. |
| MESSAGE ▲▼ | | ■ NEUTRAL IOC2 ■ | |
| MESSAGE ▲▼ | | ■ NEUTRAL IOC3 ■ | |
| MESSAGE ▲▼ | | ■ NEUTRAL IOC4 ■ | |
| MESSAGE ▲▼ | | ■ NEUTRAL IOC5 ■ | *Note:* *Seen only if slot F or slot M has an 8H or 8J CT module installed.* |
| MESSAGE ▲▼ | | ■ NEUTRAL IOC6 ■ | *Note:* *Seen only if slot F or slot M has an 8H or 8J CT module installed.* |
| MESSAGE ▲▼ | | ■ NEUTRAL IOC7 ■ | *Note:* *Seen only if slot F and slot M have 8H or 8J CT modules installed.* |
| MESSAGE ▲ | | ■ NEUTRAL IOC8 ■ | *Note:* *Seen only if slot F and slot M have 8H or 8J CT modules installed.* |

The C60 contains protection elements for neutral time overcurrent (ANSI device 51N) and neutral instantaneous overcurrent (ANSI device 50N). A maximum of six neutral time overcurrent elements and eight neutral instantaneous overcurrent elements are available, dependent on the CT/VT modules ordered with the relay. See the following table for details.

| CT/VT MODULES | | NUMBER OF ELEMENTS | |
|---|---|---|---|
| SLOT F | SLOT M | NEUTRAL TOC | NEUTRAL IOC |
| 8F/8G | 8F/8G | 4 | 4 |
| 8F/8G | 8H/8J | 6 | 6 |
| 8H/8J | 8F/8G | 6 | 6 |
| 8H/8J | 8H/8J | 6 | 8 |

### b) NEUTRAL TIME OVERCURRENT (ANSI 51N)

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

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

The Neutral Time Overcurrent element can provide a desired time-delay operating characteristic versus the applied current or be used as a simple Definite Time element. The neutral current input value is a quantity calculated as 3Io from the phase currents and may be programmed as fundamental phasor magnitude or total waveform RMS magnitude as required by the application.

Two methods of resetting operation are available: "Timed" and "Instantaneous" (refer to the *Inverse TOC 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.
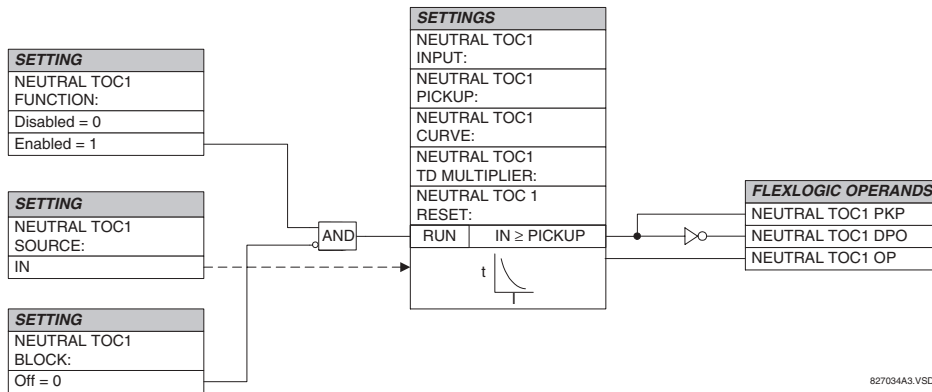


**Figure 5–46: NEUTRAL TOC1 SCHEME LOGIC**

### c) NEUTRAL INSTANTANEOUS OVERCURRENT  (ANSI 50N)

**PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ NEUTRAL CURRENT ⇨⇩ NEUTRAL IOC1(8)**

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

The Neutral Instantaneous Overcurrent element may be used as an instantaneous function with no intentional delay or as a Definite Time function. The element essentially responds to the magnitude of a neutral current fundamental frequency phasor calculated from the phase currents. A "positive-sequence restraint" is applied for better performance. A small portion (6.25%) of the positive-sequence current magnitude is subtracted from the zero-sequence current magnitude when forming the operating quantity of the element as follows:

$$I_{op} = 3 \times (|I\_0| - K \cdot |I\_1|) \quad \text{where } K = 1/16 \tag{EQ 5.14}$$

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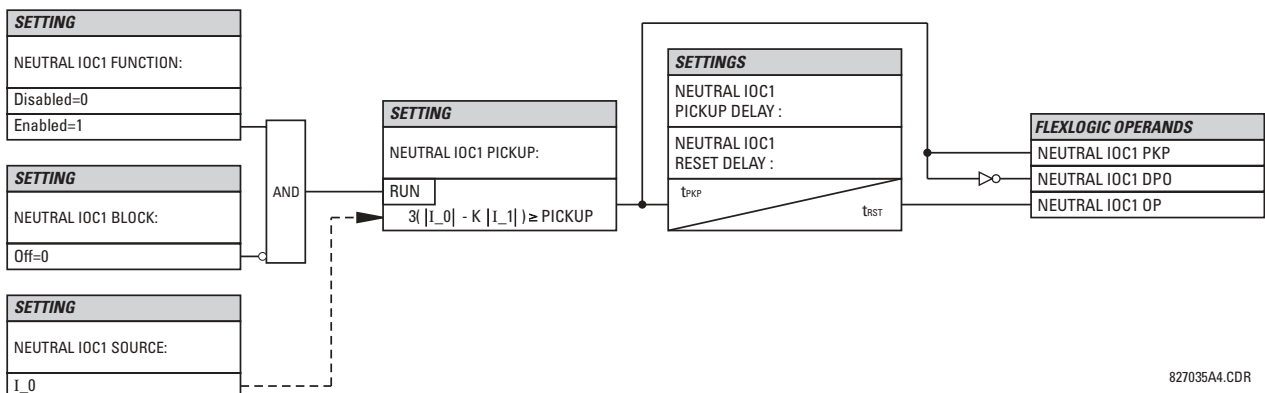


**Figure 5–47: NEUTRAL IOC1 SCHEME LOGIC**

**a) MAIN MENU**

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

| | | | |
|---|---|---|---|
| ■ GROUND CURRENT ■ | ◀▷ | ■ GROUND TOC1 ■ | See page 5–97. |
| MESSAGE | ⬆⬇ | ■ GROUND TOC2 ■ | |
| MESSAGE | ⬆⬇ | ■ GROUND TOC3 ■ | |
| MESSAGE | ⬆⬇ | ■ GROUND TOC4 ■ | |
| MESSAGE | ⬆⬇ | ■ GROUND TOC5 ■ | *Note:* *Seen only if slot F or slot M has an 8H or 8J CT module installed.* |
| MESSAGE | ⬆⬇ | ■ GROUND TOC6 ■ | *Note:* *Seen only if slot F or slot M has an 8H or 8J CT module installed.* |
| MESSAGE | ⬆⬇ | ■ GROUND IOC1 ■ | See page 5–95. |
| MESSAGE | ⬆⬇ | ■ GROUND IOC2 ■ | |
| MESSAGE | ⬆⬇ | ■ GROUND IOC3 ■ | |
| MESSAGE | ⬆⬇ | ■ GROUND IOC4 ■ | |
| MESSAGE | ⬆⬇ | ■ GROUND IOC5 ■ | *Note:* *Seen only if slot F or slot M has an 8H or 8J CT module installed.* |
| MESSAGE | ⬆⬇ | ■ GROUND IOC6 ■ | *Note:* *Seen only if slot F or slot M has an 8H or 8J CT module installed.* |
| MESSAGE | ⬆⬇ | ■ GROUND IOC7 ■ | *Note:* *Seen only if slot F and slot M have an 8H or 8J CT module installed.* |
| MESSAGE | ⬆ | ■ GROUND IOC8 ■ | *Note:* *Seen only if slot F and slot M have 8H or 8J CT modules installed.* |

The C60 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 | | NUMBER OF ELEMENTS | |
|---|---|---|---|
| SLOT F | SLOT M | GROUND TOC | GROUND IOC |
| 8F/8G | 8F/8G | 4 | 4 |
| 8F/8G | 8H/8J | 6 | 6 |
| 8H/8J | 8F/8G | 6 | 6 |
| 8H/8J | 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<br>■ | ◀▶ | GROUND TOC1<br>FUNCTION: Disabled | Range: Disabled, Enabled |
|---|---|---|---|
| MESSAGE | ▲▼ | GROUND TOC1 SIGNAL<br>SOURCE: SRC 1 | Range: SRC 1, SRC 2, SRC 3, SRC 4 |
| MESSAGE | ▲▼ | GROUND TOC1<br>INPUT: Phasor | Range: Phasor, RMS |
| MESSAGE | ▲▼ | GROUND TOC1<br>PICKUP:   1.000 pu | Range: 0.000 to 30.000 pu in steps of 0.001 |
| MESSAGE | ▲▼ | GROUND TOC1<br>CURVE: IEEE Mod Inv | Range: see the Overcurrent Curve Types table |
| MESSAGE | ▲▼ | GROUND TOC1<br>TD MULTIPLIER:   1.00 | Range: 0.00 to 600.00 in steps of 0.01 |
| MESSAGE | ▲▼ | GROUND TOC1<br>RESET: Instantaneous | Range: Instantaneous, Timed |
| MESSAGE | ▲▼ | GROUND TOC1 BLOCK:<br>Off | Range: FlexLogic™ operand |
| MESSAGE | ▲▼ | GROUND TOC1<br>TARGET: Self-reset | Range: Self-reset, Latched, Disabled |
| MESSAGE | ▲ | GROUND TOC1<br>EVENTS: Disabled | Range: Disabled, Enabled |

This element can provide a desired time-delay operating characteristic versus the applied current or be used as a simple Definite Time element. The ground current input value is the quantity measured by the ground input CT and is the fundamental phasor or RMS magnitude. Two methods of resetting operation are available; "Timed" and "Instantaneous" (refer to the *Inverse Time Overcurrent Curve Characteristics* section for details). When the element is blocked, the time accumulator will reset according to the reset characteristic. For example, if the element reset characteristic is set to "Instantaneous" and the element is blocked, the time accumulator will be cleared immediately.

**NOTE**  These elements measure the current that is connected to the ground channel of a CT/VT module. This channel may be equipped with a standard or sensitive input. The conversion range of a standard channel is from 0.02 to 46 times the CT rating. The conversion range of a sensitive channel is from 0.002 to 4.6 times the CT rating.
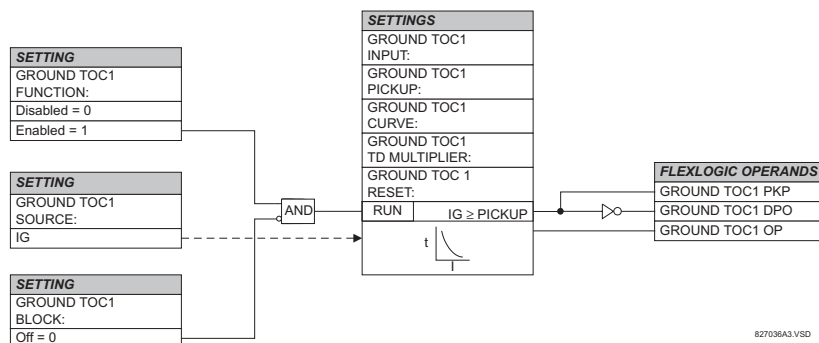


**Figure 5–48: GROUND TOC1 SCHEME LOGIC**

### c) GROUND INSTANTANEOUS OVERCURRENT  (ANSI 50G)

**PATH: SETTINGS** ⇨⇩ **GROUPED ELEMENTS** ⇨ **SETTING GROUP 1(6)** ⇨⇩ **GROUND CURRENT** ⇨⇩ **GROUND IOC1(8)**

| | | Range: |
|---|---|---|
| ■ 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* |
| MESSAGE | ▲▼ | GROUND IOC1 PICKUP:  1.000 pu | *Range:  0.000 to 30.000 pu in steps of 0.001* |
| MESSAGE | ▲▼ | GROUND IOC1 PICKUP DELAY:   0.00 s | *Range:  0.00 to 600.00 s in steps of 0.01* |
| MESSAGE | ▲▼ | GROUND IOC1 RESET DELAY:   0.00 s | *Range:  0.00 to 600.00 s in steps of 0.01* |
| MESSAGE | ▲▼ | GROUND IOC1 BLOCK: Off | *Range:  FlexLogic™ operand* |
| MESSAGE | ▲▼ | GROUND IOC1 TARGET: Self-reset | *Range:  Self-reset, Latched, Disabled* |
| MESSAGE | ▲ | GROUND IOC1 EVENTS: Disabled | *Range:  Disabled, Enabled* |

The Ground Instantaneous Overcurrent element may be used as an instantaneous element with no intentional delay or as a Definite Time element. The ground current input is the quantity measured by the ground input CT and is the fundamental phasor magnitude.
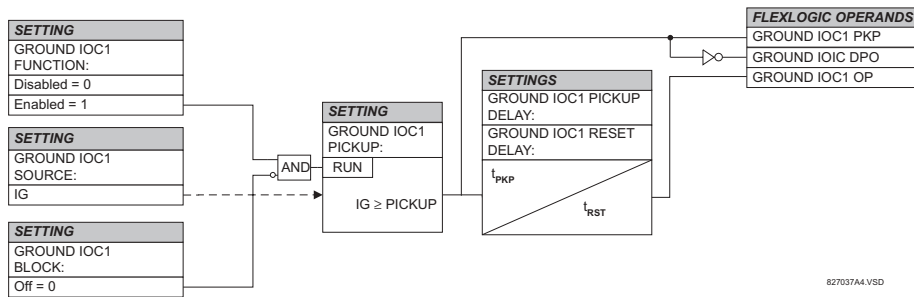


**Figure 5–49: GROUND IOC1 SCHEME LOGIC**

**NOTE** These elements measure the current that is connected to the ground channel of a CT/VT module. This channel may be equipped with a standard or sensitive input. The conversion range of a standard channel is from 0.02 to 46 times the CT rating. The conversion range of a sensitive channel is from 0.002 to 4.6 times the CT rating.

**a) MAIN MENU**

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

| ■ VOLTAGE ELEMENTS ■ | ◀▶ | ■ PHASE ■ UNDERVOLTAGE1 | See page 5–100. |
|---|---|---|---|
| *MESSAGE* ▲▼ | | ■ PHASE ■ UNDERVOLTAGE2 | See page 5–100. |
| *MESSAGE* ▲▼ | | ■ NEUTRAL OV1 ■ | See page 5–101. |
| *MESSAGE* ▲▼ | | ■ AUXILIARY UV1 ■ | See page 5–102. |
| *MESSAGE* ▲ | | ■ AUXILIARY OV1 ■ | See page 5–103. |

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 10 ms. 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.

$$T = \frac{D}{\left(1 - \dfrac{V}{V_{pickup}}\right)}$$

where:   $T$ = Operating Time
         $D$ = Undervoltage Delay Setting
             ($D$ = 0.00 operates instantaneously)
         $V$ = Secondary Voltage applied to the relay
         $V_{pickup}$ = Pickup Level

**NOTE**  **At 0% of pickup, the operating time equals the UNDERVOLTAGE DELAY setting.**
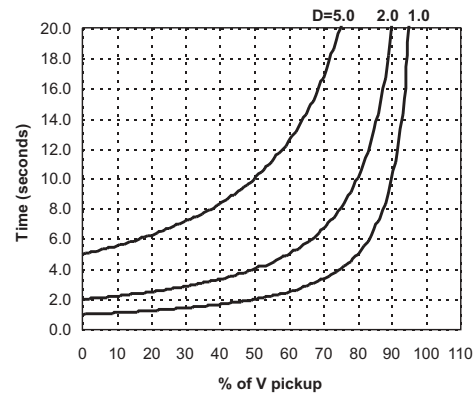
**Figure 5–50: INVERSE TIME UNDERVOLTAGE CURVES**

## b) PHASE UNDERVOLTAGE (ANSI 27P)

**PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ VOLTAGE ELEMENTS ⇨ PHASE UNDERVOLTAGE1(2)**

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

This element may be used to give a desired time-delay operating characteristic versus the applied fundamental voltage (phase-to-ground or phase-to-phase for Wye VT connection, or phase-to-phase for Delta VT connection) or as a Definite Time element. The element resets instantaneously if the applied voltage exceeds the dropout voltage. The delay setting selects the minimum operating time of the phase undervoltage. The minimum voltage setting selects the operating voltage below which the element is blocked (a setting of "0" will allow a dead source to be considered a fault condition).
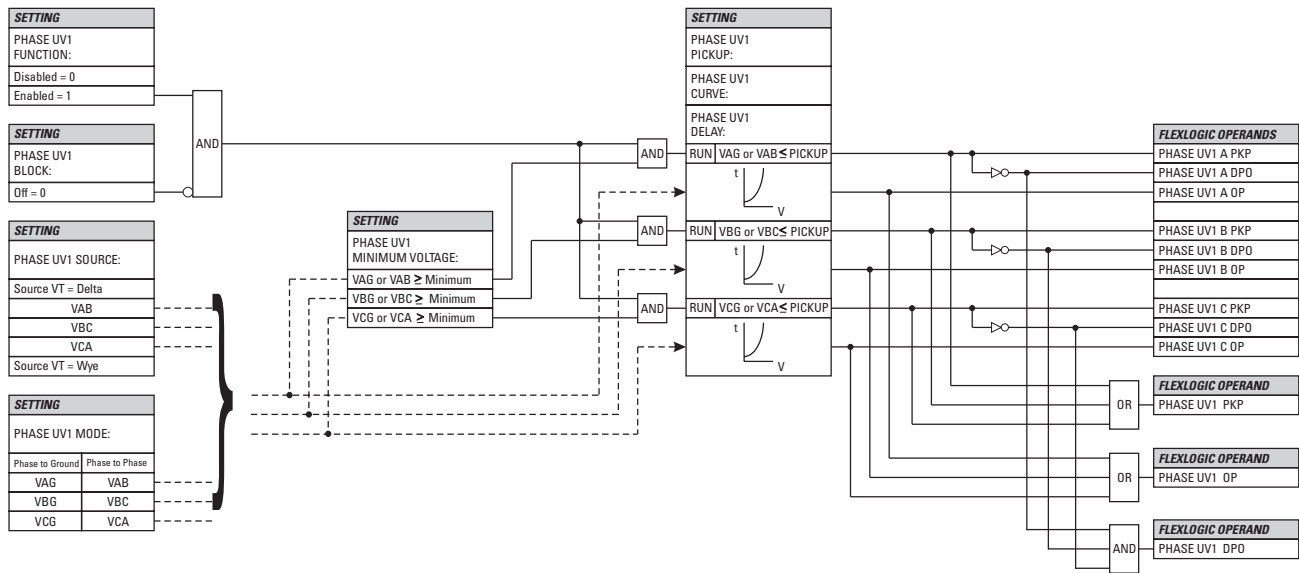


**Figure 5–51: PHASE UNDERVOLTAGE1 SCHEME LOGIC**

**c) NEUTRAL OVERVOLTAGE** (ANSI 59N)

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

| ■ NEUTRAL OV1 ■ | ◄▶ | NEUTRAL OV1 FUNCTION: Disabled | Range: Disabled, Enabled |
|---|---|---|---|
| MESSAGE | ▲▼ | NEUTRAL OV1 SIGNAL SOURCE: SRC 1 | Range: SRC 1, SRC 2, SRC 3, SRC 4 |
| MESSAGE | ▲▼ | NEUTRAL OV1 PICKUP: 0.300 pu | Range: 0.000 to 1.250 pu in steps of 0.001 |
| 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 |

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.

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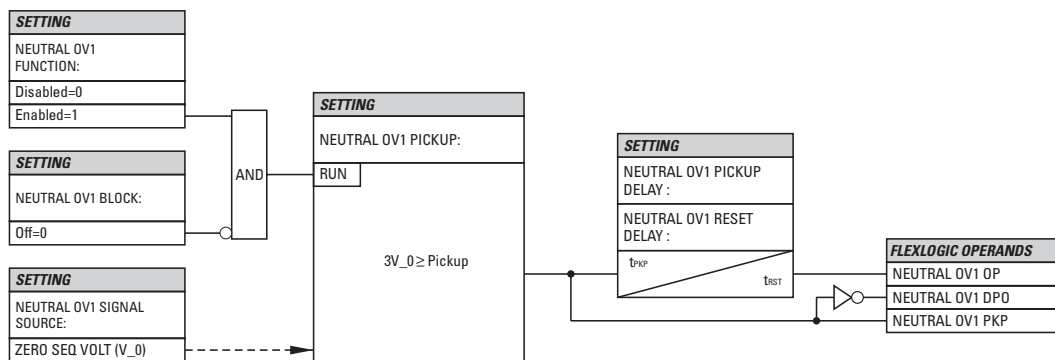


**Figure 5–52: NEUTRAL OVERVOLTAGE1 SCHEME LOGIC**

### d) AUXILIARY UNDERVOLTAGE (ANSI 27X)

**PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ VOLTAGE ELEMENTS ⇨⇩ AUXILIARY UV1**

| ■ AUXILIARY UV1 ■ | | AUX UV1 FUNCTION: Disabled | *Range: Disabled, Enabled* |
|---|---|---|---|
| | MESSAGE | AUX UV1 SIGNAL SOURCE: SRC 1 | *Range: SRC 1, SRC 2, SRC 3, SRC 4* |
| | MESSAGE | AUX UV1 PICKUP: 0.700 pu | *Range: 0.000 to 3.000 pu in steps of 0.001* |
| | MESSAGE | AUX UV1 CURVE: Definite Time | *Range: Definite Time, Inverse Time* |
| | MESSAGE | AUX UV1 DELAY: 1.00 s | *Range: 0.00 to 600.00 s in steps of 0.01* |
| | MESSAGE | AUX UV1 MINIMUM: VOLTAGE: 0.100 pu | *Range: 0.000 to 3.000 pu in steps of 0.001* |
| | MESSAGE | AUX UV1 BLOCK: Off | *Range: FlexLogic™ operand* |
| | MESSAGE | AUX UV1 TARGET: Self-reset | *Range: Self-reset, Latched, Disabled* |
| | MESSAGE | AUX UV1 EVENTS: Disabled | *Range: Disabled, Enabled* |

This element is intended for monitoring undervoltage conditions of the auxiliary voltage. The **AUX UV1 PICKUP** selects the voltage level at which the time undervoltage element starts timing. The nominal secondary voltage of the auxiliary voltage channel entered under **SETTINGS ⇨⇩ SYSTEM SETUP ⇨ AC INPUTS ⇨⇩ VOLTAGE BANK X5 ⇨⇩ AUXILIARY VT X5 SECONDARY** is the p.u. base used when setting the pickup level.

The **AUX UV1 DELAY** setting selects the minimum operating time of the auxiliary undervoltage element. Both **AUX UV1 PICKUP** and **AUX UV1 DELAY** settings establish the operating curve of the undervoltage element. The auxiliary undervoltage element can be programmed to use either Definite Time Delay or Inverse Time Delay characteristics. The operating characteristics and equations for both Definite and Inverse Time Delay are as for the Phase Undervoltage element.

The element resets instantaneously. The minimum voltage setting selects the operating voltage below which the element is blocked.
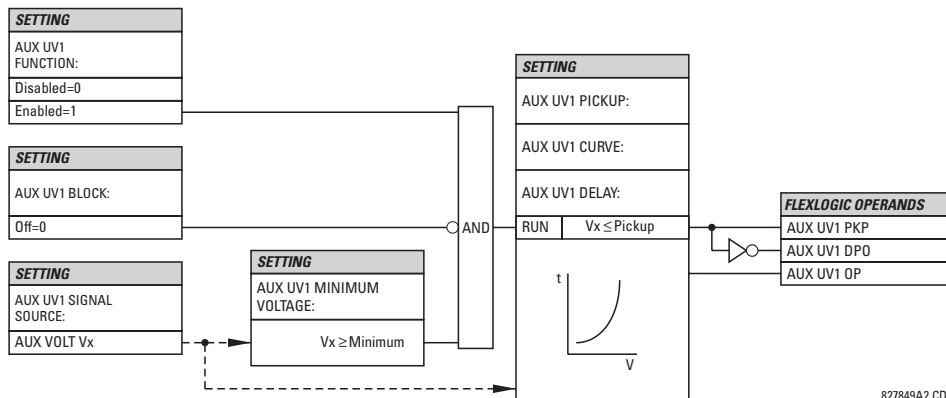


**Figure 5–53: AUXILIARY UNDERVOLTAGE SCHEME LOGIC**

**e) AUXILIARY OVERVOLTAGE**  (ANSI 59X)

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

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

This element is intended for monitoring overvoltage conditions of the auxiliary voltage. A typical application for this element is monitoring the zero-sequence voltage (3V_0) supplied from an open-corner-delta VT connection. The nominal secondary voltage of the auxiliary voltage channel entered under **SYSTEM SETUP ⇨ AC INPUTS ⇩⇨ VOLTAGE BANK X5 ⇩⇨ AUXILIARY VT X5 SECONDARY** is the p.u. base used when setting the pickup level.
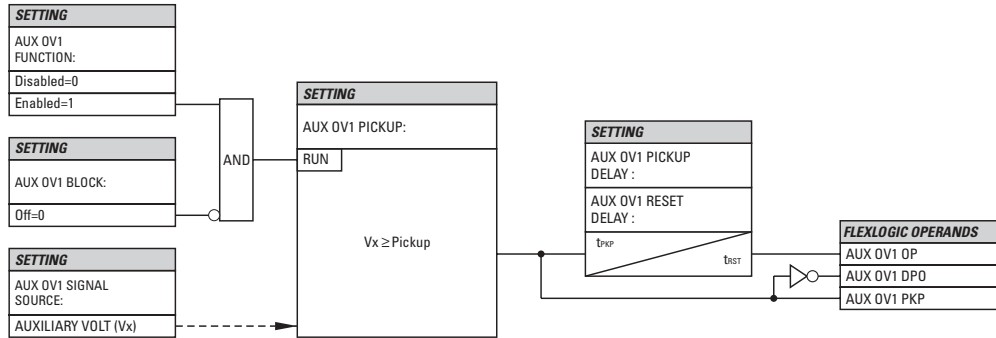


**Figure 5–54: AUXILIARY OVERVOLTAGE SCHEME LOGIC**

**PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ SENSITIVE DIRECTIONAL... ⇨ DIRECTIONAL POWER 1(2)**

| | | | |
|---|---|---|---|
| ■ DIRECTIONAL ■ POWER 1 | ◀▷ | DIR POWER 1 FUNCTION: Disabled | *Range: Disabled, Enabled* |
| MESSAGE | ⏶⏷ | DIR POWER 1 SOURCE: SRC 1 | *Range: SRC 1, SRC 2, SRC 3, SRC 4* |
| MESSAGE | ⏶⏷ | DIR POWER 1 RCA: 0° | *Range: 0 to 359° in steps of 1* |
| MESSAGE | ⏶⏷ | DIR POWER 1 CALIBRATION: 0.00° | *Range: 0 to 0.95° in steps of 0.05* |
| MESSAGE | ⏶⏷ | DIR POWER 1 STG1 SMIN: 0.100 pu | *Range: –1.200 to 1.200 pu in steps of 0.001* |
| MESSAGE | ⏶⏷ | DIR POWER 1 STG1 DELAY: 0.50 s | *Range: 0.00 to 600.00 s in steps of 0.01* |
| MESSAGE | ⏶⏷ | DIR POWER 1 STG2 SMIN: 0.100 pu | *Range: –1.200 to 1.200 pu in steps of 0.001* |
| MESSAGE | ⏶⏷ | DIR POWER 1 STG2 DELAY: 20.00 s | *Range: 0.00 to 600.00 s in steps of 0.01* |
| MESSAGE | ⏶⏷ | DIR POWER 1 BLK: Off | *Range: FlexLogic™ operand* |
| MESSAGE | ⏶⏷ | DIR POWER 1 TARGET: Self-Reset | *Range: Self-Reset, Latched, Disabled* |
| MESSAGE | ⏶ | DIR POWER 1 EVENTS: Disabled | *Range: Disabled, Enabled* |

The Directional Power element responds to three-phase active power and is designed for reverse power and low forward power applications for synchronous machines or interconnections involving co-generation. The relay measures the three-phase power from either full set of wye-connected VTs or full-set of delta-connected VTs. In the latter case, the two-wattmeter method is used. Refer to the *UR Metering Conventions* section in Chapter 6 for conventions regarding the active and reactive powers used by the Directional Power element.

The element has an adjustable characteristic angle and minimum operating power as shown in the Directional Power Characteristic diagram. The element responds to the following condition:

$$P\cos\theta + Q\sin\theta > SMIN \tag{EQ 5.15}$$

where:  $P$ and $Q$ are active and reactive powers as measured per the UR convention,
  $\theta$ is a sum of the element characteristic (**DIR POWER 1 RCA**) and calibration (**DIR POWER 1 CALIBRATION**) angles, and
  $SMIN$ is the minimum operating power

The operating quantity is available for display as under **ACTUAL VALUES ⇨ METERING ⇨⇩ SENSITIVE DIRECTIONAL POWER 1(2)**. The element has two independent (as to the pickup and delay settings) stages for alarm and trip, respectively.
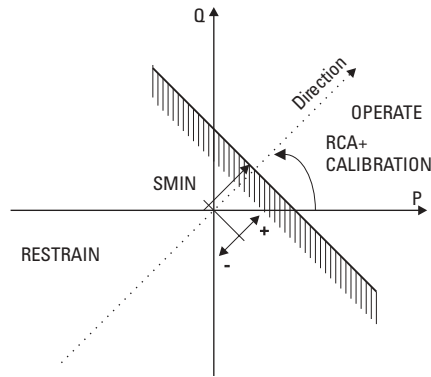
**Figure 5–55: DIRECTIONAL POWER CHARACTERISTIC**

By making the characteristic angle adjustable and providing for both negative and positive values of the minimum operating power a variety of operating characteristics can be achieved as presented in the figure below. For example, Figure (a) below shows settings for reverse power application, while Figure (b) shows settings for low forward power application.
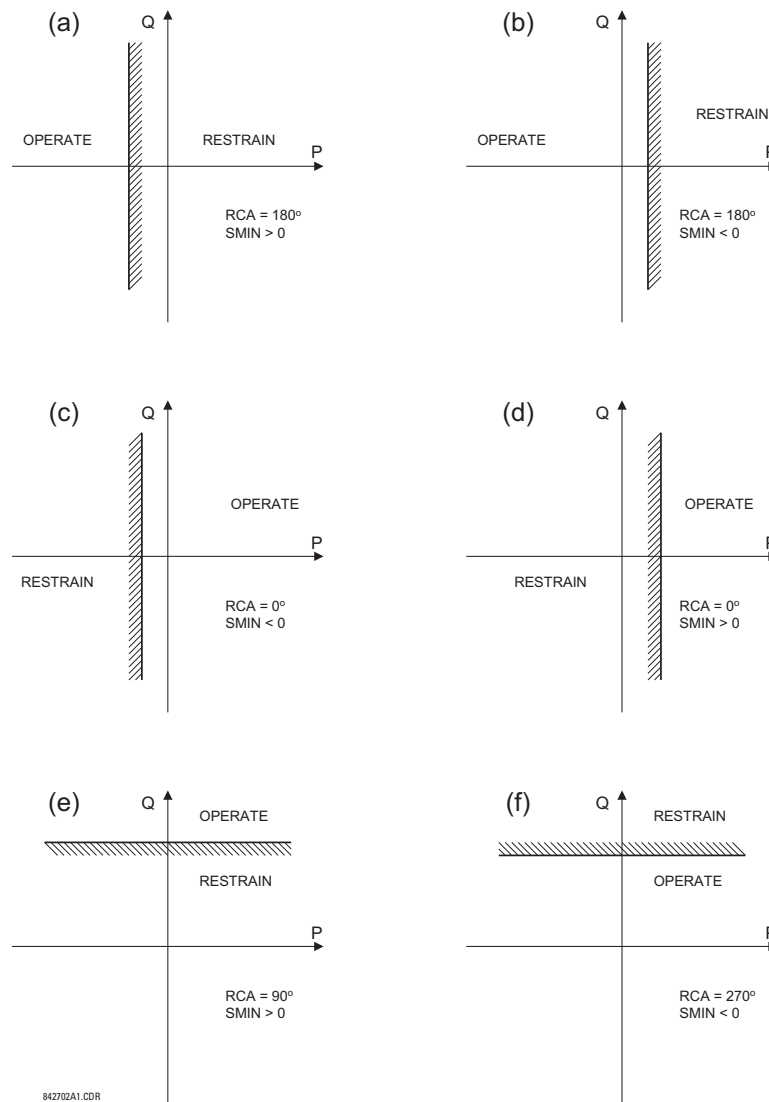


**Figure 5–56: DIRECTIONAL POWER ELEMENT SAMPLE APPLICATIONS**

- **DIR POWER 1(2) RCA:** Specifies the relay characteristic angle (RCA) for the directional power function. Application of this setting is threefold:

  1. It allows the element to respond to active or reactive power in any direction (active overpower/underpower, etc.).

  2. Together with a precise calibration angle, it allows compensation for any CT and VT angular errors to permit more sensitive settings.

  3. It allows for required direction in situations when the voltage signal is taken from behind a delta-wye connected power transformer and the phase angle compensation is required.

  For example, the active overpower characteristic is achieved by setting **DIR POWER 1(2) RCA** to "0°", reactive overpower by setting **DIR POWER 1(2) RCA** to "90°", active underpower by setting **DIR POWER 1(2) RCA** to "180°", and reactive underpower by setting **DIR POWER 1(2) RCA** to "270°".

- **DIR POWER 1(2) CALIBRATION:** This setting allows the RCA to change in small steps of 0.05°. This may be useful when a small difference in VT and CT angular errors is to be compensated to permit more sensitive settings. This setting virtually enables calibration of the Directional Power function in terms of the angular error of applied VTs and CTs.

  The element responds to the sum of the **DIR POWER 1(2) RCA** and **DIR POWER 1(2) CALIBRATION** settings.

- **DIR POWER 1(2) STG1 SMIN:** This setting specifies the minimum power as defined along the RCA angle for the stage 1 of the element. The positive values imply a shift towards the operate region along the RCA line. The negative values imply a shift towards the restrain region along the RCA line. Refer to the *Directional Power Sample Applications* figure for an illustration. Together with the RCA, this setting enables a wide range of operating characteristics. This setting applies to three-phase power and is entered in pu. The base quantity is $3 \times$ VT pu base $\times$ CT pu base.

  For example, a setting of 2% for a 200 MW machine, is $0.02 \times 200$ MW = 4 MW. If 7.967 kV is a primary VT voltage and 10 kA is a primary CT current, the source pu quantity is 239 MVA, and thus, SMIN should be set at 4 MW / 239 MVA = 0.0167 pu ≈ 0.017 pu. If the reverse power application is considered, RCA = 180° and SMIN = 0.017 pu.

  The element drops out if the magnitude of the positive-sequence current becomes virtually zero, that is, it drops below the cutoff level.

- **DIR POWER 1(2) STG1 DELAY:** This setting specifies a time delay for Stage 1. For reverse power or low forward power applications for a synchronous machine, Stage 1 is typically applied for alarming and Stage 2 for tripping.
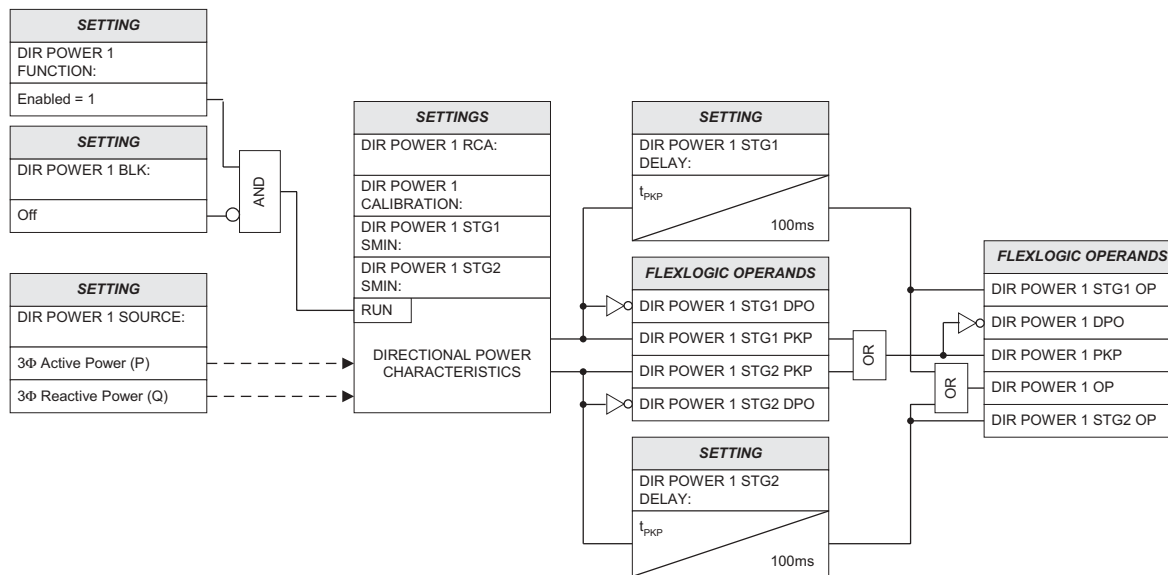


**Figure 5–57: DIRECTIONAL POWER SCHEME LOGIC**

**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**

```
■ SETTING GROUPS        ◁▷    SETTING GROUPS           Range:  Disabled, Enabled
■                             FUNCTION: Disabled

                              SETTING GROUPS BLK:      Range:  FlexLogic™ operand
            MESSAGE           Off

                              GROUP 2 ACTIVATE ON:     Range:  FlexLogic™ operand
            MESSAGE           Off

                                         ↓

                              GROUP 6 ACTIVATE ON:     Range:  FlexLogic™ operand
            MESSAGE           Off

                              SETTING GROUP            Range:  Disabled, Enabled
            MESSAGE           EVENTS: Disabled
```
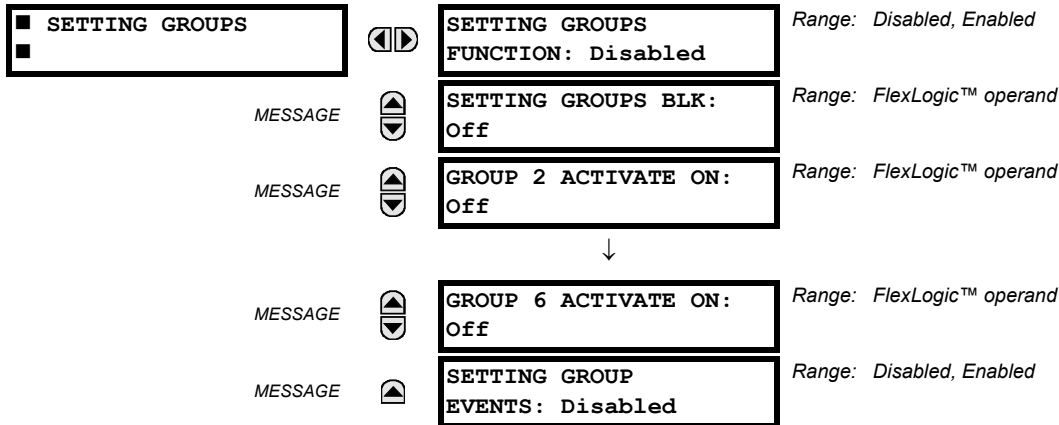
The Setting Groups menu controls the activation/deactivation of up to six possible groups of settings in the **GROUPED ELEMENTS** settings menu. The faceplate 'Settings In Use' LEDs indicate which active group (with a non-flashing energized LED) is in service.

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.

Each **GROUP n ACTIVATE ON** setting selects 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 **GROUP n 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 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 (e.g. VIRTUAL INPUT 1) or from a local contact input (e.g. H7a) 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.
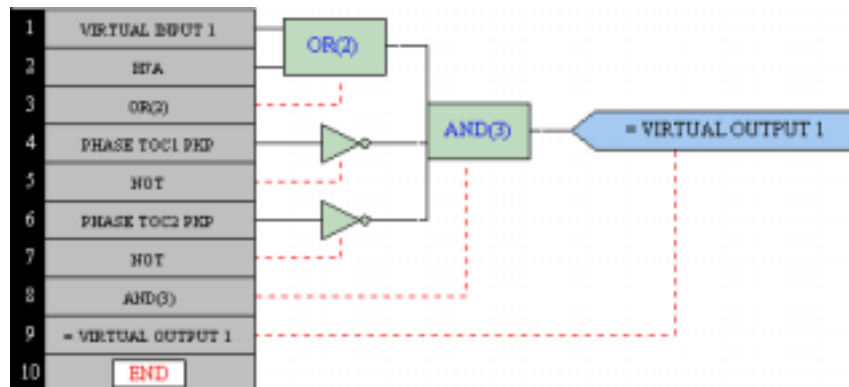


**Figure 5–58: EXAMPLE FLEXLOGIC™ CONTROL OF A SETTINGS GROUP**

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

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

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

The element provides for two control inputs. The step-up control allows stepping through selector position one step at a time with each pulse of the control input, such as a user-programmable pushbutton. The 3-bit control input allows setting the selector to the position defined by a 3-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 3-bit word (user setting). Basic alarm functionality alerts the user under abnormal conditions; e.g. the 3-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 3-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 3-bit control input of the selector. The 3-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 3-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 3-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 3-bit control inputs (**SELECTOR 1 3BIT A0** through **A2**) lock-out mutually: once the stepping up sequence is initiated, the 3-bit control input is inactive; once the 3-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 3-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 3-bit control inputs. Note that the stepping up control input and 3-bit control input have independent acknowledging signals (**SELECTOR 1 ACK** and **SELECTOR 1 3BIT ACK**, accordingly).

- **SELECTOR 1 POWER-UP MODE**: This setting specifies behavior of the element on power up of the relay. When set to "Restore", the last selector position, stored in non-volatile memory, is restored after powering up the relay. When set to "Synchronize", the selector sets to the current 3-bit control input after powering up the relay. This operation does not wait for time-out or the acknowledging input. When powering up, the rest position (0, 0, 0) and the out-of-range 3-bit control words are also ignored, the output is set to Position 0 (no output operand selected), and an alarm is established (SELECTOR 1 PWR ALARM). 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).

- **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 3-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.
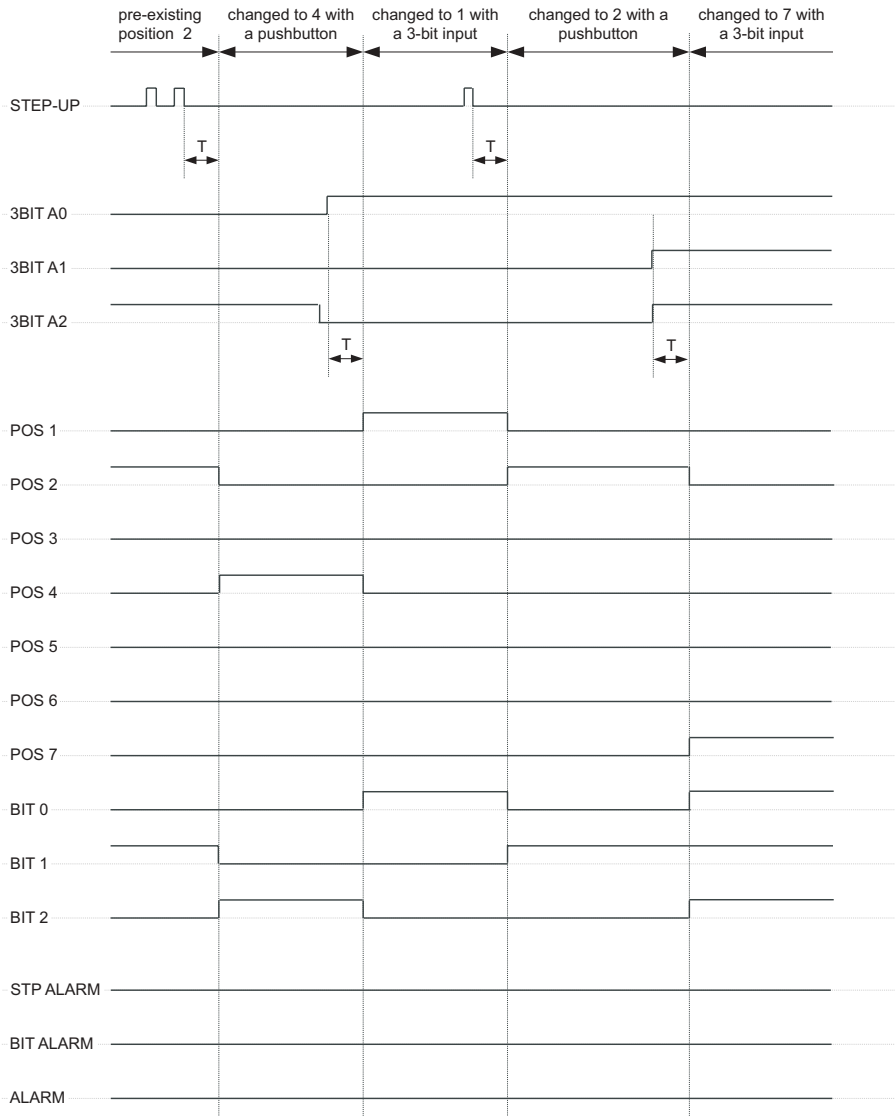


**Figure 5–59: TIME-OUT MODE**
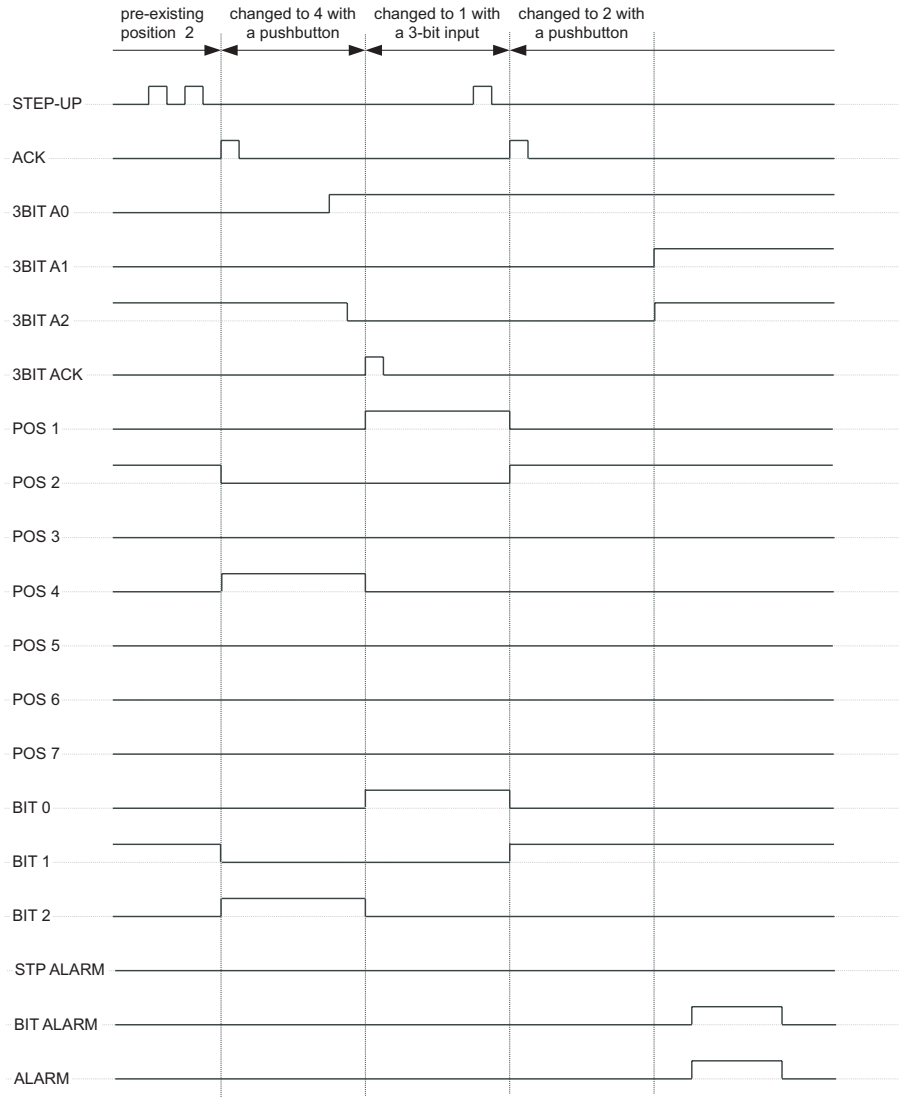
**Figure 5–60: ACKNOWLEDGE MODE**

**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 3-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 3-bit control input.

Make the following changes to Setting Group Control in the **SETTINGS** ⇨⇩ **CONTROL ELEMENTS** ⇨ **SETTING GROUPS** menu:

**SETTING GROUPS FUNCTION:** "Enabled"                **GROUP 4 ACTIVATE ON:** "SELECTOR 1 POS 4"
**SETTING GROUPS BLK:** "Off"                         **GROUP 5 ACTIVATE ON:** "Off"
**GROUP 2 ACTIVATE ON:** "SELECTOR 1 POS 2"           **GROUP 6 ACTIVATE ON:** "Off"
**GROUP 3 ACTIVATE ON:** "SELECTOR 1 POS 3"

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 3BIT A0:** "CONT IP 1 ON"
**SELECTOR 1 FULL-RANGE:** "4"                        **SELECTOR 1 3BIT A1:** "CONT IP 2 ON"
**SELECTOR 1 STEP-UP MODE:** "Time-out"               **SELECTOR 1 3BIT A2:** "CONT IP 3 ON"
**SELECTOR 1 TIME-OUT:** "5.0 s"                      **SELECTOR 1 3BIT MODE:** "Time-out"
**SELECTOR 1 STEP-UP:** "PUSHBUTTON 1 ON"             **SELECTOR 1 3BIT ACK:** "Off"
**SELECTOR 1 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:
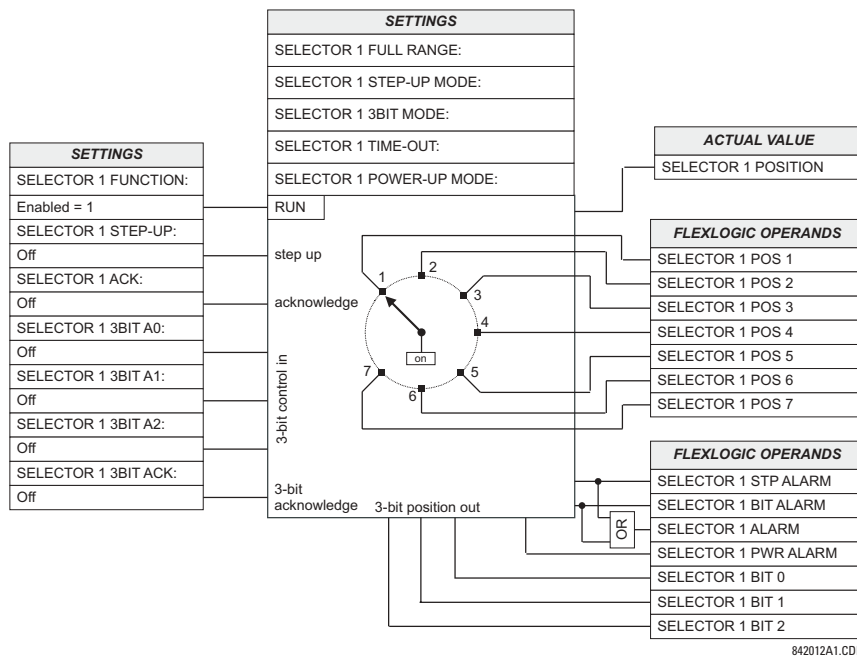


**Figure 5–61: SELECTOR SWITCH LOGIC**

**PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ SYNCHROCHECK ⇨ SYNCHROCHECK 1(2)**

| | | | |
|---|---|---|---|
| ■ SYNCHROCHECK 1 ■ | ◀▶ | SYNCHK1 FUNCTION: Disabled | *Range: Disabled, Enabled* |
| MESSAGE | ▲▼ | SYNCHK1 BLOCK: Off | *Range: FlexLogic™ operand* |
| MESSAGE | ▲▼ | SYNCHK1 V1 SOURCE: SRC 1 | *Range: SRC 1, SRC 2, SRC 3, SRC 4* |
| MESSAGE | ▲▼ | SYNCHK1 V2 SOURCE: SRC 2 | *Range: SRC 1, SRC 2, SRC 3, SRC 4* |
| MESSAGE | ▲▼ | SYNCHK1 MAX VOLT DIFF: 10000 V | *Range: 0 to 100000 V in steps of 1* |
| MESSAGE | ▲▼ | SYNCHK1 MAX ANGLE DIFF: 30° | *Range: 0 to 100° in steps of 1* |
| MESSAGE | ▲▼ | SYNCHK1 MAX FREQ DIFF: 1.00 Hz | *Range: 0.00 to 2.00 Hz in steps of 0.01* |
| MESSAGE | ▲▼ | SYNCHK1 MAX FREQ HYSTERESIS: 0.06 Hz | *Range: 0.00 to 0.10 Hz in steps of 0.01* |
| MESSAGE | ▲▼ | SYNCHK1 DEAD SOURCE SELECT: LV1 and DV2 | *Range: None, LV1 and DV2, DV1 and LV2, DV1 or DV2, DV1 Xor DV2, DV1 and DV2* |
| MESSAGE | ▲▼ | SYNCHK1 DEAD V1 MAX VOLT: 0.30 pu | *Range: 0.00 to 1.25 pu in steps of 0.01* |
| MESSAGE | ▲▼ | SYNCHK1 DEAD V2 MAX VOLT: 0.30 pu | *Range: 0.00 to 1.25 pu in steps of 0.01* |
| MESSAGE | ▲▼ | SYNCHK1 LIVE V1 MIN VOLT: 0.70 pu | *Range: 0.00 to 1.25 pu in steps of 0.01* |
| MESSAGE | ▲▼ | SYNCHK1 LIVE V2 MIN VOLT: 0.70 pu | *Range: 0.00 to 1.25 pu in steps of 0.01* |
| MESSAGE | ▲▼ | SYNCHK1 TARGET: Self-reset | *Range: Self-reset, Latched, Disabled* |
| MESSAGE | ▲ | SYNCHK1 EVENTS: Disabled | *Range: Disabled, Enabled* |

The are two identical synchrocheck elements available, numbered 1 and 2.

The synchronism check function is intended for supervising the paralleling of two parts of a system which are to be joined by the closure of a circuit breaker. The synchrocheck elements are typically used at locations where the two parts of the system are interconnected through at least one other point in the system.

Synchrocheck verifies that the voltages (V1 and V2) on the two sides of the supervised circuit breaker are within set limits of magnitude, angle and frequency differences. The time that the two voltages remain within the admissible angle difference is determined by the setting of the phase angle difference $\Delta\Phi$ and the frequency difference $\Delta F$ (slip frequency). It can be defined as the time it would take the voltage phasor V1 or V2 to traverse an angle equal to $2 \times \Delta\Phi$ at a frequency equal to the frequency difference $\Delta F$. This time can be calculated by:

$$T = \frac{1}{\frac{360°}{2 \times \Delta\Phi} \times \Delta F}$$

**(EQ 5.16)**

where: $\Delta\Phi$ = phase angle difference in degrees; $\Delta F$ = frequency difference in Hz.

As an example; for the default values ($\Delta\Phi = 30°$, $\Delta F = 0.1$ Hz), the time while the angle between the two voltages will be less than the set value is:

$$T = \frac{1}{\dfrac{360°}{2 \times \Delta\Phi} \times \Delta F} = \frac{1}{\dfrac{360°}{2 \times 30°} \times 0.1 \text{ Hz}} = 1.66 \text{ sec.}$$  **(EQ 5.17)**

If one or both sources are de-energized, the synchrocheck programming can allow for closing of the circuit breaker using undervoltage control to by-pass the synchrocheck measurements (Dead Source function).

- **SYNCHK1 V1 SOURCE**: This setting selects the source for voltage V1 (see NOTES below).

- **SYNCHK1 V2 SOURCE**: This setting selects the source for voltage V2, which must not be the same as used for the V1 (see NOTES below).

- **SYNCHK1 MAX VOLT DIFF**: This setting selects the maximum primary voltage difference in 'kV' between the two sources. A primary voltage magnitude difference between the two input voltages below this value is within the permissible limit for synchronism.

- **SYNCHK1 MAX ANGLE DIFF:** This setting selects the maximum angular difference in degrees between the two sources. An angular difference between the two input voltage phasors below this value is within the permissible limit for synchronism.

- **SYNCHK1 MAX FREQ DIFF:** This setting selects the maximum frequency difference in 'Hz' between the two sources. A frequency difference between the two input voltage systems below this value is within the permissible limit for synchronism.

- **SYNCHK1 MAX FREQ HYSTERESIS**: This setting specifies the required hysteresis for the maximum frequency difference condition. The condition becomes satisfied when the frequency difference becomes lower than **SYNCHK1 MAX FREQ DIFF**. Once the Synchrocheck element has operated, the frequency difference must increase above the **SYNCHK1 MAX FREQ DIFF** + **SYNCHK1 MAX FREQ HYSTERESIS** sum to drop out (assuming the other two conditions, voltage and angle, remain satisfied).

- **SYNCHK1 DEAD SOURCE SELECT:** This setting selects the combination of dead and live sources that will by-pass synchronism check function and permit the breaker to be closed when one or both of the two voltages (V1 or/and V2) are below the maximum voltage threshold. A dead or live source is declared by monitoring the voltage level. Six options are available:

| | |
|---|---|
| None: | Dead Source function is disabled |
| LV1 and DV2: | Live V1 and Dead V2 |
| DV1 and LV2: | Dead V1 and Live V2 |
| DV1 or DV2: | Dead V1 or Dead V2 |
| DV1 Xor DV2: | Dead V1 exclusive-or Dead V2 (one source is Dead and the other is Live) |
| DV1 and DV2: | Dead V1 and Dead V2 |

- **SYNCHK1 DEAD V1 MAX VOLT:** This setting establishes a maximum voltage magnitude for V1 in 1 'pu'. Below this magnitude, the V1 voltage input used for synchrocheck will be considered "Dead" or de-energized.

- **SYNCHK1 DEAD V2 MAX VOLT**: This setting establishes a maximum voltage magnitude for V2 in 'pu'. Below this magnitude, the V2 voltage input used for synchrocheck will be considered "Dead" or de-energized.

- **SYNCHK1 LIVE V1 MIN VOLT**: This setting establishes a minimum voltage magnitude for V1 in 'pu'. Above this magnitude, the V1 voltage input used for synchrocheck will be considered "Live" or energized.

- **SYNCHK1 LIVE V2 MIN VOLT**: This setting establishes a minimum voltage magnitude for V2 in 'pu'. Above this magnitude, the V2 voltage input used for synchrocheck will be considered "Live" or energized.

**Notes on the Synchrocheck Function:**

1.  The selected sources for synchrocheck inputs V1 and V2 (which must not be the same source) may include both a three-phase and an auxiliary voltage. The relay will automatically select the specific voltages to be used by the synchrocheck element in accordance with the following table.

| NO. | V1 OR V2 (SOURCE Y) | V2 OR V1 (SOURCE Z) | AUTO-SELECTED COMBINATION | | AUTO-SELECTED VOLTAGE |
|---|---|---|---|---|---|
| | | | SOURCE Y | SOURCE Z | |
| 1 | Phase VTs and Auxiliary VT | Phase VTs and Auxiliary VT | Phase | Phase | VAB |
| 2 | Phase VTs and Auxiliary VT | Phase VT | Phase | Phase | VAB |
| 3 | Phase VT | Phase VT | Phase | Phase | VAB |
| 4 | Phase VT and Auxiliary VT | Auxiliary VT | Phase | Auxiliary | V auxiliary (as set for Source z) |
| 5 | Auxiliary VT | Auxiliary VT | Auxiliary | Auxiliary | V auxiliary (as set for selected sources) |

The voltages V1 and V2 will be matched automatically so that the corresponding voltages from the two sources will be used to measure conditions. A phase to phase voltage will be used if available in both sources; if one or both of the Sources have only an auxiliary voltage, this voltage will be used. For example, if an auxiliary voltage is programmed to VAG, the synchrocheck element will automatically select VAG from the other source. If the comparison is required on a specific voltage, the user can externally connect that specific voltage to auxiliary voltage terminals and then use this "Auxiliary Voltage" to check the synchronism conditions.

If using a single CT/VT module with both phase voltages and an auxiliary voltage, ensure that <u>only</u> the auxiliary voltage is programmed in one of the sources to be used for synchrocheck.

> *Exception: Synchronism cannot be checked between Delta connected phase VTs and a Wye connected auxiliary voltage.*
>
> **NOTE**

2.  The relay measures frequency and Volts/Hz from an input on a given source with priorities as established by the configuration of input channels to the source. The relay will use the phase channel of a three-phase set of voltages if programmed as part of that source. The relay will use the auxiliary voltage channel only if that channel is programmed as part of the Source and a three-phase set is not.

**5**
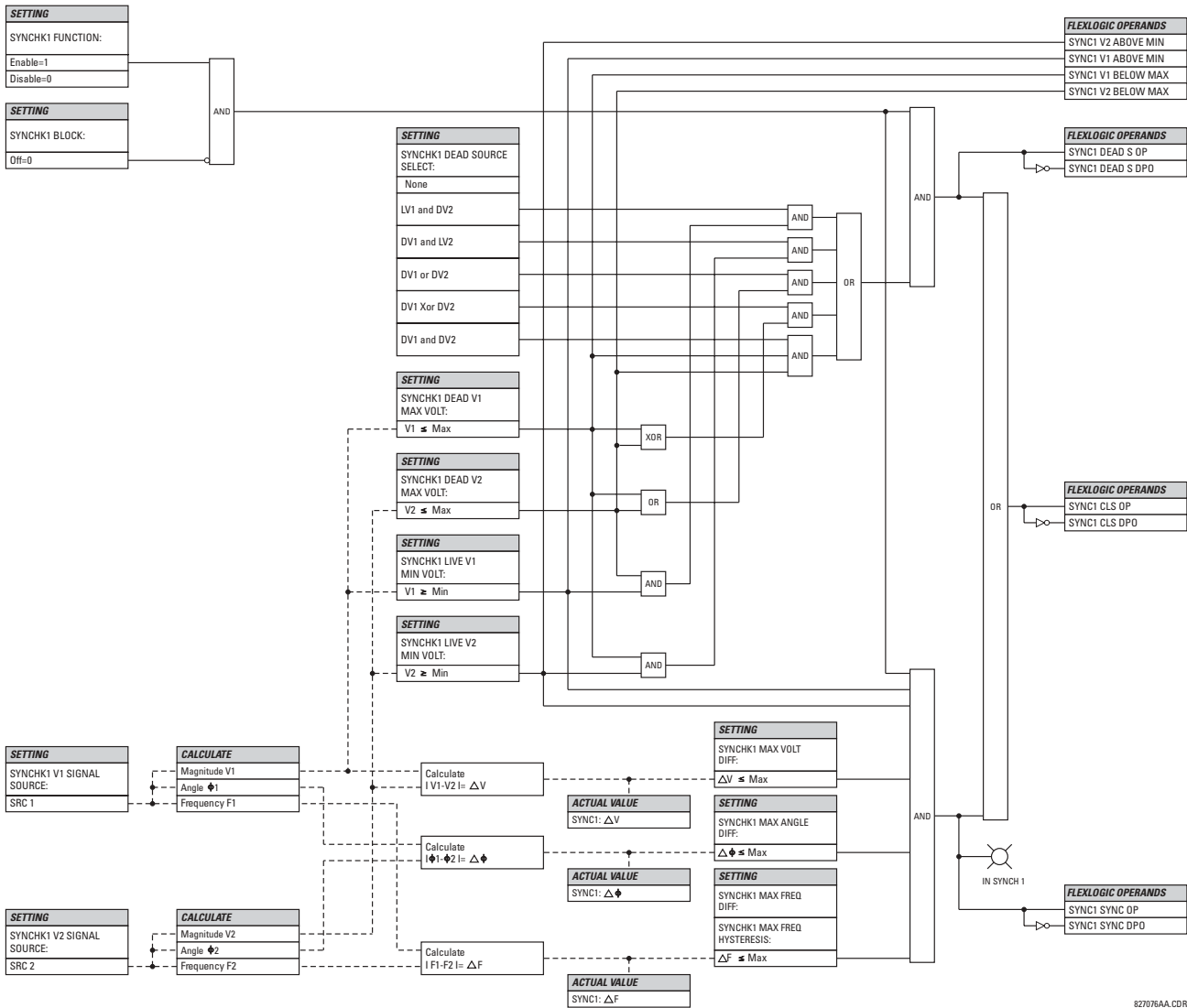
**Figure 5–62: SYNCHROCHECK SCHEME LOGIC**

**PATH: SETTINGS** ⇨⇩ **CONTROL ELEMENTS** ⇨⇩ **AUTORECLOSE** ⇨ **AUTORECLOSE**

| | | | |
|---|---|---|---|
| ■ AUTORECLOSE ■ | ◀▶ | **AR FUNCTION:** Disabled | *Range: Disabled, Enabled* |
| | MESSAGE ⬆⬇ | **AR MODE:** 1 & 3 Pole | *Range: 1 & 3 Pole, 1 Pole, 3 Pole-A, 3 Pole-B* |
| | MESSAGE ⬆⬇ | **AR MAX NUMBER OF SHOTS: 2** | *Range: 1, 2* |
| | MESSAGE ⬆⬇ | **AR BLOCK BKR1:** Off | *Range: FlexLogic™ operand* |
| | MESSAGE ⬆⬇ | **AR CLOSE TIME BKR 1:** 0.10 s | *Range: 0.00 to 655.35 s in steps of 0.01* |
| | MESSAGE ⬆⬇ | **AR BKR MAN CLOSE:** Off | *Range: FlexLogic™ operand* |
| | MESSAGE ⬆⬇ | **AR BLK TIME UPON MAN CLS: 10.00 s** | *Range: 0.00 to 655.35 s in steps of 0.01* |
| | MESSAGE ⬆⬇ | **AR 1P INIT:** Off | *Range: FlexLogic™ operand* |
| | MESSAGE ⬆⬇ | **AR 3P INIT:** Off | *Range: FlexLogic™ operand* |
| | MESSAGE ⬆⬇ | **AR 3P TD INIT:** Off | *Range: FlexLogic™ operand* |
| | MESSAGE ⬆⬇ | **AR MULTI-P FAULT:** Off | *Range: FlexLogic™ operand* |
| | MESSAGE ⬆⬇ | **BKR ONE POLE OPEN:** Off | *Range: FlexLogic™ operand* |
| | MESSAGE ⬆⬇ | **BKR 3 POLE OPEN:** Off | *Range: FlexLogic™ operand* |
| | MESSAGE ⬆⬇ | **AR 3-P DEAD TIME 1:** 0.50 s | *Range: 0.00 to 655.35 s in steps of 0.01* |
| | MESSAGE ⬆⬇ | **AR 3-P DEAD TIME 2:** 1.20 s | *Range: 0.00 to 655.35 s in steps of 0.01* |
| | MESSAGE ⬆⬇ | **AR 3-P DEAD TIME 3:** 2.00 s | *Range: 0.00 to 655.35 s in steps of 0.01* |
| | MESSAGE ⬆⬇ | **AR 3-P DEAD TIME 4:** 4.00 s | *Range: 0.00 to 655.35 s in steps of 0.01* |
| | MESSAGE ⬆⬇ | **AR EXTEND DEAD T 1:** Off | *Range: FlexLogic™ operand* |
| | MESSAGE ⬆⬇ | **AR DEAD TIME 1 EXTENSION: 0.50 s** | *Range: 0.00 to 655.35 s in steps of 0.01* |
| | MESSAGE ⬆⬇ | **AR RESET:** Off | *Range: FlexLogic™ operand* |
| | MESSAGE ⬆⬇ | **AR RESET TIME:** 60.00 s | *Range: 0 to 655.35 s in steps of 0.01* |

**5**

MESSAGE

| AR BKR CLOSED: |
| Off |

Range: *FlexLogic™ operand*

MESSAGE

| AR BLOCK: |
| Off |

Range: *FlexLogic™ operand*

MESSAGE

| AR PAUSE: |
| Off |

Range: *FlexLogic™ operand*

MESSAGE

| AR INCOMPLETE SEQ |
| TIME: 5.00 s |

Range: *0 to 655.35 s in steps of 0.01*

MESSAGE

| AR BLOCK BKR2: |
| Off |

Range: *FlexLogic™ operand*

MESSAGE

| AR CLOSE TIME BKR2: |
| 0.10 s |

Range: *0.00 to 655.35 s in steps of 0.01*

MESSAGE

| AR TRANSFER 1 TO 2: |
| No |

Range: *Yes, No*

MESSAGE

| AR TRANSFER 2 TO 1: |
| No |

Range: *Yes, No*

MESSAGE

| AR BKR1 FAIL OPTION: |
| Continue |

Range: *Continue, Lockout*

MESSAGE

| AR BKR2 FAIL OPTION: |
| Continue |

Range: *Continue, Lockout*

MESSAGE

| AR 1-P DEAD TIME: |
| 1.00 s |

Range: *0 to 655.35 s in steps of 0.01*

MESSAGE

| AR BKR SEQUENCE: |
| 1-2 |

Range: *1, 2, 1&2, 1–2, 2–1*

MESSAGE

| AR TRANSFER TIME: |
| 4.00 s |

Range: *0 to 655.35 s in steps of 0.01*

MESSAGE

| AR EVENT: |
| Disabled |

Range: *Enabled, Disabled*

The autoreclose scheme is intended for use on transmission lines with circuit breakers operated in both the single pole and three pole modes, in one or two breaker arrangements. The autoreclose scheme provides four programs with different operating cycles, depending on the fault type. Each of the four programs can be set to trigger up to two reclosing attempts. The second attempt always performs three pole reclosing and has an independent dead time delay.

When used in two breaker applications, the reclosing sequence is selectable. The reclose signal can be sent to one selected breaker only, to both breakers simultaneously or to both breakers in sequence (one breaker first and then, after a delay to check that the reclose was successful, to the second breaker). When reclosing in sequence, the first breaker should reclose with either the 1-Pole or 3-Pole dead time according to the fault type and reclose mode; the second breaker should follow the successful reclosure of the first breaker. When reclosing simultaneously, for the first shot both breakers should reclose with either the 1-Pole or 3-Pole dead time, according to the fault type and the reclose mode.

The signal used to initiate the autoreclose scheme is the trip output from protection. This signal can be single pole tripping for single phase faults and three phase tripping for multiphase faults. The autoreclose scheme has five operating states.

| STATE | CHARACTERISTICS |
| --- | --- |
| Enabled | Scheme is permitted to operate |
| Disabled | Scheme is not permitted to operate |
| Reset | Scheme is permitted to operate and shot count is reset to 0 |
| Reclose In Progress | Scheme has been initiated but the reclose cycle is not finished (successful or not) |
| Lockout | Scheme is not permitted to operate until reset received |

**AR PROGRAMS:**

The autorecloser provides four programs that can cause from one to four reclose attempts (shots). After the first shot, all subsequent recloses will always be three-pole. If the maximum number of shots selected is "1" (only one reclose attempt) and the fault is persistent, after the first reclose the scheme will go to Lockout upon another Initiate signal.

For the 3-pole reclose programs (modes 3 and 4), an AR FORCE 3-P FlexLogic™ operand is set. This operand can be used in connection with the tripping logic to cause a three-pole trip for single-phase faults.

**Table 5–17: AUTORECLOSE PROGRAMS**

| MODE | AR MODE | FIRST SHOT | | SECOND SHOT | | THIRD SHOT | | FOURTH SHOT | |
|------|---------|------------|------------|-------------|------------|------------|------------|-------------|------------|
| | | SINGLE-PHASE FAULT | MULTI-PHASE FAULT | SINGLE-PHASE FAULT | MULTI-PHASE FAULT | SINGLE-PHASE FAULT | MULTI-PHASE FAULT | SINGLE-PHASE FAULT | MULTI-PHASE FAULT |
| 1 | 1 & 3 POLE | 1 POLE | 3 POLE | 3 POLE or LO | 3 POLE or LO | 3 POLE or LO | 3 POLE or LO | 3 POLE or LO | 3 POLE or LO |
| 2 | 1 POLE | 1 POLE | LO | 3 POLE or LO | 3 POLE or LO | 3 POLE or LO | 3 POLE or LO | 3 POLE or LO | 3 POLE or LO |
| 3 | 3 POLE-A | 3 POLE | LO | 3 POLE or LO | LO | 3 POLE or LO | LO | 3 POLE or LO | LO |
| 4 | 3 POLE-B | 3 POLE | 3 POLE | 3 POLE or LO | 3 POLE or LO | 3 POLE or LO | 3 POLE or LO | 3 POLE or LO | 3 POLE or LO |

The four autoreclose modes are described below:

1. "1 & 3 Pole": In this mode, the autorecloser starts the **AR 1-P DEAD TIME** timer for the first shot if the autoreclose is single-phase initiated, the **AR 3-P DEAD TIME 1** timer if the autoreclose is three-pole initiated, and the **AR 3-P DEAD TIME 2** timer if the autoreclose is three-phase time delay initiated. If two or more shots are enabled, the second, third, and fourth shots are always three-pole and start the **AR 3-P DEAD TIME 2(4)** timers.

2. "1 Pole": In this mode, the autorecloser starts the **AR 1-P DEAD TIME** for the first shot if the fault is single phase. If the fault is three-phase *or a three-pole trip on the breaker occurred during the single-pole initiation*, the scheme goes to lockout without reclosing. If two or more shots are enabled, the second, third, and fourth shots are always three-pole and start the **AR 3-P DEAD TIME 2(4)** timers.

3. "3 Pole-A": In this mode, the autorecloser is initiated only for single phase faults, although the trip is three pole. The autorecloser uses the **AR 3-P DEAD TIME 1** for the first shot if the fault is single phase. If the fault is multi phase the scheme will go to Lockout without reclosing. If two or more shots are enabled, the second, third, and fourth shots are always three-phase and start the **AR 3-P DEAD TIME 2(4)** timers.

4. "3 Pole-B": In this mode, the autorecloser is initiated for any type of fault and starts the **AR 3-P DEAD TIME 1** for the first shot. If the initiating signal is **AR 3P TD INIT** the scheme starts **AR 3-P DEAD TIME 2** for the first shot. If two or more shots are enabled, the second, third, and fourth shots are always three-phase and start the **AR 3-P DEAD TIME 2(4)** timers.

**BASIC RECLOSING OPERATION:**

Reclosing operation is determined primarily by the **AR MODE** and **AR BKR SEQUENCE** settings. The reclosing sequences are started by the initiate inputs. A reclose initiate signal will send the scheme into the reclose-in-progress (RIP) state, asserting the AR RIP FlexLogic™ operand. The scheme is latched into the RIP state and resets only when an AR CLS BKR 1 (autoreclose breaker 1) or AR CLS BKR 2 (autoreclose breaker 2) operand is generated or the scheme goes to the Lockout state.

The dead time for the initial reclose operation will be determined by either the **AR 1-P DEAD TIME**, **AR 3-P DEAD TIME 1**, or **AR 3-P DEAD TIME 2** setting, depending on the fault type and the mode selected. After the dead time interval the scheme will assert the AR CLOSE BKR 1 or AR CLOSE BKR 2 operands, as determined by the sequence selected. These operands are latched until the breaker closes or the scheme goes to Reset or Lockout.

There are three initiate programs: single pole initiate, three pole initiate and three pole, time delay initiate. Any of these reclose initiate signals will start the reclose cycle and set the reclose-in-progress (AR RIP) operand. The reclose-in-progress operand is sealed-in until the Lockout or Reset signal appears.

The three-pole initiate and three-pole time delay initiate signals are latched until the CLOSE BKR1 OR BKR2 or Lockout or Reset signal appears.

**AR PAUSE:**

The pause input offers the possibility of freezing the autoreclose cycle until the pause signal disappears. This may be done when a trip occurs and simultaneously or previously, some conditions are detected such as out-of step or loss of guard frequency, or a remote transfer trip signal is received. The pause signal blocks all three dead timers. When the 'pause' signal disappears the autoreclose cycle is resumed by initiating **AR 3-P DEAD TIME 2**.

This feature can be also used when a transformer is tapped from the protected line and a reclose is not desirable until the transformer is removed from the line. In this case, the reclose scheme is 'paused' until the transformer is disconnected. The **AR PAUSE** input will force a three-pole trip through the **3-P DEADTIME 2** path.

**EVOLVING FAULTS:**

1.25 cycles after the single pole dead time has been initiated, the AR FORCE 3P TRIP operand is set and it will be reset only when the scheme is reset or goes to Lockout. This will ensure that when a fault on one phase evolves to include another phase during the single pole dead time of the auto-recloser the scheme will force a 3 pole trip and reclose.

**RECLOSING SCHEME OPERATION FOR ONE BREAKER:**

*   **Permanent Fault**: Consider Mode 1, which calls for 1-Pole or 3-Pole Time Delay 1 for the first reclosure and 3-Pole Time Delay 2 for the second reclosure, and assume a permanent fault on the line. Also assume the scheme is in the Reset state. For the first single-phase fault the **AR 1-P DEAD TIME** timer will be started, while for the first multi-phase fault the **AR 3-P DEAD TIME 1** timer will be started. If the **AR 3P TD INIT** signal is high, the **AR 3-P DEAD TIME 2** will be started for the first shot.

    If **AR MAX NO OF SHOTS** is set to "1", upon the first reclose the shot counter is set to 1. Upon reclosing, the fault is again detected by protection and reclose is initiated. The breaker is tripped three-pole through the AR SHOT COUNT >0 operand that will set the AR FORCE 3P operand. Because the shot counter has reached the maximum number of shots permitted the scheme is sent to the Lockout state.

    If **AR MAX NO OF SHOTS** is set to "2", upon the first reclose the shot counter is set to 1. Upon reclosing, the fault is again detected by protection and reclose is initiated. The breaker is tripped three-pole through the AR SHOT COUNT >0 operand that will set the AR FORCE 3P operand. After the second reclose the shot counter is set to 2. Upon reclosing, the fault is again detected by protection, the breaker is tripped three-pole, and reclose is initiated again. Because the shot counter has reached the maximum number of shots permitted the scheme is sent to the lockout state.

*   **Transient Fault**: When a reclose output signal is sent to close the breaker the reset timer is started. If the reclosure sequence is successful (there is no initiating signal and the breaker is closed) the reset timer will time out returning the scheme to the reset state with the shot counter set to "0" making it ready for a new reclose cycle.

**RECLOSING SCHEME OPERATION FOR TWO BREAKERS:**

*   **Permanent Fault**: The general method of operation is the same as that outlined for the one breaker applications except for the following description, which assumes **AR BKR SEQUENCE** is "1-2" (reclose Breaker 1 before Breaker 2) The signal output from the dead time timers passes through the breaker selection logic to initiate reclosing of Breaker 1. The Close Breaker 1 signal will initiate the Transfer Timer. After the reclose of the first breaker the fault is again detected by the protection, the breaker is tripped three pole and the autoreclose scheme is initiated. The Initiate signal will stop the transfer timer. After the 3-P dead time times out the Close Breaker 1 signal will close first breaker again and will start the transfer timer. Since the fault is permanent the protection will trip again initiating the autoreclose scheme that will be sent to Lockout by the SHOT COUNT = MAX signal.

*   **Transient Fault**: When the first reclose output signal is sent to close Breaker 1, the reset timer is started. The close Breaker 1 signal initiates the transfer timer that times out and sends the close signal to the second breaker. If the reclosure sequence is successful (both breakers closed and there is no initiating signal) the reset timer will time out, returning the scheme to the reset state with the shot counter set to 0. The scheme will be ready for a new reclose cycle.

**AR BKR1(2) RECLS FAIL:**

If the selected sequence is "1–2" or "2–1" and after the first or second reclose attempt the breaker fails to close, there are two options. If the **AR BKR 1(2) FAIL OPTION** is set to "Lockout", the scheme will go to lockout state. If the **AR BKR 1(2) FAIL OPTION** is set to "Continue", the reclose process will continue with Breaker 2. At the same time the shot counter will be decreased (since the closing process was not completed).

**SCHEME RESET AFTER RECLOSURE:**

When a reclose output signal is sent to close either breaker 1 or 2 the reset timer is started. If the reclosure sequence is successful (there is no initiating signal and the breakers are closed) the reset timer will time out, returning the scheme to the reset state, with the shot counter set to 0, making it ready for a new reclose cycle.

In two breaker schemes, if one breaker is in the out-of-service state and the other is closed at the end of the reset time, the scheme will also reset. If at the end of the reset time at least one breaker, which is not in the out-of-service state, is open the scheme will be sent to Lockout.

The reset timer is stopped if the reclosure sequence is not successful: an initiating signal present or the scheme is in Lock-out state. The reset timer is also stopped if the breaker is manually closed or the scheme is otherwise reset from lockout.

**LOCKOUT:**

When a reclose sequence is started by an initiate signal the scheme moves into the reclose-in-progress state and starts the incomplete sequence timer. The setting of this timer determines the maximum time interval allowed for a single reclose shot. If a close breaker 1 or 2 signal is not present before this time expires, the scheme goes to "Lockout".

There are four other conditions that can take the scheme to the Lockout state, as shown below:

• Receipt of 'Block' input while in the reclose-in-progress state

• The reclosing program logic: when a 3P Initiate is present and the autoreclose mode is either 1 Pole or 3Pole-A (3 pole autoreclose for single pole faults only)

• Initiation of the scheme when the count is at the maximum allowed

• If at the end of the reset time at least one breaker, which is not in the out-of-service state, is open the scheme will be sent to Lockout. The scheme will be also sent to Lockout if one breaker fails to reclose and the setting **AR BKR FAIL OPTION** is set to "Lockout".

Once the Lockout state is set it will be latched until one or more of the following occurs:

• The scheme is intentionally reset from Lockout, employing the Reset setting of the Autorecloser;

• The Breaker(s) is(are) manually closed from panel switch, SCADA or other remote control through the **AR BRK MAN CLOSE** setting;

• 10 seconds after breaker control detects that breaker(s) were closed.

**BREAKER OPEN BEFORE FAULT:**

A logic circuit is provided that inhibits the Close Breaker 1(2) output if a reclose initiate (RIP) indicator is not present within 30 ms of the Breaker Any Phase Open input. This feature is intended to prevent reclosing if one of the breakers was open in advance of a reclose initiate input to the recloser. This logic circuit resets when the breaker is closed.

**TRANSFER RECLOSE WHEN BREAKER IS BLOCKED:**

1. When the reclosing sequence 1-2 is selected and Breaker 1 is blocked (AR BKR1 BLK operand is set) the reclose signal can be transferred direct to the Breaker 2 if **AR TRANSFER 1 TO 2** is set to "Yes". If set to "No", the scheme will be sent to Lockout by the incomplete sequence timer.

2. When the reclosing sequence 2-1 is selected and Breaker 2 is blocked (AR BKR2 BLK operand is set) the reclose signal can be transferred direct to the Breaker 1 if **AR TRANSFER 2 TO 1** is set to "Yes". If set to "No" the scheme will be sent to Lockout by the incomplete sequence timer.

**FORCE 3-POLE TRIPPING:**

The reclosing scheme contains logic that is used to signal trip logic that three-pole tripping is required for certain conditions. This signal is activated by any of the following:

• Autoreclose scheme is paused after it was initiated.

• Autoreclose scheme is in the Lockout state.

• Autoreclose mode is programmed for three-pole operation

• The shot counter is not at 0, i.e. the scheme is not in the reset state. This ensures a second trip will be three-pole when reclosing onto a permanent single phase fault.

• 1.25 cycles after the single-pole reclose is initiated by the AR 1P INIT signal.

**ZONE 1 EXTENT:**

The Zone 1 extension philosophy here is to apply an overreaching zone permanently as long as the relay is ready to reclose, and reduce the reach when reclosing. Another Zone 1 extension approach is to operate normally from an under-reaching zone, and use an overreaching distance zone when reclosing the line with the other line end open. This philosophy could be programmed via the Line Pickup scheme.

The "Extended Zone 1" is 0 when Autoreclose is in Lockout or Disabled and 1 when Autoreclose is in Reset.

1.  When "Extended Zone 1" is 0, the distance functions shall be set to normal underreach Zone 1 setting.

2.  When "Extended Zone 1" is 1, the distance functions may be set to Extended Zone 1 Reach, which is an overreaching setting.

3.  During a reclose cycle, "Extended Zone 1" goes to 0 as soon as the first CLOSE BREAKER signal is issued (AR SHOT COUNT > 0) and remains 0 until the recloser goes back to Reset.

**USE OF SETTINGS:**

The single-phase autoreclose settings are described below.

*   **AR MODE**: This setting selects the Autoreclose operating mode, which functions in conjunction with signals received at the initiation inputs as described previously.

*   **AR MAX NUMBER OF SHOTS**: This setting specifies the number of reclosures that can be attempted before reclosure goes to Lockout when the fault is permanent.

*   **AR BLOCK BKR1**: This input selects an operand that will block the reclose command for Breaker 1. This condition can be for example: breaker low air pressure, reclose in progress on another line (for the central breaker in a breaker and a half arrangement), or a sum of conditions combined in FlexLogic™.

*   **AR CLOSE TIME BKR1**:This setting represents the closing time for the Breaker 1 from the moment the "Close" command is sent to the moment the contacts are closed.

*   **AR BKR MAN CLOSE:** This setting selects a FlexLogic™ operand that represents manual close command to a breaker associated with the autoreclose scheme.

*   **AR BLK TIME UPON MAN CLS**: The autoreclose scheme can be disabled for a programmable time delay after an associated circuit breaker is manually commanded to close, preventing reclosing onto an existing fault such as grounds on the line. This delay must be longer than the slowest expected trip from any protection not blocked after manual closing. If the autoreclose scheme is not initiated after a manual close and this time expires the autoreclose scheme is set to the Reset state.

*   **AR 1P INIT**: This setting selects a FlexLogic™ operand that is intended to initiate single-pole autoreclosure.

*   **AR 3P INIT**: This setting selects a FlexLogic™ operand that is intended to initiate three-pole autoreclosure, first timer (AR 3P DEAD TIME 1) that can be used for a high-speed autoreclosure.

*   **AR 3P TD INIT**: This setting selects a FlexLogic™ operand intended to initiate three-pole autoreclosure. second timer (AR 3P DEAD TIME 2) can be used for a time-delay autoreclosure.

*   **AR MULTI-P FAULT:** This setting selects a FlexLogic™ operand that indicates a multi-phase fault. The operand value should be zero for single-phase to ground faults.

*   **BKR ONE POLE OPEN:** This setting selects a FlexLogic™ operand which indicates that the breaker(s) has opened correctly following a single phase to ground fault and the autoreclose scheme can start timing the single pole dead time (for 1-2 reclose sequence for example, Breaker 1 should trip single pole and Breaker 2 should trip 3 pole).

    The scheme has a pre-wired input that indicates breaker(s) status.

*   **BKR 3 POLE OPEN:** This setting selects a FlexLogic™ operand which indicates that the breaker(s) has opened three pole and the autoreclose scheme can start timing the three pole dead time. The scheme has a pre-wired input that indicates breaker(s) status.

*   **AR 3-P DEAD TIME 1**: This is the dead time following the first three pole trip. This intentional delay can be used for a high-speed three-pole autoreclose. However, it should be set longer than the estimated de-ionizing time following the three-pole trip.

*   **AR 3-P DEAD TIME 2**: This is the dead time following the second three-pole trip or initiated by the AR 3P TD INIT input. This intentional delay is typically used for a time delayed three-pole autoreclose (as opposed to high speed three-pole autoreclose).

- **AR 3-P DEAD TIME 3(4)**: These settings represent the dead time following the third(fourth) three-pole trip.

- **AR EXTEND DEAD T 1**: This setting selects an operand that will adapt the duration of the dead time for the first shot to the possibility of non-simultaneous tripping at the two line ends. Typically this is the operand set when the communication channel is out of service

- **AR DEAD TIME 1 EXTENSION**: This timer is used to set the length of the dead time 1 extension for possible non-simultaneous tripping of the two ends of the line.

- **AR RESET**: This setting selects the operand that forces the autoreclose scheme from any state to Reset. Typically this is a manual reset from lockout, local or remote.

- **AR RESET TIME**: A reset timer output resets the recloser following a successful reclosure sequence. The setting is based on the breaker time which is the minimum time required between successive reclose sequences.

- **AR BKR CLOSED:** This setting selects an operand that indicates that the breaker(s) are closed at the end of the reset time and the scheme can reset.

- **AR BLOCK**: This setting selects the operand that blocks the Autoreclose scheme (it can be a sum of conditions such as: time delayed tripping, breaker failure, bus differential protection, etc.). If the block signal is present before autoreclose scheme initiation the AR DISABLED FlexLogic™ operand will be set. If the block signal occurs when the scheme is in the RIP state the scheme will be sent to Lockout.

- **AR PAUSE**: The pause input offers the ability to freeze the autoreclose cycle until the pause signal disappears. This may be done when a trip occurs and simultaneously or previously, some conditions are detected such as out-of step or loss of guard frequency, or a remote transfer trip signal is received. When the 'pause' signal disappears the autoreclose cycle is resumed. This feature can also be used when a transformer is tapped from the protected line and a reclose is not desirable until the it is disconnected from the line. In this situation, the reclose scheme is 'paused' until the transformer is disconnected.

- **AR INCOMPLETE SEQ TIME**: This timer is used to set the maximum time interval allowed for a single reclose shot. It is started whenever a reclosure is initiated and is active until the CLOSE BKR1 or CLOSE BKR2 signal is sent. If all conditions allowing a breaker closure are not satisfied when this time expires, the scheme goes to "Lockout". The minimum permissible setting is established by the **AR 3-P DEAD TIME 2** timer setting. Settings beyond this will determine the 'wait' time for the breaker to open so that the reclose cycle can continue and/or for the AR PAUSE signal to reset and allow the reclose cycle to continue and/or for the AR BKR1(2) BLK signal to disappear and allow the AR CLOSE BKR1(2) signal to be sent.

- **AR BLOCK BKR2**: This input selects an operand that will block the reclose command for Breaker 2. This condition can be for example: breaker low air pressure, reclose in progress on another line (for the central breaker in a breaker and a half arrangement), or a sum of conditions combined in FlexLogic™.

- **AR BKR2 MNL CLOSE**: This setting selects an operand asserted when Breaker 2 is manually commanded to close.

- **AR CLOSE TIME BKR2**: This setting represents the closing time for the Breaker 2 from the moment the 'Close' command is sent to the moment the contacts are closed.

- **AR TRANSFER 1 TO 2**: This setting establishes how the scheme performs when the breaker closing sequence is 1-2 and Breaker 1 is blocked. When set to "Yes" the closing command will be transferred direct to Breaker 2 without waiting the transfer time. When set to "No" the closing command will be blocked by the AR BKR1 BLK signal and the scheme will be sent to Lockout by the incomplete sequence timer.

- **AR TRANSFER 2 TO 1**: This setting establishes how the scheme performs when the breaker closing sequence is 2-1 and Breaker 2 is blocked. When set to "Yes" the closing command will be transferred direct to Breaker 1 without waiting the transfer time. When set to "No", the closing command will be blocked by the AR BKR2 BLK signal and the scheme will be sent to Lockout by the incomplete sequence timer.

- **AR BKR1 FAIL OPTION**: This setting establishes how the scheme performs when the breaker closing sequence is 1-2 and Breaker 1 has failed to close. When set to "Continue" the closing command will be transferred to Breaker 2 which will continue the reclosing cycle until successful (the scheme will reset) or unsuccessful (the scheme will go to Lockout). When set to "Lockout" the scheme will go to lockout without attempting to reclose Breaker 2.

- **AR BKR2 FAIL OPTION**: This setting establishes how the scheme performs when the breaker closing sequence is 2-1 and Breaker 2 has failed to close. When set to "Continue" the closing command will be transferred to Breaker 1 which will continue the reclosing cycle until successful (the scheme will reset) or unsuccessful (the scheme will go to Lockout). When set to "Lockout" the scheme will go to lockout without attempting to reclose Breaker 1.

- **AR 1-P DEAD TIME**: Set this intentional delay longer than the estimated de-ionizing time after the first single-pole trip.

- **AR BREAKER SEQUENCE**: This setting selects the breakers reclose sequence: Select "1" for reclose breaker 1 only, "2" for reclose breaker 2 only, "1&2" for reclose both breakers simultaneously, "1-2" for reclose breakers sequentially; Breaker 1 first, and "2-1" for reclose breakers sequentially; Breaker 2 first.

- **AR TRANSFER TIME**: The transfer time is used only for breaker closing sequence 1-2 or 2-1, when the two breakers are reclosed sequentially. The transfer timer is initiated by a close signal to the first breaker. The transfer timer transfers the reclose signal from the breaker selected to close first to the second breaker. The time delay setting is based on the maximum time interval between the autoreclose signal and the protection trip contact closure assuming a permanent fault (unsuccessful reclose). Therefore, the minimum setting is equal to the maximum breaker closing time plus the maximum line protection operating time plus a suitable margin. This setting will prevent the autoreclose scheme from transferring the close signal to the second breaker unless a successful reclose of the first breaker occurs.

> **NOTE**
>
> **For correct operation of the autoreclose scheme, the Breaker Control feature must be enabled and configured properly. When the breaker reclose sequence is "1-2" or "2-1" the breaker that will reclose second in sequence (Breaker 2 for sequence 1-2 and Breaker 1 for sequence 2-1) must be configured to trip three-pole for any type of fault.**
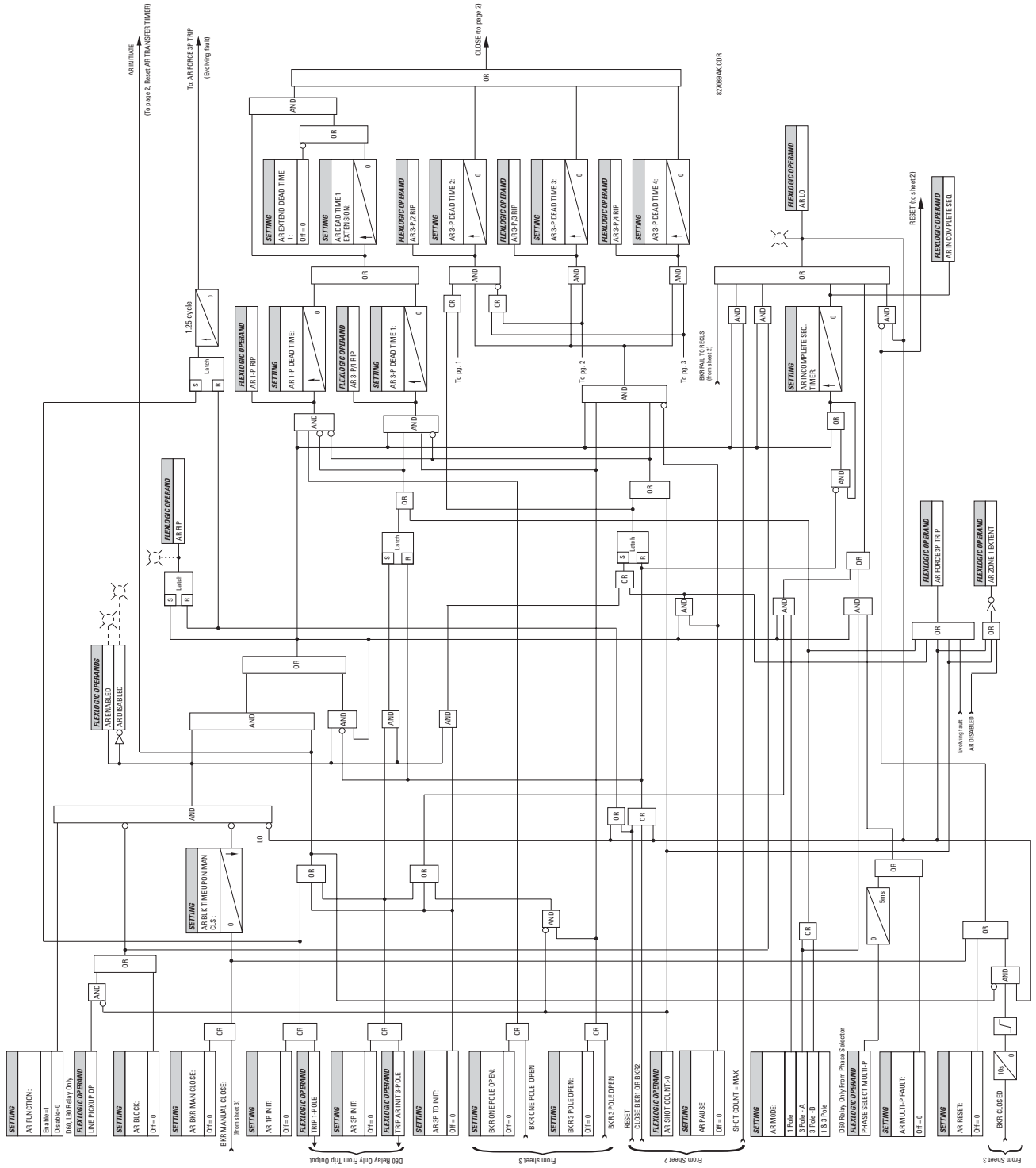
**Figure 5–63: SINGLE-POLE AUTORECLOSE LOGIC (Sheet 1 of 3)**
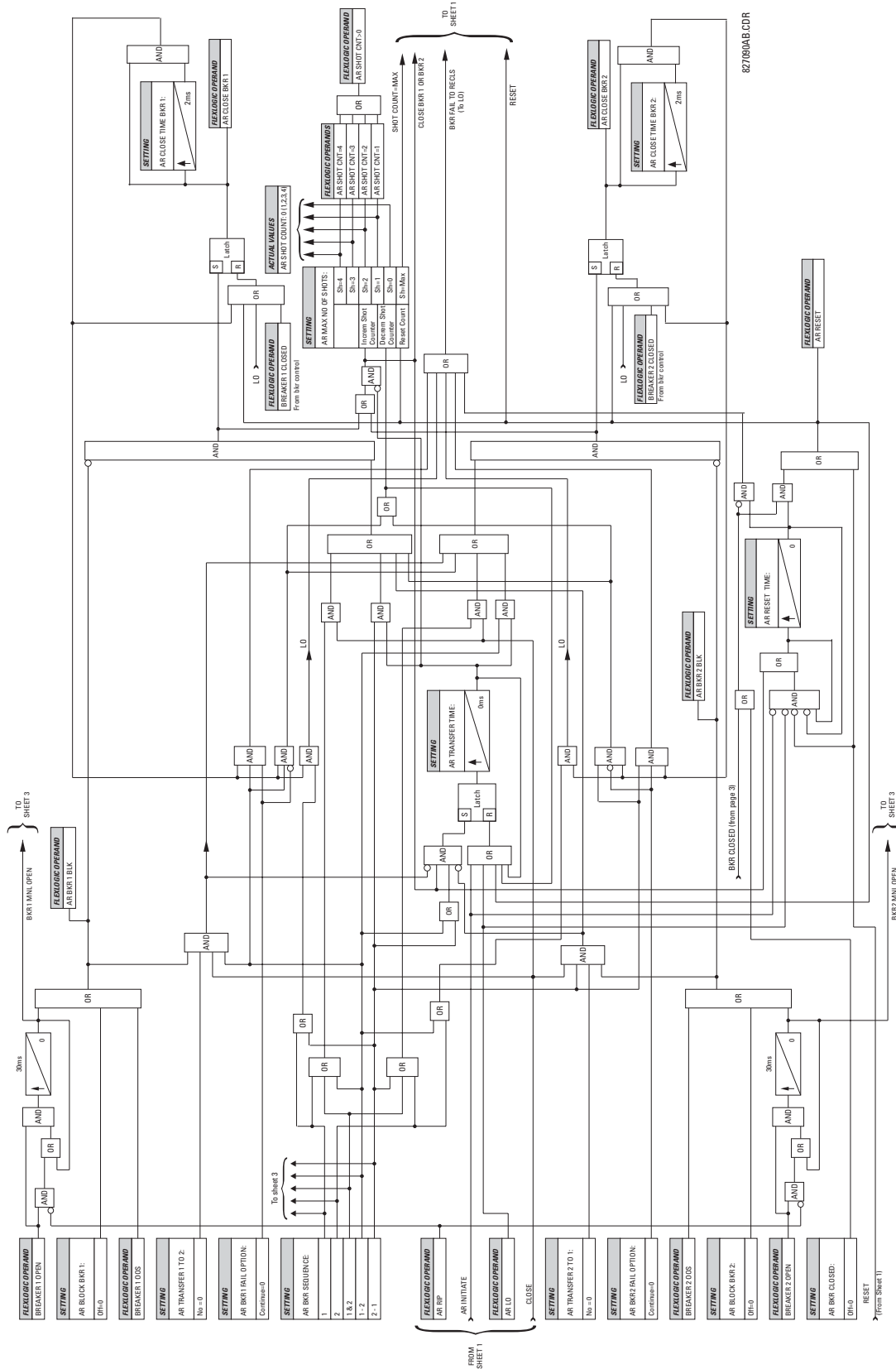
**Figure 5–64: SINGLE-POLE AUTORECLOSE LOGIC (Sheet 2 of 3)**
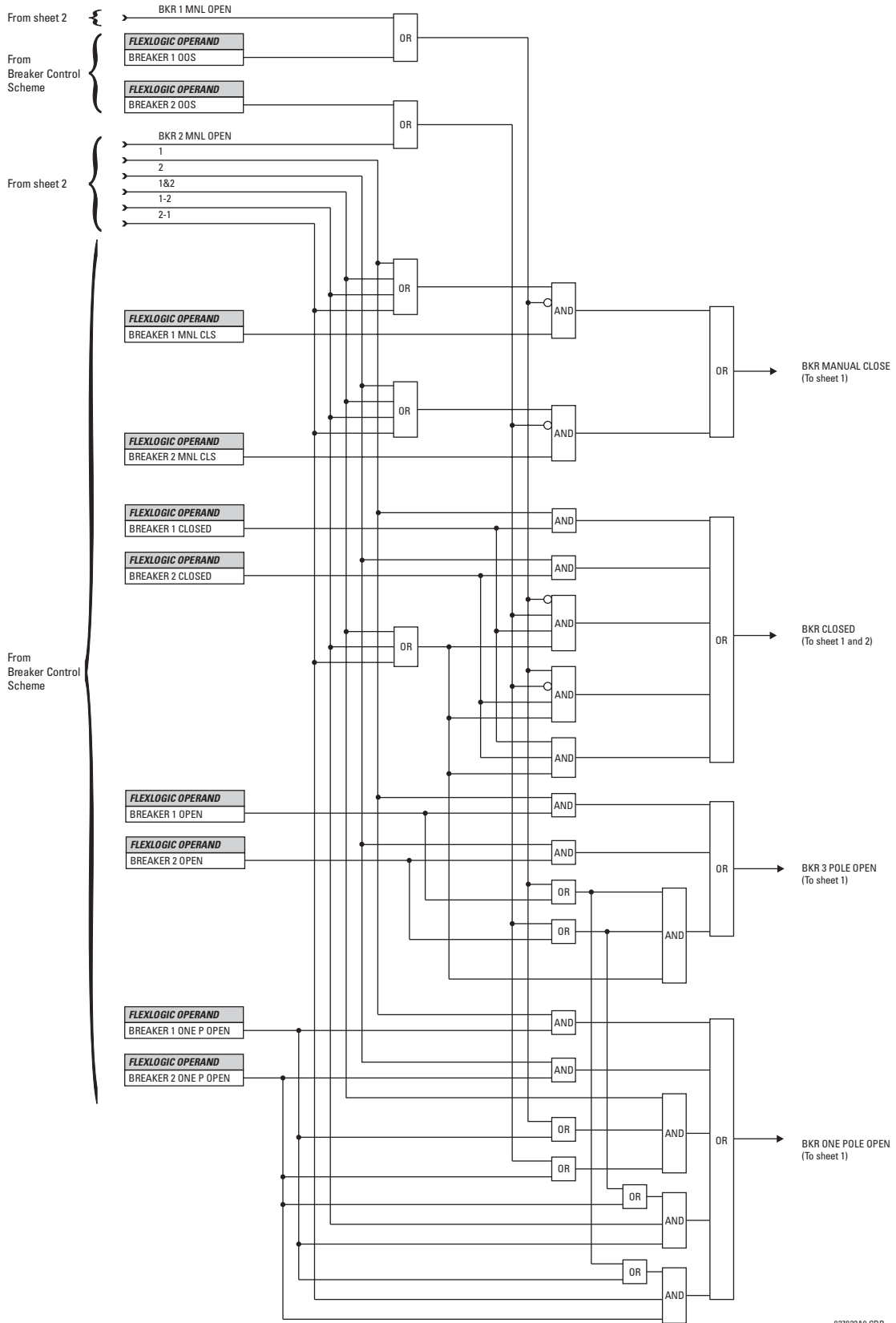
**Figure 5–65: SINGLE-POLE AUTORECLOSE LOGIC (Sheet 3 of 3)**

**5**
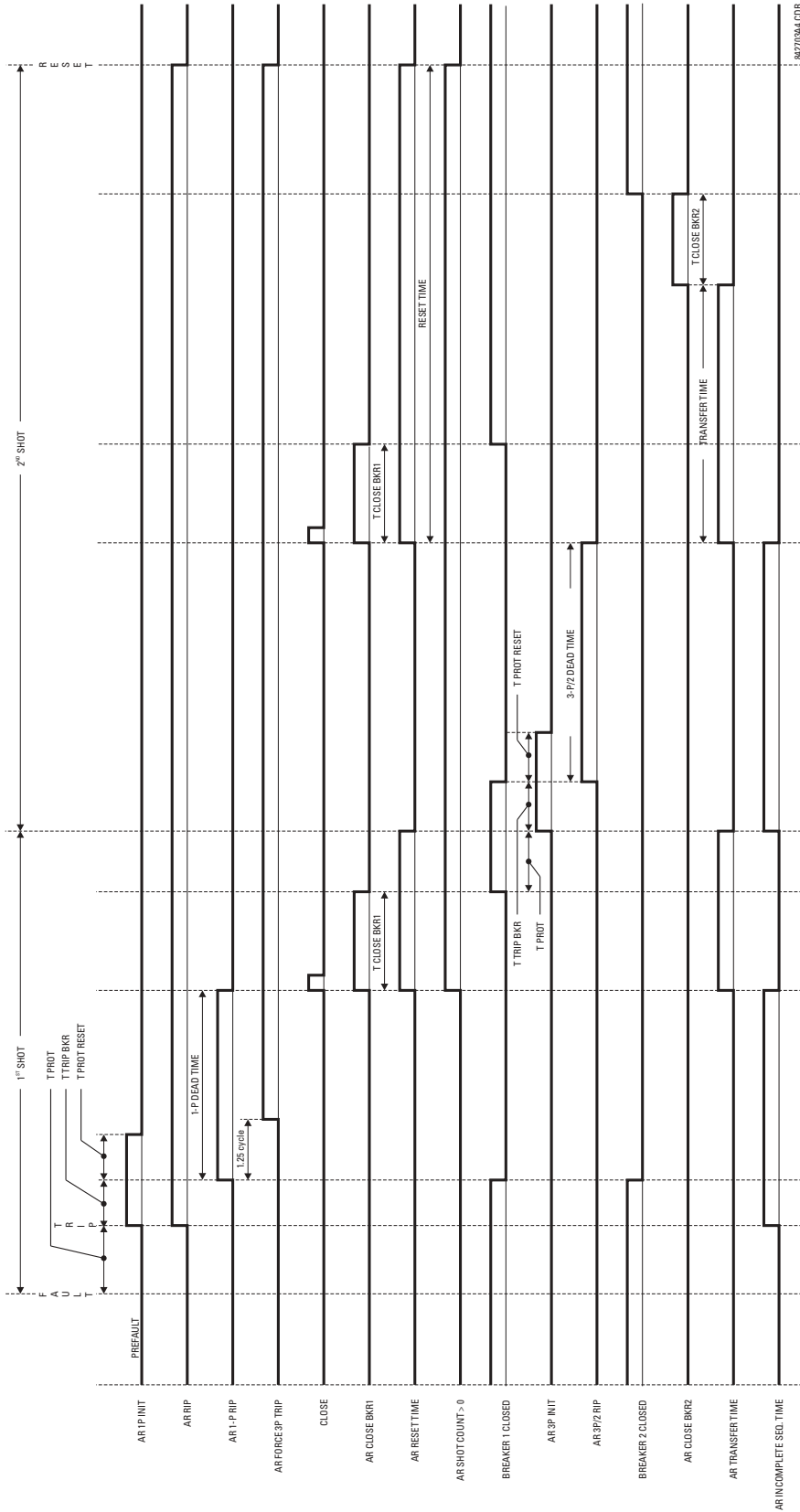


**Figure 5–66: EXAMPLE RECLOSING SEQUENCE**

**PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ DIGITAL ELEMENTS ⇨ DIGITAL ELEMENT 1(16)**

| | | | |
|---|---|---|---|
| ■ 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 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 16 identical Digital Elements available, numbered 1 to 16. 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".
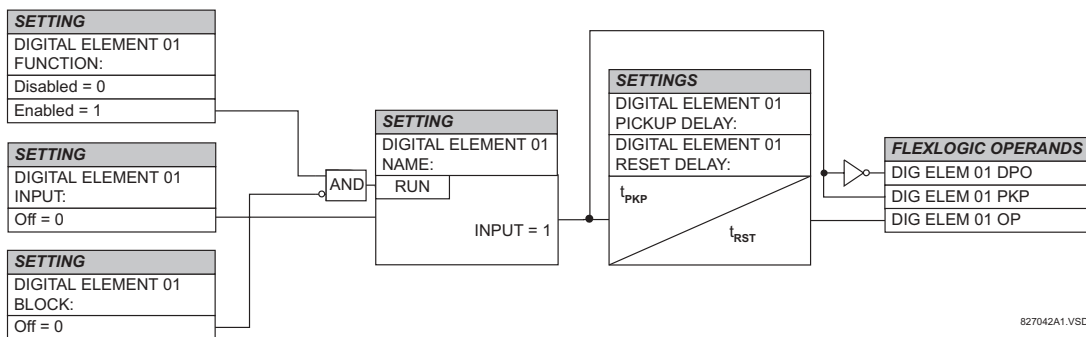


**Figure 5–67: DIGITAL ELEMENT SCHEME LOGIC**

**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.
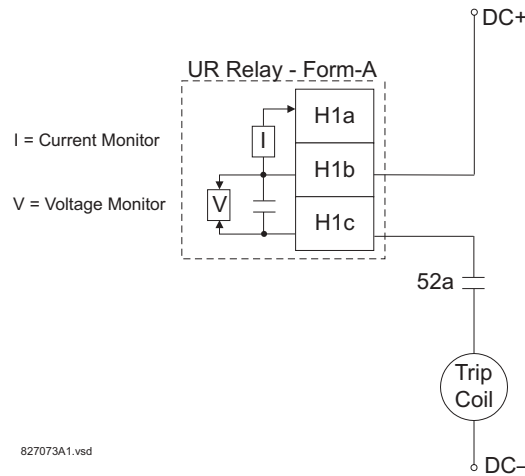


**Figure 5–68: TRIP CIRCUIT EXAMPLE 1**

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. Using Digital Element 1 to monitor the breaker trip circuit, the settings will be:



**NOTE**

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

**EXAMPLE 2: BREAKER TRIP CIRCUIT INTEGRITY MONITORING**

If it is required to monitor the trip circuit continuously, independent of the breaker position (open or closed), a method to maintain the monitoring current flow through the trip circuit when the breaker is open must be provided (as shown in the figure below). This can be achieved by connecting a suitable resistor (see figure below) across the auxiliary contact in the trip circuit. In this case, it is not required to supervise the monitoring circuit with the breaker position – the **BLOCK** setting is selected to "Off". In this case, the settings will be:

```
■ DIGITAL ELEMENT  1           ◄►      DIGITAL ELEMENT  1
■                                      FUNCTION: Enabled
```

```
        MESSAGE      ▲           DIG ELEM  1 NAME:
                     ▼           Bkr Trip Cct Out
```

```
        MESSAGE      ▲           DIG ELEM  1 INPUT:
                     ▼           Cont Op 1 VOff
```

```
        MESSAGE      ▲           DIG ELEM  1 PICKUP
                     ▼           DELAY:     0.200 s
```

```
        MESSAGE      ▲           DIG ELEM  1 RESET
                     ▼           DELAY:     0.100 s
```

```
        MESSAGE      ▲           DIG ELEM  1 BLOCK:
                     ▼           Off
```

```
        MESSAGE      ▲           DIGITAL ELEMENT  1
                     ▼           TARGET: Self-reset
```

```
        MESSAGE      ▲           DIGITAL ELEMENT  1
                                 EVENTS: Enabled
```
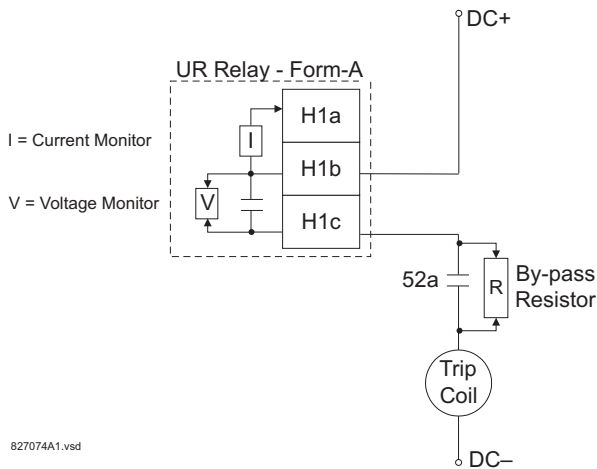


**Table 5–18: VALUES OF RESISTOR 'R'**

| 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 5–69: TRIP CIRCUIT EXAMPLE 2**

**PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ DIGITAL COUNTERS ⇨ COUNTER 1(8)**

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

There are 8 identical digital counters, numbered from 1 to 8. A digital counter counts the number of state transitions from Logic 0 to Logic 1. The counter is used to count operations such as the pickups of an element, the changes of state of an external contact (e.g. breaker auxiliary switch), or pulses from a watt-hour meter.

- **COUNTER 1 UNITS:** Assigns a label to identify the unit of measure pertaining to the digital transitions to be counted. The units label will appear in the corresponding actual values status.

- **COUNTER 1 PRESET:** Sets the count to a required preset value before counting operations begin, as in the case where a substitute relay is to be installed in place of an in-service relay, or while the counter is running.

- **COUNTER 1 COMPARE:** Sets the value to which the accumulated count value is compared. Three FlexLogic™ output operands are provided to indicate if the present value is 'more than (HI)', 'equal to (EQL)', or 'less than (LO)' the set value.

- **COUNTER 1 UP:** Selects the FlexLogic™ operand for incrementing the counter. If an enabled UP input is received when the accumulated value is at the limit of +2,147,483,647 counts, the counter will rollover to –2,147,483,648.

- **COUNTER 1 DOWN:** Selects the FlexLogic™ operand for decrementing the counter. If an enabled DOWN input is received when the accumulated value is at the limit of –2,147,483,648 counts, the counter will rollover to +2,147,483,647.

- **COUNTER 1 BLOCK:** Selects the FlexLogic™ operand for blocking the counting operation. All counter operands are blocked.

- **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.
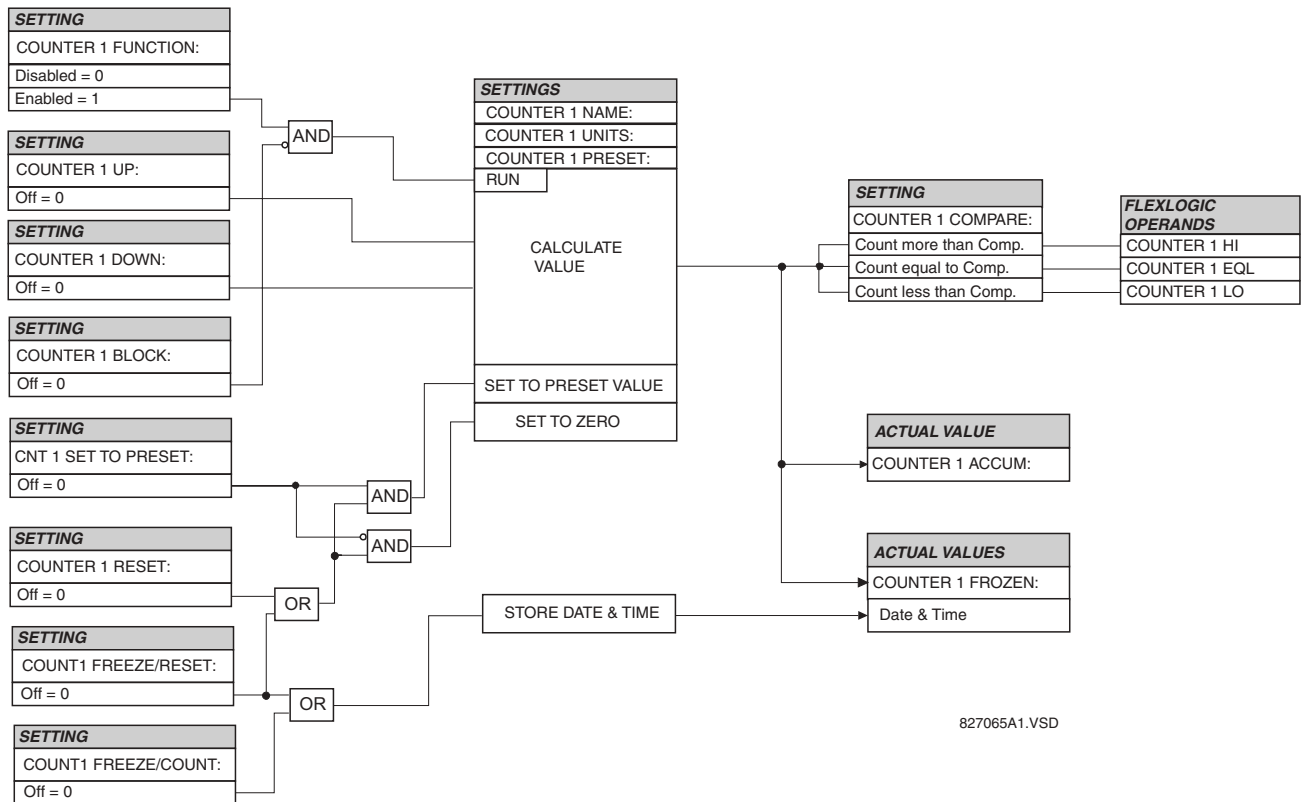


**Figure 5–70: DIGITAL COUNTER SCHEME LOGIC**

**a) MAIN MENU**

**PATH: SETTINGS** ⇨⇩ **CONTROL ELEMENTS** ⇨⇩ **MONITORING ELEMENTS**

```
■ MONITORING          ◄▎▶    ■ BREAKER 1
■ ELEMENTS                   ■ ARCING CURRENT      See below.

              MESSAGE  (▲▼)   ■ BREAKER 2
                             ■ ARCING CURRENT      See below.

              MESSAGE  (▲▼)   ■ BREAKER
                             ■ FLASHOVER 1         See page 5-136.

              MESSAGE  (▲▼)   ■ BREAKER
                             ■ FLASHOVER 2         See page 5-136.

              MESSAGE  (▲▼)   ■ VT FUSE FAILURE 1
                             ■                     See page 5-140.

              MESSAGE  (▲▼)   ■ VT FUSE FAILURE 2
                             ■                     See page 5-140.

              MESSAGE  (▲▼)   ■ VT FUSE FAILURE 3
                             ■                     See page 5-140.

              MESSAGE  (▲)    ■ VT FUSE FAILURE 4
                             ■                     See page 5-140.
```

**b) BREAKER ARCING CURRENT**

**PATH: SETTINGS** ⇨⇩ **CONTROL ELEMENTS** ⇨⇩ **MONITORING ELEMENTS** ⇨ **BREAKER 1(4) ARCING CURRENT**

```
■ BREAKER 1           ◄▎▶    BKR 1 ARC AMP         Range: Disabled, Enabled
■ ARCING CURRENT             FUNCTION: Disabled

              MESSAGE  (▲▼)   BKR 1 ARC AMP         Range: SRC 1, SRC 2, SRC 3, SRC 4
                             SOURCE: SRC 1

              MESSAGE  (▲▼)   BKR 1 ARC AMP INIT-A:  Range: FlexLogic™ operand
                             Off

              MESSAGE  (▲▼)   BKR 1 ARC AMP INIT-B:  Range: FlexLogic™ operand
                             Off

              MESSAGE  (▲▼)   BKR 1 ARC AMP INIT-C:  Range: FlexLogic™ operand
                             Off

              MESSAGE  (▲▼)   BKR 1 ARC AMP         Range: 0.000 to 65.535 s in steps of 0.001
                             DELAY:   0.000 s

              MESSAGE  (▲▼)   BKR 1 ARC AMP LIMIT:   Range: 0 to 50000 kA²-cycle in steps of 1
                              1000 kA2-cyc

              MESSAGE  (▲▼)   BKR 1 ARC AMP BLOCK:   Range: FlexLogic™ operand
                             Off

              MESSAGE  (▲▼)   BKR 1 ARC AMP         Range: Self-reset, Latched, Disabled
                             TARGET: Self-reset

              MESSAGE  (▲)    BKR 1 ARC AMP         Range: Disabled, Enabled
                             EVENTS: Disabled
```

There is one Breaker Arcing Current element available per CT bank, with a minimum of 2 elements. This element calculates an estimate of the per-phase wear on the breaker contacts by measuring and integrating the current squared passing through the breaker contacts as an arc. These per-phase values are added to accumulated totals for each phase and compared to a programmed threshold value. When the threshold is exceeded in any phase, the relay can set an output operand to "1". The accumulated value for each phase can be displayed as an actual value.

The operation of the scheme is shown in the following logic diagram. The same output operand that is selected to operate the output relay used to trip the breaker, indicating a tripping sequence has begun, is used to initiate this feature. A time delay is introduced between initiation and the starting of integration to prevent integration of current flow through the breaker before the contacts have parted. This interval includes the operating time of the output relay, any other auxiliary relays and the breaker mechanism. For maximum measurement accuracy, the interval between change-of-state of the operand (from 0 to 1) and contact separation should be measured for the specific installation. Integration of the measured current continues for 100 ms, which is expected to include the total arcing period.

The feature is programmed to perform fault duration calculations. Fault duration is defined as a time between operation of the disturbance detector occurring before initiation of this feature, and reset of an internal low-set overcurrent function. Correction is implemented to account for a non-zero reset time of the overcurrent function.

Breaker arcing currents and fault duration values are available under the **ACTUAL VALUES** ⇨⇩ **RECORDS** ⇨⇩ **MAINTENANCE** ⇨ **BREAKER 1(4)** menus.

*   **BKR 1(4) ARC AMP INIT-A(C):** Select the same output operands that are configured to operate the output relays used to trip the breaker. In three-pole tripping applications, the same operand should be configured to initiate arcing current calculations for poles A, B and C of the breaker. In single-pole tripping applications, per-pole tripping operands should be configured to initiate the calculations for the poles that are actually tripped.

*   **BKR 1(4) ARC AMP DELAY:** This setting is used to program the delay interval between the time the tripping sequence is initiated and the time the breaker contacts are expected to part, starting the integration of the measured current.

*   **BKR 1(4) ARC AMP LIMIT:** Selects the threshold value above which the output operand is set.

**5**
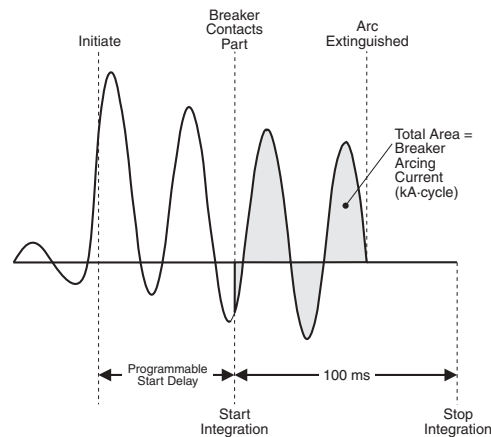
**Figure 5–71: ARCING CURRENT MEASUREMENT**
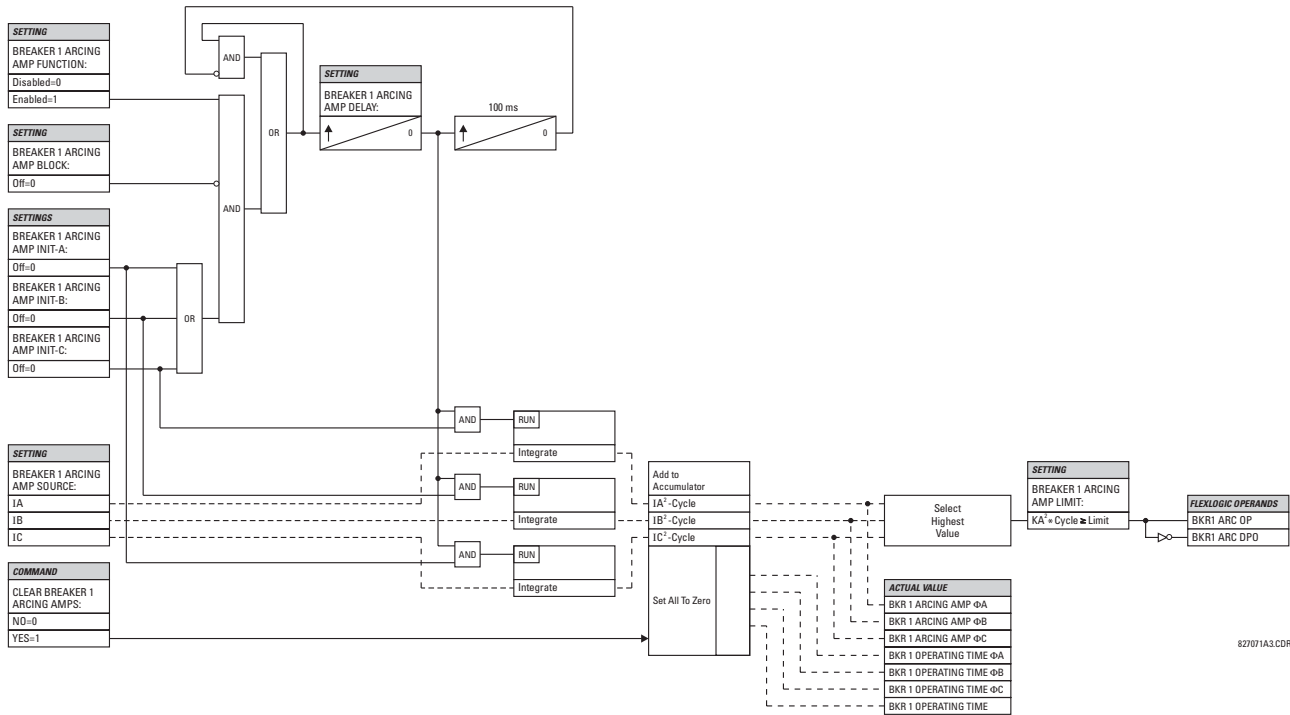
**Figure 5–72: BREAKER ARCING CURRENT SCHEME LOGIC**

### c) BREAKER FLASHOVER

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ MONITORING ELEMENTS ⇨ BREAKER FLASHOVER 1(2)

| ■ 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 |
| MESSAGE | | BKR 1 FLSHOVR SIDE 2 SRC: SRC 1 | Range: None, SRC 1, SRC 2, SRC 3, SRC 4 |
| 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:<br>Off | *Range:* *FlexLogic™ operand* |
| *MESSAGE* | ⬆⬇ | BKR 1 FLSHOVR SPV C:<br>Off | *Range:* *FlexLogic™ operand* |
| *MESSAGE* | ⬆⬇ | BKR 1 FLSHOVR BLOCK:<br>Off | *Range:* *FlexLogic™ operand* |
| *MESSAGE* | ⬆⬇ | BKR 1 FLSHOVR TAR-<br>GET: Self-reset | *Range:* *Self-reset, Latched, Disabled* |
| *MESSAGE* | ⬆ | BKR 1 FLSHOVR<br>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.

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

The flashover detection will reset if the current drops back to zero, the breaker closes, or the selected FlexLogic™ operand for supervision changes to high. Using supervision through the **BRK 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:
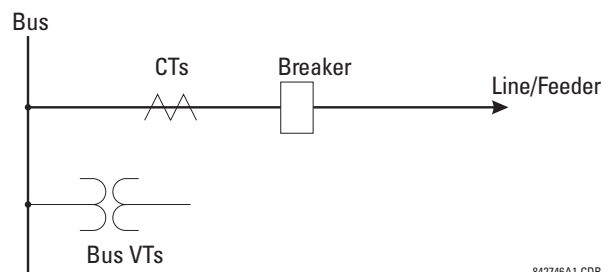


The source 1 (SRC1) phase currents are feeder CTs and phase voltages are bus VTs, and Contact Input 1 is set as Breaker 52a contact. The conditions prior to flashover detection are:

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. $\Delta$VA is greater than pickup (not applicable in this scheme)

The conditions at flashover detection are:

1. 52a status = 0

2. VAg, VBg, or VCg is lower than the pickup setting

3. IA, IB, or IC is greater than the pickup current flowing through the breaker

4. ∆VA is greater than pickup (not applicable in this scheme)

**Six VT Breaker Flashover Application**

The per-phase voltage difference approaches zero when the breaker is closed. The is well below any typical minimum pickup voltage. Select the level of the **BRK 1(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** (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:
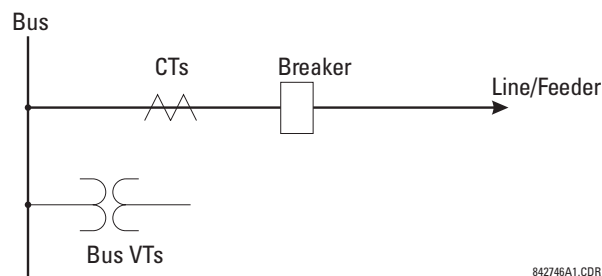


The source 1 (SRC1) phase currents are CTs and phase voltages are bus VTs. The source 2 (SRC2) phase voltages are bus VTs. Contact Input 1 is set as Breaker 52a contact (optional).

The conditions prior to flashover detection are:

1. ∆VA is greater than pickup

2. VAg, VBg, or VCg is greater than the pickup setting

3. IA, IB, IC = 0; no current flows through the breaker

4. 52a status = 0 (optional)

The conditions at flashover detection are:

1. ∆VA is less than pickup

2. VAg, VBg, or VCg is lower than the pickup setting

3. IA, IB, or IC is greater than the pickup current flowing through the breaker

4. 52a status = 0 (optional)

> **NOTE**
>
> **The element is operational only when phase-to-ground voltages are connected to relay terminals. The flashover element will not operate if delta voltages are applied.**

The Breaker Flashover settings are described below.

- **BRK 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 3 VTs are available across the breaker.

- **BRK 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 STATUS CLSD A(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 FLSHOVR V PKP**: This setting specifies a pickup level for the phase voltages from both sides of the breaker. If 6 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 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 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 FLSHOVR SPV A(C)**: This setting specifies a FlexLogic™ operand (per breaker pole) that supervises the operation of the element per phase. Supervision can be provided by operation of other protection elements, breaker failure, and close and trip commands. A 6-cycle time delay applies after the selected FlexLogic™ operand resets.

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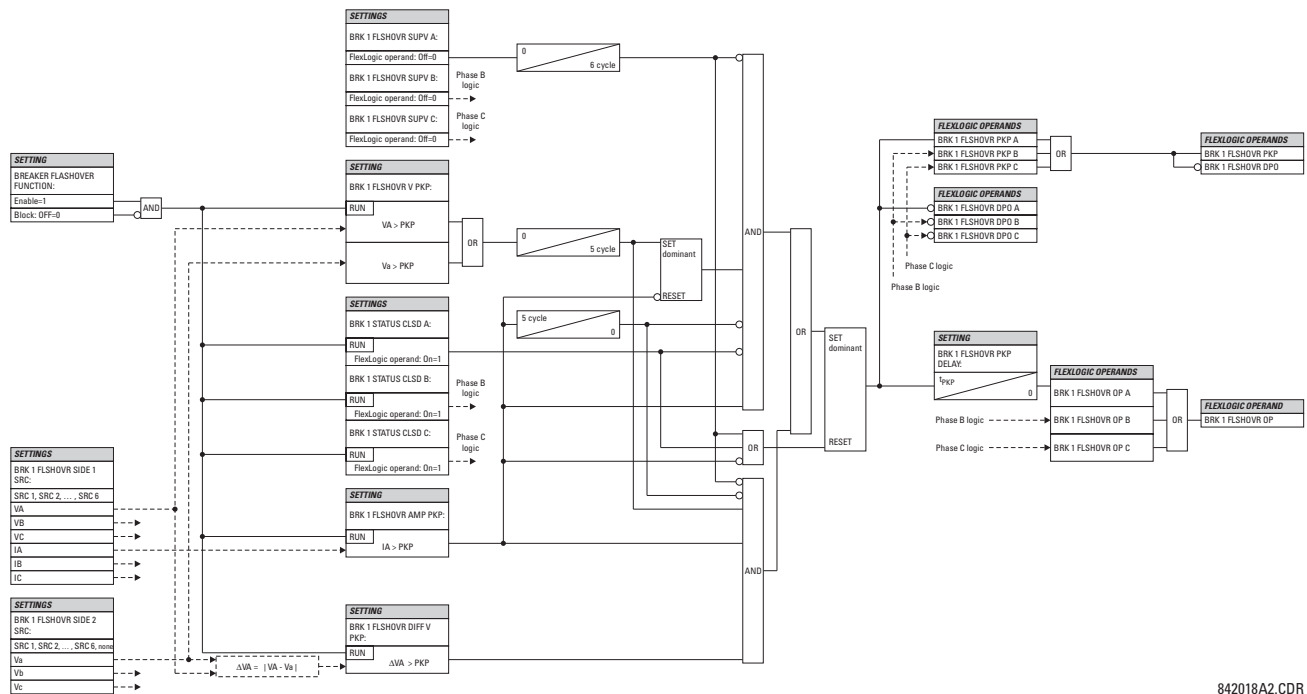


**Figure 5–73: BREAKER FLASHOVER SCHEME LOGIC**

**d) VT FUSE FAILURE**

**PATH: SETTINGS** ⇨⇩ **CONTROL ELEMENTS** ⇨⇩ **MONITORING ELEMENTS** ⇨⇩ **VT FUSE FAILURE 1(4)**

```
■ VT FUSE FAILURE 1
■
```
◀▶
```
VT FUSE FAILURE 1
FUNCTION: Disabled
```
*Range:  Disabled, Enabled*

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 **VT FUSE FAILURE 1(4) FUNCTION** setting enables/disables the fuse failure feature for each source.
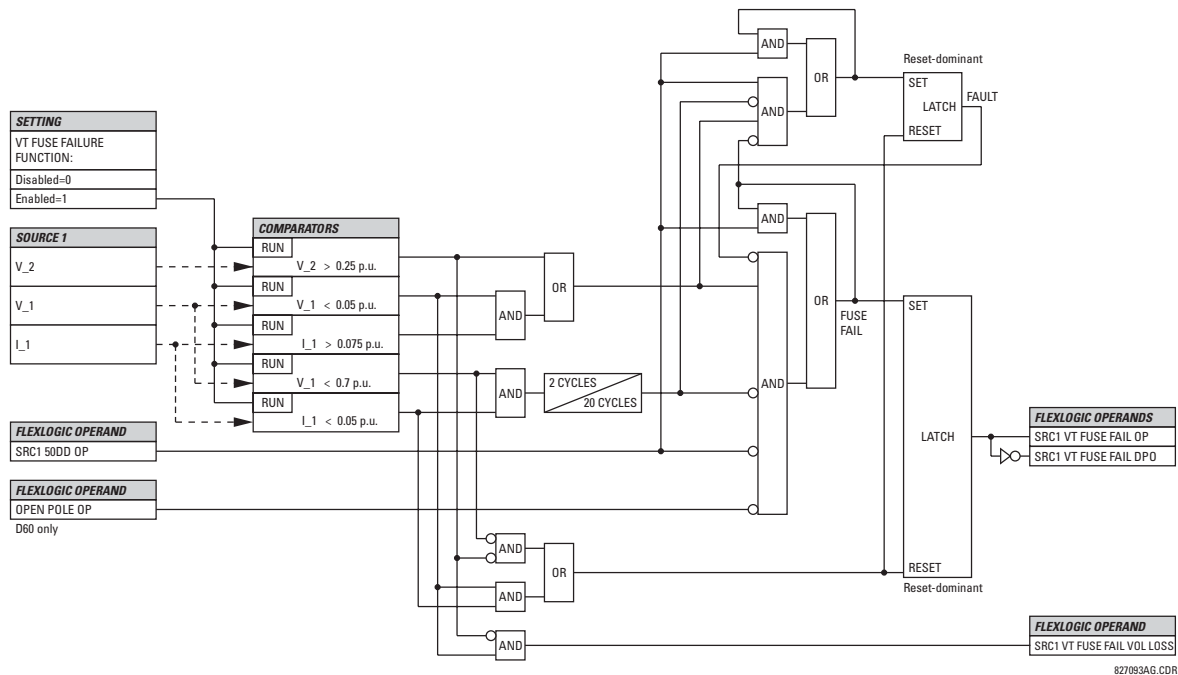


**Figure 5–74: VT FUSE FAIL SCHEME LOGIC**

**PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨ CONTACT INPUTS**

```
■ CONTACT INPUTS
■
```

```
          ◄►   ■ CONTACT INPUT H5a
                 ■
```

MESSAGE ◄►
```
CONTACT INPUT H5a ID:
Cont Ip 1
```
*Range:  up to 12 alphanumeric characters*

MESSAGE ▲▼
```
CONTACT INPUT H5a
DEBNCE TIME: 2.0 ms
```
*Range:  0.0 to 16.0 ms in steps of 0.5*

MESSAGE ▲
```
CONTACT INPUT H5a
EVENTS: Disabled
```
*Range:  Disabled, Enabled*

↓

▲▼
```
■ CONTACT INPUT xxx
■
```

▲
```
■ CONTACT INPUT
■ THRESHOLDS
```

MESSAGE ◄►
```
Ips H5a,H5c,H6a,H6c
THRESHOLD: 33 Vdc
```
*Range:  17, 33, 84, 166 Vdc*

MESSAGE ▲▼
```
Ips H7a,H7c,H8a,H8c
THRESHOLD: 33 Vdc
```
*Range:  17, 33, 84, 166 Vdc*

↓

MESSAGE ▲
```
Ips xxx,xxx,xxx,xxx
THRESHOLD: 33 Vdc
```
*Range:  17, 33, 84, 166 Vdc*

The contact inputs menu contains configuration settings for each contact input as well as voltage thresholds for each group of four contact inputs. Upon startup, the relay processor determines (from an assessment of the installed modules) which contact inputs are available and then display settings for only those inputs.

An alphanumeric ID may be assigned to a contact input for diagnostic, setting, and event recording purposes. The CONTACT IP X On" (Logic 1) FlexLogic™ operand corresponds to contact input "X" being closed, while CONTACT IP X Off corresponds to contact input "X" being open. The **CONTACT INPUT DEBNCE TIME** defines the time required for the contact to overcome 'contact bouncing' conditions. As this time differs for different contact types and manufacturers, set it as a maximum contact debounce time (per manufacturer specifications) plus some margin to ensure proper operation. If **CONTACT INPUT EVENTS** is set to "Enabled", every change in the contact input state will trigger an event.

A raw status is scanned for all Contact Inputs synchronously at the constant rate of 0.5 ms as shown in the figure below. The DC input voltage is compared to a user-settable threshold. A new contact input state must be maintained for a user-settable debounce time in order for the C60 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.
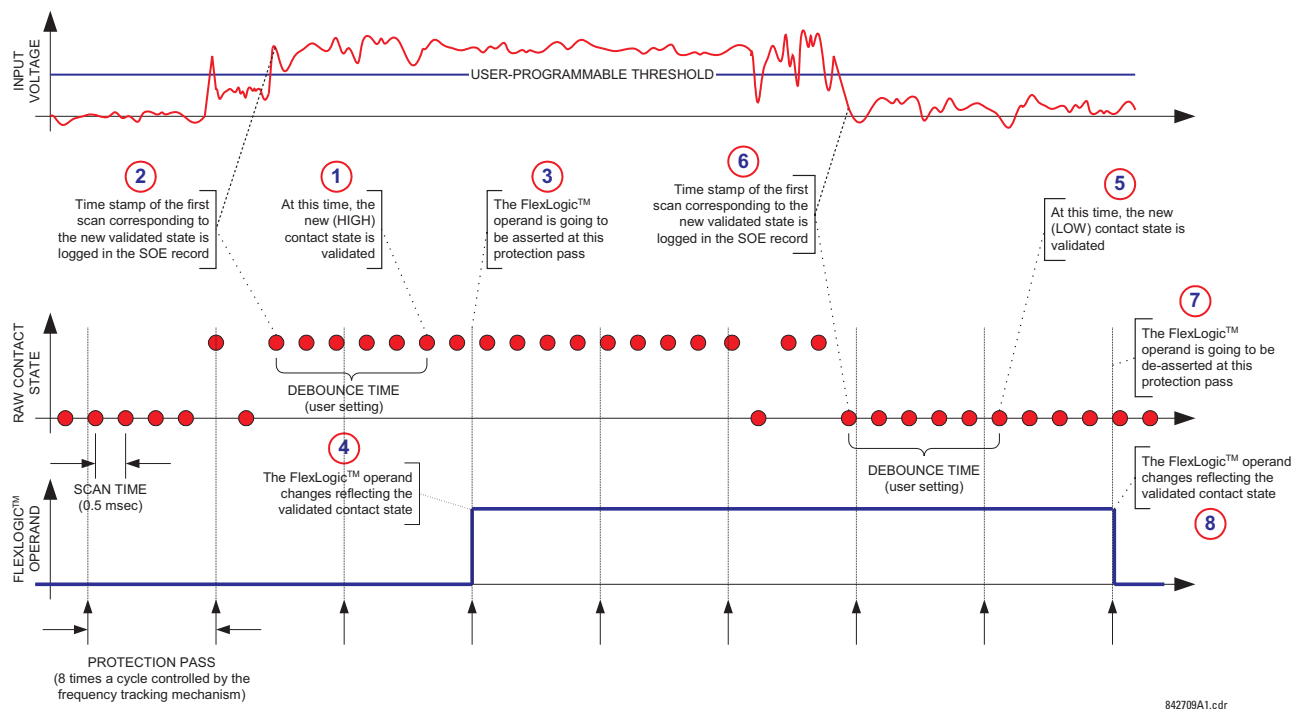


**Figure 5–75: INPUT CONTACT DEBOUNCING MECHANISM AND TIME-STAMPING SAMPLE TIMING**

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.

**PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ VIRTUAL INPUTS ⇨ VIRTUAL INPUT 1(32)**

```
■ VIRTUAL INPUT  1                ◄I►    VIRTUAL INPUT  1          Range:  Disabled, Enabled
■                                        FUNCTION: Disabled

                      MESSAGE     ▲▼     VIRTUAL INPUT  1 ID:      Range:  Up to 12 alphanumeric characters
                                         Virt Ip 1

                      MESSAGE     ▲▼     VIRTUAL INPUT  1          Range:  Self-Reset, Latched
                                         TYPE: Latched

                      MESSAGE     ▲      VIRTUAL INPUT  1          Range:  Disabled, Enabled
                                         EVENTS: Disabled
```

There are 32 virtual inputs that can be individually programmed to respond to input signals from the keypad (Commands menu) and communications protocols. All virtual input operands are defaulted to OFF = 0 unless the appropriate input signal is received. **Virtual input states are preserved through a control power loss**.

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 = 0 to ON = 1, the output operand will be set to ON = 1 for only one evaluation of the FlexLogic™ equations and then return to OFF = 0. If set to "Latched", the virtual input sets the state of the output operand to the same state as the most recent received input, ON =1 or OFF = 0.

> **NOTE**
> **The "Self-Reset" operating mode generates the output operand for a single evaluation of the FlexLogic™ equations. If the operand is to be used anywhere other than internally in a FlexLogic™ equation, it will likely have to be lengthened in time. A FlexLogic™ timer with a delayed reset can perform this function.**
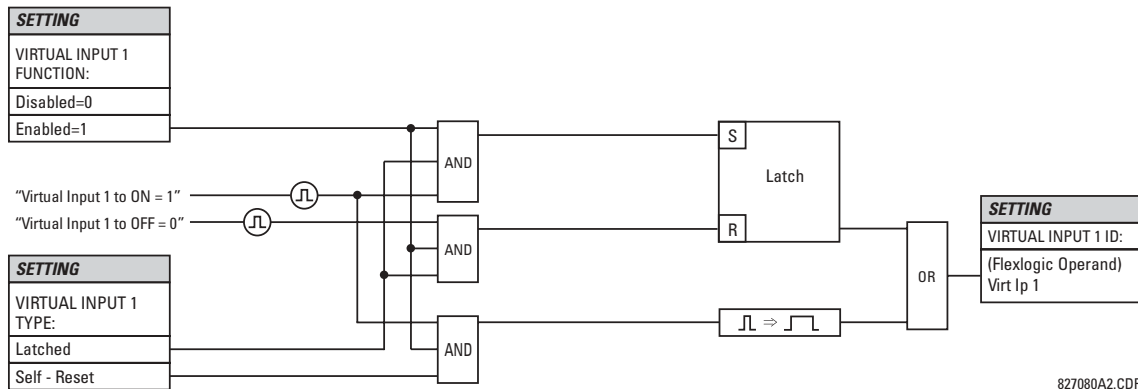


**Figure 5–76: VIRTUAL INPUTS SCHEME LOGIC**

### 5.7.3 CONTACT 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; e.g. '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 C60 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"

### 5.7.4 LATCHING OUTPUTS

**PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ LATCHING OUTPUTS ⇨ LATCHING OUTPUT H1a**

| ■ LATCHING ■ 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 C60 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/OUTPUT** ⇨⇩ **LATCHING OUTPUTS** ⇨ **LATCHING 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"           **PUSHBUTTON 2 FUNCTION:** "Self-reset"
    **PUSHBTN 1 DROP-OUT TIME:** "0.00 s"         **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/OUTPUT** ⇨⇩ **LATCHING OUTPUTS** ⇨ **LATCHING OUTPUT H1a** and **LATCHING OUTPUT H1c** menus (assuming an H4L module):

    **OUTPUT H1a OPERATE:** "VO1"               **OUTPUT H1c OPERATE:** "VO2"
    **OUTPUT H1a RESET:** "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):



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/OUTPUT** ⇨⇩ **LATCHING OUT-PUTS** ⇨ **LATCHING OUTPUT H1a** and **LATCHING OUTPUT H1c** menus (assuming an H4L module):

**OUTPUT H1a OPERATE:** "VO1"                                          **OUTPUT H1c OPERATE:** "VO2"
**OUTPUT H1a RESET:** "VO4"                                              **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):



Program the Latching Outputs by making the following changes in the **SETTINGS** ⇨⇩ **INPUTS/OUTPUT** ⇨⇩ **LATCHING OUT-PUTS** ⇨ **LATCHING OUTPUT H1a** menu (assuming an H4L module):

**OUTPUT H1a OPERATE:** "VO1"
**OUTPUT H1a RESET:** "VO2"

**5.7.5 VIRTUAL OUTPUTS**

**PATH: SETTINGS** ⇨⇩ **INPUTS/OUTPUTS** ⇨⇩ **VIRTUAL OUTPUTS** ⇨ **VIRTUAL OUTPUT 1(64)**



There are 64 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"

### a) REMOTE INPUTS/OUTPUTS OVERVIEW

Remote inputs and outputs, which are a means of exchanging information regarding the state of digital points between remote devices, are provided in accordance with the IEC 61850 "Generic Object Oriented Substation Event (GSSE)" specifications.

> **NOTE**  **The IEC 61850 specification requires that communications between devices be implemented on Ethernet communications facilities. For UR-series relays, Ethernet communications is provided only on the type 9G and 9H versions of the CPU module.**

The sharing of digital point state information between GSSE equipped relays is essentially an extension to FlexLogic™ to allow distributed FlexLogic™ by making operands available to/from devices on a common communications network. In addition to digital point states, GSSE 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 from only those messages that have originated in selected devices.

GSSE messages are designed to be short, high priority and with a high level of reliability. The GSSE message structure contains space for 128 bit pairs representing digital point state information. The IEC 61850 specification provides 32 "DNA" bit pairs, which are status bits representing pre-defined events. All remaining bit pairs are "UserSt" bit pairs, which are status bits representing user-definable events. The C60 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 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 to three times the programmed default time, which is 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 'hold' time for the device. The receiving relay sets a timer assigned to the originating device to the 'hold' 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. This mechanism allows a receiving device to fail to detect a single transmission from a remote device which is sending messages at the slowest possible rate, as set by its 'default update' timer, without reverting to use of the programmed default states. If a message is received from a remote device before the 'hold' time 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 GSSE facility provides for 32 remote inputs and 64 remote outputs.

### b) LOCAL DEVICES: ID OF DEVICE FOR TRANSMITTING GSSE MESSAGES

In a C60 relay, the device ID that identifies the originator of the message is programmed in the **SETTINGS** ⇨ **PRODUCT SETUP** ⇨ ⇩ **INSTALLATION** ⇨ ⇩ **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<br>■ | ◀▮▶ | REMOTE DEVICE  1 ID:<br>Remote Device 1 | *Range:  up to 20 alphanumeric characters* |
|---|---|---|---|

Sixteen remote devices, numbered from 1 to 16, can be selected 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.

**PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ REMOTE INPUTS ⇨ REMOTE INPUT 1(32)**

```
■ REMOTE INPUT 1          ◄▐▶   REMOTE IN  1 DEVICE:      Range:  1 to 16 inclusive
■                               Remote Device  1

            MESSAGE      ▲      REMOTE IN  1 BIT          Range:  None, DNA-1 to DNA-32, UserSt-1 to UserSt-32
                         ▼      PAIR: None

            MESSAGE      ▲      REMOTE IN  1 DEFAULT      Range:  On, Off, Latest/On, Latest/Off
                         ▼      STATE: Off

            MESSAGE      ▲      REMOTE IN  1             Range:  Disabled, Enabled
                                EVENTS: Disabled
```

Remote Inputs which create FlexLogic™ operands at the receiving relay, are extracted from GSSE messages originating in remote devices. The relay provides 32 remote inputs, each of which 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 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.

**REMOTE IN 1 DEVICE** 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** *NN* **ID** (see the *Remote Devices* section). **REMOTE IN 1 BIT PAIR** selects the specific bits of the GSSE message required.

The **REMOTE IN 1 DEFAULT STATE** setting selects the logic state for this point if the local relay has just completed startup or the remote device sending the point is declared to be non-communicating. The following choices are available:

- Setting **REMOTE IN 1 DEFAULT STATE** to "On" value defaults the input to Logic 1.

- Setting **REMOTE IN 1 DEFAULT STATE** to "Off" value defaults the input to Logic 0.

- Setting **REMOTE IN 1 DEFAULT STATE** to "Latest/On" freezes the input in case of lost communications. If the latest state is not known, such as after relay power-up but before the first communication exchange, the input will default to Logic 1. When communication resumes, the input becomes fully operational.

- Setting **REMOTE IN 1 DEFAULT STATE** to "Latest/Off" freezes the input in case of lost communications. If the latest state is not known, such as after relay power-up but before the first communication exchange, the input will default to Logic 0. When communication resumes, the input becomes fully operational.

**NOTE** **For additional information on the GSSE specification, refer to the *Remote Devices* section in this chapter.**

### a) DNA BIT PAIRS

**PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ REMOTE OUTPUTS DNA BIT PAIRS ⇨ REMOTE OUPUTS DNA- 1(32) BIT PAIR**

```
■ REMOTE OUTPUTS
■ DNA- 1 BIT PAIR
```
◀▮▶

```
DNA- 1 OPERAND:
Off
```
*Range: FlexLogic™ Operand*

MESSAGE ▲

```
DNA- 1 EVENTS:
Disabled
```
*Range: Disabled, Enabled*

Remote Outputs (1 to 32) are FlexLogic™ operands inserted into GSSE 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 5–19: IEC 61850 DNA2 ASSIGNMENTS**

| DNA | DEFINITION | INTENDED FUNCTION | LOGIC 0 | LOGIC 1 |
|-----|-----------|-------------------|---------|---------|
| 1 | OperDev | | Trip | Close |
| 2 | Lock Out | | LockoutOff | LockoutOn |
| 3 | Initiate Reclosing | Initiate remote reclose sequence | InitRecloseOff | InitRecloseOn |
| 4 | Block Reclosing | Prevent/cancel remote reclose sequence | BlockOff | BlockOn |
| 5 | Breaker Failure Initiate | Initiate remote breaker failure scheme | BFIOff | BFIOn |
| 6 | Send Transfer Trip | Initiate remote trip operation | TxXfrTripOff | TxXfrTripOn |
| 7 | Receive Transfer Trip | Report receipt of remote transfer trip command | RxXfrTripOff | RxXfrTripOn |
| 8 | Send Perm | Report permissive affirmative | TxPermOff | TxPermOn |
| 9 | Receive Perm | Report receipt of permissive affirmative | RxPermOff | RxPermOn |
| 10 | Stop Perm | Override permissive affirmative | StopPermOff | StopPermOn |
| 11 | Send Block | Report block affirmative | TxBlockOff | TxBlockOn |
| 12 | Receive Block | Report receipt of block affirmative | RxBlockOff | RxBlockOn |
| 13 | Stop Block | Override block affirmative | StopBlockOff | StopBlockOn |
| 14 | BkrDS | Report breaker disconnect 3-phase state | Open | Closed |
| 15 | BkrPhsADS | Report breaker disconnect phase A state | Open | Closed |
| 16 | BkrPhsBDS | Report breaker disconnect phase B state | Open | Closed |
| 17 | BkrPhsCDS | Report breaker disconnect phase C state | Open | Closed |
| 18 | DiscSwDS | | Open | Closed |
| 19 | Interlock DS | | DSLockOff | DSLockOn |
| 20 | LineEndOpen | Report line open at local end | Open | Closed |
| 21 | Status | Report operating status of local GSSE device | Offline | Available |
| 22 | Event | | EventOff | EventOn |
| 23 | Fault Present | | FaultOff | FaultOn |
| 24 | Sustained Arc | Report sustained arc | SustArcOff | SustArcOn |
| 25 | Downed Conductor | Report downed conductor | DownedOff | DownedOn |
| 26 | Sync Closing | | SyncClsOff | SyncClsOn |
| 27 | Mode | Report mode status of local GSSE device | Normal | Test |
| 28→32 | Reserved | | | |

**NOTE** ▽ For more information on GSSE specifications, see the *Remote Inputs/Outputs Overview* in the *Remote Devices* section.

### b) USERST BIT PAIRS

**PATH: SETTINGS** ⇨⇩ **INPUTS/OUTPUTS** ⇨⇩ **REMOTE OUTPUTS UserSt BIT PAIRS** ⇨ **REMOTE OUTPUTS UserSt- 1(32) BIT PAIR**

```
■ REMOTE OUTPUTS              UserSt- 1 OPERAND:        Range:  FlexLogic™ operand
■ UserSt- 1 BIT PAIR   ◀▐▶    Off
```

```
                              UserSt- 1 EVENTS:         Range:  Disabled, Enabled
              MESSAGE  ▲       Disabled
```

Remote Outputs 1 to 32 originate as GSSE 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 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** settings menu.

```
                              DEFAULT GSSE UPDATE       Range:  1 to 60 s in steps of 1
                              TIME: 60 s
```

> **NOTE**
>
> **For more information on GSSE specifications, see the *Remote Inputs/Outputs Overview* in the *Remote Devices* section.**

---

**5.7.9 RESETTING**

**PATH: SETTINGS** ⇨⇩ **INPUTS/OUTPUTS** ⇨⇩ **RESETTING**

```
■ RESETTING                   RESET OPERAND:            Range:  FlexLogic™ operand
■                      ◀▐▶    Off
```

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

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

---

**5.7.10 DIRECT INPUTS/OUTPUTS**

### a) DIRECT INPUTS

**PATH: SETTINGS** ⇨⇩ **INPUTS/OUTPUTS** ⇨⇩ **DIRECT INPUTS** ⇨ **DIRECT INPUT 1(32)**

```
■ DIRECT INPUT   1            DIRECT INPUT   1          Range:  1 to 16
■                      ◀▐▶    DEVICE ID: 1
```

```
                              DIRECT INPUT   1          Range:  1 to 32
              MESSAGE  ▲▼      BIT NUMBER:  1
```

```
                              DIRECT INPUT   1          Range:  On, Off, Latest/On, Latest/Off
              MESSAGE  ▲▼      DEFAULT STATE: Off
```

```
                              DIRECT INPUT   1          Range:  Enabled, Disabled
              MESSAGE  ▲       EVENTS: Disabled
```

These settings specify how the direct input information is processed. The **DIRECT INPUT DEVICE ID** represents the source of this direct input. 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 this direct input. Direct Input *x* is driven by the bit identified here as **DIRECT INPUT 1 BIT NUMBER**. This corresponds to the direct output number of the sending device.

The **DIRECT INPUT 1 DEFAULT STATE** represents the state of the direct input when the associated direct device is offline. The following choices are available:

- Setting **DIRECT INPUT 1 DEFAULT STATE** to "On" value defaults the input to Logic 1.

- Setting **DIRECT INPUT 1 DEFAULT STATE** to "Off" value defaults the input to Logic 0.

- Setting **DIRECT INPUT 1 DEFAULT STATE** to "Latest/On" freezes the input in case of lost communications. If the latest state is not known, such as after relay power-up but before the first communication exchange, the input will default to Logic 1. When communication resumes, the input becomes fully operational.

- Setting **DIRECT INPUT 1 DEFAULT STATE** to "Latest/Off" freezes the input in case of lost communications. If the latest state is not known, such as after relay power-up but before the first communication exchange, the input will default to Logic 0. When communication resumes, the input becomes fully operational.

### b) DIRECT OUTPUTS

**PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ DIRECT OUTPUTS ⇨ DIRECT OUTPUT 1(32)**

```
■ DIRECT OUTPUT  1
■
```
⬤▷

```
DIRECT OUT  1 OPERAND:
Off
```
*Range:  FlexLogic™ operand*

MESSAGE  ⬆

```
DIRECT OUTPUT  1
EVENTS: Disabled
```
*Range:  Enabled, Disabled*

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/Outputs* section (part of the *Product Setup* section) direct inputs/outputs are continued below to illustrate usage of the direct inputs and outputs.

**Example 1: Extending input/output capabilities of a C60 relay**

Consider an application that requires additional quantities of digital inputs and/or output contacts and/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.
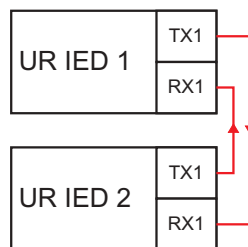


**Figure 5–77: INPUT/OUTPUT EXTENSION VIA DIRECT INPUTS/OUTPUTS**

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"        UR IED 2:    **DIRECT OUT 12 OPERAND** = "Cont Ip 1 On"
                **DIRECT INPUT 5 BIT NUMBER** = "12"

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.
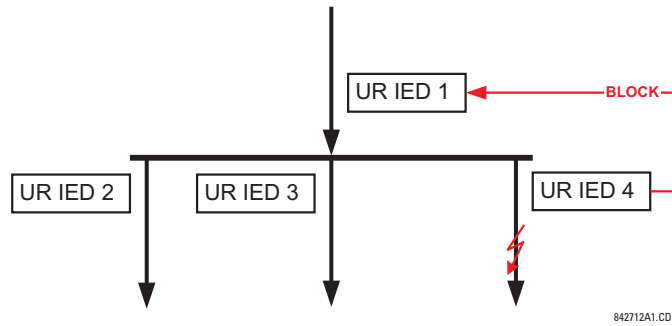
**Figure 5–78: SAMPLE INTERLOCKING BUSBAR PROTECTION SCHEME**

Assume that Phase Instantaneous Overcurrent 1 is used by Devices 2, 3, and 4 to block Device 1. If not blocked, Device 1 would trip the bus upon detecting a fault and applying a short coordination time delay.

The following settings should be applied (assume Bit 3 is used by all 3 devices to sent the blocking signal and Direct Inputs 7, 8, and 9 are used by the receiving device to monitor the three blocking signals):

UR IED 2:    **DIRECT OUT 3 OPERAND**: "PHASE IOC1 OP"

UR IED 3:    **DIRECT OUT 3 OPERAND**: "PHASE IOC1 OP"

UR IED 4:    **DIRECT OUT 3 OPERAND**: "PHASE IOC1 OP"

UR IED 1:    **DIRECT INPUT 7 DEVICE ID**: "2"
             **DIRECT INPUT 7 BIT NUMBER**: "3"
             **DIRECT INPUT 7 DEFAULT STATE**: select "On" for security, select "Off" for dependability

             **DIRECT INPUT 8 DEVICE ID**: "3"
             **DIRECT INPUT 8 BIT NUMBER**: "3"
             **DIRECT INPUT 8 DEFAULT STATE**: select "On" for security, select "Off" for dependability

             **DIRECT INPUT 9 DEVICE ID**: "4"
             **DIRECT INPUT 9 BIT NUMBER**: "3"
             **DIRECT INPUT 9 DEFAULT STATE**: select "On" for security, select "Off" for dependability

Now the three blocking signals are available in UR IED 1 as DIRECT INPUT 7 ON, DIRECT INPUT 8 ON, and DIRECT INPUT 9 ON. Upon losing communications or a device, the scheme is inclined to block (if any default state is set to "On"), or to trip the bus on any overcurrent condition (all default states set to "Off").

**Example 2: Pilot-aided schemes**

Consider a three-terminal line protection application shown in the figure below.
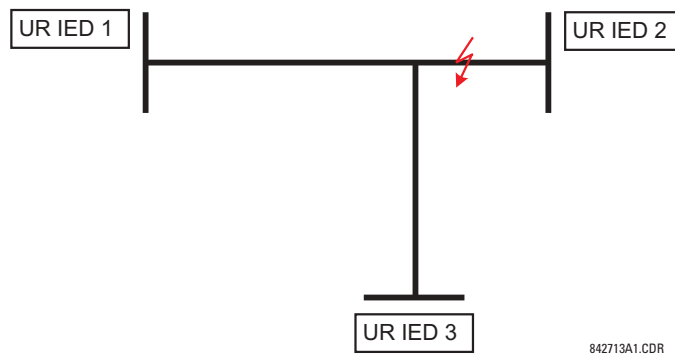


**Figure 5–79: THREE-TERMINAL LINE APPLICATION**

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.
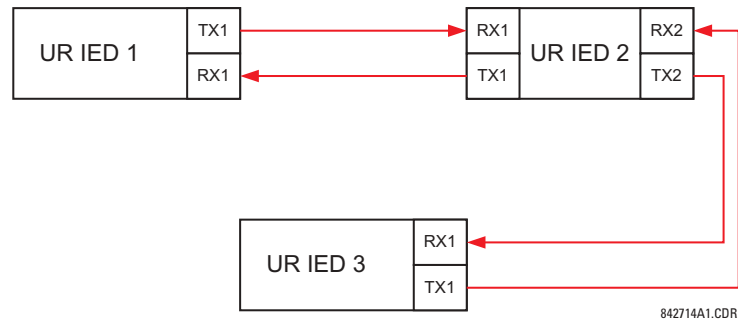
**Figure 5–80: SINGLE-CHANNEL OPEN-LOOP CONFIGURATION**

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:
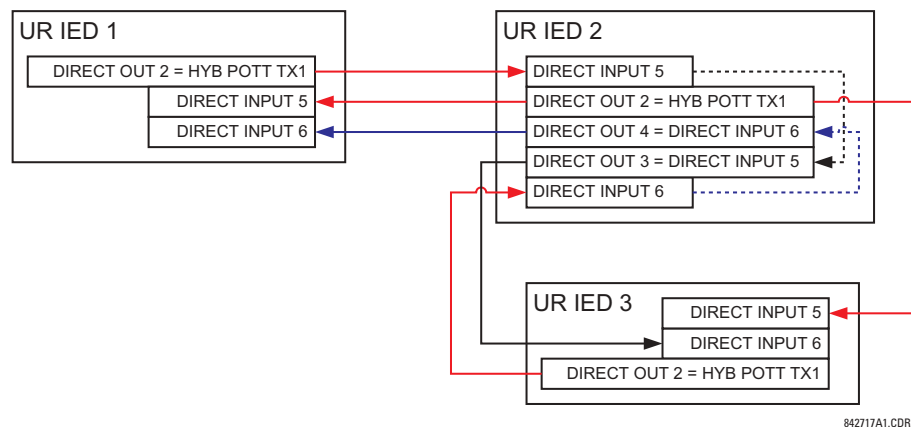


**Figure 5–81: SIGNAL FLOW FOR DIRECT INPUT/OUTPUT EXAMPLE 3**

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).

**PATH: SETTINGS ⇨⇩ TRANSDUCER I/O ⇨⇩ DCMA INPUTS ⇨ DCMA INPUT H1(W8)**

```
■ DCMA INPUT H1               DCMA INPUT H1              Range:  Disabled, Enabled
■                             FUNCTION: Disabled

                              DCMA INPUT H1 ID:          Range:  up to 20 alphanumeric characters
              MESSAGE         DCMA Ip 1

                              DCMA INPUT H1              Range:  6 alphanumeric characters
              MESSAGE         UNITS: µA

                              DCMA INPUT H1              Range:  0 to –1 mA, 0 to +1 mA, –1 to +1 mA, 0 to 5 mA,
              MESSAGE         RANGE: 0 to -1 mA                  0 to 10mA, 0 to 20 mA, 4 to 20 mA

                              DCMA INPUT H1 MIN          Range:  –9999.999 to +9999.999 in steps of 0.001
              MESSAGE         VALUE:    0.000

                              DCMA INPUT H1 MAX          Range:  –9999.999 to +9999.999 in steps of 0.001
              MESSAGE         VALUE:    0.000
```

Hardware and software is provided to receive signals from external transducers and convert these signals into a digital format for use as required. The relay will accept inputs in the range of –1 to +20 mA DC, suitable for use with most common transducer output ranges; all inputs are assumed to be linear over the complete range. Specific hardware details are contained in Chapter 3.

Before the dcmA input signal can be used, the value of the signal measured by the relay must be converted to the range and quantity of the external transducer primary input parameter, such as DC voltage or temperature. The relay simplifies this process by internally scaling the output from the external transducer and displaying the actual primary parameter.

dcmA input channels are arranged in a manner similar to CT and VT channels. The user configures individual channels with the settings shown here.

The channels are arranged in sub-modules of two channels, numbered from 1 through 8 from top to bottom. On power-up, the relay will automatically generate configuration settings for every channel, based on the order code, in the same general manner that is used for CTs and VTs. Each channel is assigned a slot letter followed by the row number, 1 through 8 inclusive, which is used as the channel number. The relay generates an actual value for each available input channel.

Settings are automatically generated for every channel available in the specific relay as shown above for the first channel of a type 5F transducer module installed in slot H.

The function of the channel may be either "Enabled" or "Disabled". If "Disabled", no actual values are created for the channel. An alphanumeric "ID" is assigned to each channel; this ID will be included in the channel actual value, along with the programmed units associated with the parameter measured by the transducer, such as volts, °C, megawatts, etc. This ID is also used to reference the channel as the input parameter to features designed to measure this type of parameter. The **DCMA INPUT H1 RANGE** setting specifies the mA DC range of the transducer connected to the input channel.

The **DCMA INPUT H1 MIN VALUE** and **DCMA INPUT H1 MAX VALUE** settings are used to program the span of the transducer in primary units. For example, a temperature transducer might have a span from 0 to 250°C; in this case the **DCMA INPUT H1 MIN VALUE** value is "0" and the **DCMA INPUT H1 MAX VALUE** value is "250". Another example would be a watts transducer with a span from –20 to +180 MW; in this case the **DCMA INPUT H1 MIN VALUE** value would be "–20" and the **DCMA INPUT H1 MAX VALUE** value "180". Intermediate values between the min and max values are scaled linearly.

**PATH: SETTINGS ⇨⇩ TRANSDUCER I/O ⇨⇩ RTD INPUTS ⇨ RTD INPUT H1(W8)**

```
■ RTD INPUT H1
■
```
◁▷

*Range:*  *Disabled, Enabled*
```
RTD INPUT H1
FUNCTION: Disabled
```

MESSAGE  ⬆⬇
```
RTD INPUT H1 ID:
RTD Ip 1
```
*Range:*  *Up to 20 alphanumeric characters*

MESSAGE  ⬆
```
RTD INPUT H1 TYPE:
100Ω Nickel
```
*Range:*  *100Ω Nickel, 10Ω Copper, 100Ω Platinum, 120Ω Nickel*

Hardware and software is provided to receive signals from external Resistance Temperature Detectors and convert these signals into a digital format for use as required. These channels are intended to be connected to any of the RTD types in common use. Specific hardware details are contained in Chapter 3.

RTD input channels are arranged in a manner similar to CT and VT channels. The user configures individual channels with the settings shown here.

The channels are arranged in sub-modules of two channels, numbered from 1 through 8 from top to bottom. On power-up, the relay will automatically generate configuration settings for every channel, based on the order code, in the same general manner that is used for CTs and VTs. Each channel is assigned a slot letter followed by the row number, 1 through 8 inclusive, which is used as the channel number. The relay generates an actual value for each available input channel.

Settings are automatically generated for every channel available in the specific relay as shown above for the first channel of a type 5C transducer module installed in slot H.

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.

**5.8.3 DCMA OUTPUTS**

**PATH: SETTINGS ⇨⇩ TRANSDUCER I/O ⇨⇩ DCMA OUTPUTS ⇨ DCMA OUTPUT H1(W8)**

```
■ DCMA OUTPUT H1
■
```
◁▷

*Range:*  *Off, any analog actual value parameter*
```
DCMA OUTPUT H1
SOURCE: Off
```

MESSAGE  ⬆⬇
```
DCMA OUTPUT H1
RANGE: −1 to 1 mA
```
*Range:*  *−1 to 1 mA, 0 to 1 mA, 4 to 20 mA*

MESSAGE  ⬆⬇
```
DCMA OUTPUT H1
MIN VAL: 0.000 pu
```
*Range:*  *−90.000 to 90.000 pu in steps of 0.001*

MESSAGE  ⬆
```
DCMA OUTPUT H1
MAX VAL: 1.000 pu
```
*Range:*  *−90.000 to 90.000 pu in steps of 0.001*

Hardware and software is provided to generate dcmA signals that allow interfacing with external equipment. Specific hardware details are contained in Chapter 3. The dcmA output channels are arranged in a manner similar to transducer input or CT and VT channels. The user configures individual channels with the settings shown below.

The channels are arranged in sub-modules of two channels, numbered 1 through 8 from top to bottom. On power-up, the relay automatically generates configuration settings for every channel, based on the order code, in the same manner used for CTs and VTs. Each channel is assigned a slot letter followed by the row number, 1 through 8 inclusive, which is used as the channel number.

Both the output range and a signal driving a given output are user-programmable via the following settings menu (an example for channel M5 is shown).

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:

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

(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:

$$k = \frac{I_{max} - I_{min}}{\textbf{MAX VAL} - \textbf{MIN VAL}}$$

(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.
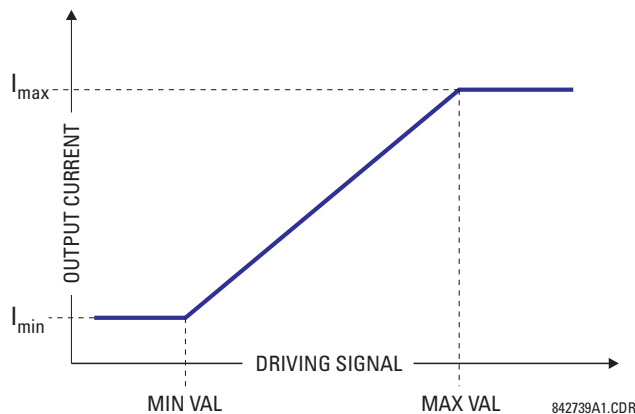


**Figure 5–82: DCMA OUTPUT CHARACTERISTIC**

The dcmA output settings are described below.

*   **DCMA OUTPUT H1 SOURCE**: This setting specifies an internal analog value to drive the analog output. Actual values (FlexAnalog parameters) such as power, current amplitude, voltage amplitude, power factor, etc. can be configured as sources driving dcmA outputs. Refer to Appendix A for a complete list of FlexAnalog parameters.

*   **DCMA OUTPUT H1 RANGE**: This setting allows selection of the output range. Each dcmA channel may be set independently to work with different ranges. The three most commonly used output ranges are available.

*   **DCMA OUTPUT H1 MIN VAL**: This setting allows setting the minimum limit for the signal that drives the output. This setting is used to control the mapping between an internal analog value and the output current (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 H1 MAX VAL**: This setting allows setting the maximum limit for the signal that drives the output. This setting is used to control the mapping between an internal analog value and the output current (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.

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:

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

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

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

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

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

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

$$\text{minimum power} = \frac{-20.65 \text{ MW}}{16.56 \text{ MW}} = -1.247 \text{ pu}, \quad \text{maximum power} = \frac{20.65 \text{ MW}}{16.56 \text{ MW}} = 1.247 \text{ pu}$$ **(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 MIN VALL** "1.247 pu"

With the above settings, the output will represent the power with the scale of 1 mA per 20.65 MW. The worst-case error for this application can be calculated by superimposing the following two sources of error:

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

- ±1% of reading error for the active power at power factor of 0.9

For example at the reading of 20 MW, the worst-case error is 0.01 × 20 MW + 0.207 MW = 0.407 MW.

**Example 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:

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

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

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

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

$$\text{minimum current} = \frac{0 \text{ kA}}{5 \text{ kA}} = 0 \text{ pu}, \quad \text{maximum current} = \frac{6.3 \text{ kA}}{5 \text{ kA}} = 1.26 \text{ pu}$$ **(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 MIN VAL**: "1.260 pu"

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

- ±0.5% of the full scale for the analog output module, or $\pm 0.005 \times (20 - 4) \times 6.3 \text{ kA} = \pm 0.504 \text{ kA}$

- ±0.25% of reading or ±0.1% of rated (whichever is greater) for currents between 0.1 and 2.0 of nominal

For example, at the reading of 4.2 kA, the worst-case error is max(0.0025 × 4.2 kA, 0.001 × 5 kA) + 0.504 kA = 0.515 kA.

**Example 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:

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

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

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

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

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

The following settings should be entered:

> **DCMA OUTPUT H3 SOURCE**: "SRC 2 V_1 mag"
> **DCMA OUTPUT H3 RANGE**: "0 to 1 mA"
> **DCMA OUTPUT H3 MIN VAL**: "0.404 pu"
> **DCMA OUTPUT H3 MIN VAL**: "0.635 pu"

The limit settings differ from the expected 0.7 pu and 1.1 pu because the relay calculates the positive-sequence quantities scaled to the phase-to-ground voltages, even if the VTs are connected in "Delta" (refer to the *Metering Conventions* section in Chapter 6), while at the same time the VT nominal voltage is 1 pu for the settings. Consequently the settings required in this example differ from naturally expected by the factor of $\sqrt{3}$ .

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

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

- ±0.5% of reading

For example, under nominal conditions, the positive-sequence reads 230.94 kV and the worst-case error is 0.005 x 230.94 kV + 1.27 kV = 2.42 kV.

**5.9.1 TEST MODE**

**PATH: SETTINGS ⇨⇩ TESTING ⇨ TEST MODE**

```
■■ SETTINGS
■■ TESTING
```
◀▷
```
TEST MODE
FUNCTION: Disabled
```
*Range: Disabled, Enabled*

MESSAGE ⬆
```
TEST MODE INITIATE:
On
```
*Range: FlexLogic™ operand*
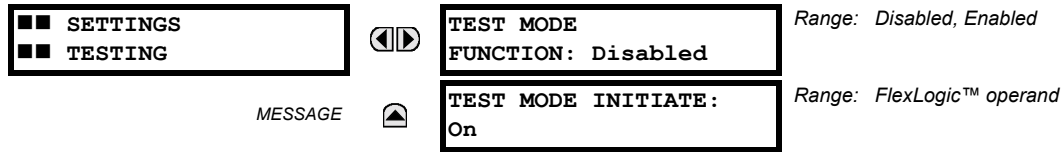
The relay provides test settings to verify that functionality using simulated conditions for contact inputs and outputs. The Test Mode is indicated on the relay faceplate by a flashing Test Mode LED indicator.

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 C60 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**

```
■ FORCE CONTACT
■ INPUTS
```
◀▷
```
FORCE Cont Ip 1
:Disabled
```
*Range: Disabled, Open, Closed*

MESSAGE ⬆⬇
```
FORCE Cont Ip 2
:Disabled
```
*Range: Disabled, Open, Closed*

↓

MESSAGE ⬆
```
FORCE Cont Ip xx
:Disabled
```
*Range: Disabled, Open, Closed*
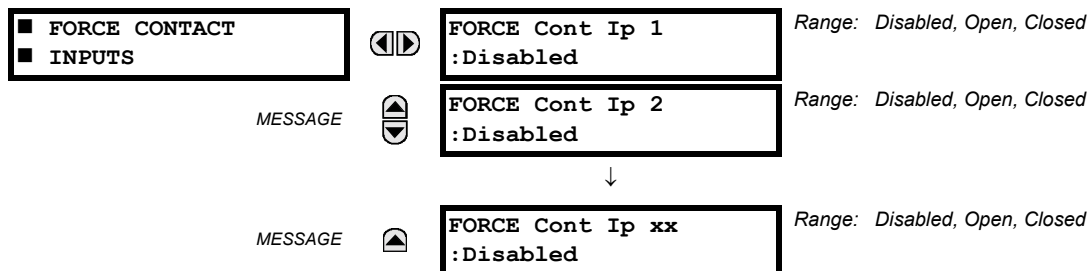
The relay digital inputs (contact inputs) could be pre-programmed to respond to the Test Mode in the following ways:

•   If set to "Disabled", the input remains fully operational. It is controlled by the voltage across its input terminals and can be turned on and off by external circuitry. This value should be selected if a given input must be operational during the test. This includes, for example, an input initiating the test, or being a part of a user pre-programmed test sequence.

•   If set to "Open", the input is forced to report as opened (Logic 0) for the entire duration of the Test Mode regardless of the voltage across the input terminals.

•   If set to "Closed", the input is forced to report as closed (Logic 1) for the entire duration of the Test Mode regardless of the voltage across the input terminals.

The Force Contact Inputs feature provides a method of performing checks on the function of all contact inputs. Once enabled, the relay is placed into Test Mode, allowing this feature to override the normal function of contact inputs. The Test Mode LED will be On, indicating that the relay is in Test Mode. The state of each contact input may be programmed as "Disabled", "Open", or "Closed". All contact input operations return to normal when all settings for this feature are disabled.

**PATH: SETTINGS ⇨⇩ TESTING ⇨⇩ FORCE CONTACT OUTPUTS**

```
■ FORCE CONTACT
■ OUTPUTS
```
◀▷

```
FORCE Cont Op 1
:Disabled
```
*Range:  Disabled, Energized, De-energized, Freeze*

*MESSAGE* ▲▼
```
FORCE Cont Op 2
:Disabled
```
*Range:  Disabled, Energized, De-energized, Freeze*

↓

*MESSAGE* ▲
```
FORCE Cont Op xx
:Disabled
```
*Range:  Disabled, Energized, De-energized, Freeze*
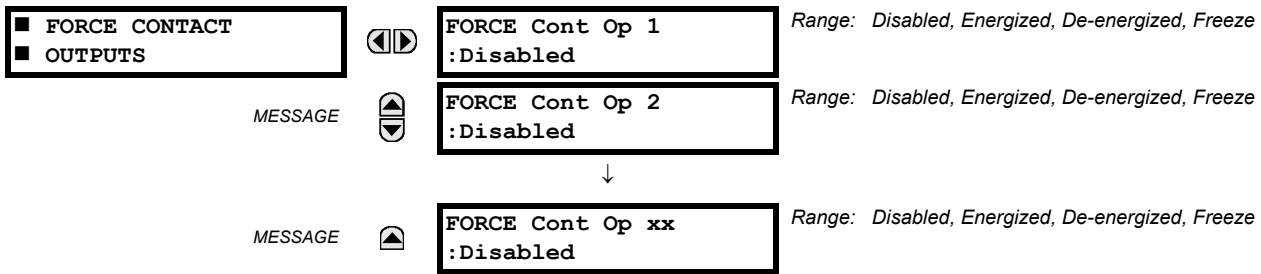
The relay contact outputs can be pre-programmed to respond to the Test Mode.

If set to "Disabled", the contact output remains fully operational. If operates when its control operand is Logic 1 and will resets when its control operand is Logic 0. If set to "Energize", 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-energize", 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 a Test from User-Programmable Pushbutton 1**

The Test Mode should 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 I/Os. In the **SETTINGS ⇨⇩ TESTING ⇨⇩ FORCE CONTACT INPUTS** and **FORCE CONTACT INPUTS** 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:** "Open", and **FORCE Cont Op 4:** "Disabled"

**Example 2: Initiating a Test from User-Programmable Pushbutton 1 or through Remote Input 1**

The Test should 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". The required settings are shown below.

Write the following FlexLogic™ equation (enerVista UR Setup example shown):

| 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 | Write Virtual Output[Assign] | = Virt Op 1 (VO1) | |
| FlexLogic Entry 5 | End of List | | ▼ |

D60 with Pushbuttons.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"

```
■■ ACTUAL VALUES          ■ CONTACT INPUTS
■■ STATUS          ◁▷    ■                    See page 6-3.

        ▼               ■ VIRTUAL INPUTS
                        ■                    See page 6-3.

                        ■ REMOTE INPUTS
                        ■                    See page 6-3.

                        ■ CONTACT OUTPUTS
                        ■                    See page 6-4.

                        ■ VIRTUAL OUTPUTS
                        ■                    See page 6-4.

                        ■ AUTORECLOSE
                        ■                    See page 6-4.

                        ■ REMOTE DEVICES
                        ■ STATUS             See page 6-4.

                        ■ REMOTE DEVICES
                        ■ STATISTICS         See page 6-5.

                        ■ DIGITAL COUNTERS
                        ■                    See page 6-5.

                        ■ SELECTOR SWITCHES
                        ■                    See page 6-5.

                        ■ FLEX STATES
                        ■                    See page 6-5.

                        ■ ETHERNET
                        ■                    See page 6-6.

                        ■ DIRECT INPUTS
                        ■                    See page 6-6.

                        ■ DIRECT DEVICES
                        ■ STATUS             See page 6-7.

                        ■ EGD PROTOCOL
                        ■ STATUS             See page 6-7.


■■ ACTUAL VALUES          ■ SOURCE SRC 1
■■ METERING        ◁▷    ■                    See page 6-11.

        ▼               ■ SOURCE SRC 2
                        ■

                        ■ SOURCE SRC 3
                        ■

                        ■ SOURCE SRC 4
                        ■

                        ■ SYNCHROCHECK
                        ■                    See page 6-14.

                        ■ TRACKING FREQUENCY
                        ■                    See page 6-15.
```

**6**

```
                              ▲    ■ FLEXELEMENTS
                              ▼    ■                      See page 6-15.

                              ▲    ■ SENSITIVE
                              ▼    ■ DIRECTIONAL POWER    See page 6-15.

                              ▲    ■ TRANSDUCER I/O
                              ▼    ■ DCMA INPUTS          See page 6-16.

                              ▲    ■ TRANSDUCER I/O
                                   ■ RTD INPUTS           See page 6-16.

                    ▲
  ■■ ACTUAL VALUES            ◀▶   ■ FAULT REPORTS
  ■■ RECORDS                        ■                     See page 6-17.

                    ▼         ▲    ■ EVENT RECORDS
                              ▼    ■                      See page 6-19.

                              ▲    ■ OSCILLOGRAPHY
                              ▼    ■                      See page 6-19.

                              ▲    ■ DATA LOGGER
                              ▼    ■                      See page 6-19.

                              ▲    ■ MAINTENANCE
                                   ■                      See page 6-20.

                    ▲
  ■■ ACTUAL VALUES            ◀▶   ■ MODEL INFORMATION
  ■■ PRODUCT INFO                   ■                     See page 6-21.

                              ▲    ■ FIRMWARE REVISIONS
                                   ■                      See page 6-21.
```

**NOTE**

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

**6.2.1 CONTACT INPUTS**

**PATH: ACTUAL VALUES ⇨ STATUS ⇨ CONTACT INPUTS**

```
■ CONTACT INPUTS        ◄▮►    Cont Ip 1
■                              Off
```
                                        ↓
```
              MESSAGE    ▲      Cont Ip xx
                               Off
```
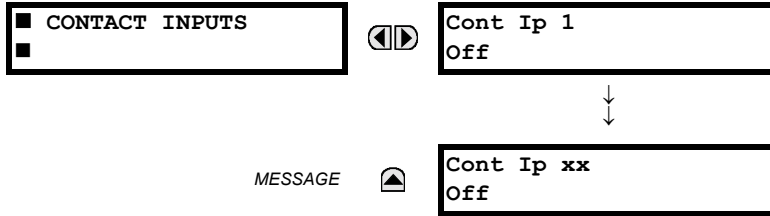
The present status of the contact inputs is shown here. The first line of a message display indicates the ID of the contact input. For example, 'Cont Ip 1' refers to the contact input in terms of the default name-array index. The second line of the display indicates the logic state of the contact input.

**6.2.2 VIRTUAL INPUTS**

**PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ VIRTUAL INPUTS**

```
■ VIRTUAL INPUTS        ◄▮►    Virt Ip 1
■                              Off
```
                                        ↓
```
              MESSAGE    ▲      Virt Ip 32
                               Off
```
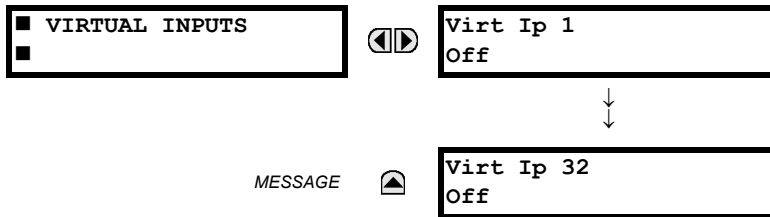
The present status of the 32 virtual inputs is shown here. The first line of a message display indicates the ID of the virtual input. For example, 'Virt Ip 1' refers to the virtual input in terms of the default name. The second line of the display indicates the logic state of the virtual input.

**6.2.3 REMOTE INPUTS**

**PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ REMOTE INPUTS**

```
■ REMOTE INPUTS         ◄▮►    REMOTE INPUT  1     Range:  On, Off
■                              STATUS: Off
```
                                        ↓
```
              MESSAGE    ▲      REMOTE INPUT 32     Range:  On, Off
                               STATUS: Off
```
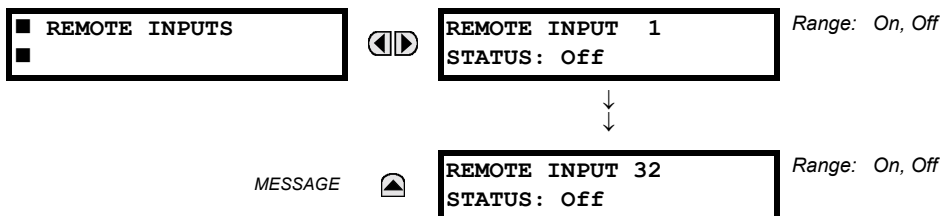
The present state of the 32 remote inputs is shown here.

The state displayed will be that of the remote point unless the remote device has been established to be "Offline" in which case the value shown is the programmed default state for the remote input.

**6.2.4 CONTACT OUTPUTS**

**PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ CONTACT OUTPUTS**

```
■ CONTACT OUTPUTS        ◄▢►      Cont Op 1
■                                 Off
```
                                      ↓
```
         MESSAGE         ▲        Cont Op xx
                                  Off
```
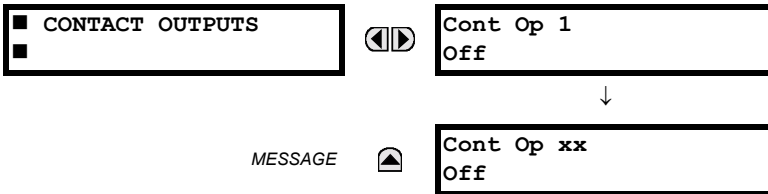
The present state of the contact outputs is shown here. The first line of a message display indicates the ID of the contact output. For example, 'Cont Op 1' refers to the contact output in terms of the default name-array index. The second line of the display indicates the logic state of the contact output.

**NOTE** **For Form-A outputs, the state of the voltage(V) and/or current(I) detectors will show as: Off, VOff, IOff, On, VOn, and/or IOn. For Form-C outputs, the state will show as Off or On.**

**6.2.5 VIRTUAL OUTPUTS**

**PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ VIRTUAL OUTPUTS**

```
■ VIRTUAL OUTPUTS        ◄▢►      Virt Op 1
■                                 Off
```
                                      ↓
```
         MESSAGE         ▲        Virt Op 64
                                  Off
```
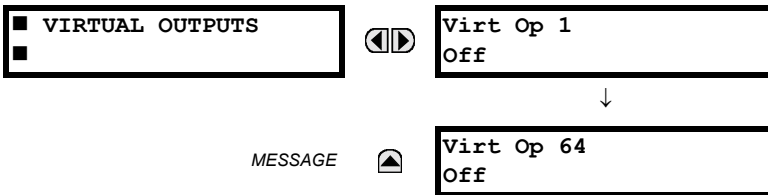
The present state of up to 64 virtual outputs is shown here. The first line of a message display indicates the ID of the virtual output. For example, 'Virt Op 1' refers to the virtual output in terms of the default name-array index. The second line of the display indicates the logic state of the virtual output, as calculated by the FlexLogic™ equation for that output.

**6.2.6 AUTORECLOSE**

**PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ AUTORECLOSE**

```
■ AUTORECLOSE            ◄▢►      AUTORECLOSE           Range:  0, 1, 2, 3, 4
■                                 SHOT COUNT:      0
```
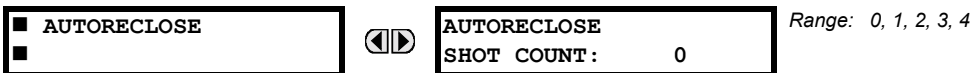
The automatic reclosure shot count is shown here.

**6.2.7 REMOTE DEVICES**

**a) STATUS**

**PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ REMOTE DEVICES STATUS**

```
■ REMOTE DEVICES         ◄▢►      All REMOTE DEVICES    Range:  Yes, No
■ STATUS                          ONLINE: No
```
```
         MESSAGE         ▲▼       REMOTE DEVICE  1      Range:  Online, Offline
                                  STATUS: Offline
```
                                      ↓
```
         MESSAGE         ▲        REMOTE DEVICE 16      Range:  Online, Offline
                                  STATUS: Offline
```
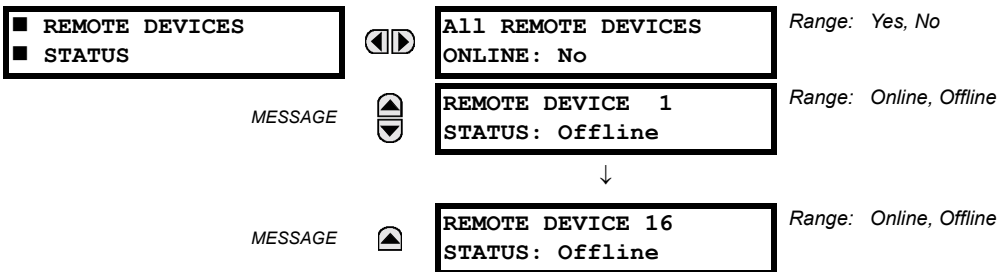
The present state of up to 16 programmed Remote Devices is shown here. The **ALL REMOTE DEVICES ONLINE** message indicates whether or not all programmed Remote Devices are online. If the corresponding state is "No", then at least one required Remote Device is not online.

**b) STATISTICS**

**PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ REMOTE DEVICES STATISTICS ⇨ REMOTE DEVICE 1(16)**

```
■ REMOTE DEVICE  1        ◄◙►    REMOTE DEVICE  1
■                                StNum:         0
```

```
            MESSAGE  ▲         REMOTE DEVICE  1
                                 SqNum:         0
```

Statistical data (2 types) for up to 16 programmed Remote Devices is shown here.

The **StNum** number is obtained from the indicated Remote Device and is incremented whenever a change of state of at least one DNA or UserSt bit occurs. The **SqNum** number is obtained from the indicated Remote Device and is incremented whenever a GSSE message is sent. This number will rollover to zero when a count of 4,294,967,295 is incremented.

## 6.2.8 DIGITAL COUNTERS

**PATH: ACTUAL VALUES ⇨ DIGITAL COUNTERS ⇨⇩ DIGITAL COUNTERS ⇨ DIGITAL COUNTERS Counter 1(8)**

```
■ DIGITAL COUNTERS        ◄◙►    Counter 1      ACCUM:
■ Counter 1                                          0
```

```
            MESSAGE  ▲▼        Counter 1      FROZEN:
                                                    0
```

```
            MESSAGE  ▲▼        Counter 1      FROZEN:
                               YYYY/MM/DD HH:MM:SS
```

```
            MESSAGE  ▲         Counter 1      MICROS:
                                                    0
```

The present status of the 8 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/time stamp for the frozen count. The **Counter n MICROS** value refers to the microsecond portion of the time stamp.

## 6.2.9 SELECTOR SWITCHES

**PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ SELECTOR SWITCHES**

```
■ SELECTOR SWITCHES       ◄◙►    SELECTOR SWITCH 1      Range:  Current Position / 7
■                                POSITION: 0/7
```

```
            MESSAGE  ▲         SELECTOR SWITCH 2      Range:  Current Position / 7
                               POSITION: 0/7
```

The display shows both the current position and the full range. The current position only (an integer from 0 through 7) is the actual value.

## 6.2.10 FLEX STATES

**PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ FLEX STATES**

```
■ FLEX STATES             ◄◙►    PARAM   1: Off        Range:  Off, On
■                                Off
```

```
                                        ↓
```

```
            MESSAGE  ▲         PARAM 256: Off        Range:  Off, On
                               Off
```

There are 256 FlexState bits available. The second line value indicates the state of the given FlexState bit.

**6**

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ ETHERNET

```
■ ETHERNET           ◁▷    ETHERNET PRI LINK      Range:  Fail, OK
■                          STATUS: OK

        MESSAGE      ▲      ETHERNET SEC LINK      Range:  Fail, OK
                           STATUS: OK
```

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ DIRECT INPUTS

```
■ DIRECT INPUTS      ◁▷    AVG MSG RETURN
■                          TIME CH1: 0 ms

        MESSAGE      ▲▼     UNRETURNED MSG
                           COUNT CH1: 0

        MESSAGE      ▲▼     CRC FAIL COUNT
                           CH1: 0

        MESSAGE      ▲▼     AVG MSG RETURN
                           TIME CH2: 0 ms

        MESSAGE      ▲▼     UNRETURNED MSG
                           COUNT CH2: 0

        MESSAGE      ▲▼     CRC FAIL COUNT
                           CH2: 0

        MESSAGE      ▲▼     DIRECT INPUT 1:
                           On
                             ↓
        MESSAGE      ▲      DIRECT INPUT 32:
                           On
```

The **AVERAGE MSG RETURN TIME** is the time taken for direct output messages to return to the sender in a direct input/output ring configuration (this value is not applicable for non-ring configurations). This is a rolling average calculated for the last 10 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 the relay(s). The **UNRETURNED MSG COUNT** and **CRC FAIL COUNT** values can be cleared using the **CLEAR DIRECT I/O COUNTERS** command.

The **DIRECT INPUT x** values represent the state of the *x*-th direct input.

**6.2.13 DIRECT DEVICES STATUS**

**PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ DIRECT DEVICES STATUS**

```
■ DIRECT DEVICES          ◀I▶    DIRECT DEVICE 1
■ STATUS                          STATUS: Offline

              MESSAGE     ⬆      DIRECT DEVICE 2
                           ⬇      STATUS: Offline

                                        ↓

              MESSAGE     ⬆      DIRECT DEVICE 8
                                  STATUS: Offline
```
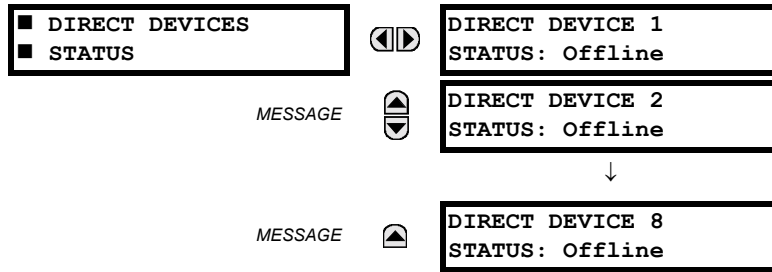
These actual values represent the state of Direct Devices 1 through 8.

**6.2.14 EGD PROTOCOL STATUS**

**a) FAST EXCHANGE**

**PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ EGD PROTOCOL STATUS ⇨ PRODUCER STATUS ⇨ FAST EXCHANGE 1**
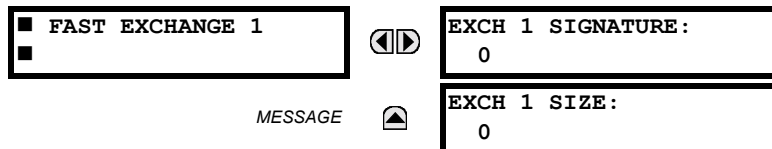
```
■ FAST EXCHANGE 1         ◀I▶    EXCH 1 SIGNATURE:
■                                    0

              MESSAGE     ⬆      EXCH 1 SIZE:
                                     0
```

These values provide information that may be useful for debugging an EGD network. The EGD signature and packet size for the fast EGD exchange is displayed.

**b) SLOW EXCHANGE**

**PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ EGD PROTOCOL STATUS ⇨ PRODUCER STATUS ⇨⇩ SLOW EXCHANGE 1(2)**
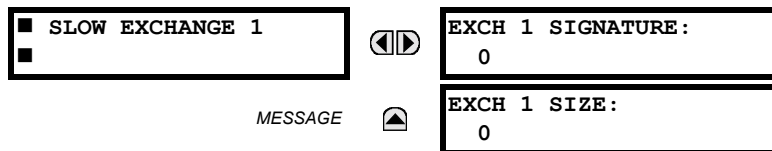
```
■ SLOW EXCHANGE 1         ◀I▶    EXCH 1 SIGNATURE:
■                                    0

              MESSAGE     ⬆      EXCH 1 SIZE:
                                     0
```

These values provide information that may be useful for debugging an EGD network. The EGD signature and packet size for the slow EGD exchanges are displayed.

**a) UR CONVENTION FOR MEASURING POWER AND ENERGY**

The following figure illustrates the conventions established for use in UR-series relays.
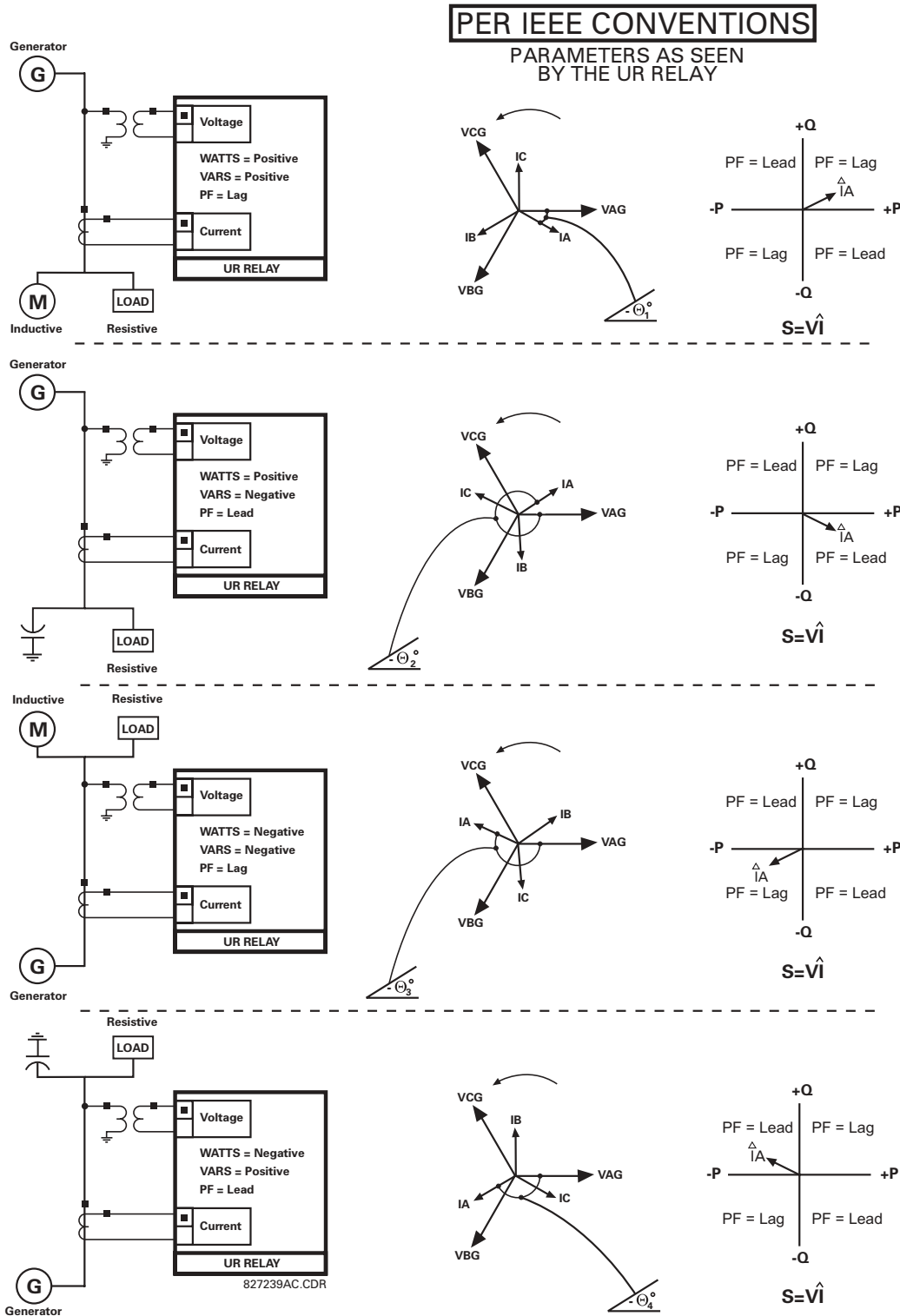
Figure 6–1: FLOW DIRECTION OF SIGNED VALUES FOR WATTS AND VARS

**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 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.
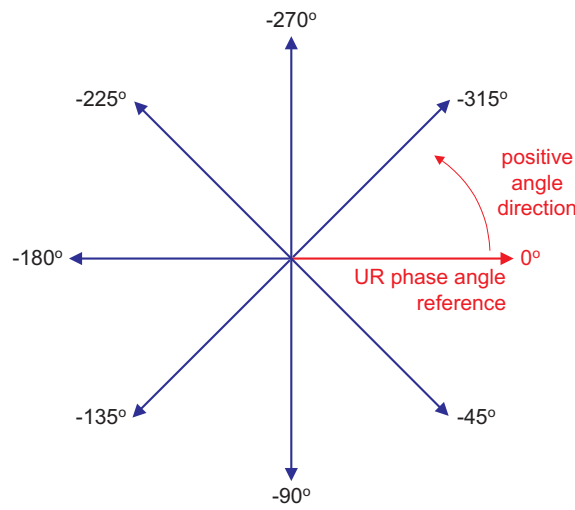


**Figure 6–2: UR PHASE ANGLE MEASUREMENT CONVENTION**

**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:

$$V\_0 = \frac{1}{3}(V_{AG} + V_{BG} + V_{CG})$$

$$V\_1 = \frac{1}{3}(V_{AG} + aV_{BG} + a^2 V_{CG})$$

$$V\_2 = \frac{1}{3}(V_{AG} + a^2 V_{BG} + aV_{CG})$$

- ACB phase rotation:

$$V\_0 = \frac{1}{3}(V_{AG} + V_{BG} + V_{CG})$$

$$V\_1 = \frac{1}{3}(V_{AG} + a^2 V_{BG} + aV_{CG})$$

$$V\_2 = \frac{1}{3}(V_{AG} + aV_{BG} + a^2 V_{CG})$$

The above equations apply to currents as well.

**DELTA-Connected Instrument Transformers:**

- ABC phase rotation:

$$V\_0 = N/A$$

$$V\_1 = \frac{1\angle{-30°}}{3\sqrt{3}}(V_{AB} + aV_{BC} + a^2V_{CA})$$

$$V\_2 = \frac{1\angle{30°}}{3\sqrt{3}}(V_{AB} + a^2V_{BC} + aV_{CA})$$

- ACB phase rotation:

$$V\_0 = N/A$$

$$V\_1 = \frac{1\angle{30°}}{3\sqrt{3}}(V_{AB} + a^2V_{BC} + aV_{CA})$$

$$V\_2 = \frac{1\angle{-30°}}{3\sqrt{3}}(V_{AB} + aV_{BC} + a^2V_{CA})$$

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

**Table 6–1: SYMMETRICAL COMPONENTS CALCULATION EXAMPLE**

| SYSTEM VOLTAGES, SEC. V * | | | | | | VT CONN. | RELAY INPUTS, SEC. V | | | SYMM. COMP, SEC. V | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $V_{AG}$ | $V_{BG}$ | $V_{CG}$ | $V_{AB}$ | $V_{BC}$ | $V_{CA}$ | | F5AC | F6AC | F7AC | $V_0$ | $V_1$ | $V_2$ |
| 13.9 $\angle 0°$ | 76.2 $\angle{-125°}$ | 79.7 $\angle{-250°}$ | 84.9 $\angle{-313°}$ | 138.3 $\angle{-97°}$ | 85.4 $\angle{-241°}$ | WYE | 13.9 $\angle 0°$ | 76.2 $\angle{-125°}$ | 79.7 $\angle{-250°}$ | 19.5 $\angle{-192°}$ | 56.5 $\angle{-7°}$ | 23.3 $\angle{-187°}$ |
| UNKNOWN (only $V_1$ and $V_2$ can be determined) | | | 84.9 $\angle 0°$ | 138.3 $\angle{-144°}$ | 85.4 $\angle{-288°}$ | DELTA | 84.9 $\angle 0°$ | 138.3 $\angle{-144°}$ | 85.4 $\angle{-288°}$ | N/A | 56.5 $\angle{-54°}$ | 23.3 $\angle{-234°}$ |

\* The power system voltages are phase-referenced – for simplicity – to *VAG* and *VAB*, respectively. This, however, is a relative matter. It is important to remember that the UR 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.
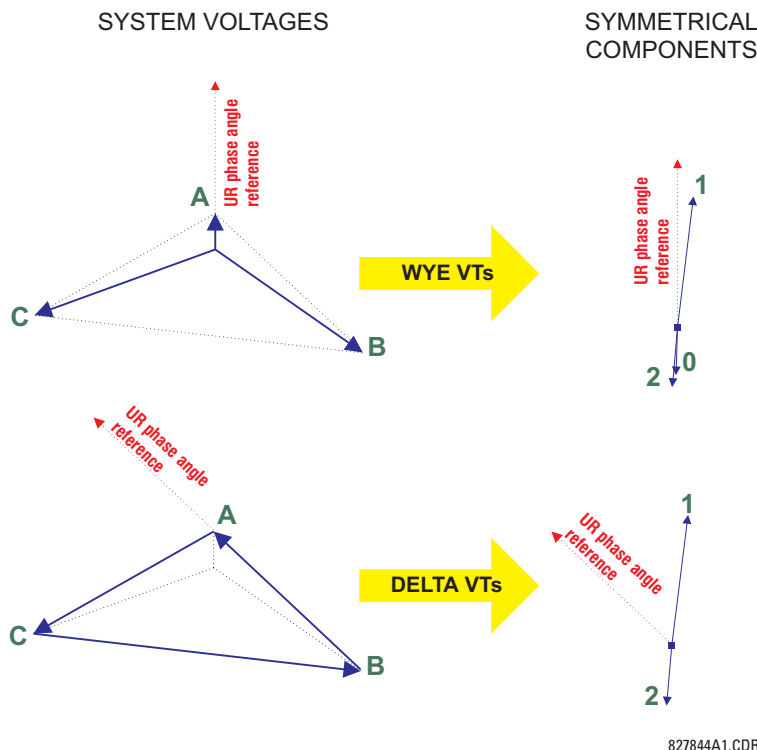


**Figure 6–3: MEASUREMENT CONVENTION FOR SYMMETRICAL COMPONENTS**

**PATH: ACTUAL VALUES ⇨ ⇩ METERING ⇨ SOURCE SRC 1 ⇨**

> **NOTE** Because energy values are accumulated, these values should be recorded and then reset immediately prior to changing CT or VT characteristics.

■ 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°
```

■ 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°
```

■ PHASE VOLTAGE
■ SRC 1
◁▷
```
SRC 1   RMS Vag:
 0.000  V
```

MESSAGE
```
SRC 1   RMS Vbg:
 0.000  V
```

MESSAGE
```
SRC 1   RMS Vcg:
 0.000  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:
 0.000  V
```

*MESSAGE*
```
SRC 1   RMS Vbc:
 0.000  V
```

*MESSAGE*
```
SRC 1   RMS Vca:
 0.000  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°
```

```
■ AUXILIARY VOLTAGE
■ SRC 1
```
```
SRC 1   RMS Vx:
 0.000  V
```

*MESSAGE*
```
SRC 1   PHASOR Vx:
 0.000  V        0.0°
```

```
■ POWER
■ SRC 1
```
```
SRC 1   REAL POWER
3φ:  0.000   W
```

*MESSAGE*
```
SRC 1   REAL POWER
φa:  0.000   W
```

*MESSAGE*
```
SRC 1   REAL POWER
φb:  0.000   W
```

*MESSAGE*
```
SRC 1   REAL POWER
φc:  0.000   W
```

*MESSAGE*
```
SRC 1   REACTIVE PWR
3φ:  0.000   var
```

*MESSAGE*
```
SRC 1   REACTIVE PWR
φa:  0.000   var
```

*MESSAGE*
```
SRC 1   REACTIVE PWR
φb:  0.000   var
```

*MESSAGE*
```
SRC 1   REACTIVE PWR
φc:  0.000   var
```

**6**

*MESSAGE* ⬆⬇
```
SRC 1   APPARENT PWR
3φ:  0.000   VA
```

*MESSAGE* ⬆⬇
```
SRC 1   APPARENT PWR
φa:  0.000   VA
```

*MESSAGE* ⬆⬇
```
SRC 1   APPARENT PWR
φb:  0.000   VA
```

*MESSAGE* ⬆⬇
```
SRC 1   APPARENT PWR
φc:  0.000   VA
```

*MESSAGE* ⬆⬇
```
SRC 1   POWER FACTOR
3φ:       1.000
```

*MESSAGE* ⬆⬇
```
SRC 1   POWER FACTOR
φa:       1.000
```

*MESSAGE* ⬆⬇
```
SRC 1   POWER FACTOR
φb:       1.000
```

*MESSAGE* ⬆
```
SRC 1   POWER FACTOR
φc:       1.000
```

⬆

```
■ ENERGY
■ SRC 1
```
◀▶
```
SRC 1   POS WATTHOUR:
 0.000   Wh
```

*MESSAGE* ⬆⬇
```
SRC 1   NEG WATTHOUR:
 0.000   Wh
```

*MESSAGE* ⬆⬇
```
SRC 1   POS VARHOUR:
 0.000   varh
```

*MESSAGE* ⬆
```
SRC 1   NEG VARHOUR:
 0.000   varh
```

⬆

```
■ DEMAND
■ SRC 1
```
◀▶
```
SRC 1   DMD IA:
 0.000   A
```

*MESSAGE* ⬆⬇
```
SRC 1   DMD IA MAX:
 0.000   A
```

*MESSAGE* ⬆⬇
```
SRC 1   DMD IA DATE:
2001/07/31 16:30:07
```

*MESSAGE* ⬆⬇
```
SRC 1   DMD IB:
 0.000   A
```

*MESSAGE* ⬆⬇
```
SRC 1   DMD IB MAX:
 0.000   A
```

*MESSAGE* ⬆⬇
```
SRC 1   DMD IB DATE:
2001/07/31 16:30:07
```

*MESSAGE* ⬆⬇
```
SRC 1   DMD IC:
 0.000   A
```

*MESSAGE* ⬆⬇
```
SRC 1   DMD IC MAX:
 0.000   A
```

*MESSAGE* ⬆⬇
```
SRC 1   DMD IC DATE:
2001/07/31 16:30:07
```

**6**

MESSAGE
```
SRC 1    DMD W:
 0.000   W
```

MESSAGE
```
SRC 1    DMD W MAX:
 0.000   W
```

MESSAGE
```
SRC 1    DMD W DATE:
2001/07/31 16:30:07
```

MESSAGE
```
SRC 1    DMD VAR:
 0.000   var
```

MESSAGE
```
SRC 1    DMD VAR MAX:
 0.000   var
```

MESSAGE
```
SRC 1    DMD VAR DATE:
2001/07/31 16:30:07
```

MESSAGE
```
SRC 1    DMD VA:
 0.000   VA
```

MESSAGE
```
SRC 1    DMD VA MAX:
 0.000   VA
```

MESSAGE
```
SRC 1    DMD VA DATE:
2001/07/31 16:30:07
```

```
■ FREQUENCY
■ SRC 1
```
◀▶
```
SRC 1    FREQUENCY:
0.00 Hz
```

Four identical Source menus are available. 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**).

The relay measures (absolute values only) **SOURCE DEMAND** on each phase and average three phase demand for real, reactive, and apparent power. These parameters can be monitored to reduce supplier demand penalties or for statistical metering purposes. Demand calculations are based on the measurement type selected in the **SETTINGS ⇨ PRODUCT SETUP ⇨⇩ DEMAND** menu. For each quantity, the relay displays the demand over the most recent demand time interval, the maximum demand since the last maximum demand reset, and the time and date stamp of this maximum demand value. Maximum demand quantities can be reset to zero with the **CLEAR RECORDS ⇨⇩ CLEAR DEMAND RECORDS** command.

**SOURCE FREQUENCY** is measured via software-implemented zero-crossing detection of an AC signal. The signal is either a Clarke transformation of three-phase voltages or currents, auxiliary voltage, or ground current as per source configuration (see the **SYSTEM SETUP ⇨⇩ POWER SYSTEM** settings). The signal used for frequency estimation is low-pass filtered. The final frequency measurement is passed through a validation filter that eliminates false readings due to signal distortions and transients.

**6.3.3 SYNCHROCHECK**

**PATH: ACTUAL VALUES ⇨⇩ METERING ⇨⇩ SYNCHROCHECK ⇨ SYNCHROCHECK 1(2)**

```
■ SYNCHROCHECK 1
■
```
◀▶
```
SYNCHROCHECK 1 DELTA
VOLT:  0.000 V
```

MESSAGE
```
SYNCHROCHECK 1 DELTA
PHASE:    0.0°
```

MESSAGE
```
SYNCHROCHECK 1 DELTA
FREQ:   0.00 Hz
```

The Actual Values menu for Synchrocheck 2 is identical to that of Synchrocheck 1. If a synchrocheck function setting is "Disabled", the corresponding actual values menu item will not be displayed.

### 6.3.4 TRACKING FREQUENCY

**PATH: ACTUAL VALUES ⇨⇩ METERING ⇨⇩ TRACKING FREQUENCY**

```
■ TRACKING FREQUENCY          ◄I►   TRACKING FREQUENCY:
■                                   60.00 Hz
```

The tracking frequency is displayed here. The frequency is tracked based on configuration of the reference source. The **TRACKING FREQUENCY** is based upon positive sequence current phasors from all line terminals and is synchronously adjusted at all terminals. If currents are below 0.125 pu, then the **NOMINAL FREQUENCY** is used.

### 6.3.5 FLEXELEMENTS™

**PATH: ACTUAL VALUES ⇨⇩ METERING ⇨⇩ FLEXELEMENTS ⇨ FLEXELEMENT 1(8)**

```
■ FLEXELEMENT 1               ◄I►   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**

| | |
|---|---|
| BREAKER ARCING AMPS (Brk X Arc Amp A, B, and C) | BASE = 2000 kA$^2$ × cycle |
| dcmA | BASE = maximum value of the **DCMA INPUT MAX** setting for the two transducers configured under the +IN and –IN inputs. |
| FREQUENCY | $f_{BASE}$ = 1 Hz |
| PHASE ANGLE | $\varphi_{BASE}$ = 360 degrees (see the UR angle referencing convention) |
| POWER FACTOR | $PF_{BASE}$ = 1.00 |
| RTDs | BASE = 100°C |
| SENSITIVE DIR POWER (Sns Dir Power) | $P_{BASE}$ = maximum value of $3 \times V_{BASE} \times I_{BASE}$ for the +IN and –IN inputs of the sources configured for the sensitive power directional element(s). |
| SOURCE CURRENT | $I_{BASE}$ = maximum nominal primary RMS value of the +IN and –IN inputs |
| SOURCE ENERGY (SRC X Positive and Negative Watthours); (SRC X Positive and Negative Varhours) | $E_{BASE}$ = 10000 MWh or MVAh, respectively |
| SOURCE POWER | $P_{BASE}$ = maximum value of $V_{BASE} \times I_{BASE}$ for the +IN and –IN inputs |
| SOURCE VOLTAGE | $V_{BASE}$ = maximum nominal primary RMS value of the +IN and –IN inputs |
| SYNCHROCHECK (Max Delta Volts) | $V_{BASE}$ = maximum primary RMS value of all the sources related to the +IN and –IN inputs |

### 6.3.6 SENSITIVE DIRECTIONAL POWER

**PATH: ACTUAL VALUES ⇨⇩ METERING ⇨⇩ SENSITIVE DIRECTIONAL POWER**

```
■ SENSITIVE                   ◄I►   DIRECTIONAL POWER 1
■ DIRECTIONAL POWER                 3Φ: 0.000 W


            MESSAGE    ▲       DIRECTIONAL POWER 2
                               3Φ: 0.000 W
```
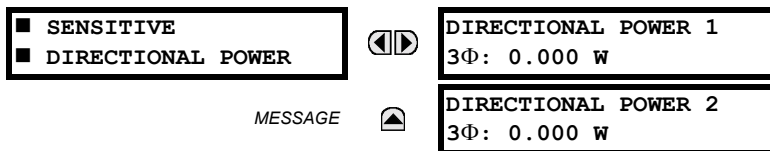
The effective operating quantities of the sensitive directional power elements are displayed here. The display may be useful to calibrate the feature by compensating the angular errors of the CTs and VTs with the use of the **RCA** and **CALIBRATION** settings.

**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**

**PATH: ACTUAL VALUES ⇨⇩ RECORDS ⇨ FAULT REPORTS ⇨ FAULT REPORT 1(15)**

```
NO FAULTS TO REPORT
```
*or*

```
■ FAULT REPORT 1
■
```
◁▷
```
FAULT 1
LINE ID: SRC 1
```
*Range:* *SRC 1, SRC 2, SRC 3, SRC 4*

*MESSAGE* ⯅⯆
```
FAULT 1     DATE:
2000/08/11
```
*Range:* *YYYY/MM/DD*

*MESSAGE* ⯅⯆
```
FAULT 1     TIME:
 00:00:00.000000
```
*Range:* *HH:MM:SS.ssssss*

*MESSAGE* ⯅⯆
```
FAULT 1     TYPE:
ABG
```
*Range:* *where applicable; not seen if the source VTs are in the "Delta" configuration*

*MESSAGE* ⯅⯆
```
FAULT 1     LOCATION
    00.0 km
```
*Range:* *where applicable; not seen if the source VTs are in the "Delta" configuration*

*MESSAGE* ⯅
```
FAULT 1     RECLOSE
SHOT: 0
```
*Range:* *where applicable*

The latest 15 fault reports can be stored. The most recent fault location calculation (when applicable) is displayed in this menu, along with the date and time stamp of the event which triggered the calculation. See the **SETTINGS ⇨ PRODUCT SETUP ⇨⇩ FAULT REPORTS ⇨ FAULT REPORT 1** menu for assigning the source and trigger for fault calculations. Refer to the **COMMANDS ⇨⇩ CLEAR RECORDS** menu for manual clearing of the fault reports and to the **SETTINGS ⇨ PRODUCT SETUP ⇨⇩ CLEAR RELAY RECORDS** menu for automated clearing of the fault reports.

Fault type determination is required for calculation of fault location – the algorithm uses the angle between the negative and positive sequence components of the relay currents. To improve accuracy and speed of operation, the fault components of the currents are used, i.e., the pre-fault phasors are subtracted from the measured current phasors. In addition to the angle relationships, certain extra checks are performed on magnitudes of the negative and zero-sequence currents.

The single-ended fault location method assumes that the fault components of the currents supplied from the local (A) and remote (B) systems are in phase. The figure below shows an equivalent system for fault location.
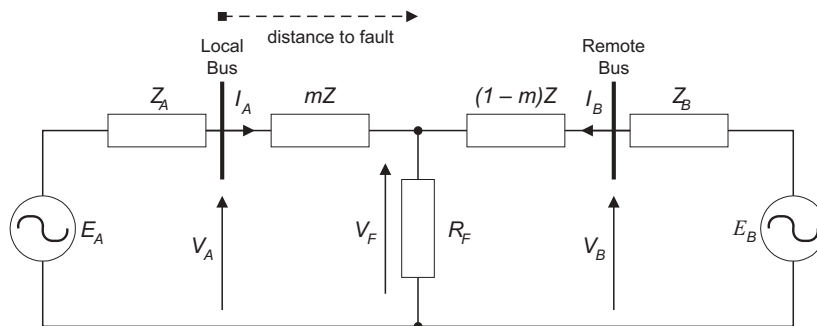


**Figure 6–4: EQUIVALENT SYSTEM FOR FAULT LOCATION**

The following equations hold true for this equivalent system.

$$V_A = m \cdot Z \cdot I_A + R_F \cdot (I_A + I_B)$$

**(EQ 6.1)**

where:   $m$ = sought pu distance to fault, $Z$ = positive sequence impedance of the line.

The currents from the local and remote systems can be parted between their fault (F) and pre-fault load (pre) components:

$$I_A = I_{AF} + I_{Apre}$$

**(EQ 6.2)**

and neglecting shunt parameters of the line:

$$I_B = I_{BF} - I_{Apre}$$

**(EQ 6.3)**

Inserting the $I_A$ and $I_B$ equations into the $V_A$ equation and solving for the fault resistance yields:

$$R_F = \frac{V_A - m \cdot Z \cdot I_A}{I_{AF} \cdot \left(1 + \dfrac{I_{BF}}{I_{AF}}\right)}$$

**(EQ 6.4)**

Assuming the fault components of the currents, $I_{AF}$ and $I_{BF}$ are in phase, and observing that the fault resistance, as impedance, does not have any imaginary part gives:

$$\text{Im}\left(\frac{V_A - m \cdot Z \cdot I_A}{I_{AF}}\right) = 0$$

**(EQ 6.5)**

where: Im() represents the imaginary part of a complex number. Solving the above equation for the unknown $m$ creates the following fault location algorithm:

$$m = \frac{\text{Im}(V_A \cdot I_{AF}{}^*)}{\text{Im}(Z \cdot I_A \cdot I_{AF}{}^*)}$$

**(EQ 6.6)**

where * denotes the complex conjugate and:

$$I_{AF} = I_A - I_{Apre}$$

**(EQ 6.7)**

Depending on the fault type, appropriate voltage and current signals are selected from the phase quantities before applying the two equations above (the superscripts denote phases, the subscripts denote stations):

- For AG faults: $V_A = V_A^A$,    $I_A = I_A^A + K_0 \cdot I_{0A}$
- For BG faults: $V_A = V_A^B$,    $I_A = I_A^B + K_0 \cdot I_{0A}$
- For CG faults: $V_A = V_A^C$,    $I_A = I_A^{BC} + K_0 \cdot I_{0A}$
- For AB and ABG faults: $V_A = V_A^A - V_A^B$,    $I_A = I_A^A - I_A^B$
- For BC and BCG faults: $V_A = V_A^B - V_A^C$,    $I_A = I_A^B - I_A^C$
- For CA and CAG faults: $V_A = V_A^C - V_A^A$,    $I_A = I_A^C - I_A^A$
  where $K_0$ is the zero sequence compensation factor (for the first six equations above)
- For ABC faults, all three AB, BC, and CA loops are analyzed and the final result is selected based upon consistency of the results

The element calculates the distance to the fault (with $m$ in miles or kilometers) and the phases involved in the fault.
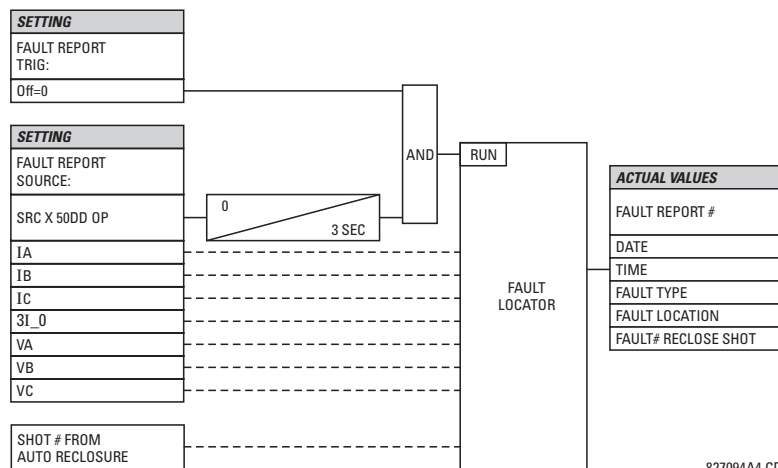


**Figure 6–5: FAULT LOCATOR SCHEME**

**PATH: ACTUAL VALUES** ⇨⇩ **RECORDS** ⇨⇩ **EVENT RECORDS**

```
■ EVENT RECORDS           ◀▮▶    EVENT: XXXX
■                                 RESET OP(PUSHBUTTON)
```
                                          ↓

```
MESSAGE   ▲▼   EVENT: 3         ◀▮▶   ▼   EVENT 3
               POWER ON                    DATE: 2000/07/14

MESSAGE   ▲▼   EVENT: 2               ▲   EVENT 3
               POWER OFF                   TIME: 14:53:00.03405

MESSAGE   ▲    EVENT: 1                    Date and Time Stamps
               EVENTS CLEARED
```
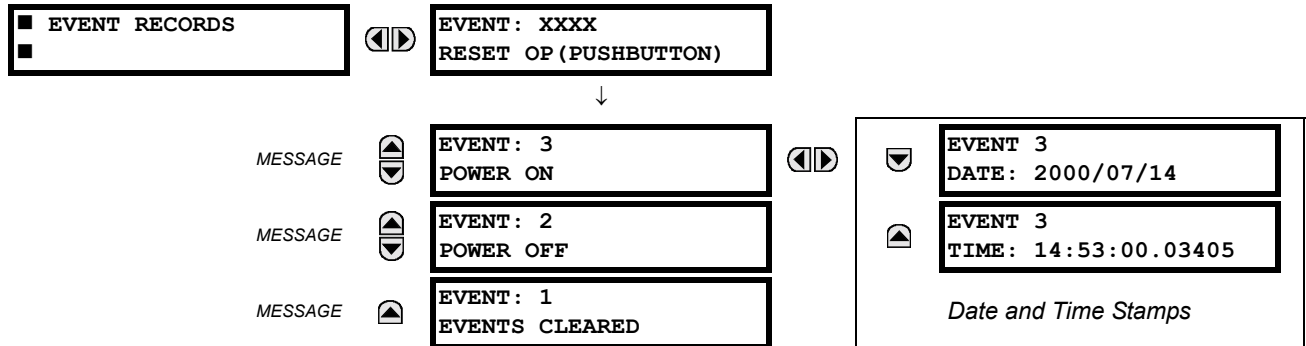
The Event Records menu shows the contextual data associated with up to the last 1024 events, listed in chronological order from most recent to oldest. If all 1024 event records have been filled, the oldest record will be removed as a new record is added. Each event record shows the event identifier/sequence number, cause, and date/time stamp associated with the event trigger. Refer to the **COMMANDS** ⇩ **CLEAR RECORDS** menu for clearing event records.

**PATH: ACTUAL VALUES** ⇨⇩ **RECORDS** ⇨⇩ **OSCILLOGRAPHY**

```
■ OSCILLOGRAPHY           ◀▮▶    FORCE TRIGGER?          Range:  No, Yes
■                                 No

MESSAGE   ▲▼   NUMBER OF TRIGGERS:
                    0

MESSAGE   ▲▼   AVAILABLE RECORDS:
                    0

MESSAGE   ▲▼   CYCLES PER RECORD:
                    0.0

MESSAGE   ▲    LAST CLEARED DATE:
               2000/07/14 015:40:16
```
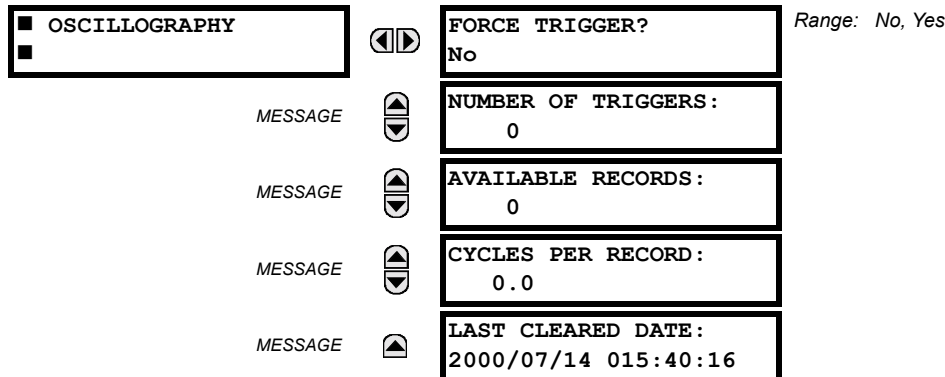
This menu allows the user to view the number of triggers involved and number of oscillography traces available. The 'cycles per record' value is calculated to account for the fixed amount of data storage for oscillography. See the Oscillography section of Chapter 5 for further details.

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 clearing the oscillography records.

**PATH: ACTUAL VALUES** ⇨⇩ **RECORDS** ⇨⇩ **DATA LOGGER**

```
■ DATA LOGGER             ◀▮▶    OLDEST SAMPLE TIME:
■                                 2000/01/14 13:45:51

MESSAGE   ▲    NEWEST SAMPLE TIME:
               2000/01/14 15:21:19
```
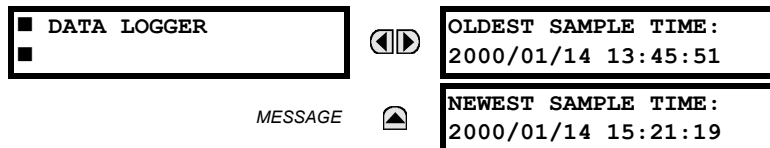
The **OLDEST SAMPLE TIME** is the time at which the oldest available samples were taken. It will be static until the log gets full, at which time it will start counting at the defined sampling rate. The **NEWEST SAMPLE TIME** is the time the most recent samples were taken. It counts up at the defined sampling rate. If Data Logger channels are defined, then both values are static.

Refer to the **COMMANDS** ⇨⇩ **CLEAR RECORDS** menu for clearing data logger records.

**PATH: ACTUAL VALUES** ⇨⇩ **RECORDS** ⇨⇩ **MAINTENANCE** ⇨ **BREAKER 1(4)**

```
■ BREAKER 1                        BKR 1 ARCING AMP φA:
■                                  0.00 kA2-cyc
```

```
        MESSAGE                    BKR 1 ARCING AMP φB:
                                   0.00 kA2-cyc
```

```
        MESSAGE                    BKR 1 ARCING AMP φC:
                                   0.00 kA2-cyc
```

```
        MESSAGE                    BKR 1 OPERATING TIME
                                   φA:      0 ms
```

```
        MESSAGE                    BKR 1 OPERATING TIME
                                   φB:      0 ms
```

```
        MESSAGE                    BKR 1 OPERATING TIME
                                   φC:      0 ms
```

```
        MESSAGE                    BKR 1 OPERATING
                                   TIME:    0 ms
```

There is an identical menu for each of the breakers. The **BKR 1 ARCING AMP** values are in units of kA$^2$-cycles. Refer to the **COMMANDS** ⇨⇩ **CLEAR RECORDS** menu for clearing breaker arcing current records. The **BREAKER OPERATING TIME** is defined as the slowest operating time of breaker poles that were initiated to open.

**6**

**6.5.1 MODEL INFORMATION**

**PATH: ACTUAL VALUES** ⇨ ⇩ **PRODUCT INFO** ⇨ **MODEL INFORMATION**

```
■ MODEL INFORMATION     ◄►    ORDER CODE LINE 1:        Example code shown
■                             C60-E00-HCH-F8F-H6A

              MESSAGE ▲▼       ORDER CODE LINE 2:


              MESSAGE ▲▼       ORDER CODE LINE 3:


              MESSAGE ▲▼       ORDER CODE LINE 4:


              MESSAGE ▲▼       SERIAL NUMBER:


              MESSAGE ▲▼       ETHERNET MAC ADDRESS
                              000000000000

              MESSAGE ▲▼       MANUFACTURING DATE:       Range:  YYYY/MM/DD HH:MM:SS
                              0

              MESSAGE ▲         OPERATING TIME:
                                    0:00:00
```

The product order code, serial number, Ethernet MAC address, date/time of manufacture, and operating time are shown here.

**6.5.2 FIRMWARE REVISIONS**

**PATH: ACTUAL VALUES** ⇨ ⇩ **PRODUCT INFO** ⇨ ⇩ **FIRMWARE REVISIONS**

```
■ FIRMWARE REVISIONS    ◄►    C60 Breaker Relay         Range:  0.00 to 655.35
■                             REVISION:     4.40                Revision number of the application firmware.

              MESSAGE ▲▼       MODIFICATION FILE         Range:  0 to 65535 (ID of the MOD FILE)
                              NUMBER:       0                   Value is 0 for each standard firmware release.

              MESSAGE ▲▼       BOOT PROGRAM              Range:  0.00 to 655.35
                              REVISION:     1.13                Revision number of the boot program firmware.

              MESSAGE ▲▼       FRONT PANEL PROGRAM       Range:  0.00 to 655.35
                              REVISION:     0.08                Revision number of faceplate program firmware.

              MESSAGE ▲▼       COMPILE DATE:             Range:  Any valid date and time.
                              2004/09/15 04:55:16              Date and time when product firmware was built.

              MESSAGE ▲         BOOT DATE:                Range:  Any valid date and time.
                              2004/09/15 16:41:32              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.

**6**

**6**

**7.1.1 COMMANDS MENU**

```
                            ┌────────┐
                            │  MENU  │
                            └────────┘
                        ┌────────────────────┐
                        │  COMMANDS          │
                        │                    │
                        └────────────────────┘
                                 ⇩
                        ┌────────────────────┐
  MESSAGE    ▼          │ ■■  COMMANDS       │
                        │ ■■  VIRTUAL INPUTS │
                        └────────────────────┘
                        ┌────────────────────┐
  MESSAGE    ▲          │ ■■  COMMANDS       │
             ▼          │ ■■  CLEAR RECORDS  │
                        └────────────────────┘
                        ┌──────────────────────┐
  MESSAGE    ▲          │ ■■  COMMANDS         │
             ▼          │ ■■  SET DATE AND TIME│
                        └──────────────────────┘
                        ┌──────────────────────┐
  MESSAGE    ▲          │ ■■  COMMANDS         │
                        │ ■■  RELAY MAINTENANCE│
                        └──────────────────────┘
```
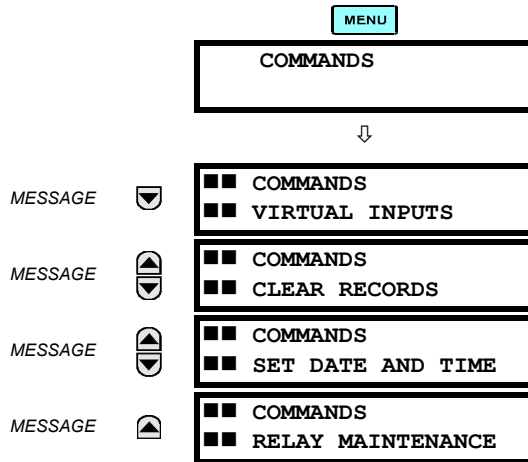
The Commands menu contains relay directives intended for operations personnel. All commands can be protected from unauthorized access via the Command Password; see the Password Security section of Chapter 5. The following flash message appears after successfully command entry:

```
                        ┌────────────────────┐
                        │     COMMAND        │
                        │     EXECUTED       │
                        └────────────────────┘
```

**7.1.2 VIRTUAL INPUTS**

**PATH: COMMANDS ⇩ COMMANDS VIRTUAL INPUTS**

```
┌────────────────────┐        ┌────────────────────┐
│ ■■  COMMANDS       │ ◄I►    │ Virt Ip 1          │   Range:  Off, On
│ ■■  VIRTUAL INPUTS │        │ Off                │
└────────────────────┘        └────────────────────┘
                                       ↓
                                       ↓
                              ┌────────────────────┐
                 MESSAGE  ▲   │ Virt Ip 32         │   Range:  Off, On
                              │ Off                │
                              └────────────────────┘
```
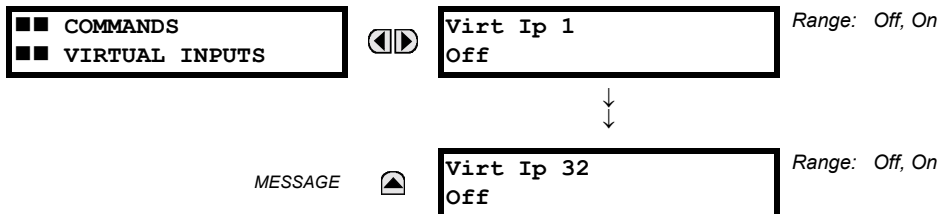
The states of up to 32 virtual inputs are changed here. The first line of the display indicates the ID of the virtual input. The second line indicates the current or selected status of the virtual input. This status will be a logical state 'Off' (0) or 'On' (1).

**7.1.3 CLEAR RECORDS**

**PATH: COMMANDS ⇩ COMMANDS CLEAR RECORDS**

```
┌────────────────────┐        ┌────────────────────┐
│ ■■  COMMANDS       │ ◄I►    │ CLEAR FAULT REPORTS?│   Range:  No, Yes
│ ■■  CLEAR RECORDS  │        │ No                 │
└────────────────────┘        └────────────────────┘
                              ┌────────────────────┐
                          ▲   │ CLEAR OSCILLOGRAPHY?│   Range:  No, Yes
                          ▼   │ No                 │
                              └────────────────────┘
                              ┌────────────────────┐
                          ▲   │ CLEAR DATA LOGGER? │   Range:  No, Yes
                          ▼   │ No                 │
                              └────────────────────┘
                              ┌────────────────────┐
                          ▲   │ CLEAR BREAKER 1    │   Range:  No, Yes
                          ▼   │ ARCING AMPS? No    │
                              └────────────────────┘
```
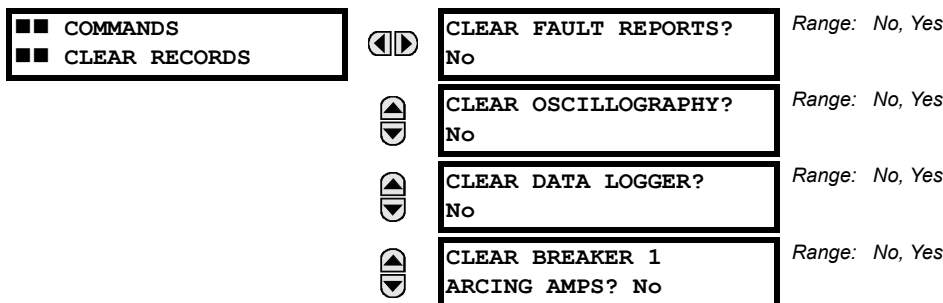
| | CLEAR BREAKER 2<br>ARCING AMPS? No | *Range: No, Yes* |
| | CLEAR DEMAND<br>RECORDS?: No | *Range: No, Yes* |
| | CLEAR ENERGY?<br>No | *Range: No, Yes* |
| | CLEAR UNAUTHORIZED<br>ACCESS? No | *Range: No, Yes* |
| | CLEAR DIRECT I/O<br>COUNTERS? No | *Range: No, Yes*<br>*Valid only for units with Direct I/O module.* |
| | CLEAR ALL RELAY<br>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".

### 7.1.4 SET DATE AND TIME

**PATH: COMMANDS ⇩ SET DATE AND TIME**

| ■■ COMMANDS<br>■■ SET DATE AND TIME | ◄► | SET DATE AND TIME:<br>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 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.

### 7.1.5 RELAY MAINTENANCE

**PATH: COMMANDS ⇩ RELAY MAINTENANCE**

| ■■ COMMANDS<br>■■ RELAY MAINTENANCE | ◄► | PERFORM LAMPTEST?<br>No | *Range: No, Yes* |
| | | UPDATE ORDER CODE?<br>No | *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 LAMPTEST** command turns on all faceplate LEDs and display pixels for a short duration. The **UPDATE ORDER CODE** command causes the relay to scan the backplane for the hardware modules and update the order code to match. If an update occurs, the following message is shown.

```
UPDATING...
PLEASE WAIT
```

There is no impact if there have been no changes to the hardware modules. When an update does not occur, the **ORDER CODE NOT UPDATED** message will be shown.

```
                            ┌──────────┐
                            │   MENU   │
                            └──────────┘
                    ┌──────────────────────────────┐
                    │            TARGETS            │
                    │                               │
                    └──────────────────────────────┘
                                   ⇩
                    ┌──────────────────────────────┐
MESSAGE   ▼         │ DIGITAL ELEMENT  1:           │   Displayed only if targets for this element are active.
                    │ LATCHED                       │   Example shown.
                    └──────────────────────────────┘

MESSAGE   ▲▼        ┌──────────────────────────────┐
                    │ DIGITAL ELEMENT 16:           │   Displayed only if targets for this element are active.
                    │ LATCHED                       │   Example shown.
                    └──────────────────────────────┘

MESSAGE   ▲                         ↓
                                    ↓
```
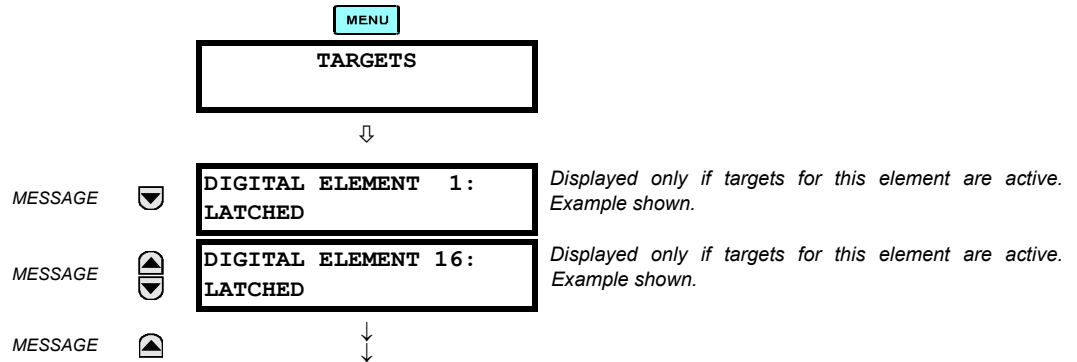
The status of any active targets will be displayed in the Targets menu. If no targets are active, the display will read **No Active Targets**:

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.

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

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.

**Table 7–2: MAJOR SELF-TEST ERROR MESSAGES**

| SELF-TEST ERROR MESSAGE | LATCHED TARGET MESSAGE? | DESCRIPTION OF PROBLEM | HOW OFTEN THE TEST IS PERFORMED | WHAT TO DO |
|---|---|---|---|---|
| DSP ERRORS: A/D Calibration, A/D Interrupt, A/D Reset, Inter DSP Rx, Sample Int, Rx Interrupt, Tx Interrupt, Rx Sample Index, Invalid Settings, Rx Checksum | Yes | CT/VT module with digital signal processor may have a problem. | Every 1/8th of a cycle. | Cycle the control power (if the problem recurs, contact the factory). |
| DSP ERROR: INVALID REVISION | Yes | One or more DSP modules in a multiple DSP unit has Rev. C hardware | Rev. C DSP needs to be replaced with a Rev. D DSP. | Contact the factory |
| EQUIPMENT MISMATCH with 2nd-line detail | No | Configuration of modules does not match the order code stored in the CPU. | On power up; thereafter, the backplane is checked for missing cards every 5 seconds. | Check all modules against the order code, ensure they are inserted properly, and cycle control power (if problem persists, contact factory). |
| FLEXLOGIC ERR TOKEN with 2nd-line detail | No | FlexLogic™ equations do not compile properly. | Event driven; whenever Flex-Logic™ equations are modified. | Finish all equation editing and use self test to debug any errors. |
| LATCHING OUTPUT ERROR | No | Discrepancy in the position of a latching contact between firmware and hardware has been detected. | Every 1/8th of a cycle. | The latching output module failed. Replace the Module. |
| PROGRAM MEMORY Test Failed | Yes | Error was found while checking Flash memory. | Once flash is uploaded with new firmware. | Contact the factory. |
| UNIT NOT CALIBRATED | No | Settings indicate the unit is not calibrated. | On power up. | Contact the factory. |
| UNIT NOT PROGRAMMED | No | **PRODUCT SETUP** ⇨ ⇩ **INSTALLATION** setting indicates relay is not in a programmed state. | On power up and whenever the **RELAY PROGRAMMED** setting is altered. | Program all settings (especially those under **PRODUCT SETUP** ⇨ ⇩ **INSTALLATION**). |

**Table 7–3: MINOR SELF-TEST ERROR MESSAGES**

| SELF-TEST ERROR MESSAGE | LATCHED TARGET MESSAGE | DESCRIPTION OF PROBLEM | HOW OFTEN THE TEST IS PERFORMED | WHAT TO DO |
|---|---|---|---|---|
| BATTERY FAIL | Yes | Battery is not functioning. | Monitored every 5 seconds. Reported after 1 minute if problem persists. | Replace the battery located in the power supply module (1H or 1L). |
| DIRECT RING BREAK | No | Direct input/output settings configured for a ring, but the connection is not in a ring. | Every second. | Check direct input/output configuration and/or wiring. |
| DIRECT DEVICE OFF | No | A direct device is configured but not connected. | Every second. | Check direct input/output configuration and/or wiring. |
| EEPROM DATA ERROR | Yes | The non-volatile memory has been corrupted. | On power up only. | If this message appears after an order code update is preformed, press the RESET key to clear target message. In other cases, contact the factory. |
| IRIG-B FAILURE | No | A bad IRIG-B input signal has been detected | Monitored whenever an IRIG-B signal is received. | Ensure the IRIG-B cable is connected, check cable functionality (i.e. look for physical damage or perform continuity test), ensure IRIG-B receiver is functioning, and check input signal level (it may be less than specification). If none of these apply, contact the factory. |
| LATCHING OUT ERROR | Yes | Latching output failure. | Event driven. | Contact the factory. |
| LOW ON MEMORY | Yes | Memory is close to 100% capacity. | Monitored every 5 seconds. | Contact the factory. |
| PRI ETHERNET FAIL | Yes | Primary Ethernet connection failed. | Monitored every 2 seconds | Check connections. |
| PROTOTYPE FIRMWARE | Yes | A prototype version of the firmware is loaded. | On power up only. | Contact the factory. |
| REMOTE DEVICE OFF | No | One or more GOOSE devices are not responding. | Event driven – occurs when a device programmed to receive GOOSE messages stops receiving. Every 1 to 60 s, depending on GOOSE packets. | Check GOOSE setup. |
| SEC ETHERNET FAIL | Yes | Sec. Ethernet connection failed. | Monitored every 2 seconds | Check connections. |
| SNTP FAILURE | No | SNTP server not responding. | 10 to 60 seconds. | Check SNTP configuration and/or network connections. |
| SYSTEM EXCEPTION | Yes | Abnormal restart from modules being removed/inserted when powered-up, abnormal DC supply, or internal relay failure. | Event driven. | Contact the factory. |
| WATCHDOG ERROR | No | Some tasks are behind schedule. | Event driven. | Contact the factory. |

**7**

**Table A–1: FLEXANALOG DATA ITEMS (Sheet 1 of 8)**

| ADDR | DATA ITEM | FLEXANALOG NAME |
|------|-----------|-----------------|
| 5760 | Sens Dir Power 1 Actual | Sns Dir Power 1 |
| 5762 | Sens Dir Power 2 Actual | Sns Dir Power 2 |
| 6144 | SRC 1 Phase A Current RMS | SRC 1 Ia RMS |
| 6146 | SRC 1 Phase B Current RMS | SRC 1 Ib RMS |
| 6148 | SRC 1 Phase C Current RMS | SRC 1 Ic RMS |
| 6150 | SRC 1 Neutral Current RMS | SRC 1 In RMS |
| 6152 | SRC 1 Phase A Current Magnitude | SRC 1 Ia Mag |
| 6154 | SRC 1 Phase A Current Angle | SRC 1 Ia Angle |
| 6155 | SRC 1 Phase B Current Magnitude | SRC 1 Ib Mag |
| 6157 | SRC 1 Phase B Current Angle | SRC 1 Ib Angle |
| 6158 | SRC 1 Phase C Current Magnitude | SRC 1 Ic Mag |
| 6160 | SRC 1 Phase C Current Angle | SRC 1 Ic Angle |
| 6161 | SRC 1 Neutral Current Magnitude | SRC 1 In Mag |
| 6163 | SRC 1 Neutral Current Angle | SRC 1 In Angle |
| 6164 | SRC 1 Ground Current RMS | SRC 1 Ig RMS |
| 6166 | SRC 1 Ground Current Magnitude | SRC 1 Ig Mag |
| 6168 | SRC 1 Ground Current Angle | SRC 1 Ig Angle |
| 6169 | SRC 1 Zero Seq. Current Magnitude | SRC 1 I_0 Mag |
| 6171 | SRC 1 Zero Sequence Current Angle | SRC 1 I_0 Angle |
| 6172 | SRC 1 Pos. Seq. Current Magnitude | SRC 1 I_1 Mag |
| 6174 | SRC 1 Pos. Seq. Current Angle | SRC 1 I_1 Angle |
| 6175 | SRC 1 Neg. Seq. Current Magnitude | SRC 1 I_2 Mag |
| 6177 | SRC 1 Neg. Seq. Current Angle | SRC 1 I_2 Angle |
| 6178 | SRC 1 Differential Gnd Current Mag. | SRC 1 Igd Mag |
| 6180 | SRC 1 Diff. Gnd. Current Angle | SRC 1 Igd Angle |
| 6208 | SRC 2 Phase A Current RMS | SRC 2 Ia RMS |
| 6210 | SRC 2 Phase B Current RMS | SRC 2 Ib RMS |
| 6212 | SRC 2 Phase C Current RMS | SRC 2 Ic RMS |
| 6214 | SRC 2 Neutral Current RMS | SRC 2 In RMS |
| 6216 | SRC 2 Phase A Current Magnitude | SRC 2 Ia Mag |
| 6218 | SRC 2 Phase A Current Angle | SRC 2 Ia Angle |
| 6219 | SRC 2 Phase B Current Magnitude | SRC 2 Ib Mag |
| 6221 | SRC 2 Phase B Current Angle | SRC 2 Ib Angle |
| 6222 | SRC 2 Phase C Current Magnitude | SRC 2 Ic Mag |
| 6224 | SRC 2 Phase C Current Angle | SRC 2 Ic Angle |
| 6225 | SRC 2 Neutral Current Magnitude | SRC 2 In Mag |
| 6227 | SRC 2 Neutral Current Angle | SRC 2 In Angle |
| 6228 | SRC 2 Ground Current RMS | SRC 2 Ig RMS |
| 6230 | SRC 2 Ground Current Magnitude | SRC 2 Ig Mag |
| 6232 | SRC 2 Ground Current Angle | SRC 2 Ig Angle |
| 6233 | SRC 2 Zero Seq. Current Magnitude | SRC 2 I_0 Mag |
| 6235 | SRC 2 Zero Sequence Current Angle | SRC 2 I_0 Angle |
| 6236 | SRC 2 Pos. Seq. Current Magnitude | SRC 2 I_1 Mag |
| 6238 | SRC 2 Positive Seq. Current Angle | SRC 2 I_1 Angle |
| 6239 | SRC 2 Neg. Seq. Current Magnitude | SRC 2 I_2 Mag |
| 6241 | SRC 2 Negative Seq. Current Angle | SRC 2 I_2 Angle |
| 6242 | SRC 2 Differential Gnd Current Mag. | SRC 2 Igd Mag |
| 6244 | SRC 2 Diff. Gnd Current Angle | SRC 2 Igd Angle |
| 6272 | SRC 3 Phase A Current RMS | SRC 3 Ia RMS |
| 6274 | SRC 3 Phase B Current RMS | SRC 3 Ib RMS |
| 6276 | SRC 3 Phase C Current RMS | SRC 3 Ic RMS |

**Table A–1: FLEXANALOG DATA ITEMS (Sheet 2 of 8)**

| ADDR | DATA ITEM | FLEXANALOG NAME |
|------|-----------|-----------------|
| 6278 | SRC 3 Neutral Current RMS | SRC 3 In RMS |
| 6280 | SRC 3 Phase A Current Magnitude | SRC 3 Ia Mag |
| 6282 | SRC 3 Phase A Current Angle | SRC 3 Ia Angle |
| 6283 | SRC 3 Phase B Current Magnitude | SRC 3 Ib Mag |
| 6285 | SRC 3 Phase B Current Angle | SRC 3 Ib Angle |
| 6286 | SRC 3 Phase C Current Magnitude | SRC 3 Ic Mag |
| 6288 | SRC 3 Phase C Current Angle | SRC 3 Ic Angle |
| 6289 | SRC 3 Neutral Current Magnitude | SRC 3 In Mag |
| 6291 | SRC 3 Neutral Current Angle | SRC 3 In Angle |
| 6292 | SRC 3 Ground Current RMS | SRC 3 Ig RMS |
| 6294 | SRC 3 Ground Current Magnitude | SRC 3 Ig Mag |
| 6296 | SRC 3 Ground Current Angle | SRC 3 Ig Angle |
| 6297 | SRC 3 Zero Seq. Current Magnitude | SRC 3 I_0 Mag |
| 6299 | SRC 3 Zero Sequence Current Angle | SRC 3 I_0 Angle |
| 6300 | SRC 3 Pos. Seq. Current Magnitude | SRC 3 I_1 Mag |
| 6302 | SRC 3 Positive Seq. Current Angle | SRC 3 I_1 Angle |
| 6303 | SRC 3 Neg. Seq. Current Magnitude | SRC 3 I_2 Mag |
| 6305 | SRC 3 Negative Seq. Current Angle | SRC 3 I_2 Angle |
| 6306 | SRC 3 Differential Gnd Current Mag. | SRC 3 Igd Mag |
| 6308 | SRC 3 Differential Gnd Current Angle | SRC 3 Igd Angle |
| 6336 | SRC 4 Phase A Current RMS | SRC 4 Ia RMS |
| 6338 | SRC 4 Phase B Current RMS | SRC 4 Ib RMS |
| 6340 | SRC 4 Phase C Current RMS | SRC 4 Ic RMS |
| 6342 | SRC 4 Neutral Current RMS | SRC 4 In RMS |
| 6344 | SRC 4 Phase A Current Magnitude | SRC 4 Ia Mag |
| 6346 | SRC 4 Phase A Current Angle | SRC 4 Ia Angle |
| 6347 | SRC 4 Phase B Current Magnitude | SRC 4 Ib Mag |
| 6349 | SRC 4 Phase B Current Angle | SRC 4 Ib Angle |
| 6350 | SRC 4 Phase C Current Magnitude | SRC 4 Ic Mag |
| 6352 | SRC 4 Phase C Current Angle | SRC 4 Ic Angle |
| 6353 | SRC 4 Neutral Current Magnitude | SRC 4 In Mag |
| 6355 | SRC 4 Neutral Current Angle | SRC 4 In Angle |
| 6356 | SRC 4 Ground Current RMS | SRC 4 Ig RMS |
| 6358 | SRC 4 Ground Current Magnitude | SRC 4 Ig Mag |
| 6360 | SRC 4 Ground Current Angle | SRC 4 Ig Angle |
| 6361 | SRC 4 Zero Seq. Current Magnitude | SRC 4 I_0 Mag |
| 6363 | SRC 4 Zero Seq. Current Angle | SRC 4 I_0 Angle |
| 6364 | SRC 4 Positive Seq. Current Mag. | SRC 4 I_1 Mag |
| 6366 | SRC 4 Positive Seq. Current Angle | SRC 4 I_1 Angle |
| 6367 | SRC 4 Negative Seq. Current Mag. | SRC 4 I_2 Mag |
| 6369 | SRC 4 Negative Seq. Current Angle | SRC 4 I_2 Angle |
| 6370 | SRC 4 Differential Gnd Current Mag. | SRC 4 Igd Mag |
| 6372 | SRC 4 Differential Gnd Current Angle | SRC 4 Igd Angle |
| 6656 | SRC 1 Phase AG Voltage RMS | SRC 1 Vag RMS |
| 6658 | SRC 1 Phase BG Voltage RMS | SRC 1 Vbg RMS |
| 6660 | SRC 1 Phase CG Voltage RMS | SRC 1 Vcg RMS |
| 6662 | SRC 1 Phase AG Voltage Magnitude | SRC 1 Vag Mag |
| 6664 | SRC 1 Phase AG Voltage Angle | SRC 1 Vag Angle |
| 6665 | SRC 1 Phase BG Voltage Magnitude | SRC 1 Vbg Mag |
| 6667 | SRC 1 Phase BG Voltage Angle | SRC 1 Vbg Angle |
| 6668 | SRC 1 Phase CG Voltage Magnitude | SRC 1 Vcg Mag |

**A**

Table A–1: FLEXANALOG DATA ITEMS (Sheet 3 of 8)

| ADDR | DATA ITEM | FLEXANALOG NAME |
|---|---|---|
| 6670 | SRC 1 Phase CG Voltage Angle | SRC 1 Vcg Angle |
| 6671 | SRC 1 Phase AB Voltage RMS | SRC 1 Vab RMS |
| 6673 | SRC 1 Phase BC Voltage RMS | SRC 1 Vbc RMS |
| 6675 | SRC 1 Phase CA Voltage RMS | SRC 1 Vca RMS |
| 6677 | SRC 1 Phase AB Voltage Magnitude | SRC 1 Vab Mag |
| 6679 | SRC 1 Phase AB Voltage Angle | SRC 1 Vab Angle |
| 6680 | SRC 1 Phase BC Voltage Magnitude | SRC 1 Vbc Mag |
| 6682 | SRC 1 Phase BC Voltage Angle | SRC 1 Vbc Angle |
| 6683 | SRC 1 Phase CA Voltage Magnitude | SRC 1 Vca Mag |
| 6685 | SRC 1 Phase CA Voltage Angle | SRC 1 Vca Angle |
| 6686 | SRC 1 Auxiliary Voltage RMS | SRC 1 Vx RMS |
| 6688 | SRC 1 Auxiliary Voltage Magnitude | SRC 1 Vx Mag |
| 6690 | SRC 1 Auxiliary Voltage Angle | SRC 1 Vx Angle |
| 6691 | SRC 1 Zero Sequence Voltage Mag. | SRC 1 V_0 Mag |
| 6693 | SRC 1 Zero Sequence Voltage Angle | SRC 1 V_0 Angle |
| 6694 | SRC 1 Positive Seq. Voltage Mag. | SRC 1 V_1 Mag |
| 6696 | SRC 1 Positive Seq. Voltage Angle | SRC 1 V_1 Angle |
| 6697 | SRC 1 Negative Seq. Voltage Mag. | SRC 1 V_2 Mag |
| 6699 | SRC 1 Negative Seq. Voltage Angle | SRC 1 V_2 Angle |
| 6720 | SRC 2 Phase AG Voltage RMS | SRC 2 Vag RMS |
| 6722 | SRC 2 Phase BG Voltage RMS | SRC 2 Vbg RMS |
| 6724 | SRC 2 Phase CG Voltage RMS | SRC 2 Vcg RMS |
| 6726 | SRC 2 Phase AG Voltage Magnitude | SRC 2 Vag Mag |
| 6728 | SRC 2 Phase AG Voltage Angle | SRC 2 Vag Angle |
| 6729 | SRC 2 Phase BG Voltage Magnitude | SRC 2 Vbg Mag |
| 6731 | SRC 2 Phase BG Voltage Angle | SRC 2 Vbg Angle |
| 6732 | SRC 2 Phase CG Voltage Magnitude | SRC 2 Vcg Mag |
| 6734 | SRC 2 Phase CG Voltage Angle | SRC 2 Vcg Angle |
| 6735 | SRC 2 Phase AB Voltage RMS | SRC 2 Vab RMS |
| 6737 | SRC 2 Phase BC Voltage RMS | SRC 2 Vbc RMS |
| 6739 | SRC 2 Phase CA Voltage RMS | SRC 2 Vca RMS |
| 6741 | SRC 2 Phase AB Voltage Magnitude | SRC 2 Vab Mag |
| 6743 | SRC 2 Phase AB Voltage Angle | SRC 2 Vab Angle |
| 6744 | SRC 2 Phase BC Voltage Magnitude | SRC 2 Vbc Mag |
| 6746 | SRC 2 Phase BC Voltage Angle | SRC 2 Vbc Angle |
| 6747 | SRC 2 Phase CA Voltage Magnitude | SRC 2 Vca Mag |
| 6749 | SRC 2 Phase CA Voltage Angle | SRC 2 Vca Angle |
| 6750 | SRC 2 Auxiliary Voltage RMS | SRC 2 Vx RMS |
| 6752 | SRC 2 Auxiliary Voltage Magnitude | SRC 2 Vx Mag |
| 6754 | SRC 2 Auxiliary Voltage Angle | SRC 2 Vx Angle |
| 6755 | SRC 2 Zero Seq. Voltage Magnitude | SRC 2 V_0 Mag |
| 6757 | SRC 2 Zero Sequence Voltage Angle | SRC 2 V_0 Angle |
| 6758 | SRC 2 Positive Seq. Voltage Mag. | SRC 2 V_1 Mag |
| 6760 | SRC 2 Positive Seq. Voltage Angle | SRC 2 V_1 Angle |
| 6761 | SRC 2 Negative Seq. Voltage Mag. | SRC 2 V_2 Mag |
| 6763 | SRC 2 Negative Seq. Voltage Angle | SRC 2 V_2 Angle |
| 6784 | SRC 3 Phase AG Voltage RMS | SRC 3 Vag RMS |
| 6786 | SRC 3 Phase BG Voltage RMS | SRC 3 Vbg RMS |
| 6788 | SRC 3 Phase CG Voltage RMS | SRC 3 Vcg RMS |
| 6790 | SRC 3 Phase AG Voltage Magnitude | SRC 3 Vag Mag |
| 6792 | SRC 3 Phase AG Voltage Angle | SRC 3 Vag Angle |
| 6793 | SRC 3 Phase BG Voltage Magnitude | SRC 3 Vbg Mag |

Table A–1: FLEXANALOG DATA ITEMS (Sheet 4 of 8)

| ADDR | DATA ITEM | FLEXANALOG NAME |
|---|---|---|
| 6795 | SRC 3 Phase BG Voltage Angle | SRC 3 Vbg Angle |
| 6796 | SRC 3 Phase CG Voltage Magnitude | SRC 3 Vcg Mag |
| 6798 | SRC 3 Phase CG Voltage Angle | SRC 3 Vcg Angle |
| 6799 | SRC 3 Phase AB Voltage RMS | SRC 3 Vab RMS |
| 6801 | SRC 3 Phase BC Voltage RMS | SRC 3 Vbc RMS |
| 6803 | SRC 3 Phase CA Voltage RMS | SRC 3 Vca RMS |
| 6805 | SRC 3 Phase AB Voltage Magnitude | SRC 3 Vab Mag |
| 6807 | SRC 3 Phase AB Voltage Angle | SRC 3 Vab Angle |
| 6808 | SRC 3 Phase BC Voltage Magnitude | SRC 3 Vbc Mag |
| 6810 | SRC 3 Phase BC Voltage Angle | SRC 3 Vbc Angle |
| 6811 | SRC 3 Phase CA Voltage Magnitude | SRC 3 Vca Mag |
| 6813 | SRC 3 Phase CA Voltage Angle | SRC 3 Vca Angle |
| 6814 | SRC 3 Auxiliary Voltage RMS | SRC 3 Vx RMS |
| 6816 | SRC 3 Auxiliary Voltage Magnitude | SRC 3 Vx Mag |
| 6818 | SRC 3 Auxiliary Voltage Angle | SRC 3 Vx Angle |
| 6819 | SRC 3 Zero Seq. Voltage Magnitude | SRC 3 V_0 Mag |
| 6821 | SRC 3 Zero Sequence Voltage Angle | SRC 3 V_0 Angle |
| 6822 | SRC 3 Positive Seq. Voltage Mag. | SRC 3 V_1 Mag |
| 6824 | SRC 3 Positive Seq. Voltage Angle | SRC 3 V_1 Angle |
| 6825 | SRC 3 Negative Seq. Voltage Mag. | SRC 3 V_2 Mag |
| 6827 | SRC 3 Negative Seq. Voltage Angle | SRC 3 V_2 Angle |
| 6848 | SRC 4 Phase AG Voltage RMS | SRC 4 Vag RMS |
| 6850 | SRC 4 Phase BG Voltage RMS | SRC 4 Vbg RMS |
| 6852 | SRC 4 Phase CG Voltage RMS | SRC 4 Vcg RMS |
| 6854 | SRC 4 Phase AG Voltage Magnitude | SRC 4 Vag Mag |
| 6856 | SRC 4 Phase AG Voltage Angle | SRC 4 Vag Angle |
| 6857 | SRC 4 Phase BG Voltage Magnitude | SRC 4 Vbg Mag |
| 6859 | SRC 4 Phase BG Voltage Angle | SRC 4 Vbg Angle |
| 6860 | SRC 4 Phase CG Voltage Magnitude | SRC 4 Vcg Mag |
| 6862 | SRC 4 Phase CG Voltage Angle | SRC 4 Vcg Angle |
| 6863 | SRC 4 Phase AB Voltage RMS | SRC 4 Vab RMS |
| 6865 | SRC 4 Phase BC Voltage RMS | SRC 4 Vbc RMS |
| 6867 | SRC 4 Phase CA Voltage RMS | SRC 4 Vca RMS |
| 6869 | SRC 4 Phase AB Voltage Magnitude | SRC 4 Vab Mag |
| 6871 | SRC 4 Phase AB Voltage Angle | SRC 4 Vab Angle |
| 6872 | SRC 4 Phase BC Voltage Magnitude | SRC 4 Vbc Mag |
| 6874 | SRC 4 Phase BC Voltage Angle | SRC 4 Vbc Angle |
| 6875 | SRC 4 Phase CA Voltage Magnitude | SRC 4 Vca Mag |
| 6877 | SRC 4 Phase CA Voltage Angle | SRC 4 Vca Angle |
| 6878 | SRC 4 Auxiliary Voltage RMS | SRC 4 Vx RMS |
| 6880 | SRC 4 Auxiliary Voltage Magnitude | SRC 4 Vx Mag |
| 6882 | SRC 4 Auxiliary Voltage Angle | SRC 4 Vx Angle |
| 6883 | SRC 4 Zero Seq. Voltage Magnitude | SRC 4 V_0 Mag |
| 6885 | SRC 4 Zero Sequence Voltage Angle | SRC 4 V_0 Angle |
| 6886 | SRC 4 Positive Seq. Voltage Mag. | SRC 4 V_1 Mag |
| 6888 | SRC 4 Positive Seq. Voltage Angle | SRC 4 V_1 Angle |
| 6889 | SRC 4 Negative Seq. Voltage Mag. | SRC 4 V_2 Mag |
| 6891 | SRC 4 Negative Seq. Voltage Angle | SRC 4 V_2 Angle |
| 7168 | SRC 1 Three Phase Real Power | SRC 1 P |
| 7170 | SRC 1 Phase A Real Power | SRC 1 Pa |
| 7172 | SRC 1 Phase B Real Power | SRC 1 Pb |
| 7174 | SRC 1 Phase C Real Power | SRC 1 Pc |

**Table A–1: FLEXANALOG DATA ITEMS (Sheet 5 of 8)**

| ADDR | DATA ITEM | FLEXANALOG NAME |
|---|---|---|
| 7176 | SRC 1 Three Phase Reactive Power | SRC 1 Q |
| 7178 | SRC 1 Phase A Reactive Power | SRC 1 Qa |
| 7180 | SRC 1 Phase B Reactive Power | SRC 1 Qb |
| 7182 | SRC 1 Phase C Reactive Power | SRC 1 Qc |
| 7184 | SRC 1 Three Phase Apparent Power | SRC 1 S |
| 7186 | SRC 1 Phase A Apparent Power | SRC 1 Sa |
| 7188 | SRC 1 Phase B Apparent Power | SRC 1 Sb |
| 7190 | SRC 1 Phase C Apparent Power | SRC 1 Sc |
| 7192 | SRC 1 Three Phase Power Factor | SRC 1 PF |
| 7193 | SRC 1 Phase A Power Factor | SRC 1 Phase A PF |
| 7194 | SRC 1 Phase B Power Factor | SRC 1 Phase B PF |
| 7195 | SRC 1 Phase C Power Factor | SRC 1 Phase C PF |
| 7200 | SRC 2 Three Phase Real Power | SRC 2 P |
| 7202 | SRC 2 Phase A Real Power | SRC 2 Pa |
| 7204 | SRC 2 Phase B Real Power | SRC 2 Pb |
| 7206 | SRC 2 Phase C Real Power | SRC 2 Pc |
| 7208 | SRC 2 Three Phase Reactive Power | SRC 2 Q |
| 7210 | SRC 2 Phase A Reactive Power | SRC 2 Qa |
| 7212 | SRC 2 Phase B Reactive Power | SRC 2 Qb |
| 7214 | SRC 2 Phase C Reactive Power | SRC 2 Qc |
| 7216 | SRC 2 Three Phase Apparent Power | SRC 2 S |
| 7218 | SRC 2 Phase A Apparent Power | SRC 2 Sa |
| 7220 | SRC 2 Phase B Apparent Power | SRC 2 Sb |
| 7222 | SRC 2 Phase C Apparent Power | SRC 2 Sc |
| 7224 | SRC 2 Three Phase Power Factor | SRC 2 PF |
| 7225 | SRC 2 Phase A Power Factor | SRC 2 Phase A PF |
| 7226 | SRC 2 Phase B Power Factor | SRC 2 Phase B PF |
| 7227 | SRC 2 Phase C Power Factor | SRC 2 Phase C PF |
| 7232 | SRC 3 Three Phase Real Power | SRC 3 P |
| 7234 | SRC 3 Phase A Real Power | SRC 3 Pa |
| 7236 | SRC 3 Phase B Real Power | SRC 3 Pb |
| 7238 | SRC 3 Phase C Real Power | SRC 3 Pc |
| 7240 | SRC 3 Three Phase Reactive Power | SRC 3 Q |
| 7242 | SRC 3 Phase A Reactive Power | SRC 3 Qa |
| 7244 | SRC 3 Phase B Reactive Power | SRC 3 Qb |
| 7246 | SRC 3 Phase C Reactive Power | SRC 3 Qc |
| 7248 | SRC 3 Three Phase Apparent Power | SRC 3 S |
| 7250 | SRC 3 Phase A Apparent Power | SRC 3 Sa |
| 7252 | SRC 3 Phase B Apparent Power | SRC 3 Sb |
| 7254 | SRC 3 Phase C Apparent Power | SRC 3 Sc |
| 7256 | SRC 3 Three Phase Power Factor | SRC 3 PF |
| 7257 | SRC 3 Phase A Power Factor | SRC 3 Phase A PF |
| 7258 | SRC 3 Phase B Power Factor | SRC 3 Phase B PF |
| 7259 | SRC 3 Phase C Power Factor | SRC 3 Phase C PF |
| 7264 | SRC 4 Three Phase Real Power | SRC 4 P |
| 7266 | SRC 4 Phase A Real Power | SRC 4 Pa |
| 7268 | SRC 4 Phase B Real Power | SRC 4 Pb |
| 7270 | SRC 4 Phase C Real Power | SRC 4 Pc |
| 7272 | SRC 4 Three Phase Reactive Power | SRC 4 Q |
| 7274 | SRC 4 Phase A Reactive Power | SRC 4 Qa |
| 7276 | SRC 4 Phase B Reactive Power | SRC 4 Qb |
| 7278 | SRC 4 Phase C Reactive Power | SRC 4 Qc |

**Table A–1: FLEXANALOG DATA ITEMS (Sheet 6 of 8)**

| ADDR | DATA ITEM | FLEXANALOG NAME |
|---|---|---|
| 7280 | SRC 4 Three Phase Apparent Power | SRC 4 S |
| 7282 | SRC 4 Phase A Apparent Power | SRC 4 Sa |
| 7284 | SRC 4 Phase B Apparent Power | SRC 4 Sb |
| 7286 | SRC 4 Phase C Apparent Power | SRC 4 Sc |
| 7288 | SRC 4 Three Phase Power Factor | SRC 4 PF |
| 7289 | SRC 4 Phase A Power Factor | SRC 4 Phase A PF |
| 7290 | SRC 4 Phase B Power Factor | SRC 4 Phase B PF |
| 7291 | SRC 4 Phase C Power Factor | SRC 4 Phase C PF |
| 7552 | SRC 1 Frequency | SRC 1 Frequency |
| 7553 | SRC 2 Frequency | SRC 2 Frequency |
| 7554 | SRC 3 Frequency | SRC 3 Frequency |
| 7555 | SRC 4 Frequency | SRC 4 Frequency |
| 7680 | SRC 1 Demand Ia | SRC 1 Demand Ia |
| 7682 | SRC 1 Demand Ib | SRC 1 Demand Ib |
| 7684 | SRC 1 Demand Ic | SRC 1 Demand Ic |
| 7686 | SRC 1 Demand Watt | SRC 1 Demand Watt |
| 7688 | SRC 1 Demand Var | SRC 1 Demand var |
| 7690 | SRC 1 Demand Va | SRC 1 Demand Va |
| 7696 | SRC 2 Demand Ia | SRC 2 Demand Ia |
| 7698 | SRC 2 Demand Ib | SRC 2 Demand Ib |
| 7700 | SRC 2 Demand Ic | SRC 2 Demand Ic |
| 7702 | SRC 2 Demand Watt | SRC 2 Demand Watt |
| 7704 | SRC 2 Demand Var | SRC 2 Demand var |
| 7706 | SRC 2 Demand Va | SRC 2 Demand Va |
| 7712 | SRC 3 Demand Ia | SRC 3 Demand Ia |
| 7714 | SRC 3 Demand Ib | SRC 3 Demand Ib |
| 7716 | SRC 3 Demand Ic | SRC 3 Demand Ic |
| 7718 | SRC 3 Demand Watt | SRC 3 Demand Watt |
| 7720 | SRC 3 Demand Var | SRC 3 Demand var |
| 7722 | SRC 3 Demand Va | SRC 3 Demand Va |
| 7728 | SRC 4 Demand Ia | SRC 4 Demand Ia |
| 7730 | SRC 4 Demand Ib | SRC 4 Demand Ib |
| 7732 | SRC 4 Demand Ic | SRC 4 Demand Ic |
| 7734 | SRC 4 Demand Watt | SRC 4 Demand Watt |
| 7736 | SRC 4 Demand Var | SRC 4 Demand var |
| 7738 | SRC 4 Demand Va | SRC 4 Demand Va |
| 9024 | Fault 1 Prefault Ph A Current Mag. | Prefault Ia Mag [0] |
| 9026 | Fault 1 Prefault Ph A Current Angle | Prefault Ia Ang [0] |
| 9027 | Fault 1 Prefault Ph B Current Mag. | Prefault Ib Mag [0] |
| 9029 | Fault 1 Prefault Ph B Current Angle | Prefault Ib Ang [0] |
| 9030 | Fault 1 Prefault Ph C Current Mag. | Prefault Ic Mag [0] |
| 9032 | Fault 1 Prefault Ph C Current Angle | Prefault Ic Ang [0] |
| 9033 | Fault 1 Prefault Ph A Voltage Mag. | Prefault Va Mag [0] |
| 9035 | Fault 1 Prefault Ph A Voltage Angle | Prefault Va Ang [0] |
| 9036 | Fault 1 Prefault Ph B Voltage Mag. | Prefault Vb Mag [0] |
| 9038 | Fault 1 Prefault Ph B Voltage Angle | Prefault Vb Ang [0] |
| 9039 | Fault 1 Prefault Ph C Voltage Mag. | Prefault Vc Mag [0] |
| 9041 | Fault 1 Prefault Ph C Voltage Angle | Prefault Vc Ang [0] |
| 9042 | Fault 1 Postfault Ph A Current Mag. | Postfault Ia Mag [0] |
| 9044 | Fault 1 Postfault Ph A Current Angle | Postfault Ia Ang [0] |
| 9045 | Fault 1 Postfault Ph B Current Mag. | Postfault Ib Mag [0] |
| 9047 | Fault 1 Postfault Ph B Current Angle | Postfault Ib Ang [0] |

**A**

**Table A–1: FLEXANALOG DATA ITEMS (Sheet 7 of 8)**

| ADDR | DATA ITEM | FLEXANALOG NAME |
|---|---|---|
| 9048 | Fault 1 Postfault Ph C Current Mag. | Postfault Ic Mag [0] |
| 9050 | Fault 1 Postfault Ph C Current Angle | Postfault Ic Ang [0] |
| 9051 | Fault 1 Postfault Ph A Voltage Mag. | Postfault Va Mag [0] |
| 9053 | Fault 1 Postfault Ph A Voltage Angle | Postfault Va Ang [0] |
| 9054 | Fault 1 Postfault Ph B Voltage Mag. | Postfault Vb Mag [0] |
| 9056 | Fault 1 Postfault Ph B Voltage Angle | Postfault Vb Ang [0] |
| 9057 | Fault 1 Postfault Ph C Voltage Mag. | Postfault Vc Mag [0] |
| 9059 | Fault 1 Postfault Ph C Voltage Angle | Postfault Vc Ang [0] |
| 9060 | Fault 1 Type | Fault Type [0] |
| 9061 | Fault 1 Location | Fault Location [0] |
| 9216 | Synchrocheck 1 Delta Voltage | Synchchk 1 Delta V |
| 9218 | Synchrocheck 1 Delta Frequency | Synchchk 1 Delta F |
| 9219 | Synchrocheck 1 Delta Phase | Synchchk 1 Delta Phs |
| 9220 | Synchrocheck 2 Delta Voltage | Synchchk 2 Delta V |
| 9222 | Synchrocheck 2 Delta Frequency | Synchchk 2 Delta F |
| 9223 | Synchrocheck 2 Delta Phase | Synchchk 2 Delta Phs |
| 13504 | DCMA Inputs 1 Value | DCMA Inputs 1 Value |
| 13506 | DCMA Inputs 2 Value | DCMA Inputs 2 Value |
| 13508 | DCMA Inputs 3 Value | DCMA Inputs 3 Value |
| 13510 | DCMA Inputs 4 Value | DCMA Inputs 4 Value |
| 13512 | DCMA Inputs 5 Value | DCMA Inputs 5 Value |
| 13514 | DCMA Inputs 6 Value | DCMA Inputs 6 Value |
| 13516 | DCMA Inputs 7 Value | DCMA Inputs 7 Value |
| 13518 | DCMA Inputs 8 Value | DCMA Inputs 8 Value |
| 13520 | DCMA Inputs 9 Value | DCMA Inputs 9 Value |
| 13522 | DCMA Inputs 10 Value | DCMA Inputs 10 Value |
| 13524 | DCMA Inputs 11 Value | DCMA Inputs 11 Value |
| 13526 | DCMA Inputs 12 Value | DCMA Inputs 12 Value |
| 13528 | DCMA Inputs 13 Value | DCMA Inputs 13 Value |
| 13530 | DCMA Inputs 14 Value | DCMA Inputs 14 Value |
| 13532 | DCMA Inputs 15 Value | DCMA Inputs 15 Value |
| 13534 | DCMA Inputs 16 Value | DCMA Inputs 16 Value |
| 13536 | DCMA Inputs 17 Value | DCMA Inputs 17 Value |
| 13538 | DCMA Inputs 18 Value | DCMA Inputs 18 Value |
| 13540 | DCMA Inputs 19 Value | DCMA Inputs 19 Value |
| 13542 | DCMA Inputs 20 Value | DCMA Inputs 20 Value |
| 13544 | DCMA Inputs 21 Value | DCMA Inputs 21 Value |
| 13546 | DCMA Inputs 22 Value | DCMA Inputs 22 Value |
| 13548 | DCMA Inputs 23 Value | DCMA Inputs 23 Value |
| 13550 | DCMA Inputs 24 Value | DCMA Inputs 24 Value |
| 13552 | RTD Inputs 1 Value | RTD Inputs 1 Value |
| 13553 | RTD Inputs 2 Value | RTD Inputs 2 Value |
| 13554 | RTD Inputs 3 Value | RTD Inputs 3 Value |
| 13555 | RTD Inputs 4 Value | RTD Inputs 4 Value |
| 13556 | RTD Inputs 5 Value | RTD Inputs 5 Value |
| 13557 | RTD Inputs 6 Value | RTD Inputs 6 Value |
| 13558 | RTD Inputs 7 Value | RTD Inputs 7 Value |
| 13559 | RTD Inputs 8 Value | RTD Inputs 8 Value |
| 13560 | RTD Inputs 9 Value | RTD Inputs 9 Value |
| 13561 | RTD Inputs 10 Value | RTD Inputs 10 Value |
| 13562 | RTD Inputs 11 Value | RTD Inputs 11 Value |
| 13563 | RTD Inputs 12 Value | RTD Inputs 12 Value |

**Table A–1: FLEXANALOG DATA ITEMS (Sheet 8 of 8)**

| ADDR | DATA ITEM | FLEXANALOG NAME |
|---|---|---|
| 13564 | RTD Inputs 13 Value | RTD Inputs 13 Value |
| 13565 | RTD Inputs 14 Value | RTD Inputs 14 Value |
| 13566 | RTD Inputs 15 Value | RTD Inputs 15 Value |
| 13567 | RTD Inputs 16 Value | RTD Inputs 16 Value |
| 13568 | RTD Inputs 17 Value | RTD Inputs 17 Value |
| 13569 | RTD Inputs 18 Value | RTD Inputs 18 Value |
| 13570 | RTD Inputs 19 Value | RTD Inputs 19 Value |
| 13571 | RTD Inputs 20 Value | RTD Inputs 20 Value |
| 13572 | RTD Inputs 21 Value | RTD Inputs 21 Value |
| 13573 | RTD Inputs 22 Value | RTD Inputs 22 Value |
| 13574 | RTD Inputs 23 Value | RTD Inputs 23 Value |
| 13575 | RTD Inputs 24 Value | RTD Inputs 24 Value |
| 13576 | RTD Inputs 25 Value | RTD Inputs 25 Value |
| 13577 | RTD Inputs 26 Value | RTD Inputs 26 Value |
| 13578 | RTD Inputs 27 Value | RTD Inputs 27 Value |
| 13579 | RTD Inputs 28 Value | RTD Inputs 28 Value |
| 13580 | RTD Inputs 29 Value | RTD Inputs 29 Value |
| 13581 | RTD Inputs 30 Value | RTD Inputs 30 Value |
| 13582 | RTD Inputs 31 Value | RTD Inputs 31 Value |
| 13583 | RTD Inputs 32 Value | RTD Inputs 32 Value |
| 13584 | RTD Inputs 33 Value | RTD Inputs 33 Value |
| 13585 | RTD Inputs 34 Value | RTD Inputs 34 Value |
| 13586 | RTD Inputs 35 Value | RTD Inputs 35 Value |
| 13587 | RTD Inputs 36 Value | RTD Inputs 36 Value |
| 13588 | RTD Inputs 37 Value | RTD Inputs 37 Value |
| 13589 | RTD Inputs 38 Value | RTD Inputs 38 Value |
| 13590 | RTD Inputs 39 Value | RTD Inputs 39 Value |
| 13591 | RTD Inputs 40 Value | RTD Inputs 40 Value |
| 13592 | RTD Inputs 41 Value | RTD Inputs 41 Value |
| 13593 | RTD Inputs 42 Value | RTD Inputs 42 Value |
| 13594 | RTD Inputs 43 Value | RTD Inputs 43 Value |
| 13595 | RTD Inputs 44 Value | RTD Inputs 44 Value |
| 13596 | RTD Inputs 45 Value | RTD Inputs 45 Value |
| 13597 | RTD Inputs 46 Value | RTD Inputs 46 Value |
| 13598 | RTD Inputs 47 Value | RTD Inputs 47 Value |
| 13599 | RTD Inputs 48 Value | RTD Inputs 48 Value |
| 32768 | Tracking Frequency | Tracking Frequency |
| 39425 | FlexElement 1 Actual | FlexElement 1 Value |
| 39427 | FlexElement 2 Actual | FlexElement 2 Value |
| 39429 | FlexElement 3 Actual | FlexElement 3 Value |
| 39431 | FlexElement 4 Actual | FlexElement 4 Value |
| 39433 | FlexElement 5 Actual | FlexElement 5 Value |
| 39435 | FlexElement 6 Actual | FlexElement 6 Value |
| 39437 | FlexElement 7 Actual | FlexElement 7 Value |
| 39439 | FlexElement 8 Actual | FlexElement 8 Value |
| 40971 | Current Setting Group | Active Setting Group |

**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, 10BaseT, or 10BaseF. Data flow is half-duplex in all configurations. See Chapter 3 for details on wiring.

Each data byte is transmitted in an asynchronous format consisting of 1 start bit, 8 data bits, 1 stop bit, and possibly 1 parity bit. This produces a 10 or 11 bit data frame. This can be important for transmission through modems at high bit rates (11 bit data frames are not supported by many modems at baud rates greater than 300).

The baud rate and parity are independently programmable for each communications port. Baud rates of 300, 1200, 2400, 4800, 9600, 14400, 19200, 28800, 33600, 38400, 57600, or 115200 bps are available. Even, odd, and no parity are available. Refer to the *Communications* section of Chapter 5 for further details.

The master device in any system must know the address of the slave device with which it is to communicate. The relay will not act on a request from a master if the address in the request does not match the relay's slave address (unless the address is the broadcast address – see below).

A single setting selects the slave address used for all ports, with the exception that for the faceplate port, the relay will accept any address when the Modbus® RTU protocol is used.

**B.1.3 DATA LINK LAYER**

Communications takes place in packets which are groups of asynchronously framed byte data. The master transmits a packet to the slave and the slave responds with a packet. The end of a packet is marked by 'dead-time' on the communications line. The following describes general format for both transmit and receive packets. For exact details on packet formatting, refer to subsequent sections describing each function code.

**Table B–1: MODBUS PACKET FORMAT**

| DESCRIPTION | SIZE |
| --- | --- |
| SLAVE ADDRESS | 1 byte |
| FUNCTION CODE | 1 byte |
| DATA | N bytes |
| CRC | 2 bytes |
| DEAD TIME | 3.5 bytes transmission time |

- **SLAVE ADDRESS:** This is the address of the slave device that is intended to receive the packet sent by the master and to perform the desired action. Each slave device on a communications bus must have a unique address to prevent bus contention. All of the relay's ports have the same address which is programmable from 1 to 254; see Chapter 5 for details. Only the addressed slave will respond to a packet that starts with its address. Note that the faceplate port is an exception to this rule; it will act on a message containing any slave address.

  A master transmit packet with slave address 0 indicates a broadcast command. All slaves on the communication link take action based on the packet, but none respond to the master. Broadcast mode is only recognized when associated with Function Code 05h. For any other function code, a packet with broadcast mode slave address 0 will be ignored.

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- **FUNCTION CODE:** This is one of the supported functions codes of the unit which tells the slave what action to perform. See the Supported Function Codes section for complete details. An exception response from the slave is indicated by setting the high order bit of the function code in the response packet. See the Exception Responses section for further details.

- **DATA:** This will be a variable number of bytes depending on the function code. This may include actual values, settings, or addresses sent by the master to the slave or by the slave to the master.

- **CRC:** This is a two byte error checking code. The RTU version of Modbus$^®$ includes a 16-bit cyclic redundancy check (CRC-16) with every packet which is an industry standard method used for error detection. If a Modbus slave device receives a packet in which an error is indicated by the CRC, the slave device will not act upon or respond to the packet thus preventing any erroneous operations. See the CRC-16 Algorithm section for details on calculating the CRC.

- **DEAD TIME:** A packet is terminated when no data is received for a period of 3.5 byte transmission times (about 15 ms at 2400 bps, 2 ms at 19200 bps, and 300 μs at 115200 bps). Consequently, the transmitting device must not allow gaps between bytes longer than this interval. Once the dead time has expired without a new byte transmission, all slaves start listening for a new packet from the master except for the addressed slave.

**B.1.4 CRC-16 ALGORITHM**

The CRC-16 algorithm essentially treats the entire data stream (data bits only; start, stop and parity ignored) as one continuous binary number. This number is first shifted left 16 bits and then divided by a characteristic polynomial (11000000000000101B). The 16 bit remainder of the division is appended to the end of the packet, MSByte first. The resulting packet including CRC, when divided by the same polynomial at the receiver will give a zero remainder if no transmission errors have occurred. This algorithm requires the characteristic polynomial to be reverse bit ordered. The most significant bit of the characteristic polynomial is dropped, since it does not affect the value of the remainder.

A C programming language implementation of the CRC algorithm will be provided upon request.

**Table B–2: CRC-16 ALGORITHM**

| SYMBOLS: | --> | data transfer |
|---|---|---|
| | A | 16 bit working register |
| | Alow | low order byte of A |
| | Ahigh | high order byte of A |
| | CRC | 16 bit CRC-16 result |
| | i,j | loop counters |
| | (+) | logical EXCLUSIVE-OR operator |
| | N | total number of data bytes |
| | Di | i-th data byte (i = 0 to N-1) |
| | G | 16 bit characteristic polynomial = 1010000000000001 (binary) with MSbit dropped and bit order reversed |
| | shr (x) | right shift operator (th LSbit of x is shifted into a carry flag, a '0' is shifted into the MSbit of x, all other bits are shifted right one location) |

| ALGORITHM: | 1. | FFFF (hex) --> A | |
|---|---|---|---|
| | 2. | 0 --> i | |
| | 3. | 0 --> j | |
| | 4. | Di (+) Alow --> Alow | |
| | 5. | j + 1 --> j | |
| | 6. | shr (A) | |
| | 7. | Is there a carry? | No: go to 8; Yes: G (+) A --> A and continue. |
| | 8. | Is j = 8? | No: go to 5; Yes: continue |
| | 9. | i + 1 --> i | |
| | 10. | Is i = N? | No: go to 3; Yes: continue |
| | 11. | A --> CRC | |

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 relay 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 3 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 |

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 dec) 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 101F | VIRTUAL IN 1-32 ON/OFF | Sets the states of Virtual Inputs 1 to 32 either "ON" or "OFF". |

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 |

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## 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** | **EXMAPLE (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 |

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**a) DESCRIPTION**

The UR relay has a generic file transfer facility, meaning that you use the same method to obtain all of the different types of files from the unit. The Modbus registers that implement file transfer are found in the "Modbus File Transfer (Read/Write)" and "Modbus File Transfer (Read Only)" modules, starting at address 3100 in the Modbus Memory Map. To read a file from the UR relay, use the following steps:

1.   Write the filename to the "Name of file to read" register using a write multiple registers command. If the name is shorter than 80 characters, you may write only enough registers to include all the text of the filename. Filenames are not case sensitive.

2.   Repeatedly read all the registers in "Modbus File Transfer (Read Only)" using a read multiple registers command. It is not necessary to read the entire data block, since the UR relay will remember which was the last register you read. The "position" register is initially zero and thereafter indicates how many bytes (2 times the number of registers) you have read so far. The "size of..." register indicates the number of bytes of data remaining to read, to a maximum of 244.

3.   Keep reading until the "size of..." register is smaller than the number of bytes you are transferring. This condition indicates end of file. Discard any bytes you have read beyond the indicated block size.

4.   If you need to re-try a block, read only the "size of.." and "block of data", without reading the position. The file pointer is only incremented when you read the position register, so the same data block will be returned as was read in the previous operation. On the next read, check to see if the position is where you expect it to be, and discard the previous block if it is not (this condition would indicate that the UR relay did not process your original read request).

The UR relay retains connection-specific file transfer information, so files may be read simultaneously on multiple Modbus connections.

**b) OTHER PROTOCOLS**

All the files available via Modbus may also be retrieved using the standard file transfer mechanisms in other protocols (for example, TFTP or MMS).

**c) COMTRADE, OSCILLOGRAPHY, AND DATA LOGGER FILES**

Oscillography and data logger files are formatted using the COMTRADE file format per IEEE PC37.111 Draft 7c (02 September 1997). The files may be obtained in either text or binary COMTRADE format.

**d) READING OSCILLOGRAPHY FILES**

Familiarity with the oscillography feature is required to understand the following description. Refer to the Oscillography section in Chapter 5 for additional details.

The Oscillography Number of Triggers register is incremented by one every time a new oscillography file is triggered (captured) and cleared to zero when oscillography data is cleared. When a new trigger occurs, the associated oscillography file is assigned a file identifier number equal to the incremented value of this register; the newest file number is equal to the Oscillography_Number_of_Triggers register. This register can be used to determine if any new data has been captured by periodically reading it to see if the value has changed; if the number has increased then new data is available.

The Oscillography Number of Records register specifies the maximum number of files (and the number of cycles of data per file) that can be stored in memory of the relay. The Oscillography Available Records register specifies the actual number of files that are stored and still available to be read out of the relay.

Writing "Yes" (i.e. the value 1) to the Oscillography Clear Data register clears oscillography data files, clears both the Oscillography Number of Triggers and Oscillography Available Records registers to zero, and sets the Oscillography Last Cleared Date to the present date and time.

To read binary COMTRADE oscillography files, read the following filenames:

        `OSCnnnn.CFG` and `OSCnnn.DAT`

Replace "nnn" with the desired oscillography trigger number. For ASCII format, use the following file names

        `OSCAnnnn.CFG` and `OSCAnnn.DAT`

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### e) READING DATA LOGGER FILES

Familiarity with the data logger feature is required to understand this description. Refer to the Data Logger section of Chapter 5 for details. To read the entire data logger in binary COMTRADE format, read the following files.

`datalog.cfg` and `datalog.dat`

To read the entire data logger in ASCII COMTRADE format, read the following files.

`dataloga.cfg` and `dataloga.dat`

To limit the range of records to be returned in the COMTRADE files, append the following to the filename before writing it:

- To read from a specific time to the end of the log: <space> startTime

- To read a specific range of records: <space> startTime <space> endTime

- Replace <startTime> and <endTime> with Julian dates (seconds since Jan. 1 1970) as numeric text.

### f) READING EVENT RECORDER FILES

To read the entire event recorder contents in ASCII format (the only available format), use the following filename:

`EVT.TXT`

To read from a specific record to the end of the log, use the following filename:

`EVTnnn.TXT`   (replace `nnn` with the desired starting record number)

To read from a specific record to another specific record, use the following filename:

`EVT.TXT xxxxx yyyyy` (replace `xxxxx` with the starting record number and `yyyyy` with the ending record number)

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### B.3.2 MODBUS PASSWORD OPERATION

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 (0 for 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.

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**Table B–9: MODBUS MEMORY MAP (Sheet 1 of 37)**

| 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 x State (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) (32 modules)** | | | | | | |
| 0400 | Virtual Input 1 State | 0 to 1 | --- | 1 | F108 | 0 (Off) |
| 0401 | ...Repeated for module number 2 | | | | | |
| 0402 | ...Repeated for module number 3 | | | | | |
| 0403 | ...Repeated for module number 4 | | | | | |
| 0404 | ...Repeated for module number 5 | | | | | |
| 0405 | ...Repeated for module number 6 | | | | | |
| 0406 | ...Repeated for module number 7 | | | | | |
| 0407 | ...Repeated for module number 8 | | | | | |
| 0408 | ...Repeated for module number 9 | | | | | |
| 0409 | ...Repeated for module number 10 | | | | | |
| 040A | ...Repeated for module number 11 | | | | | |
| 040B | ...Repeated for module number 12 | | | | | |
| 040C | ...Repeated for module number 13 | | | | | |
| 040D | ...Repeated for module number 14 | | | | | |
| 040E | ...Repeated for module number 15 | | | | | |
| 040F | ...Repeated for module number 16 | | | | | |
| 0410 | ...Repeated for module number 17 | | | | | |
| 0411 | ...Repeated for module number 18 | | | | | |
| 0412 | ...Repeated for module number 19 | | | | | |
| 0413 | ...Repeated for module number 20 | | | | | |
| 0414 | ...Repeated for module number 21 | | | | | |
| 0415 | ...Repeated for module number 22 | | | | | |
| 0416 | ...Repeated for module number 23 | | | | | |
| 0417 | ...Repeated for module number 24 | | | | | |
| 0418 | ...Repeated for module number 25 | | | | | |
| 0419 | ...Repeated for module number 26 | | | | | |
| 041A | ...Repeated for module number 27 | | | | | |
| 041B | ...Repeated for module number 28 | | | | | |

**Table B–9: MODBUS MEMORY MAP (Sheet 2 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---------------|-------|-------|------|--------|---------|
| 041C | ...Repeated for module number 29 | | | | | |
| 041D | ...Repeated for module number 30 | | | | | |
| 041E | ...Repeated for module number 31 | | | | | |
| 041F | ...Repeated for module number 32 | | | | | |
| **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 module number 2 | | | | | |
| 0810 | ...Repeated for module number 3 | | | | | |
| 0818 | ...Repeated for module number 4 | | | | | |
| 0820 | ...Repeated for module number 5 | | | | | |
| 0828 | ...Repeated for module number 6 | | | | | |
| 0830 | ...Repeated for module number 7 | | | | | |
| 0838 | ...Repeated for module number 8 | | | | | |
| **FlexStates (Read Only)** | | | | | | |
| 0900 | FlexState Bits (16 items) | 0 to 65535 | --- | 1 | F001 | 0 |
| **Element States (Read Only)** | | | | | | |
| 1000 | Element Operate States (64 items) | 0 to 65535 | --- | 1 | F502 | 0 |
| **User Displays Actuals (Read Only)** | | | | | | |
| 1080 | Formatted user-definable displays (16 items) | --- | --- | --- | F200 | (none) |
| **Modbus User Map Actuals (Read Only)** | | | | | | |
| 1200 | User Map Values (256 items) | 0 to 65535 | --- | 1 | F001 | 0 |
| **Element Targets (Read Only)** | | | | | | |
| 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 I/O States (Read Only)** | | | | | | |
| 1500 | Contact Input States (6 items) | 0 to 65535 | --- | 1 | F500 | 0 |
| 1508 | Virtual Input States (2 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 (4 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 1 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) |
| **Remote Device Status (Read Only) (16 modules)** | | | | | | |
| 1551 | Remote Device 1 StNum | 0 to 4294967295 | --- | 1 | F003 | 0 |
| 1553 | Remote Device 1 SqNum | 0 to 4294967295 | --- | 1 | F003 | 0 |
| 1555 | ...Repeated for module number 2 | | | | | |
| 1559 | ...Repeated for module number 3 | | | | | |
| 155D | ...Repeated for module number 4 | | | | | |
| 1561 | ...Repeated for module number 5 | | | | | |
| 1565 | ...Repeated for module number 6 | | | | | |
| 1569 | ...Repeated for module number 7 | | | | | |
| 156D | ...Repeated for module number 8 | | | | | |

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**Table B–9: MODBUS MEMORY MAP (Sheet 3 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---------------|-------|-------|------|--------|---------|
| 1571 | ...Repeated for module number 9 | | | | | |
| 1575 | ...Repeated for module number 10 | | | | | |
| 1579 | ...Repeated for module number 11 | | | | | |
| 157D | ...Repeated for module number 12 | | | | | |
| 1581 | ...Repeated for module number 13 | | | | | |
| 1585 | ...Repeated for module number 14 | | | | | |
| 1589 | ...Repeated for module number 15 | | | | | |
| 158D | ...Repeated for module number 16 | | | | | |
| **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 | CHNL | 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 |
| **Sensitive Directional Power Actuals (Read Only) (2 modules)** | | | | | | |
| 1680 | Sensitive Directional Power 1 Power | -2147483647 to 2147483647 | W | 1 | F060 | 0 |
| 1682 | ...Repeated for module number 2 | | | | | |
| **Source Current (Read Only) (6 modules)** | | | | | | |
| 1800 | Phase A Current RMS | 0 to 999999.999 | A | 0.001 | F060 | 0 |
| 1802 | Phase B Current RMS | 0 to 999999.999 | A | 0.001 | F060 | 0 |
| 1804 | Phase C Current RMS | 0 to 999999.999 | A | 0.001 | F060 | 0 |
| 1806 | Neutral Current RMS | 0 to 999999.999 | A | 0.001 | F060 | 0 |
| 1808 | Phase A Current Magnitude | 0 to 999999.999 | A | 0.001 | F060 | 0 |
| 180A | Phase A Current Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 180B | Phase B Current Magnitude | 0 to 999999.999 | A | 0.001 | F060 | 0 |
| 180D | Phase B Current Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 180E | Phase C Current Magnitude | 0 to 999999.999 | A | 0.001 | F060 | 0 |
| 1810 | Phase C Current Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 1811 | Neutral Current Magnitude | 0 to 999999.999 | A | 0.001 | F060 | 0 |
| 1813 | Neutral Current Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 1814 | Ground Current RMS | 0 to 999999.999 | A | 0.001 | F060 | 0 |
| 1816 | Ground Current Magnitude | 0 to 999999.999 | A | 0.001 | F060 | 0 |
| 1818 | Ground Current Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 1819 | Zero Sequence Current Magnitude | 0 to 999999.999 | A | 0.001 | F060 | 0 |
| 181B | Zero Sequence Current Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 181C | Positive Sequence Current Magnitude | 0 to 999999.999 | A | 0.001 | F060 | 0 |
| 181E | Positive Sequence Current Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 181F | Negative Sequence Current Magnitude | 0 to 999999.999 | A | 0.001 | F060 | 0 |
| 1821 | Negative Sequence Current Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 1822 | Differential Ground Current Magnitude | 0 to 999999.999 | A | 0.001 | F060 | 0 |
| 1824 | Differential Ground Current Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |

**Table B–9: MODBUS MEMORY MAP (Sheet 4 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---------------|-------|-------|------|--------|---------|
| 1825 | Reserved (27 items) | --- | --- | --- | F001 | 0 |
| 1840 | ...Repeated for module number 2 | | | | | |
| 1880 | ...Repeated for module number 3 | | | | | |
| 18C0 | ...Repeated for module number 4 | | | | | |
| 1900 | ...Repeated for module number 5 | | | | | |
| 1940 | ...Repeated for module number 6 | | | | | |
| **Source Voltage (Read Only) (6 modules)** | | | | | | |
| 1A00 | Phase AG Voltage RMS | 0 to 999999.999 | V | 0.001 | F060 | 0 |
| 1A02 | Phase BG Voltage RMS | 0 to 999999.999 | V | 0.001 | F060 | 0 |
| 1A04 | Phase CG Voltage RMS | 0 to 999999.999 | V | 0.001 | F060 | 0 |
| 1A06 | Phase AG Voltage Magnitude | 0 to 999999.999 | V | 0.001 | F060 | 0 |
| 1A08 | Phase AG Voltage Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 1A09 | Phase BG Voltage Magnitude | 0 to 999999.999 | V | 0.001 | F060 | 0 |
| 1A0B | Phase BG Voltage Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 1A0C | Phase CG Voltage Magnitude | 0 to 999999.999 | V | 0.001 | F060 | 0 |
| 1A0E | Phase CG Voltage Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 1A0F | Phase AB or AC Voltage RMS | 0 to 999999.999 | V | 0.001 | F060 | 0 |
| 1A11 | Phase BC or BA Voltage RMS | 0 to 999999.999 | V | 0.001 | F060 | 0 |
| 1A13 | Phase CA or CB Voltage RMS | 0 to 999999.999 | V | 0.001 | F060 | 0 |
| 1A15 | Phase AB or AC Voltage Magnitude | 0 to 999999.999 | V | 0.001 | F060 | 0 |
| 1A17 | Phase AB or AC Voltage Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 1A18 | Phase BC or BA Voltage Magnitude | 0 to 999999.999 | V | 0.001 | F060 | 0 |
| 1A1A | Phase BC or BA Voltage Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 1A1B | Phase CA or CB Voltage Magnitude | 0 to 999999.999 | V | 0.001 | F060 | 0 |
| 1A1D | Phase CA or CB Voltage Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 1A1E | Auxiliary Voltage RMS | 0 to 999999.999 | V | 0.001 | F060 | 0 |
| 1A20 | Auxiliary Voltage Magnitude | 0 to 999999.999 | V | 0.001 | F060 | 0 |
| 1A22 | Auxiliary Voltage Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 1A23 | Zero Sequence Voltage Magnitude | 0 to 999999.999 | V | 0.001 | F060 | 0 |
| 1A25 | Zero Sequence Voltage Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 1A26 | Positive Sequence Voltage Magnitude | 0 to 999999.999 | V | 0.001 | F060 | 0 |
| 1A28 | Positive Sequence Voltage Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 1A29 | Negative Sequence Voltage Magnitude | 0 to 999999.999 | V | 0.001 | F060 | 0 |
| 1A2B | Negative Sequence Voltage Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 1A2C | Reserved (20 items) | --- | --- | --- | F001 | 0 |
| 1A40 | ...Repeated for module number 2 | | | | | |
| 1A80 | ...Repeated for module number 3 | | | | | |
| 1AC0 | ...Repeated for module number 4 | | | | | |
| 1B00 | ...Repeated for module number 5 | | | | | |
| 1B40 | ...Repeated for module number 6 | | | | | |
| **Source Power (Read Only) (6 modules)** | | | | | | |
| 1C00 | Three Phase Real Power | -1000000000000 to 1000000000000 | W | 0.001 | F060 | 0 |
| 1C02 | Phase A Real Power | -1000000000000 to 1000000000000 | W | 0.001 | F060 | 0 |
| 1C04 | Phase B Real Power | -1000000000000 to 1000000000000 | W | 0.001 | F060 | 0 |
| 1C06 | Phase C Real Power | -1000000000000 to 1000000000000 | W | 0.001 | F060 | 0 |
| 1C08 | Three Phase Reactive Power | -1000000000000 to 1000000000000 | var | 0.001 | F060 | 0 |
| 1C0A | Phase A Reactive Power | -1000000000000 to 1000000000000 | var | 0.001 | F060 | 0 |
| 1C0C | Phase B Reactive Power | -1000000000000 to 1000000000000 | var | 0.001 | F060 | 0 |
| 1C0E | Phase C Reactive Power | -1000000000000 to 1000000000000 | var | 0.001 | F060 | 0 |

**B**

**B**

**Table B–9: MODBUS MEMORY MAP (Sheet 5 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|---|---|---|---|---|---|---|
| 1C10 | Three Phase Apparent Power | -1000000000000 to 1000000000000 | VA | 0.001 | F060 | 0 |
| 1C12 | Phase A Apparent Power | -1000000000000 to 1000000000000 | VA | 0.001 | F060 | 0 |
| 1C14 | Phase B Apparent Power | -1000000000000 to 1000000000000 | VA | 0.001 | F060 | 0 |
| 1C16 | Phase C Apparent Power | -1000000000000 to 1000000000000 | VA | 0.001 | F060 | 0 |
| 1C18 | Three Phase Power Factor | -0.999 to 1 | --- | 0.001 | F013 | 0 |
| 1C19 | Phase A Power Factor | -0.999 to 1 | --- | 0.001 | F013 | 0 |
| 1C1A | Phase B Power Factor | -0.999 to 1 | --- | 0.001 | F013 | 0 |
| 1C1B | Phase C Power Factor | -0.999 to 1 | --- | 0.001 | F013 | 0 |
| 1C1C | Reserved (4 items) | --- | --- | --- | F001 | 0 |
| 1C20 | ...Repeated for module number 2 | | | | | |
| 1C40 | ...Repeated for module number 3 | | | | | |
| 1C60 | ...Repeated for module number 4 | | | | | |
| 1C80 | ...Repeated for module number 5 | | | | | |
| 1CA0 | ...Repeated for module number 6 | | | | | |
| **Source Energy (Read Only Non-Volatile) (6 modules)** | | | | | | |
| 1D00 | Positive Watthour | 0 to 1000000000000 | Wh | 0.001 | F060 | 0 |
| 1D02 | Negative Watthour | 0 to 1000000000000 | Wh | 0.001 | F060 | 0 |
| 1D04 | Positive Varhour | 0 to 1000000000000 | varh | 0.001 | F060 | 0 |
| 1D06 | Negative Varhour | 0 to 1000000000000 | varh | 0.001 | F060 | 0 |
| 1D08 | Reserved (8 items) | --- | --- | --- | F001 | 0 |
| 1D10 | ...Repeated for module number 2 | | | | | |
| 1D20 | ...Repeated for module number 3 | | | | | |
| 1D30 | ...Repeated for module number 4 | | | | | |
| 1D40 | ...Repeated for module number 5 | | | | | |
| 1D50 | ...Repeated for module number 6 | | | | | |
| **Energy Commands (Read/Write Command)** | | | | | | |
| 1D60 | Energy Clear Command | 0 to 1 | --- | 1 | F126 | 0 (No) |
| **Source Frequency (Read Only) (6 modules)** | | | | | | |
| 1D80 | Frequency | 2 to 90 | Hz | 0.01 | F001 | 0 |
| 1D81 | ...Repeated for module number 2 | | | | | |
| 1D82 | ...Repeated for module number 3 | | | | | |
| 1D83 | ...Repeated for module number 4 | | | | | |
| 1D84 | ...Repeated for module number 5 | | | | | |
| 1D85 | ...Repeated for module number 6 | | | | | |
| **Source Demand (Read Only) (6 modules)** | | | | | | |
| 1E00 | Demand Ia | 0 to 999999.999 | A | 0.001 | F060 | 0 |
| 1E02 | Demand Ib | 0 to 999999.999 | A | 0.001 | F060 | 0 |
| 1E04 | Demand Ic | 0 to 999999.999 | A | 0.001 | F060 | 0 |
| 1E06 | Demand Watt | 0 to 999999.999 | W | 0.001 | F060 | 0 |
| 1E08 | Demand Var | 0 to 999999.999 | var | 0.001 | F060 | 0 |
| 1E0A | Demand Va | 0 to 999999.999 | VA | 0.001 | F060 | 0 |
| 1E0C | Reserved (4 items) | --- | --- | --- | F001 | 0 |
| 1E10 | ...Repeated for module number 2 | | | | | |
| 1E20 | ...Repeated for module number 3 | | | | | |
| 1E30 | ...Repeated for module number 4 | | | | | |
| 1E40 | ...Repeated for module number 5 | | | | | |
| 1E50 | ...Repeated for module number 6 | | | | | |
| **Source Demand Peaks (Read Only Non-Volatile) (6 modules)** | | | | | | |
| 1E80 | SRC 1 Demand Ia Max | 0 to 999999.999 | A | 0.001 | F060 | 0 |
| 1E82 | SRC 1 Demand Ia Max Date | 0 to 4294967295 | --- | 1 | F050 | 0 |
| 1E84 | SRC 1 Demand Ib Max | 0 to 999999.999 | A | 0.001 | F060 | 0 |

**Table B–9: MODBUS MEMORY MAP (Sheet 6 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---------------|-------|-------|------|--------|---------|
| 1E86 | SRC 1 Demand Ib Max Date | 0 to 4294967295 | --- | 1 | F050 | 0 |
| 1E88 | SRC 1 Demand Ic Max | 0 to 999999.999 | A | 0.001 | F060 | 0 |
| 1E8A | SRC 1 Demand Ic Max Date | 0 to 4294967295 | --- | 1 | F050 | 0 |
| 1E8C | SRC 1 Demand Watt Max | 0 to 999999.999 | W | 0.001 | F060 | 0 |
| 1E8E | SRC 1 Demand Watt Max Date | 0 to 4294967295 | --- | 1 | F050 | 0 |
| 1E90 | SRC 1 Demand Var | 0 to 999999.999 | var | 0.001 | F060 | 0 |
| 1E92 | SRC 1 Demand Var Max Date | 0 to 4294967295 | --- | 1 | F050 | 0 |
| 1E94 | SRC 1 Demand Va Max | 0 to 999999.999 | VA | 0.001 | F060 | 0 |
| 1E96 | SRC 1 Demand Va Max Date | 0 to 4294967295 | --- | 1 | F050 | 0 |
| 1E98 | Reserved (8 items) | --- | --- | --- | F001 | 0 |
| 1EA0 | ...Repeated for module number 2 | | | | | |
| 1EC0 | ...Repeated for module number 3 | | | | | |
| 1EE0 | ...Repeated for module number 4 | | | | | |
| 1F00 | ...Repeated for module number 5 | | | | | |
| 1F20 | ...Repeated for module number 6 | | | | | |
| **Breaker Flashover (Read/Write Setting) (2 modules)** | | | | | | |
| 21A6 | Breaker 1 Flashover Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 21A7 | Breaker 1 Flashover Side 1 Source | 0 to 5 | --- | 1 | F167 | 0 (SRC 1) |
| 21A8 | Breaker 1 Flashover Side 2 Source | 0 to 6 | --- | 1 | F211 | 0 (None) |
| 21A9 | Breaker 1 Flashover Status Closed A | 0 to 65535 | --- | 1 | F300 | 0 |
| 21AA | Breaker 1 Flashover Status Closed B | 0 to 65535 | --- | 1 | F300 | 0 |
| 21AB | Breaker 1 Flashover Status Closed C | 0 to 65535 | --- | 1 | F300 | 0 |
| 21AC | Breaker 1 Flashover Voltage Pickup Level | 0 to 1.5 | pu | 0.001 | F001 | 850 |
| 21AD | Breaker 1 Flashover Voltage Difference Pickup Level | 0 to 100000 | V | 1 | F060 | 1000 |
| 21AF | Breaker 1 Flashover Current Pickup Level | 0 to 1.5 | pu | 0.001 | F001 | 600 |
| 21B0 | Breaker 1 Flashover Pickup Delay | 0 to 65.535 | s | 0.001 | F001 | 100 |
| 21B1 | Breaker 1 Flashover Supervision Phase A | 0 to 65535 | --- | 1 | F300 | 0 |
| 21B2 | Breaker 1 Flashover Supervision Phase B | 0 to 65535 | --- | 1 | F300 | 0 |
| 21B3 | Breaker 1 Flashover Supervision Phase C | 0 to 65535 | --- | 1 | F300 | 0 |
| 21B4 | Breaker 1 Flashover Block | 0 to 65535 | --- | 1 | F300 | 0 |
| 21B5 | Breaker 1 Flashover Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 21B6 | Breaker 1 Flashover Target | 0 to 2 | --- | 1 | F109 | 0 (Self-Reset) |
| 21B7 | Reserved (4 items) | --- | --- | --- | F001 | 0 |
| 21BB | ...Repeated for module number 2 | 0 to 99999999 | kA$^2$-cyc | 1 | F060 | 0 |
| **Breaker Arcing Current Actuals (Read Only Non-Volatile) (2 modules)** | | | | | | |
| 21E0 | Breaker 1 Arcing Current Phase A | 0 to 99999999 | kA$^2$-cyc | 1 | F060 | 0 |
| 21E2 | Breaker 1 Arcing Current Phase B | 0 to 99999999 | kA$^2$-cyc | 1 | F060 | 0 |
| 21E4 | Breaker 1 Arcing Current Phase C | 0 to 99999999 | kA$^2$-cyc | 1 | F060 | 0 |
| 21E6 | Breaker 1 Operating Time Phase A | 0 to 65535 | ms | 1 | F001 | 0 |
| 21E7 | Breaker 1 Operating Time Phase B | 0 to 65535 | ms | 1 | F001 | 0 |
| 21E8 | Breaker 1 Operating Time Phase C | 0 to 65535 | ms | 1 | F001 | 0 |
| 21E9 | Breaker 1 Operating Time | 0 to 65535 | ms | 1 | F001 | 0 |
| 21E6 | ...Repeated for module number 2 | | | | | |
| **Breaker Arcing Current Commands (Read/Write Command) (2 modules)** | | | | | | |
| 2224 | Breaker 1 Arcing Current Clear Command | 0 to 1 | --- | 1 | F126 | 0 (No) |
| 2225 | ...Repeated for module number 2 | | | | | |
| **Passwords Unauthorized Access (Read/Write Command)** | | | | | | |
| 2230 | Reset Unauthorized Access | 0 to 1 | --- | 1 | F126 | 0 (No) |
| **Fault Location (Read Only) (5 modules)** | | | | | | |
| 2340 | Prefault Phase A Current Magnitude | 0 to 999999.999 | A | 0.001 | F060 | 0 |
| 2342 | Prefault Phase A Current Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 2343 | Prefault Phase B Current Magnitude | 0 to 999999.999 | A | 0.001 | F060 | 0 |
| 2345 | Prefault Phase B Current Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 2346 | Prefault Phase C Current Magnitude | 0 to 999999.999 | A | 0.001 | F060 | 0 |

**B**

**Table B–9: MODBUS MEMORY MAP (Sheet 7 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---------------|-------|-------|------|--------|---------|
| 2348 | Prefault Phase C Current Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 2349 | Prefault Phase A Voltage Magnitude | 0 to 999999.999 | V | 0.001 | F060 | 0 |
| 234B | Prefault Phase A Voltage Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 234C | Prefault Phase B Voltage Magnitude | 0 to 999999.999 | V | 0.001 | F060 | 0 |
| 234E | Prefault Phase B Voltage Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 234F | Prefault Phase C Voltage Magnitude | 0 to 999999.999 | V | 0.001 | F060 | 0 |
| 2351 | Prefault Phase C Voltage Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 2352 | Fault 1 Phase A Current Magnitude | 0 to 999999.999 | A | 0.001 | F060 | 0 |
| 2354 | Fault 1 Phase A Current Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 2355 | Fault 1 Phase B Current Magnitude | 0 to 999999.999 | A | 0.001 | F060 | 0 |
| 2357 | Fault 1 Phase B Current Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 2358 | Fault 1 Phase C Current Magnitude | 0 to 999999.999 | A | 0.001 | F060 | 0 |
| 235A | Fault 1 Phase C Current Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 235B | Fault 1 Phase A Voltage Magnitude | 0 to 999999.999 | V | 0.001 | F060 | 0 |
| 235D | Fault 1 Phase A Voltage Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 235E | Fault 1 Phase B Voltage Magnitude | 0 to 999999.999 | V | 0.001 | F060 | 0 |
| 2360 | Fault 1 Phase B Voltage Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 2361 | Fault 1 Phase C Voltage Magnitude | 0 to 999999.999 | V | 0.001 | F060 | 0 |
| 2363 | Fault 1 Phase C Voltage Angle | -359.9 to 0 | degrees | 0.1 | F002 | 0 |
| 2364 | Fault Type | 0 to 11 | --- | 1 | F148 | 0 (NA) |
| 2365 | Fault Location based on Line length units (km or miles) | -3276.7 to 3276.7 | --- | 0.1 | F002 | 0 |
| 2366 | ...Repeated for module number 2 | | | | | |
| 238C | ...Repeated for module number 3 | | | | | |
| 23B2 | ...Repeated for module number 4 | | | | | |
| 23D8 | ...Repeated for module number 5 | | | | | |
| **Synchrocheck Actuals (Read Only) (2 modules)** | | | | | | |
| 2400 | Synchrocheck 1 Delta Voltage | -1000000000000 to 1000000000000 | V | 1 | F060 | 0 |
| 2402 | Synchrocheck 1 Delta Frequency | 0 to 655.35 | Hz | 0.01 | F001 | 0 |
| 2403 | Synchrocheck 1 Delta Phase | 0 to 359.9 | degrees | 0.1 | F001 | 0 |
| 2404 | ...Repeated for module number 2 | | | | | |
| **Autoreclose Status (Read Only) (6 modules)** | | | | | | |
| 2410 | Autoreclose Count | 0 to 65535 | --- | 1 | F001 | 0 |
| 2411 | ...Repeated for module number 2 | | | | | |
| 2412 | ...Repeated for module number 3 | | | | | |
| 2413 | ...Repeated for module number 4 | | | | | |
| 2414 | ...Repeated for module number 5 | | | | | |
| 2415 | ...Repeated for module number 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 (64 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) |

**Table B–9: MODBUS MEMORY MAP (Sheet 8 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|---|---|---|---|---|---|---|
| 3011 | Oscillography Clear Data | 0 to 1 | --- | 1 | F126 | 0 (No) |
| **Fault Report Indexing (Read Only Non-Volatile)** | | | | | | |
| 3020 | Number Of Fault Reports | 0 to 65535 | --- | 1 | F001 | 0 |
| **Fault Report Actuals (Read Only Non-Volatile) (15 modules)** | | | | | | |
| 3030 | Fault Time | 0 to 4294967295 | --- | 1 | F050 | 0 |
| 3032 | ...Repeated for module number 2 | | | | | |
| 3034 | ...Repeated for module number 3 | | | | | |
| 3036 | ...Repeated for module number 4 | | | | | |
| 3038 | ...Repeated for module number 5 | | | | | |
| 303A | ...Repeated for module number 6 | | | | | |
| 303C | ...Repeated for module number 7 | | | | | |
| 303E | ...Repeated for module number 8 | | | | | |
| 3040 | ...Repeated for module number 9 | | | | | |
| 3042 | ...Repeated for module number 10 | | | | | |
| 3044 | ...Repeated for module number 11 | | | | | |
| 3046 | ...Repeated for module number 12 | | | | | |
| 3048 | ...Repeated for module number 13 | | | | | |
| 304A | ...Repeated for module number 14 | | | | | |
| 304C | ...Repeated for module number 15 | | | | | |
| **Modbus File Transfer (Read/Write)** | | | | | | |
| 3100 | Name of file to read | --- | --- | --- | F204 | (none) |
| **Modbus File Transfer (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 (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 (Read/Write Command)** | | | | | | |
| 3406 | Event Recorder Clear Command | 0 to 1 | --- | 1 | F126 | 0 (No) |
| **DCMA Input Values (Read Only) (24 modules)** | | | | | | |
| 34C0 | DCMA Inputs 1 Value | -9999.999 to 9999.999 | --- | 0.001 | F004 | 0 |
| 34C2 | ...Repeated for module number 2 | | | | | |
| 34C4 | ...Repeated for module number 3 | | | | | |
| 34C6 | ...Repeated for module number 4 | | | | | |
| 34C8 | ...Repeated for module number 5 | | | | | |
| 34CA | ...Repeated for module number 6 | | | | | |
| 34CC | ...Repeated for module number 7 | | | | | |
| 34CE | ...Repeated for module number 8 | | | | | |
| 34D0 | ...Repeated for module number 9 | | | | | |
| 34D2 | ...Repeated for module number 10 | | | | | |
| 34D4 | ...Repeated for module number 11 | | | | | |
| 34D6 | ...Repeated for module number 12 | | | | | |
| 34D8 | ...Repeated for module number 13 | | | | | |
| 34DA | ...Repeated for module number 14 | | | | | |
| 34DC | ...Repeated for module number 15 | | | | | |
| 34DE | ...Repeated for module number 16 | | | | | |
| 34E0 | ...Repeated for module number 17 | | | | | |
| 34E2 | ...Repeated for module number 18 | | | | | |
| 34E4 | ...Repeated for module number 19 | | | | | |
| 34E6 | ...Repeated for module number 20 | | | | | |
| 34E8 | ...Repeated for module number 21 | | | | | |
| 34EA | ...Repeated for module number 22 | | | | | |

**B**

**Table B–9: MODBUS MEMORY MAP (Sheet 9 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---------------|-------|-------|------|--------|---------|
| 34EC | ...Repeated for module number 23 | | | | | |
| 34EE | ...Repeated for module number 24 | | | | | |
| **RTD Input Values (Read Only) (48 modules)** | | | | | | |
| 34F0 | RTD Inputs 1 Value | -32768 to 32767 | °C | 1 | F002 | 0 |
| 34F1 | ...Repeated for module number 2 | | | | | |
| 34F2 | ...Repeated for module number 3 | | | | | |
| 34F3 | ...Repeated for module number 4 | | | | | |
| 34F4 | ...Repeated for module number 5 | | | | | |
| 34F5 | ...Repeated for module number 6 | | | | | |
| 34F6 | ...Repeated for module number 7 | | | | | |
| 34F7 | ...Repeated for module number 8 | | | | | |
| 34F8 | ...Repeated for module number 9 | | | | | |
| 34F9 | ...Repeated for module number 10 | | | | | |
| 34FA | ...Repeated for module number 11 | | | | | |
| 34FB | ...Repeated for module number 12 | | | | | |
| 34FC | ...Repeated for module number 13 | | | | | |
| 34FD | ...Repeated for module number 14 | | | | | |
| 34FE | ...Repeated for module number 15 | | | | | |
| 34FF | ...Repeated for module number 16 | | | | | |
| 3500 | ...Repeated for module number 17 | | | | | |
| 3501 | ...Repeated for module number 18 | | | | | |
| 3502 | ...Repeated for module number 19 | | | | | |
| 3503 | ...Repeated for module number 20 | | | | | |
| 3504 | ...Repeated for module number 21 | | | | | |
| 3505 | ...Repeated for module number 22 | | | | | |
| 3506 | ...Repeated for module number 23 | | | | | |
| 3507 | ...Repeated for module number 24 | | | | | |
| 3508 | ...Repeated for module number 25 | | | | | |
| 3509 | ...Repeated for module number 26 | | | | | |
| 350A | ...Repeated for module number 27 | | | | | |
| 350B | ...Repeated for module number 28 | | | | | |
| 350C | ...Repeated for module number 29 | | | | | |
| 350D | ...Repeated for module number 30 | | | | | |
| 350E | ...Repeated for module number 31 | | | | | |
| 350F | ...Repeated for module number 32 | | | | | |
| 3510 | ...Repeated for module number 33 | | | | | |
| 3511 | ...Repeated for module number 34 | | | | | |
| 3512 | ...Repeated for module number 35 | | | | | |
| 3513 | ...Repeated for module number 36 | | | | | |
| 3514 | ...Repeated for module number 37 | | | | | |
| 3515 | ...Repeated for module number 38 | | | | | |
| 3516 | ...Repeated for module number 39 | | | | | |
| 3517 | ...Repeated for module number 40 | | | | | |
| 3518 | ...Repeated for module number 41 | | | | | |
| 3519 | ...Repeated for module number 42 | | | | | |
| 351A | ...Repeated for module number 43 | | | | | |
| 351B | ...Repeated for module number 44 | | | | | |
| 351C | ...Repeated for module number 45 | | | | | |
| 351D | ...Repeated for module number 46 | | | | | |
| 351E | ...Repeated for module number 47 | | | | | |
| 351F | ...Repeated for module number 48 | | | | | |
| **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) |

**Table B–9: MODBUS MEMORY MAP (Sheet 10 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---------------|-------|-------|------|--------|---------|
| **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)** | | | | | | |
| 4010 | Command Password Status | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 4011 | Setting Password Status | 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)** | | | | | | |
| 4050 | Flash Message Time | 0.5 to 10 | s | 0.1 | F001 | 10 |
| 4051 | Default Message Timeout | 10 to 900 | s | 1 | F001 | 300 |
| 4052 | Default Message Intensity | 0 to 3 | --- | 1 | F101 | 0 (25%) |
| 4053 | Screen Saver Feature | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 4054 | Screen Saver Wait Time | 1 to 65535 | min | 1 | F001 | 30 |
| 4055 | Current Cutoff Level | 0.002 to 0.02 | pu | 0.001 | F001 | 20 |
| 4056 | Voltage Cutoff Level | 0.1 to 1 | V | 0.1 | F001 | 10 |
| **Communications (Read/Write Setting)** | | | | | | |
| 407E | COM1 minimum response time | 0 to 1000 | ms | 10 | F001 | 0 |
| 407F | COM2 minimum response time | 0 to 1000 | ms | 10 | F001 | 0 |
| 4080 | Modbus Slave Address | 1 to 254 | --- | 1 | F001 | 254 |
| 4083 | RS485 Com1 Baud Rate | 0 to 11 | --- | 1 | F112 | 8 (115200) |
| 4084 | RS485 Com1 Parity | 0 to 2 | --- | 1 | F113 | 0 (None) |
| 4085 | RS485 Com2 Baud Rate | 0 to 11 | --- | 1 | F112 | 8 (115200) |
| 4086 | RS485 Com2 Parity | 0 to 2 | --- | 1 | F113 | 0 (None) |
| 4087 | IP Address | 0 to 4294967295 | --- | 1 | F003 | 56554706 |
| 4089 | IP Subnet Mask | 0 to 4294967295 | --- | 1 | F003 | 4294966272 |
| 408B | Gateway IP Address | 0 to 4294967295 | --- | 1 | F003 | 56554497 |
| 408D | Network Address NSAP | --- | --- | --- | F074 | 0 |
| 4097 | Default GSSE Update Time | 1 to 60 | s | 1 | F001 | 60 |
| 409A | DNP Port | 0 to 4 | --- | 1 | F177 | 0 (NONE) |
| 409B | DNP Address | 0 to 65519 | --- | 1 | F001 | 1 |
| 409C | DNP Client Addresses (2 items) | 0 to 4294967295 | --- | 1 | F003 | 0 |
| 40A0 | TCP Port Number for the Modbus protocol | 1 to 65535 | --- | 1 | F001 | 502 |
| 40A1 | TCP/UDP Port Number for the DNP Protocol | 1 to 65535 | --- | 1 | F001 | 20000 |
| 40A2 | TCP Port Number for the IEC 61850 Protocol | 1 to 65535 | --- | 1 | F001 | 102 |
| 40A3 | TCP Port Number for the HTTP (Web Server) Protocol | 1 to 65535 | --- | 1 | F001 | 80 |
| 40A4 | Main UDP Port Number for the TFTP Protocol | 1 to 65535 | --- | 1 | F001 | 69 |
| 40A5 | Data Transfer UDP Port Numbers for the TFTP Protocol (zero means "automatic") (2 items) | 0 to 65535 | --- | 1 | F001 | 0 |
| 40A7 | DNP Unsolicited Responses Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 40A8 | DNP Unsolicited Responses Timeout | 0 to 60 | s | 1 | F001 | 5 |
| 40A9 | DNP Unsolicited Responses Max Retries | 1 to 255 | --- | 1 | F001 | 10 |
| 40AA | DNP Unsolicited Responses Destination Address | 0 to 65519 | --- | 1 | F001 | 1 |
| 40AB | Ethernet Operation Mode | 0 to 1 | --- | 1 | F192 | 0 (Half-Duplex) |
| 40AC | DNP User Map Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 40AD | DNP Number of Sources used in Analog points list | 1 to 6 | --- | 1 | F001 | 1 |
| 40AE | DNP Current Scale Factor | 0 to 8 | --- | 1 | F194 | 2 (1) |

**Table B–9: MODBUS MEMORY MAP (Sheet 11 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|---|---|---|---|---|---|---|
| 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 Other Scale Factor | 0 to 8 | --- | 1 | F194 | 2 (1) |
| 40B3 | DNP Current Default Deadband | 0 to 65535 | --- | 1 | F001 | 30000 |
| 40B4 | DNP Voltage Default Deadband | 0 to 65535 | --- | 1 | F001 | 30000 |
| 40B5 | DNP Power Default Deadband | 0 to 65535 | --- | 1 | F001 | 30000 |
| 40B6 | DNP Energy Default Deadband | 0 to 65535 | --- | 1 | F001 | 30000 |
| 40B7 | DNP Other Default Deadband | 0 to 65535 | --- | 1 | F001 | 30000 |
| 40B8 | DNP IIN Time Sync Bit Period | 1 to 10080 | min | 1 | F001 | 1440 |
| 40B9 | DNP Message Fragment Size | 30 to 2048 | --- | 1 | F001 | 240 |
| 40BA | DNP Client Address 3 | 0 to 4294967295 | --- | 1 | F003 | 0 |
| 40BC | DNP Client Address 4 | 0 to 4294967295 | --- | 1 | F003 | 0 |
| 40BE | DNP Client Address 5 | 0 to 4294967295 | --- | 1 | F003 | 0 |
| 40C0 | DNP Communications Reserved (8 items) | 0 to 1 | --- | 1 | F001 | 0 |
| 40C8 | IEC 61850 Logical Device Name | --- | --- | --- | F203 | "IECDevice" |
| 40D0 | GSSE Function | 0 to 1 | --- | 1 | F102 | 1 (Enabled) |
| 40D1 | Reserved (15 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 Trans. Period | 1 to 65535 | s | 1 | F001 | 60 |
| 40E4 | IEC 60870-5-104 Sources used in M_ME_NC_1 point list | 1 to 6 | --- | 1 | F001 | 1 |
| 40E5 | 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 |
| 40E7 | IEC 60870-5-104 Power Default Threshold | 0 to 65535 | --- | 1 | F001 | 30000 |
| 40E8 | IEC 60870-5-104 Energy Default Threshold | 0 to 65535 | --- | 1 | F001 | 30000 |
| 40E9 | IEC 60870-5-104 Other Default Threshold | 0 to 65535 | --- | 1 | F001 | 30000 |
| 40EA | IEC 60870-5-104 Client Address (5 items) | 0 to 4294967295 | --- | 1 | F003 | 0 |
| 40FE | IEC 60870-5-104 Communications Reserved (2 items) | 0 to 1 | --- | 1 | F001 | 0 |
| 4100 | DNP Binary Input Block of 16 Points (58 items) | 0 to 58 | --- | 1 | F197 | 0 (Not Used) |
| 4140 | DNP Object 1 Default Variation | 1 to 2 | --- | 1 | F001 | 2 |
| 4141 | DNP Object 2 Default Variation | 1 to 2 | --- | 1 | F001 | 2 |
| 4142 | DNP Object 20 Default Variation | 0 to 3 | --- | 1 | F523 | 0 (1) |
| 4143 | DNP Object 21 Default Variation | 0 to 3 | --- | 1 | F524 | 0 (1) |
| 4144 | DNP Object 22 Default Variation | 0 to 3 | --- | 1 | F523 | 0 (1) |
| 4145 | DNP Object 23 Default Variation | 0 to 3 | --- | 1 | F523 | 0 (1) |
| 4146 | DNP Object 30 Default Variation | 1 to 5 | --- | 1 | F001 | 1 |
| 4147 | DNP Object 32 Default Variation | 0 to 5 | --- | 1 | F525 | 0 (1) |
| **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)** | | | | | | |
| 4180 | Data Logger Rate | 0 to 7 | --- | 1 | F178 | 1 (1 min) |
| 4181 | Data Logger Channel Settings (16 items) | --- | --- | --- | F600 | 0 |
| **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) |

**Table B–9: MODBUS MEMORY MAP (Sheet 12 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---------------|-------|-------|------|--------|---------|
| 41A7 | Clock Events Enable / Disable | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| **Fault Report Commands (Read/Write Command)** | | | | | | |
| 41B2 | Fault Reports Clear Data Command | 0 to 1 | --- | 1 | F126 | 0 (No) |
| **Oscillography (Read/Write Setting)** | | | | | | |
| 41C0 | Oscillography Number of Records | 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 |
| 41C4 | Oscillography AC Input Waveforms | 0 to 4 | --- | 1 | F183 | 2 (16 samples/cycle) |
| 41D0 | Oscillography Analog Channel *n* (16 items) | 0 to 65535 | --- | 1 | F600 | 0 |
| 4200 | Oscillography Digital Channel *n* (63 items) | 0 to 65535 | --- | 1 | F300 | 0 |
| **Trip and Alarm LEDs (Read/Write Setting)** | | | | | | |
| 4260 | Trip LED Input FlexLogic Operand | 0 to 65535 | --- | 1 | F300 | 0 |
| 4261 | Alarm LED Input FlexLogic Operand | 0 to 65535 | --- | 1 | F300 | 0 |
| **User Programmable LEDs (Read/Write Setting) (48 modules)** | | | | | | |
| 4280 | FlexLogic Operand to Activate LED | 0 to 65535 | --- | 1 | F300 | 0 |
| 4281 | User LED type (latched or self-resetting) | 0 to 1 | --- | 1 | F127 | 1 (Self-Reset) |
| 4282 | ...Repeated for module number 2 | | | | | |
| 4284 | ...Repeated for module number 3 | | | | | |
| 4286 | ...Repeated for module number 4 | | | | | |
| 4288 | ...Repeated for module number 5 | | | | | |
| 428A | ...Repeated for module number 6 | | | | | |
| 428C | ...Repeated for module number 7 | | | | | |
| 428E | ...Repeated for module number 8 | | | | | |
| 4290 | ...Repeated for module number 9 | | | | | |
| 4292 | ...Repeated for module number 10 | | | | | |
| 4294 | ...Repeated for module number 11 | | | | | |
| 4296 | ...Repeated for module number 12 | | | | | |
| 4298 | ...Repeated for module number 13 | | | | | |
| 429A | ...Repeated for module number 14 | | | | | |
| 429C | ...Repeated for module number 15 | | | | | |
| 429E | ...Repeated for module number 16 | | | | | |
| 42A0 | ...Repeated for module number 17 | | | | | |
| 42A2 | ...Repeated for module number 18 | | | | | |
| 42A4 | ...Repeated for module number 19 | | | | | |
| 42A6 | ...Repeated for module number 20 | | | | | |
| 42A8 | ...Repeated for module number 21 | | | | | |
| 42AA | ...Repeated for module number 22 | | | | | |
| 42AC | ...Repeated for module number 23 | | | | | |
| 42AE | ...Repeated for module number 24 | | | | | |
| 42B0 | ...Repeated for module number 25 | | | | | |
| 42B2 | ...Repeated for module number 26 | | | | | |
| 42B4 | ...Repeated for module number 27 | | | | | |
| 42B6 | ...Repeated for module number 28 | | | | | |
| 42B8 | ...Repeated for module number 29 | | | | | |
| 42BA | ...Repeated for module number 30 | | | | | |
| 42BC | ...Repeated for module number 31 | | | | | |
| 42BE | ...Repeated for module number 32 | | | | | |
| 42C0 | ...Repeated for module number 33 | | | | | |
| 42C2 | ...Repeated for module number 34 | | | | | |
| 42C4 | ...Repeated for module number 35 | | | | | |
| 42C6 | ...Repeated for module number 36 | | | | | |
| 42C8 | ...Repeated for module number 37 | | | | | |
| 42CA | ...Repeated for module number 38 | | | | | |

**Table B–9: MODBUS MEMORY MAP (Sheet 13 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---------------|-------|-------|------|--------|---------|
| 42CC | ...Repeated for module number 39 | | | | | |
| 42CE | ...Repeated for module number 40 | | | | | |
| 42D0 | ...Repeated for module number 41 | | | | | |
| 42D2 | ...Repeated for module number 42 | | | | | |
| 42D4 | ...Repeated for module number 43 | | | | | |
| 42D6 | ...Repeated for module number 44 | | | | | |
| 42D8 | ...Repeated for module number 45 | | | | | |
| 42DA | ...Repeated for module number 46 | | | | | |
| 42DC | ...Repeated for module number 47 | | | | | |
| 42DE | ...Repeated for module number 48 | | | | | |
| **Installation (Read/Write Setting)** | | | | | | |
| 43E0 | Relay Programmed State | 0 to 1 | --- | 1 | F133 | 0 (Not Programmed) |
| 43E1 | Relay Name | --- | --- | --- | F202 | "Relay-1" |
| **User Programmable Self Tests (Read/Write Setting)** | | | | | | |
| 4441 | User Programmable Detect Ring Break Function | 0 to 1 | --- | 1 | F102 | 1 (Enabled) |
| 4442 | User Programmable Direct Device Off Function | 0 to 1 | --- | 1 | F102 | 1 (Enabled) |
| 4443 | User Programmable Remote Device Off Function | 0 to 1 | --- | 1 | F102 | 1 (Enabled) |
| 4444 | User Programmable Primary Ethernet Fail Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 4445 | User Programmable Secondary Ethernet Fail Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 4446 | User Programmable Battery Fail Function | 0 to 1 | --- | 1 | F102 | 1 (Enabled) |
| 4447 | User Programmable SNTP Fail Function | 0 to 1 | --- | 1 | F102 | 1 (Enabled) |
| 4448 | User Programmable IRIG-B Fail Function | 0 to 1 | --- | 1 | F102 | 1 (Enabled) |
| **CT Settings (Read/Write Setting) (6 modules)** | | | | | | |
| 4480 | Phase CT Primary | 1 to 65000 | A | 1 | F001 | 1 |
| 4481 | Phase CT Secondary | 0 to 1 | --- | 1 | F123 | 0 (1 A) |
| 4482 | Ground CT Primary | 1 to 65000 | A | 1 | F001 | 1 |
| 4483 | Ground CT Secondary | 0 to 1 | --- | 1 | F123 | 0 (1 A) |
| 4484 | ...Repeated for module number 2 | | | | | |
| 4488 | ...Repeated for module number 3 | | | | | |
| 448C | ...Repeated for module number 4 | | | | | |
| 4490 | ...Repeated for module number 5 | | | | | |
| 4494 | ...Repeated for module number 6 | | | | | |
| **VT Settings (Read/Write Setting) (3 modules)** | | | | | | |
| 4500 | Phase VT Connection | 0 to 1 | --- | 1 | F100 | 0 (Wye) |
| 4501 | Phase VT Secondary | 50 to 240 | V | 0.1 | F001 | 664 |
| 4502 | Phase VT Ratio | 1 to 24000 | :1 | 1 | F060 | 1 |
| 4504 | Auxiliary VT Connection | 0 to 6 | --- | 1 | F166 | 1 (Vag) |
| 4505 | Auxiliary VT Secondary | 50 to 240 | V | 0.1 | F001 | 664 |
| 4506 | Auxiliary VT Ratio | 1 to 24000 | :1 | 1 | F060 | 1 |
| 4508 | ...Repeated for module number 2 | | | | | |
| 4510 | ...Repeated for module number 3 | | | | | |
| **Source Settings (Read/Write Setting) (6 modules)** | | | | | | |
| 4580 | Source Name | --- | --- | --- | F206 | "SRC 1" |
| 4583 | Source Phase CT | 0 to 63 | --- | 1 | F400 | 0 |
| 4584 | Source Ground CT | 0 to 63 | --- | 1 | F400 | 0 |
| 4585 | Source Phase VT | 0 to 63 | --- | 1 | F400 | 0 |
| 4586 | Source Auxiliary VT | 0 to 63 | --- | 1 | F400 | 0 |
| 4587 | ...Repeated for module number 2 | | | | | |
| 458E | ...Repeated for module number 3 | | | | | |
| 4595 | ...Repeated for module number 4 | | | | | |
| 459C | ...Repeated for module number 5 | | | | | |
| 45A3 | ...Repeated for module number 6 | | | | | |
| **Power System (Read/Write Setting)** | | | | | | |
| 4600 | Nominal Frequency | 25 to 60 | Hz | 1 | F001 | 60 |

**Table B–9: MODBUS MEMORY MAP (Sheet 14 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---------------|-------|-------|------|--------|---------|
| 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 Global Settings (Read/Write Setting)** | | | | | | |
| 46F0 | IEC 61850 XCBR 1 SelTimOut | 1 to 60 | s | 1 | F001 | 30 |
| **Breaker Control (Read/Write Setting) (2 modules)** | | | | | | |
| 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 3 Pole | 0 to 65535 | --- | 1 | F300 | 0 |
| 4708 | Breaker 1 Phase B | 0 to 65535 | --- | 1 | F300 | 0 |
| 4709 | Breaker 1 Phase C | 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 Push Button 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 IEC 61850 XCBR 1 SBOClass | 1 to 2 | --- | 1 | F001 | 1 |
| 4711 | Breaker 1 IEC 61850 XCBR 1 SBOEna | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 4712 | Breaker 1 Out Of Service | 0 to 65535 | --- | 1 | F300 | 0 |
| 4713 | Reserved (5 items) | 0 to 65535 | s | 1 | F001 | 0 |
| 4718 | ...Repeated for module number 2 | | | | | |
| **Synchrocheck (Read/Write Setting) (2 modules)** | | | | | | |
| 4780 | Synchrocheck 1 Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 4781 | Synchrocheck 1 V1 Source | 0 to 5 | --- | 1 | F167 | 0 (SRC 1) |
| 4782 | Synchrocheck 1 V2 Source | 0 to 5 | --- | 1 | F167 | 1 (SRC 2) |
| 4783 | Synchrocheck 1 Maximum Voltage Difference | 0 to 100000 | V | 1 | F060 | 10000 |
| 4785 | Synchrocheck 1 Maximum Angle Difference | 0 to 100 | degrees | 1 | F001 | 30 |
| 4786 | Synchrocheck 1 Maximum Frequency Difference | 0 to 2 | Hz | 0.01 | F001 | 100 |
| 4787 | Synchrocheck 1 Dead Source Select | 0 to 5 | --- | 1 | F176 | 1 (LV1 and DV2) |
| 4788 | Synchrocheck 1 Dead V1 Maximum Voltage | 0 to 1.25 | pu | 0.01 | F001 | 30 |
| 4789 | Synchrocheck 1 Dead V2 Maximum Voltage | 0 to 1.25 | pu | 0.01 | F001 | 30 |
| 478A | Synchrocheck 1 Live V1 Minimum Voltage | 0 to 1.25 | pu | 0.01 | F001 | 70 |
| 478B | Synchrocheck 1 Live V2 Minimum Voltage | 0 to 1.25 | pu | 0.01 | F001 | 70 |
| 478C | Synchrocheck 1 Target | 0 to 2 | --- | 1 | F109 | 0 (Self-reset) |
| 478D | Synchrocheck 1 Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 478E | Synchrocheck 1 Block | 0 to 65535 | --- | 1 | F300 | 0 |
| 478F | Synchrocheck 1 Frequency Hysteresis | 0 to 0.1 | Hz | 0.01 | F001 | 6 |
| 4790 | ...Repeated for module number 2 | | | | | |
| **Demand (Read/Write Setting)** | | | | | | |
| 47D0 | Demand Current Method | 0 to 2 | --- | 1 | F139 | 0 (Thrm. Exponential) |
| 47D1 | Demand Power Method | 0 to 2 | --- | 1 | F139 | 0 (Thrm. Exponential) |
| 47D2 | Demand Interval | 0 to 5 | --- | 1 | F132 | 2 (15 MIN) |
| 47D3 | Demand Input | 0 to 65535 | --- | 1 | F300 | 0 |
| **Demand (Read/Write Command)** | | | | | | |
| 47D4 | Demand Clear Record | 0 to 1 | --- | 1 | F126 | 0 (No) |
| **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 display 1 top line text | --- | --- | --- | F202 | " " |

**B**

**Table B–9: MODBUS MEMORY MAP (Sheet 15 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---------------|-------|-------|------|--------|---------|
| 4C0A | User display 1 bottom line text | --- | --- | --- | F202 | "" |
| 4C14 | Modbus addresses of displayed items (5 items) | 0 to 65535 | --- | 1 | F001 | 0 |
| 4C19 | Reserved (7 items) | --- | --- | --- | F001 | 0 |
| 4C20 | ...Repeated for module number 2 | | | | | |
| 4C40 | ...Repeated for module number 3 | | | | | |
| 4C60 | ...Repeated for module number 4 | | | | | |
| 4C80 | ...Repeated for module number 5 | | | | | |
| 4CA0 | ...Repeated for module number 6 | | | | | |
| 4CC0 | ...Repeated for module number 7 | | | | | |
| 4CE0 | ...Repeated for module number 8 | | | | | |
| 4D00 | ...Repeated for module number 9 | | | | | |
| 4D20 | ...Repeated for module number 10 | | | | | |
| 4D40 | ...Repeated for module number 11 | | | | | |
| 4D60 | ...Repeated for module number 12 | | | | | |
| 4D80 | ...Repeated for module number 13 | | | | | |
| 4DA0 | ...Repeated for module number 14 | | | | | |
| 4DC0 | ...Repeated for module number 15 | | | | | |
| 4DE0 | ...Repeated for module number 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 Reserved (2 items) | 0 to 65535 | --- | 1 | F001 | 0 |
| 4E24 | ...Repeated for module number 2 | | | | | |
| 4E48 | ...Repeated for module number 3 | | | | | |
| 4E6C | ...Repeated for module number 4 | | | | | |
| 4E90 | ...Repeated for module number 5 | | | | | |
| 4EB4 | ...Repeated for module number 6 | | | | | |
| 4ED8 | ...Repeated for module number 7 | | | | | |
| 4EFC | ...Repeated for module number 8 | | | | | |
| 4F20 | ...Repeated for module number 9 | | | | | |
| 4F44 | ...Repeated for module number 10 | | | | | |
| 4F68 | ...Repeated for module number 11 | | | | | |
| 4F8C | ...Repeated for module number 12 | | | | | |
| **Flexlogic (Read/Write Setting)** | | | | | | |
| 5000 | FlexLogic Entry (512 items) | 0 to 65535 | --- | 1 | F300 | 16384 |
| **Flexlogic Timers (Read/Write Setting) (32 modules)** | | | | | | |
| 5800 | Timer 1 Type | 0 to 2 | --- | 1 | F129 | 0 (millisecond) |
| 5801 | Timer 1 Pickup Delay | 0 to 60000 | --- | 1 | F001 | 0 |
| 5802 | Timer 1 Dropout Delay | 0 to 60000 | --- | 1 | F001 | 0 |
| 5803 | Timer 1 Reserved (5 items) | 0 to 65535 | --- | 1 | F001 | 0 |
| 5808 | ...Repeated for module number 2 | | | | | |
| 5810 | ...Repeated for module number 3 | | | | | |
| 5818 | ...Repeated for module number 4 | | | | | |
| 5820 | ...Repeated for module number 5 | | | | | |
| 5828 | ...Repeated for module number 6 | | | | | |
| 5830 | ...Repeated for module number 7 | | | | | |
| 5838 | ...Repeated for module number 8 | | | | | |
| 5840 | ...Repeated for module number 9 | | | | | |
| 5848 | ...Repeated for module number 10 | | | | | |

**Table B–9: MODBUS MEMORY MAP (Sheet 16 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---------------|-------|-------|------|--------|---------|
| 5850 | ...Repeated for module number 11 | | | | | |
| 5858 | ...Repeated for module number 12 | | | | | |
| 5860 | ...Repeated for module number 13 | | | | | |
| 5868 | ...Repeated for module number 14 | | | | | |
| 5870 | ...Repeated for module number 15 | | | | | |
| 5878 | ...Repeated for module number 16 | | | | | |
| 5880 | ...Repeated for module number 17 | | | | | |
| 5888 | ...Repeated for module number 18 | | | | | |
| 5890 | ...Repeated for module number 19 | | | | | |
| 5898 | ...Repeated for module number 20 | | | | | |
| 58A0 | ...Repeated for module number 21 | | | | | |
| 58A8 | ...Repeated for module number 22 | | | | | |
| 58B0 | ...Repeated for module number 23 | | | | | |
| 58B8 | ...Repeated for module number 24 | | | | | |
| 58C0 | ...Repeated for module number 25 | | | | | |
| 58C8 | ...Repeated for module number 26 | | | | | |
| 58D0 | ...Repeated for module number 27 | | | | | |
| 58D8 | ...Repeated for module number 28 | | | | | |
| 58E0 | ...Repeated for module number 29 | | | | | |
| 58E8 | ...Repeated for module number 30 | | | | | |
| 58F0 | ...Repeated for module number 31 | | | | | |
| 58F8 | ...Repeated for module number 32 | | | | | |
| **Phase Time Overcurrent (Read/Write Grouped Setting) (6 modules)** | | | | | | |
| 5900 | Phase TOC 1 Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 5901 | Phase TOC 1 Signal Source | 0 to 5 | --- | 1 | F167 | 0 (SRC 1) |
| 5902 | Phase TOC 1 Input | 0 to 1 | --- | 1 | F122 | 0 (Phasor) |
| 5903 | Phase TOC 1 Pickup | 0 to 30 | pu | 0.001 | F001 | 1000 |
| 5904 | Phase TOC 1 Curve | 0 to 16 | --- | 1 | F103 | 0 (IEEE Mod Inv) |
| 5905 | Phase TOC 1 Multiplier | 0 to 600 | --- | 0.01 | F001 | 100 |
| 5906 | Phase TOC 1 Reset | 0 to 1 | --- | 1 | F104 | 0 (Instantaneous) |
| 5907 | Phase TOC 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 TOC 1 Target | 0 to 2 | --- | 1 | F109 | 0 (Self-reset) |
| 590C | Phase TOC 1 Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 590D | Reserved (3 items) | 0 to 1 | --- | 1 | F001 | 0 |
| 5910 | ...Repeated for module number 2 | | | | | |
| 5920 | ...Repeated for module number 3 | | | | | |
| 5930 | ...Repeated for module number 4 | | | | | |
| 5940 | ...Repeated for module number 5 | | | | | |
| 5950 | ...Repeated for module number 6 | | | | | |
| **Phase Instantaneous Overcurrent (Read/Write Grouped Setting) (12 modules)** | | | | | | |
| 5A00 | Phase IOC1 Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 5A01 | Phase IOC1 Signal Source | 0 to 5 | --- | 1 | F167 | 0 (SRC 1) |
| 5A02 | Phase IOC1 Pickup | 0 to 30 | pu | 0.001 | F001 | 1000 |
| 5A03 | Phase IOC1 Delay | 0 to 600 | s | 0.01 | F001 | 0 |
| 5A04 | Phase IOC1 Reset Delay | 0 to 600 | s | 0.01 | F001 | 0 |
| 5A05 | Phase IOC1 Block For Each Phase (3 items) | 0 to 65535 | --- | 1 | F300 | 0 |
| 5A08 | Phase IOC1 Target | 0 to 2 | --- | 1 | F109 | 0 (Self-reset) |
| 5A09 | Phase IOC1 Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 5A0A | Reserved (6 items) | 0 to 1 | --- | 1 | F001 | 0 |
| 5A10 | ...Repeated for module number 2 | | | | | |
| 5A20 | ...Repeated for module number 3 | | | | | |
| 5A30 | ...Repeated for module number 4 | | | | | |
| 5A40 | ...Repeated for module number 5 | | | | | |

**Table B–9: MODBUS MEMORY MAP (Sheet 17 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---------------|-------|-------|------|--------|---------|
| 5A50 | ...Repeated for module number 6 | | | | | |
| 5A60 | ...Repeated for module number 7 | | | | | |
| 5A70 | ...Repeated for module number 8 | | | | | |
| 5A80 | ...Repeated for module number 9 | | | | | |
| 5A90 | ...Repeated for module number 10 | | | | | |
| 5AA0 | ...Repeated for module number 11 | | | | | |
| 5AB0 | ...Repeated for module number 12 | | | | | |
| **Neutral Time Overcurrent (Read/Write Grouped Setting) (6 modules)** | | | | | | |
| 5B00 | Neutral TOC1 Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 5B01 | Neutral TOC1 Signal Source | 0 to 5 | --- | 1 | F167 | 0 (SRC 1) |
| 5B02 | Neutral TOC1 Input | 0 to 1 | --- | 1 | F122 | 0 (Phasor) |
| 5B03 | Neutral TOC1 Pickup | 0 to 30 | pu | 0.001 | F001 | 1000 |
| 5B04 | Neutral TOC1 Curve | 0 to 16 | --- | 1 | F103 | 0 (IEEE Mod Inv) |
| 5B05 | Neutral TOC1 Multiplier | 0 to 600 | --- | 0.01 | F001 | 100 |
| 5B06 | Neutral TOC1 Reset | 0 to 1 | --- | 1 | F104 | 0 (Instantaneous) |
| 5B07 | Neutral TOC1 Block | 0 to 65535 | --- | 1 | F300 | 0 |
| 5B08 | Neutral TOC1 Target | 0 to 2 | --- | 1 | F109 | 0 (Self-reset) |
| 5B09 | Neutral TOC1 Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 5B0A | Reserved (6 items) | 0 to 1 | --- | 1 | F001 | 0 |
| 5B10 | ...Repeated for module number 2 | | | | | |
| 5B20 | ...Repeated for module number 3 | | | | | |
| 5B30 | ...Repeated for module number 4 | | | | | |
| 5B40 | ...Repeated for module number 5 | | | | | |
| 5B50 | ...Repeated for module number 6 | | | | | |
| **Neutral Instantaneous Overcurrent (Read/Write Grouped Setting) (12 modules)** | | | | | | |
| 5C00 | Neutral IOC1 Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 5C01 | Neutral IOC1 Signal Source | 0 to 5 | --- | 1 | F167 | 0 (SRC 1) |
| 5C02 | Neutral IOC1 Pickup | 0 to 30 | pu | 0.001 | F001 | 1000 |
| 5C03 | Neutral IOC1 Delay | 0 to 600 | s | 0.01 | F001 | 0 |
| 5C04 | Neutral IOC1 Reset Delay | 0 to 600 | s | 0.01 | F001 | 0 |
| 5C05 | Neutral IOC1 Block | 0 to 65535 | --- | 1 | F300 | 0 |
| 5C06 | Neutral IOC1 Target | 0 to 2 | --- | 1 | F109 | 0 (Self-reset) |
| 5C07 | Neutral IOC1 Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 5C08 | Reserved (8 items) | 0 to 1 | --- | 1 | F001 | 0 |
| 5C10 | ...Repeated for module number 2 | | | | | |
| 5C20 | ...Repeated for module number 3 | | | | | |
| 5C30 | ...Repeated for module number 4 | | | | | |
| 5C40 | ...Repeated for module number 5 | | | | | |
| 5C50 | ...Repeated for module number 6 | | | | | |
| 5C60 | ...Repeated for module number 7 | | | | | |
| 5C70 | ...Repeated for module number 8 | | | | | |
| 5C80 | ...Repeated for module number 9 | | | | | |
| 5C90 | ...Repeated for module number 10 | | | | | |
| 5CA0 | ...Repeated for module number 11 | | | | | |
| 5CB0 | ...Repeated for module number 12 | | | | | |
| **Ground Time Overcurrent (Read/Write Grouped Setting) (6 modules)** | | | | | | |
| 5D00 | Ground TOC1 Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 5D01 | Ground TOC1 Signal Source | 0 to 5 | --- | 1 | F167 | 0 (SRC 1) |
| 5D02 | Ground TOC1 Input | 0 to 1 | --- | 1 | F122 | 0 (Phasor) |
| 5D03 | Ground TOC1 Pickup | 0 to 30 | pu | 0.001 | F001 | 1000 |
| 5D04 | Ground TOC1 Curve | 0 to 16 | --- | 1 | F103 | 0 (IEEE Mod Inv) |
| 5D05 | Ground TOC1 Multiplier | 0 to 600 | --- | 0.01 | F001 | 100 |
| 5D06 | Ground TOC1 Reset | 0 to 1 | --- | 1 | F104 | 0 (Instantaneous) |
| 5D07 | Ground TOC1 Block | 0 to 65535 | --- | 1 | F300 | 0 |

**Table B–9: MODBUS MEMORY MAP (Sheet 18 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---------------|-------|-------|------|--------|---------|
| 5D08 | Ground TOC1 Target | 0 to 2 | --- | 1 | F109 | 0 (Self-reset) |
| 5D09 | Ground TOC1 Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 5D0A | Reserved (6 items) | 0 to 1 | --- | 1 | F001 | 0 |
| 5D10 | ...Repeated for module number 2 | | | | | |
| 5D20 | ...Repeated for module number 3 | | | | | |
| 5D30 | ...Repeated for module number 4 | | | | | |
| 5D40 | ...Repeated for module number 5 | | | | | |
| 5D50 | ...Repeated for module number 6 | | | | | |
| **Ground Instantaneous Overcurrent (Read/Write Grouped Setting) (12 modules)** | | | | | | |
| 5E00 | Ground IOC1 Signal Source | 0 to 5 | --- | 1 | F167 | 0 (SRC 1) |
| 5E01 | Ground IOC1 Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 5E02 | Ground IOC1 Pickup | 0 to 30 | pu | 0.001 | F001 | 1000 |
| 5E03 | Ground IOC1 Delay | 0 to 600 | s | 0.01 | F001 | 0 |
| 5E04 | Ground IOC1 Reset Delay | 0 to 600 | s | 0.01 | F001 | 0 |
| 5E05 | Ground IOC1 Block | 0 to 65535 | --- | 1 | F300 | 0 |
| 5E06 | Ground IOC1 Target | 0 to 2 | --- | 1 | F109 | 0 (Self-reset) |
| 5E07 | Ground IOC1 Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 5E08 | Reserved (8 items) | 0 to 1 | --- | 1 | F001 | 0 |
| 5E10 | ...Repeated for module number 2 | | | | | |
| 5E20 | ...Repeated for module number 3 | | | | | |
| 5E30 | ...Repeated for module number 4 | | | | | |
| 5E40 | ...Repeated for module number 5 | | | | | |
| 5E50 | ...Repeated for module number 6 | | | | | |
| 5E60 | ...Repeated for module number 7 | | | | | |
| 5E70 | ...Repeated for module number 8 | | | | | |
| 5E80 | ...Repeated for module number 9 | | | | | |
| 5E90 | ...Repeated for module number 10 | | | | | |
| 5EA0 | ...Repeated for module number 11 | | | | | |
| 5EB0 | ...Repeated for module number 12 | | | | | |
| **Sensitive Directional Power (Read/Write Grouped Setting) (2 modules)** | | | | | | |
| 66A0 | Sensitive Directional Power 1 Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 66A1 | Sensitive Directional Power 1 Signal Source | 0 to 5 | --- | 1 | F167 | 0 (SRC 1) |
| 66A2 | Sensitive Directional Power 1 RCA | 0 to 359 | degrees | 1 | F001 | 0 |
| 66A3 | Sensitive Directional Power 1 Calibration | 0 to 0.95 | degrees | 0.05 | F001 | 0 |
| 66A4 | Sensitive Directional Power 1 STG1 SMIN | -1.2 to 1.2 | pu | 0.001 | F002 | 100 |
| 66A5 | Sensitive Directional Power 1 STG1 Delay | 0 to 600 | s | 0.01 | F001 | 50 |
| 66A6 | Sensitive Directional Power 1 STG2 SMIN | -1.2 to 1.2 | pu | 0.001 | F002 | 100 |
| 66A7 | Sensitive Directional Power 1 STG2 Delay | 0 to 600 | s | 0.01 | F001 | 2000 |
| 66A8 | Sensitive Directional Power 1 Block | --- | --- | --- | F001 | 0 |
| 66A9 | Sensitive Directional Power 1 Target | 0 to 2 | --- | 1 | F109 | 0 (Self-reset) |
| 66AA | Sensitive Directional Power 1 Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 66AB | Sensitive Directional Power 1 Reserved (5 items) | 0 to 65535 | --- | 1 | F001 | 0 |
| 66B0 | ...Repeated for module number 2 | | | | | |
| **Autoreclose 1P 3P (Read/Write Setting)** | | | | | | |
| 6890 | Autoreclose Mode | 0 to 3 | --- | 1 | F080 | 0 (1 & 3 Pole) |
| 6891 | Autoreclose Maximum Number of Shots | 1 to 4 | --- | 1 | F001 | 2 |
| 6892 | Autoreclose Block Breaker 1 | 0 to 65535 | --- | 1 | F300 | 0 |
| 6893 | Autoreclose Close Time Breaker 1 | 0 to 655.35 | s | 0.01 | F001 | 10 |
| 6894 | Autoreclose Breaker Manual Close | 0 to 65535 | --- | 1 | F300 | 0 |
| 6895 | Autoreclose Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 6896 | Autoreclose Block Time Manual Close | 0 to 655.35 | s | 0.01 | F001 | 1000 |
| 6897 | Autoreclose 1P Initiate | 0 to 65535 | --- | 1 | F300 | 0 |
| 6898 | Autoreclose 3P Initiate | 0 to 65535 | --- | 1 | F300 | 0 |
| 6899 | Autoreclose 3P TD Initiate | 0 to 65535 | --- | 1 | F300 | 0 |

**B**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|--------------|-------|-------|------|--------|---------|
| 689A | Autoreclose Multi-Phase Fault | 0 to 65535 | --- | 1 | F300 | 0 |
| 689B | Autoreclose Breaker 1 Pole Open | 0 to 65535 | --- | 1 | F300 | 0 |
| 689C | Autoreclose Breaker 3 Pole Open | 0 to 65535 | --- | 1 | F300 | 0 |
| 689D | Autoreclose 3-Pole Dead Time 1 | 0 to 655.35 | s | 0.01 | F001 | 50 |
| 689E | Autoreclose 3-Pole Dead Time 2 | 0 to 655.35 | s | 0.01 | F001 | 120 |
| 689F | Autoreclose Extend Dead T1 | 0 to 65535 | --- | 1 | F300 | 0 |
| 68A0 | Autoreclose Dead T1 Extension | 0 to 655.35 | s | 0.01 | F001 | 50 |
| 68A1 | Autoreclose Reset | 0 to 65535 | --- | 1 | F300 | 0 |
| 68A2 | Autoreclose Reset Time | 0 to 655.35 | s | 0.01 | F001 | 6000 |
| 68A3 | Autoreclose Breaker Closed | 0 to 65535 | --- | 1 | F300 | 0 |
| 68A4 | Autoreclose Block | 0 to 65535 | --- | 1 | F300 | 0 |
| 68A5 | Autoreclose Pause | 0 to 65535 | --- | 1 | F300 | 0 |
| 68A6 | Autoreclose Incomplete Sequence Time | 0 to 655.35 | s | 0.01 | F001 | 500 |
| 68A7 | Autoreclose Block Breaker 2 | 0 to 65535 | --- | 1 | F300 | 0 |
| 68A8 | Autoreclose Close Time Breaker 2 | 0 to 655.35 | s | 0.01 | F001 | 10 |
| 68A9 | Autoreclose Transfer 1 to 2 | 0 to 1 | --- | 1 | F126 | 0 (No) |
| 68AA | Autoreclose Transfer 2 to 1 | 0 to 1 | --- | 1 | F126 | 0 (No) |
| 68AB | Autoreclose Breaker 1 Fail Option | 0 to 1 | --- | 1 | F081 | 0 (Continue) |
| 68AC | Autoreclose Breaker 2 Fail Option | 0 to 1 | --- | 1 | F081 | 0 (Continue) |
| 68AD | Autoreclose 1P Dead Time | 0 to 655.35 | s | 0.01 | F001 | 100 |
| 68AE | Autoreclose Breaker Sequence | 0 to 4 | --- | 1 | F082 | 3 (1 - 2) |
| 68AF | Autoreclose Transfer Time | 0 to 655.35 | s | 0.01 | F001 | 400 |
| 68B0 | Autoreclose Event | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 68B1 | Autoreclose 3P Dead Time 3 | 0 to 655.35 | s | 0.01 | F001 | 200 |
| 68B2 | Autoreclose 3P Dead Time 4 | 0 to 655.35 | s | 0.01 | F001 | 400 |
| 68B3 | Reserved (14 items) | --- | --- | --- | F001 | 0 |
| **Phase Undervoltage (Read/Write Grouped Setting) (2 modules)** | | | | | | |
| 7000 | Phase UV1 Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 7001 | Phase UV1 Signal Source | 0 to 5 | --- | 1 | F167 | 0 (SRC 1) |
| 7002 | Phase UV1 Pickup | 0 to 3 | pu | 0.001 | F001 | 1000 |
| 7003 | Phase UV1 Curve | 0 to 1 | --- | 1 | F111 | 0 (Definite Time) |
| 7004 | Phase UV1 Delay | 0 to 600 | s | 0.01 | F001 | 100 |
| 7005 | Phase UV1 Minimum Voltage | 0 to 3 | pu | 0.001 | F001 | 100 |
| 7006 | Phase UV1 Block | 0 to 65535 | --- | 1 | F300 | 0 |
| 7007 | Phase UV1 Target | 0 to 2 | --- | 1 | F109 | 0 (Self-reset) |
| 7008 | Phase UV1 Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 7009 | Phase UV Measurement Mode | 0 to 1 | --- | 1 | F186 | 0 (Phase to Ground) |
| 700A | Reserved (6 items) | 0 to 1 | --- | 1 | F001 | 0 |
| 7013 | ...Repeated for module number 2 | | | | | |
| **Breaker Failure (Read/Write Grouped Setting) (2 modules)** | | | | | | |
| 7200 | Breaker Failure 1 Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 7201 | Breaker Failure 1 Mode | 0 to 1 | --- | 1 | F157 | 0 (3-Pole) |
| 7208 | Breaker Failure 1 Source | 0 to 5 | --- | 1 | F167 | 0 (SRC 1) |
| 7209 | Breaker Failure 1 Amp Supervision | 0 to 1 | --- | 1 | F126 | 1 (Yes) |
| 720A | Breaker Failure 1 Use Seal-In | 0 to 1 | --- | 1 | F126 | 1 (Yes) |
| 720B | Breaker Failure 1 Three Pole Initiate | 0 to 65535 | --- | 1 | F300 | 0 |
| 720C | Breaker Failure 1 Block | 0 to 65535 | --- | 1 | F300 | 0 |
| 720D | Breaker Failure 1 Phase Amp Supv Pickup | 0.001 to 30 | pu | 0.001 | F001 | 1050 |
| 720E | Breaker Failure 1 Neutral Amp Supv Pickup | 0.001 to 30 | pu | 0.001 | F001 | 1050 |
| 720F | Breaker Failure 1 Use Timer 1 | 0 to 1 | --- | 1 | F126 | 1 (Yes) |
| 7210 | Breaker Failure 1 Timer 1 Pickup | 0 to 65.535 | s | 0.001 | F001 | 0 |
| 7211 | Breaker Failure 1 Use Timer 2 | 0 to 1 | --- | 1 | F126 | 1 (Yes) |
| 7212 | Breaker Failure 1 Timer 2 Pickup | 0 to 65.535 | s | 0.001 | F001 | 0 |
| 7213 | Breaker Failure 1 Use Timer 3 | 0 to 1 | --- | 1 | F126 | 1 (Yes) |

**Table B–9: MODBUS MEMORY MAP (Sheet 20 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|---|---|---|---|---|---|---|
| 7214 | Breaker Failure 1 Timer 3 Pickup | 0 to 65.535 | s | 0.001 | F001 | 0 |
| 7215 | Breaker Failure 1 Breaker Status 1 Phase A/3P | 0 to 65535 | --- | 1 | F300 | 0 |
| 7216 | Breaker Failure 1 Breaker Status 2 Phase A/3P | 0 to 65535 | --- | 1 | F300 | 0 |
| 7217 | Breaker Failure 1 Breaker Test On | 0 to 65535 | --- | 1 | F300 | 0 |
| 7218 | Breaker Failure 1 Phase Amp Hiset Pickup | 0.001 to 30 | pu | 0.001 | F001 | 1050 |
| 7219 | Breaker Failure 1 Neutral Amp Hiset Pickup | 0.001 to 30 | pu | 0.001 | F001 | 1050 |
| 721A | Breaker Failure 1 Phase Amp Loset Pickup | 0.001 to 30 | pu | 0.001 | F001 | 1050 |
| 721B | Breaker Failure 1 Neutral Amp Loset Pickup | 0.001 to 30 | pu | 0.001 | F001 | 1050 |
| 721C | Breaker Failure 1 Loset Time | 0 to 65.535 | s | 0.001 | F001 | 0 |
| 721D | Breaker Failure 1 Trip Dropout Delay | 0 to 65.535 | s | 0.001 | F001 | 0 |
| 721E | Breaker Failure 1 Target | 0 to 2 | --- | 1 | F109 | 0 (Self-reset) |
| 721F | Breaker Failure 1 Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 7220 | Breaker Failure 1 Phase A Initiate | 0 to 65535 | --- | 1 | F300 | 0 |
| 7221 | Breaker Failure 1 Phase B Initiate | 0 to 65535 | --- | 1 | F300 | 0 |
| 7222 | Breaker Failure 1 Phase C Initiate | 0 to 65535 | --- | 1 | F300 | 0 |
| 7223 | Breaker Failure 1 Breaker Status 1 Phase B | 0 to 65535 | --- | 1 | F300 | 0 |
| 7224 | Breaker Failure 1 Breaker Status 1 Phase C | 0 to 65535 | --- | 1 | F300 | 0 |
| 7225 | Breaker Failure 1 Breaker Status 2 Phase B | 0 to 65535 | --- | 1 | F300 | 0 |
| 7226 | Breaker Failure 1 Breaker Status 2 Phase C | 0 to 65535 | --- | 1 | F300 | 0 |
| 7227 | ...Repeated for module number 2 | | | | | |
| **Breaker Arcing Current Settings (Read/Write Setting) (2 modules)** | | | | | | |
| 72C0 | Breaker 1 Arcing Current Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 72C1 | Breaker 1 Arcing Current Source | 0 to 5 | --- | 1 | F167 | 0 (SRC 1) |
| 72C2 | Breaker 1 Arcing Current Initiate A | 0 to 65535 | --- | 1 | F300 | 0 |
| 72C3 | Breaker 1 Arcing Current Initiate B | 0 to 65535 | --- | 1 | F300 | 0 |
| 72C4 | Breaker 1 Arcing Current Initiate C | 0 to 65535 | --- | 1 | F300 | 0 |
| 72C5 | Breaker 1 Arcing Current Delay | 0 to 65.535 | s | 0.001 | F001 | 0 |
| 72C6 | Breaker 1 Arcing Current Limit | 0 to 50000 | kA$^2$-cyc | 1 | F001 | 1000 |
| 72C7 | Breaker 1 Arcing Current Block | 0 to 65535 | --- | 1 | F300 | 0 |
| 72C8 | Breaker 1 Arcing Current Target | 0 to 2 | --- | 1 | F109 | 0 (Self-reset) |
| 72C9 | Breaker 1 Arcing Current Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 72CA | ...Repeated for module number 2 | | | | | |
| 72D4 | ...Repeated for module number 3 | | | | | |
| 72DE | ...Repeated for module number 4 | | | | | |
| **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 | DCMA Inputs 1 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 | DCMA Inputs 1 Reserved (5 items) | 0 to 65535 | --- | 1 | F001 | 0 |
| 7318 | ...Repeated for module number 2 | | | | | |
| 7330 | ...Repeated for module number 3 | | | | | |
| 7348 | ...Repeated for module number 4 | | | | | |
| 7360 | ...Repeated for module number 5 | | | | | |
| 7378 | ...Repeated for module number 6 | | | | | |
| 7390 | ...Repeated for module number 7 | | | | | |
| 73A8 | ...Repeated for module number 8 | | | | | |
| 73C0 | ...Repeated for module number 9 | | | | | |
| 73D8 | ...Repeated for module number 10 | | | | | |
| 73F0 | ...Repeated for module number 11 | | | | | |
| 7408 | ...Repeated for module number 12 | | | | | |

**Table B–9: MODBUS MEMORY MAP (Sheet 21 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---------------|-------|-------|------|--------|---------|
| 7420 | ...Repeated for module number 13 | | | | | |
| 7438 | ...Repeated for module number 14 | | | | | |
| 7450 | ...Repeated for module number 15 | | | | | |
| 7468 | ...Repeated for module number 16 | | | | | |
| 7480 | ...Repeated for module number 17 | | | | | |
| 7498 | ...Repeated for module number 18 | | | | | |
| 74B0 | ...Repeated for module number 19 | | | | | |
| 74C8 | ...Repeated for module number 20 | | | | | |
| 74E0 | ...Repeated for module number 21 | | | | | |
| 74F8 | ...Repeated for module number 22 | | | | | |
| 7510 | ...Repeated for module number 23 | | | | | |
| 7528 | ...Repeated for module number 24 | | | | | |
| **RTD Inputs (Read/Write Setting) (48 modules)** | | | | | | |
| 7540 | RTD Inputs 1 Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 7541 | RTD Inputs 1 ID | --- | --- | --- | F205 | "RTD Ip 1" |
| 7547 | RTD Inputs 1 Reserved 1 (4 items) | 0 to 65535 | --- | 1 | F001 | 0 |
| 754B | RTD Inputs 1 Type | 0 to 3 | --- | 1 | F174 | 0 (100 Ohm Platinum) |
| 754C | RTD Inputs 1 Reserved 2 (4 items) | 0 to 65535 | --- | 1 | F001 | 0 |
| 7550 | ...Repeated for module number 2 | | | | | |
| 7560 | ...Repeated for module number 3 | | | | | |
| 7570 | ...Repeated for module number 4 | | | | | |
| 7580 | ...Repeated for module number 5 | | | | | |
| 7590 | ...Repeated for module number 6 | | | | | |
| 75A0 | ...Repeated for module number 7 | | | | | |
| 75B0 | ...Repeated for module number 8 | | | | | |
| 75C0 | ...Repeated for module number 9 | | | | | |
| 75D0 | ...Repeated for module number 10 | | | | | |
| 75E0 | ...Repeated for module number 11 | | | | | |
| 75F0 | ...Repeated for module number 12 | | | | | |
| 7600 | ...Repeated for module number 13 | | | | | |
| 7610 | ...Repeated for module number 14 | | | | | |
| 7620 | ...Repeated for module number 15 | | | | | |
| 7630 | ...Repeated for module number 16 | | | | | |
| 7640 | ...Repeated for module number 17 | | | | | |
| 7650 | ...Repeated for module number 18 | | | | | |
| 7660 | ...Repeated for module number 19 | | | | | |
| 7670 | ...Repeated for module number 20 | | | | | |
| 7680 | ...Repeated for module number 21 | | | | | |
| 7690 | ...Repeated for module number 22 | | | | | |
| 76A0 | ...Repeated for module number 23 | | | | | |
| 76B0 | ...Repeated for module number 24 | | | | | |
| 76C0 | ...Repeated for module number 25 | | | | | |
| 76D0 | ...Repeated for module number 26 | | | | | |
| 76E0 | ...Repeated for module number 27 | | | | | |
| 76F0 | ...Repeated for module number 28 | | | | | |
| 7700 | ...Repeated for module number 29 | | | | | |
| 7710 | ...Repeated for module number 30 | | | | | |
| 7720 | ...Repeated for module number 31 | | | | | |
| 7730 | ...Repeated for module number 32 | | | | | |
| 7740 | ...Repeated for module number 33 | | | | | |
| 7750 | ...Repeated for module number 34 | | | | | |
| 7760 | ...Repeated for module number 35 | | | | | |
| 7770 | ...Repeated for module number 36 | | | | | |
| 7780 | ...Repeated for module number 37 | | | | | |

**Table B–9: MODBUS MEMORY MAP (Sheet 22 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---------------|-------|-------|------|--------|---------|
| 7790 | ...Repeated for module number 38 | | | | | |
| 77A0 | ...Repeated for module number 39 | | | | | |
| 77B0 | ...Repeated for module number 40 | | | | | |
| 77C0 | ...Repeated for module number 41 | | | | | |
| 77D0 | ...Repeated for module number 42 | | | | | |
| 77E0 | ...Repeated for module number 43 | | | | | |
| 77F0 | ...Repeated for module number 44 | | | | | |
| 7800 | ...Repeated for module number 45 | | | | | |
| 7810 | ...Repeated for module number 46 | | | | | |
| 7820 | ...Repeated for module number 47 | | | | | |
| 7830 | ...Repeated for module number 48 | | | | | |
| **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 1.25 | 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 Reserved (8 items) | 0 to 65535 | --- | 1 | F001 | 0 |
| 7F10 | ...Repeated for module number 2 | | | | | |
| 7F20 | ...Repeated for module number 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 | Auxiliary Overvoltage 1 Reserved (8 items) | 0 to 65535 | --- | 1 | F001 | 0 |
| 7F40 | ...Repeated for module number 2 | | | | | |
| 7F50 | ...Repeated for module number 3 | | | | | |
| **Auxiliary Undervoltage (Read/Write Grouped Setting) (3 modules)** | | | | | | |
| 7F60 | Auxiliary Undervoltage 1 Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 7F61 | Auxiliary Undervoltage 1 Signal Source | 0 to 5 | --- | 1 | F167 | 0 (SRC 1) |
| 7F62 | Auxiliary Undervoltage 1 Pickup | 0 to 3 | pu | 0.001 | F001 | 700 |
| 7F63 | Auxiliary Undervoltage 1 Delay | 0 to 600 | s | 0.01 | F001 | 100 |
| 7F64 | Auxiliary Undervoltage 1 Curve | 0 to 1 | --- | 1 | F111 | 0 (Definite Time) |
| 7F65 | Auxiliary Undervoltage 1 Minimum Voltage | 0 to 3 | pu | 0.001 | F001 | 100 |
| 7F66 | Auxiliary Undervoltage 1 Block | 0 to 65535 | --- | 1 | F300 | 0 |
| 7F67 | Auxiliary Undervoltage 1 Target | 0 to 2 | --- | 1 | F109 | 0 (Self-reset) |
| 7F68 | Auxiliary Undervoltage 1 Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 7F69 | Auxiliary Undervoltage 1 Reserved (7 items) | 0 to 65535 | --- | 1 | F001 | 0 |
| 7F70 | ...Repeated for module number 2 | | | | | |
| 7F80 | ...Repeated for module number 3 | | | | | |
| **Frequency (Read Only)** | | | | | | |
| 8000 | Tracking Frequency | 2 to 90 | Hz | 0.01 | F001 | 0 |
| **EGD Fast Production Status (Read Only)** | | | | | | |
| 83E0 | EGD Fast Producer Exchange 1 Signature | 0 to 65535 | --- | 1 | F001 | 0 |
| 83E1 | EGD Fast Producer Exchange 1 Configuration Time | 0 to 4294967295 | --- | --- | F003 | 0 |
| 83E3 | EGD Fast Producer Exchange 1 Size | 0 to 65535 | --- | 1 | F001 | 0 |

**B**

**Table B–9: MODBUS MEMORY MAP (Sheet 23 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|---|---|---|---|---|---|---|
| **EGD Slow Production Status (Read Only) (2 modules)** | | | | | | |
| 83F0 | EGD Slow Producer Exchange 1 Signature | 0 to 65535 | --- | 1 | F001 | 0 |
| 83F1 | EGD Slow Producer Exchange 1 Configuration Time | 0 to 4294967295 | --- | --- | F003 | 0 |
| 83F3 | EGD Slow Producer Exchange 1 Size | 0 to 65535 | --- | 1 | F001 | 0 |
| 83F4 | ...Repeated for module number 2 | | | | | |
| **EGD Fast Production (Read/Write Setting)** | | | | | | |
| 8400 | EGD Fast Producer Exchange 1 Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 8401 | EGD Fast Producer Exchange 1 Destination | 0 to 4294967295 | --- | 1 | F003 | 0 |
| 8403 | EGD Fast Producer Exchange 1 Data Rate | 50 to 1000 | ms | 50 | F001 | 1000 |
| 8404 | EGD Fast Producer Exchange 1 Data Item 1 (20 items) | 0 to 65535 | --- | 1 | F001 | 0 |
| 8418 | Reserved (80 items) | --- | --- | --- | F001 | 0 |
| **EGD Slow Production (Read/Write Setting) (2 modules)** | | | | | | |
| 8500 | EGD Slow Producer Exchange 1 Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 8501 | EGD Fast Producer Exchange 1 Destination | 0 to 4294967295 | --- | 1 | F003 | 0 |
| 8503 | EGD Slow Producer Exchange 1 Data Rate | 500 to 1000 | ms | 50 | F001 | 1000 |
| 8504 | EGD Slow Producer Exchange 1 Data Item 1 (50 items) | 0 to 65535 | --- | 1 | F001 | 0 |
| 8536 | Reserved (50 items) | --- | --- | --- | F001 | 0 |
| 8568 | ...Repeated for module number 2 | | | | | |
| **FlexState Settings (Read/Write Setting)** | | | | | | |
| 8800 | FlexState Parameters (256 items) | --- | --- | --- | F300 | 0 |
| **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 module number 2 | | | | | |
| 9028 | ...Repeated for module number 3 | | | | | |
| 903C | ...Repeated for module number 4 | | | | | |
| 9050 | ...Repeated for module number 5 | | | | | |
| 9064 | ...Repeated for module number 6 | | | | | |
| 9078 | ...Repeated for module number 7 | | | | | |
| 908C | ...Repeated for module number 8 | | | | | |
| 90A0 | ...Repeated for module number 9 | | | | | |
| 90B4 | ...Repeated for module number 10 | | | | | |
| 90C8 | ...Repeated for module number 11 | | | | | |
| 90DC | ...Repeated for module number 12 | | | | | |
| 90F0 | ...Repeated for module number 13 | | | | | |
| 9104 | ...Repeated for module number 14 | | | | | |
| 9118 | ...Repeated for module number 15 | | | | | |
| 912C | ...Repeated for module number 16 | | | | | |
| **Fault Report Settings (Read/Write Setting) (5 modules)** | | | | | | |
| 9200 | Fault Report 1 Source | 0 to 5 | --- | 1 | F167 | 0 (SRC 1) |

**Table B–9: MODBUS MEMORY MAP (Sheet 24 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|---|---|---|---|---|---|---|
| 9201 | Fault Report 1 Trigger | 0 to 65535 | --- | 1 | F300 | 0 |
| 9202 | Fault Report 1 Z1 Magnitude | 0.01 to 250 | ohms | 0.01 | F001 | 300 |
| 9203 | Fault Report 1 Z1 Angle | 25 to 90 | degrees | 1 | F001 | 75 |
| 9204 | Fault Report 1 Z0 Magnitude | 0.01 to 650 | ohms | 0.01 | F001 | 900 |
| 9205 | Fault Report 1 Z0 Angle | 25 to 90 | degrees | 1 | F001 | 75 |
| 9206 | Fault Report 1 Line Length Units | 0 to 1 | --- | 1 | F147 | 0 (km) |
| 9207 | Fault Report 1 Line Length | 0 to 2000 | | 0.1 | F001 | 1000 |
| 9208 | ...Repeated for module number 2 | | | | | |
| 9210 | ...Repeated for module number 3 | | | | | |
| 9218 | ...Repeated for module number 4 | | | | | |
| 9220 | ...Repeated for module number 5 | | | | | |
| **DCMA Outputs (Read/Write Setting) (24 modules)** | | | | | | |
| 9300 | DCMA Outputs 1 Source | 0 to 65535 | --- | 1 | F600 | 0 |
| 9301 | DCMA Outputs 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 Outputs 1 Maximum | -90 to 90 | pu | 0.001 | F004 | 1000 |
| 9306 | ...Repeated for module number 2 | | | | | |
| 930C | ...Repeated for module number 3 | | | | | |
| 9312 | ...Repeated for module number 4 | | | | | |
| 9318 | ...Repeated for module number 5 | | | | | |
| 931E | ...Repeated for module number 6 | | | | | |
| 9324 | ...Repeated for module number 7 | | | | | |
| 932A | ...Repeated for module number 8 | | | | | |
| 9330 | ...Repeated for module number 9 | | | | | |
| 9336 | ...Repeated for module number 10 | | | | | |
| 933C | ...Repeated for module number 11 | | | | | |
| 9342 | ...Repeated for module number 12 | | | | | |
| 9348 | ...Repeated for module number 13 | | | | | |
| 934E | ...Repeated for module number 14 | | | | | |
| 9354 | ...Repeated for module number 15 | | | | | |
| 935A | ...Repeated for module number 16 | | | | | |
| 9360 | ...Repeated for module number 17 | | | | | |
| 9366 | ...Repeated for module number 18 | | | | | |
| 936C | ...Repeated for module number 19 | | | | | |
| 9372 | ...Repeated for module number 20 | | | | | |
| 9378 | ...Repeated for module number 21 | | | | | |
| 937E | ...Repeated for module number 22 | | | | | |
| 9384 | ...Repeated for module number 23 | | | | | |
| 938A | ...Repeated for module number 24 | | | | | |
| **FlexElement Actuals (Read Only) (16 modules)** | | | | | | |
| 9A01 | FlexElement Actual | -2147483.647 to 2147483.647 | --- | 0.001 | F004 | 0 |
| 9A03 | ...Repeated for module number 2 | | | | | |
| 9A05 | ...Repeated for module number 3 | | | | | |
| 9A07 | ...Repeated for module number 4 | | | | | |
| 9A09 | ...Repeated for module number 5 | | | | | |
| 9A0B | ...Repeated for module number 6 | | | | | |
| 9A0D | ...Repeated for module number 7 | | | | | |
| 9A0F | ...Repeated for module number 8 | | | | | |
| 9A11 | ...Repeated for module number 9 | | | | | |
| 9A13 | ...Repeated for module number 10 | | | | | |
| 9A15 | ...Repeated for module number 11 | | | | | |
| 9A17 | ...Repeated for module number 12 | | | | | |
| 9A19 | ...Repeated for module number 13 | | | | | |

**B**

**Table B–9: MODBUS MEMORY MAP (Sheet 25 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---------------|-------|-------|------|--------|---------|
| 9A1B | ...Repeated for module number 14 | | | | | |
| 9A1D | ...Repeated for module number 15 | | | | | |
| 9A1F | ...Repeated for module number 16 | | | | | |
| **Setting Groups (Read/Write Setting)** | | | | | | |
| A000 | Setting Group for Modbus Comms (0 means group 1) | 0 to 5 | --- | 1 | F001 | 0 |
| A001 | Setting Groups Block | 0 to 65535 | --- | 1 | F300 | 0 |
| A002 | FlexLogic to Activate Groups 2 through 8 (5 items) | 0 to 65535 | --- | 1 | F300 | 0 |
| A009 | Setting Group Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| A00A | Setting Group Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| **Setting Groups (Read Only)** | | | | | | |
| A00B | Current Setting Group | 0 to 5 | --- | 1 | F001 | 0 |
| **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 Actuals (Read Only)** | | | | | | |
| A400 | Selector 1 Position | 1 to 7 | --- | 1 | F001 | 0 |
| A401 | Selector 2 Position | 1 to 7 | --- | 1 | F001 | 1 |
| **Selector Switch (Read/Write Setting) (2 modules)** | | | | | | |
| A410 | Selector 1 Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| A411 | Selector 1 Range | 1 to 7 | --- | 1 | F001 | 7 |
| A412 | Selector 1 Timeout | 3 to 60 | s | 0.1 | F001 | 50 |
| A413 | Selector 1 Step Up | 0 to 65535 | --- | 1 | F300 | 0 |
| A414 | Selector 1 Step Mode | 0 to 1 | --- | 1 | F083 | 0 (Time-out) |
| A415 | Selector 1 Acknowledge | 0 to 65535 | --- | 1 | F300 | 0 |
| A416 | Selector 1 Bit0 | 0 to 65535 | --- | 1 | F300 | 0 |
| A417 | Selector 1 Bit1 | 0 to 65535 | --- | 1 | F300 | 0 |
| A418 | Selector 1 Bit2 | 0 to 65535 | --- | 1 | F300 | 0 |
| A419 | Selector 1 Bit Mode | 0 to 1 | --- | 1 | F083 | 0 (Time-out) |
| A41A | Selector 1 Bit Acknowledge | 0 to 65535 | --- | 1 | F300 | 0 |
| A41B | Selector 1 Power Up Mode | 0 to 2 | --- | 1 | F084 | 0 (Restore) |
| A41C | Selector 1 Target | 0 to 2 | --- | 1 | F109 | 0 (Self-reset) |
| A41D | Selector 1 Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| A41E | Selector 1 Reserved (10 items) | --- | --- | 1 | F001 | 0 |
| A428 | ...Repeated for module number 2 | | | | | |
| **Flexcurves C and D (Read/Write Setting)** | | | | | | |
| AC00 | FlexCurve C (120 items) | 0 to 65535 | ms | 1 | F011 | 0 |
| AC78 | FlexCurve D (120 items) | 0 to 65535 | ms | 1 | F011 | 0 |
| **Non Volatile Latches (Read/Write Setting) (16 modules)** | | | | | | |
| AD00 | Latch 1 Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| AD01 | Latch 1 Type | 0 to 1 | --- | 1 | F519 | 0 (Reset Dominant) |
| AD02 | Latch 1 Set | 0 to 65535 | --- | 1 | F300 | 0 |
| AD03 | Latch 1 Reset | 0 to 65535 | --- | 1 | F300 | 0 |
| AD04 | Latch 1 Target | 0 to 2 | --- | 1 | F109 | 0 (Self-reset) |
| AD05 | Latch 1 Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| AD06 | Latch 1 Reserved (4 items) | --- | --- | --- | F001 | 0 |
| AD0A | ...Repeated for module number 2 | | | | | |
| AD14 | ...Repeated for module number 3 | | | | | |
| AD1E | ...Repeated for module number 4 | | | | | |
| AD28 | ...Repeated for module number 5 | | | | | |
| AD32 | ...Repeated for module number 6 | | | | | |

**Table B–9: MODBUS MEMORY MAP (Sheet 26 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---------------|-------|-------|------|--------|---------|
| AD3C | ...Repeated for module number 7 | | | | | |
| AD46 | ...Repeated for module number 8 | | | | | |
| AD50 | ...Repeated for module number 9 | | | | | |
| AD5A | ...Repeated for module number 10 | | | | | |
| AD64 | ...Repeated for module number 11 | | | | | |
| AD6E | ...Repeated for module number 12 | | | | | |
| AD78 | ...Repeated for module number 13 | | | | | |
| AD82 | ...Repeated for module number 14 | | | | | |
| AD8C | ...Repeated for module number 15 | | | | | |
| AD96 | ...Repeated for module number 16 | | | | | |
| **Digital Elements (Read/Write Setting) (16 modules)** | | | | | | |
| B000 | Digital Element 1 Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| B001 | Digital Element 1 Name | --- | --- | --- | F203 | "Dig Element 1 " |
| B015 | Digital Element 1 Input | 0 to 65535 | --- | 1 | F300 | 0 |
| B016 | Digital Element 1 Pickup Delay | 0 to 999999.999 | s | 0.001 | F003 | 0 |
| B018 | Digital Element 1 Reset Delay | 0 to 999999.999 | s | 0.001 | F003 | 0 |
| B01A | Digital Element 1 Block | 0 to 65535 | --- | 1 | F300 | 0 |
| B01B | Digital Element 1 Target | 0 to 2 | --- | 1 | F109 | 0 (Self-reset) |
| B01C | Digital Element 1 Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| B01D | Digital Element 1 Reserved (3 items) | --- | --- | --- | F001 | 0 |
| B020 | ...Repeated for module number 2 | | | | | |
| B040 | ...Repeated for module number 3 | | | | | |
| B060 | ...Repeated for module number 4 | | | | | |
| B080 | ...Repeated for module number 5 | | | | | |
| B0A0 | ...Repeated for module number 6 | | | | | |
| B0C0 | ...Repeated for module number 7 | | | | | |
| B0E0 | ...Repeated for module number 8 | | | | | |
| B100 | ...Repeated for module number 9 | | | | | |
| B120 | ...Repeated for module number 10 | | | | | |
| B140 | ...Repeated for module number 11 | | | | | |
| B160 | ...Repeated for module number 12 | | | | | |
| B180 | ...Repeated for module number 13 | | | | | |
| B1A0 | ...Repeated for module number 14 | | | | | |
| B1C0 | ...Repeated for module number 15 | | | | | |
| B1E0 | ...Repeated for module number 16 | | | | | |
| **Digital Counter (Read/Write Setting) (8 modules)** | | | | | | |
| B300 | Digital Counter 1 Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| B301 | Digital Counter 1 Name | --- | --- | --- | F205 | "Counter 1" |
| B307 | Digital Counter 1 Units | --- | --- | --- | F206 | (none) |
| B30A | Digital Counter 1 Block | 0 to 65535 | --- | 1 | F300 | 0 |
| B30B | Digital Counter 1 Up | 0 to 65535 | --- | 1 | F300 | 0 |
| B30C | Digital Counter 1 Down | 0 to 65535 | --- | 1 | F300 | 0 |
| B30D | Digital Counter 1 Preset | -2147483647 to 2147483647 | --- | 1 | F004 | 0 |
| B30F | Digital Counter 1 Compare | -2147483647 to 2147483647 | --- | 1 | F004 | 0 |
| B311 | Digital Counter 1 Reset | 0 to 65535 | --- | 1 | F300 | 0 |
| B312 | Digital Counter 1 Freeze/Reset | 0 to 65535 | --- | 1 | F300 | 0 |
| B313 | Digital Counter 1 Freeze/Count | 0 to 65535 | --- | 1 | F300 | 0 |
| B314 | Digital Counter 1 Set To Preset | 0 to 65535 | --- | 1 | F300 | 0 |
| B315 | Digital Counter 1 Reserved (11 items) | --- | --- | --- | F001 | 0 |
| B320 | ...Repeated for module number 2 | | | | | |
| B340 | ...Repeated for module number 3 | | | | | |
| B360 | ...Repeated for module number 4 | | | | | |
| B380 | ...Repeated for module number 5 | | | | | |

**Table B–9: MODBUS MEMORY MAP (Sheet 27 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---------------|-------|-------|------|--------|---------|
| B3A0 | ...Repeated for module number 6 | | | | | |
| B3C0 | ...Repeated for module number 7 | | | | | |
| B3E0 | ...Repeated for module number 8 | | | | | |
| **Contact Inputs (Read/Write Setting) (96 modules)** | | | | | | |
| C000 | Contact Input 1 Name | --- | --- | --- | F205 | "Cont Ip 1 " |
| C006 | Contact Input 1 Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| C007 | Contact Input 1 Debounce Time | 0 to 16 | ms | 0.5 | F001 | 20 |
| C008 | ...Repeated for module number 2 | | | | | |
| C010 | ...Repeated for module number 3 | | | | | |
| C018 | ...Repeated for module number 4 | | | | | |
| C020 | ...Repeated for module number 5 | | | | | |
| C028 | ...Repeated for module number 6 | | | | | |
| C030 | ...Repeated for module number 7 | | | | | |
| C038 | ...Repeated for module number 8 | | | | | |
| C040 | ...Repeated for module number 9 | | | | | |
| C048 | ...Repeated for module number 10 | | | | | |
| C050 | ...Repeated for module number 11 | | | | | |
| C058 | ...Repeated for module number 12 | | | | | |
| C060 | ...Repeated for module number 13 | | | | | |
| C068 | ...Repeated for module number 14 | | | | | |
| C070 | ...Repeated for module number 15 | | | | | |
| C078 | ...Repeated for module number 16 | | | | | |
| C080 | ...Repeated for module number 17 | | | | | |
| C088 | ...Repeated for module number 18 | | | | | |
| C090 | ...Repeated for module number 19 | | | | | |
| C098 | ...Repeated for module number 20 | | | | | |
| C0A0 | ...Repeated for module number 21 | | | | | |
| C0A8 | ...Repeated for module number 22 | | | | | |
| C0B0 | ...Repeated for module number 23 | | | | | |
| C0B8 | ...Repeated for module number 24 | | | | | |
| C0C0 | ...Repeated for module number 25 | | | | | |
| C0C8 | ...Repeated for module number 26 | | | | | |
| C0D0 | ...Repeated for module number 27 | | | | | |
| C0D8 | ...Repeated for module number 28 | | | | | |
| C0E0 | ...Repeated for module number 29 | | | | | |
| C0E8 | ...Repeated for module number 30 | | | | | |
| C0F0 | ...Repeated for module number 31 | | | | | |
| C0F8 | ...Repeated for module number 32 | | | | | |
| C100 | ...Repeated for module number 33 | | | | | |
| C108 | ...Repeated for module number 34 | | | | | |
| C110 | ...Repeated for module number 35 | | | | | |
| C118 | ...Repeated for module number 36 | | | | | |
| C120 | ...Repeated for module number 37 | | | | | |
| C128 | ...Repeated for module number 38 | | | | | |
| C130 | ...Repeated for module number 39 | | | | | |
| C138 | ...Repeated for module number 40 | | | | | |
| C140 | ...Repeated for module number 41 | | | | | |
| C148 | ...Repeated for module number 42 | | | | | |
| C150 | ...Repeated for module number 43 | | | | | |
| C158 | ...Repeated for module number 44 | | | | | |
| C160 | ...Repeated for module number 45 | | | | | |
| C168 | ...Repeated for module number 46 | | | | | |
| C170 | ...Repeated for module number 47 | | | | | |
| C178 | ...Repeated for module number 48 | | | | | |

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---------------|-------|-------|------|--------|---------|
| C180 | ...Repeated for module number 49 | | | | | |
| C188 | ...Repeated for module number 50 | | | | | |
| C190 | ...Repeated for module number 51 | | | | | |
| C198 | ...Repeated for module number 52 | | | | | |
| C1A0 | ...Repeated for module number 53 | | | | | |
| C1A8 | ...Repeated for module number 54 | | | | | |
| C1B0 | ...Repeated for module number 55 | | | | | |
| C1B8 | ...Repeated for module number 56 | | | | | |
| C1C0 | ...Repeated for module number 57 | | | | | |
| C1C8 | ...Repeated for module number 58 | | | | | |
| C1D0 | ...Repeated for module number 59 | | | | | |
| C1D8 | ...Repeated for module number 60 | | | | | |
| C1E0 | ...Repeated for module number 61 | | | | | |
| C1E8 | ...Repeated for module number 62 | | | | | |
| C1F0 | ...Repeated for module number 63 | | | | | |
| C1F8 | ...Repeated for module number 64 | | | | | |
| C200 | ...Repeated for module number 65 | | | | | |
| C208 | ...Repeated for module number 66 | | | | | |
| C210 | ...Repeated for module number 67 | | | | | |
| C218 | ...Repeated for module number 68 | | | | | |
| C220 | ...Repeated for module number 69 | | | | | |
| C228 | ...Repeated for module number 70 | | | | | |
| C230 | ...Repeated for module number 71 | | | | | |
| C238 | ...Repeated for module number 72 | | | | | |
| C240 | ...Repeated for module number 73 | | | | | |
| C248 | ...Repeated for module number 74 | | | | | |
| C250 | ...Repeated for module number 75 | | | | | |
| C258 | ...Repeated for module number 76 | | | | | |
| C260 | ...Repeated for module number 77 | | | | | |
| C268 | ...Repeated for module number 78 | | | | | |
| C270 | ...Repeated for module number 79 | | | | | |
| C278 | ...Repeated for module number 80 | | | | | |
| C280 | ...Repeated for module number 81 | | | | | |
| C288 | ...Repeated for module number 82 | | | | | |
| C290 | ...Repeated for module number 83 | | | | | |
| C298 | ...Repeated for module number 84 | | | | | |
| C2A0 | ...Repeated for module number 85 | | | | | |
| C2A8 | ...Repeated for module number 86 | | | | | |
| C2B0 | ...Repeated for module number 87 | | | | | |
| C2B8 | ...Repeated for module number 88 | | | | | |
| C2C0 | ...Repeated for module number 89 | | | | | |
| C2C8 | ...Repeated for module number 90 | | | | | |
| C2D0 | ...Repeated for module number 91 | | | | | |
| C2D8 | ...Repeated for module number 92 | | | | | |
| C2E0 | ...Repeated for module number 93 | | | | | |
| C2E8 | ...Repeated for module number 94 | | | | | |
| C2F0 | ...Repeated for module number 95 | | | | | |
| C2F8 | ...Repeated for module number 96 | | | | | |
| **Contact Input Thresholds (Read/Write Setting)** | | | | | | |
| C600 | Contact Input x Threshold (24 items) | 0 to 3 | --- | 1 | F128 | 1 (33 Vdc) |
| **Virtual Inputs Global Settings (Read/Write Setting)** | | | | | | |
| C680 | Virtual Inputs SBO Timeout | 1 to 60 | s | 1 | F001 | 30 |
| **Virtual Inputs (Read/Write Setting) (32 modules)** | | | | | | |
| C690 | Virtual Input 1 Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |

**Table B–9: MODBUS MEMORY MAP (Sheet 29 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---------------|-------|-------|------|--------|---------|
| C691 | Virtual Input 1 Name | --- | --- | --- | F205 | "Virt Ip 1 " |
| C69B | Virtual Input 1 Programmed Type | 0 to 1 | --- | 1 | F127 | 0 (Latched) |
| C69C | Virtual Input 1 Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| C69D | Virtual Input 1 IEC 61850 SBOClass | 1 to 2 | --- | 1 | F001 | 1 |
| C69E | Virtual Input 1 IEC 61850 SBOEna | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| C69F | Virtual Input 1 Reserved | --- | --- | --- | F001 | 0 |
| C6A0 | ...Repeated for module number 2 | | | | | |
| C6B0 | ...Repeated for module number 3 | | | | | |
| C6C0 | ...Repeated for module number 4 | | | | | |
| C6D0 | ...Repeated for module number 5 | | | | | |
| C6E0 | ...Repeated for module number 6 | | | | | |
| C6F0 | ...Repeated for module number 7 | | | | | |
| C700 | ...Repeated for module number 8 | | | | | |
| C710 | ...Repeated for module number 9 | | | | | |
| C720 | ...Repeated for module number 10 | | | | | |
| C730 | ...Repeated for module number 11 | | | | | |
| C740 | ...Repeated for module number 12 | | | | | |
| C750 | ...Repeated for module number 13 | | | | | |
| C760 | ...Repeated for module number 14 | | | | | |
| C770 | ...Repeated for module number 15 | | | | | |
| C780 | ...Repeated for module number 16 | | | | | |
| C790 | ...Repeated for module number 17 | | | | | |
| C7A0 | ...Repeated for module number 18 | | | | | |
| C7B0 | ...Repeated for module number 19 | | | | | |
| C7C0 | ...Repeated for module number 20 | | | | | |
| C7D0 | ...Repeated for module number 21 | | | | | |
| C7E0 | ...Repeated for module number 22 | | | | | |
| C7F0 | ...Repeated for module number 23 | | | | | |
| C800 | ...Repeated for module number 24 | | | | | |
| C810 | ...Repeated for module number 25 | | | | | |
| C820 | ...Repeated for module number 26 | | | | | |
| C830 | ...Repeated for module number 27 | | | | | |
| C840 | ...Repeated for module number 28 | | | | | |
| C850 | ...Repeated for module number 29 | | | | | |
| C860 | ...Repeated for module number 30 | | | | | |
| C870 | ...Repeated for module number 31 | | | | | |
| C880 | ...Repeated for module number 32 | | | | | |
| **Virtual Outputs (Read/Write Setting) (64 modules)** | | | | | | |
| CC90 | Virtual Output 1 Name | --- | --- | --- | F205 | "Virt Op 1 " |
| CC9A | Virtual Output 1 Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| CC9B | Virtual Output 1 Reserved (5 items) | --- | --- | --- | F001 | 0 |
| CCA0 | ...Repeated for module number 2 | | | | | |
| CCB0 | ...Repeated for module number 3 | | | | | |
| CCC0 | ...Repeated for module number 4 | | | | | |
| CCD0 | ...Repeated for module number 5 | | | | | |
| CCE0 | ...Repeated for module number 6 | | | | | |
| CCF0 | ...Repeated for module number 7 | | | | | |
| CD00 | ...Repeated for module number 8 | | | | | |
| CD10 | ...Repeated for module number 9 | | | | | |
| CD20 | ...Repeated for module number 10 | | | | | |
| CD30 | ...Repeated for module number 11 | | | | | |
| CD40 | ...Repeated for module number 12 | | | | | |
| CD50 | ...Repeated for module number 13 | | | | | |
| CD60 | ...Repeated for module number 14 | | | | | |

**Table B–9: MODBUS MEMORY MAP (Sheet 30 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---------------|-------|-------|------|--------|---------|
| CD70 | ...Repeated for module number 15 | | | | | |
| CD80 | ...Repeated for module number 16 | | | | | |
| CD90 | ...Repeated for module number 17 | | | | | |
| CDA0 | ...Repeated for module number 18 | | | | | |
| CDB0 | ...Repeated for module number 19 | | | | | |
| CDC0 | ...Repeated for module number 20 | | | | | |
| CDD0 | ...Repeated for module number 21 | | | | | |
| CDE0 | ...Repeated for module number 22 | | | | | |
| CDF0 | ...Repeated for module number 23 | | | | | |
| CE00 | ...Repeated for module number 24 | | | | | |
| CE10 | ...Repeated for module number 25 | | | | | |
| CE20 | ...Repeated for module number 26 | | | | | |
| CE30 | ...Repeated for module number 27 | | | | | |
| CE40 | ...Repeated for module number 28 | | | | | |
| CE50 | ...Repeated for module number 29 | | | | | |
| CE60 | ...Repeated for module number 30 | | | | | |
| CE70 | ...Repeated for module number 31 | | | | | |
| CE80 | ...Repeated for module number 32 | | | | | |
| CE90 | ...Repeated for module number 33 | | | | | |
| CEA0 | ...Repeated for module number 34 | | | | | |
| CEB0 | ...Repeated for module number 35 | | | | | |
| CEC0 | ...Repeated for module number 36 | | | | | |
| CED0 | ...Repeated for module number 37 | | | | | |
| CEE0 | ...Repeated for module number 38 | | | | | |
| CEF0 | ...Repeated for module number 39 | | | | | |
| CF00 | ...Repeated for module number 40 | | | | | |
| CF10 | ...Repeated for module number 41 | | | | | |
| CF20 | ...Repeated for module number 42 | | | | | |
| CF30 | ...Repeated for module number 43 | | | | | |
| CF40 | ...Repeated for module number 44 | | | | | |
| CF50 | ...Repeated for module number 45 | | | | | |
| CF60 | ...Repeated for module number 46 | | | | | |
| CF70 | ...Repeated for module number 47 | | | | | |
| CF80 | ...Repeated for module number 48 | | | | | |
| CF90 | ...Repeated for module number 49 | | | | | |
| CFA0 | ...Repeated for module number 50 | | | | | |
| CFB0 | ...Repeated for module number 51 | | | | | |
| CFC0 | ...Repeated for module number 52 | | | | | |
| CFD0 | ...Repeated for module number 53 | | | | | |
| CFE0 | ...Repeated for module number 54 | | | | | |
| CFF0 | ...Repeated for module number 55 | | | | | |
| D000 | ...Repeated for module number 56 | | | | | |
| D010 | ...Repeated for module number 57 | | | | | |
| D020 | ...Repeated for module number 58 | | | | | |
| D030 | ...Repeated for module number 59 | | | | | |
| D040 | ...Repeated for module number 60 | | | | | |
| D050 | ...Repeated for module number 61 | | | | | |
| D060 | ...Repeated for module number 62 | | | | | |
| D070 | ...Repeated for module number 63 | | | | | |
| D080 | ...Repeated for module number 64 | | | | | |
| **Mandatory (Read/Write Setting)** | | | | | | |
| D280 | Test Mode Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| **Mandatory (Read/Write)** | | | | | | |
| D281 | Force VFD and LED | 0 to 1 | --- | 1 | F126 | 0 (No) |

**B**

**Table B–9: MODBUS MEMORY MAP (Sheet 31 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|--------------|-------|-------|------|--------|---------|
| **Mandatory (Read/Write Setting)** | | | | | | |
| D282 | Test Mode Initiate | 0 to 65535 | --- | 1 | F300 | 1 |
| **Mandatory (Read/Write Command)** | | | | | | |
| D283 | Clear All Relay Records Command | 0 to 1 | --- | 1 | F126 | 0 (No) |
| **Contact Outputs (Read/Write Setting) (64 modules)** | | | | | | |
| D290 | Contact Output 1 Name | --- | --- | --- | F205 | "Cont Op 1" |
| D29A | Contact Output 1 Operation | 0 to 65535 | --- | 1 | F300 | 0 |
| D29B | Contact Output 1 Seal In | 0 to 65535 | --- | 1 | F300 | 0 |
| D29C | Latching Output 1 Reset | 0 to 65535 | --- | 1 | F300 | 0 |
| D29D | Contact Output 1 Events | 0 to 1 | --- | 1 | F102 | 1 (Enabled) |
| D29E | Latching Output 1 Type | 0 to 1 | --- | 1 | F090 | 0 (Operate-dominant) |
| D29F | Reserved | --- | --- | --- | F001 | 0 |
| D2A0 | ...Repeated for module number 2 | | | | | |
| D2B0 | ...Repeated for module number 3 | | | | | |
| D2C0 | ...Repeated for module number 4 | | | | | |
| D2D0 | ...Repeated for module number 5 | | | | | |
| D2E0 | ...Repeated for module number 6 | | | | | |
| D2F0 | ...Repeated for module number 7 | | | | | |
| D300 | ...Repeated for module number 8 | | | | | |
| D310 | ...Repeated for module number 9 | | | | | |
| D320 | ...Repeated for module number 10 | | | | | |
| D330 | ...Repeated for module number 11 | | | | | |
| D340 | ...Repeated for module number 12 | | | | | |
| D350 | ...Repeated for module number 13 | | | | | |
| D360 | ...Repeated for module number 14 | | | | | |
| D370 | ...Repeated for module number 15 | | | | | |
| D380 | ...Repeated for module number 16 | | | | | |
| D390 | ...Repeated for module number 17 | | | | | |
| D3A0 | ...Repeated for module number 18 | | | | | |
| D3B0 | ...Repeated for module number 19 | | | | | |
| D3C0 | ...Repeated for module number 20 | | | | | |
| D3D0 | ...Repeated for module number 21 | | | | | |
| D3E0 | ...Repeated for module number 22 | | | | | |
| D3F0 | ...Repeated for module number 23 | | | | | |
| D400 | ...Repeated for module number 24 | | | | | |
| D410 | ...Repeated for module number 25 | | | | | |
| D420 | ...Repeated for module number 26 | | | | | |
| D430 | ...Repeated for module number 27 | | | | | |
| D440 | ...Repeated for module number 28 | | | | | |
| D450 | ...Repeated for module number 29 | | | | | |
| D460 | ...Repeated for module number 30 | | | | | |
| D470 | ...Repeated for module number 31 | | | | | |
| D480 | ...Repeated for module number 32 | | | | | |
| D490 | ...Repeated for module number 33 | | | | | |
| D4A0 | ...Repeated for module number 34 | | | | | |
| D4B0 | ...Repeated for module number 35 | | | | | |
| D4C0 | ...Repeated for module number 36 | | | | | |
| D4D0 | ...Repeated for module number 37 | | | | | |
| D4E0 | ...Repeated for module number 38 | | | | | |
| D4F0 | ...Repeated for module number 39 | | | | | |
| D500 | ...Repeated for module number 40 | | | | | |
| D510 | ...Repeated for module number 41 | | | | | |
| D520 | ...Repeated for module number 42 | | | | | |
| D530 | ...Repeated for module number 43 | | | | | |

**Table B–9: MODBUS MEMORY MAP (Sheet 32 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---------------|-------|-------|------|--------|---------|
| D540 | ...Repeated for module number 44 | | | | | |
| D550 | ...Repeated for module number 45 | | | | | |
| D560 | ...Repeated for module number 46 | | | | | |
| D570 | ...Repeated for module number 47 | | | | | |
| D580 | ...Repeated for module number 48 | | | | | |
| D590 | ...Repeated for module number 49 | | | | | |
| D5A0 | ...Repeated for module number 50 | | | | | |
| D5B0 | ...Repeated for module number 51 | | | | | |
| D5C0 | ...Repeated for module number 52 | | | | | |
| D5D0 | ...Repeated for module number 53 | | | | | |
| D5E0 | ...Repeated for module number 54 | | | | | |
| D5F0 | ...Repeated for module number 55 | | | | | |
| D600 | ...Repeated for module number 56 | | | | | |
| D610 | ...Repeated for module number 57 | | | | | |
| D620 | ...Repeated for module number 58 | | | | | |
| D630 | ...Repeated for module number 59 | | | | | |
| D640 | ...Repeated for module number 60 | | | | | |
| D650 | ...Repeated for module number 61 | | | | | |
| D660 | ...Repeated for module number 62 | | | | | |
| D670 | ...Repeated for module number 63 | | | | | |
| D680 | ...Repeated for module number 64 | | | | | |
| **Reset (Read/Write Setting)** | | | | | | |
| D800 | FlexLogic operand which initiates a reset | 0 to 65535 | --- | 1 | F300 | 0 |
| **Control Pushbuttons (Read/Write Setting) (7 modules)** | | | | | | |
| D810 | Control Pushbuttons 1 Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| D811 | Control Pushbuttons 1 Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| D812 | ...Repeated for module number 2 | | | | | |
| D814 | ...Repeated for module number 3 | | | | | |
| D816 | ...Repeated for module number 4 | | | | | |
| D818 | ...Repeated for module number 5 | | | | | |
| D81A | ...Repeated for module number 6 | | | | | |
| D81C | ...Repeated for module number 7 | | | | | |
| **Clear Records (Read/Write Setting)** | | | | | | |
| D820 | Clear Fault Reports operand | 0 to 65535 | --- | 1 | F300 | 0 |
| D822 | Clear Event Records operand | 0 to 65535 | --- | 1 | F300 | 0 |
| D823 | Clear Oscillography operand | 0 to 65535 | --- | 1 | F300 | 0 |
| D824 | Clear Data Logger operand | 0 to 65535 | --- | 1 | F300 | 0 |
| D825 | Clear Breaker 1 Arcing Current operand | 0 to 65535 | --- | 1 | F300 | 0 |
| D826 | Clear Breaker 2 Arcing Current operand | 0 to 65535 | --- | 1 | F300 | 0 |
| D827 | Clear Breaker 3 Arcing Current operand | 0 to 65535 | --- | 1 | F300 | 0 |
| D828 | Clear Breaker 4 Arcing Current operand | 0 to 65535 | --- | 1 | F300 | 0 |
| D82B | Clear Demand operand | 0 to 65535 | --- | 1 | F300 | 0 |
| D82D | Clear Energy operand | 0 to 65535 | --- | 1 | F300 | 0 |
| D82F | Clear Unauthorized Access operand | 0 to 65535 | --- | 1 | F300 | 0 |
| D831 | Clear Platform Direct Input/Output Statistics operand | 0 to 65535 | --- | 1 | F300 | 0 |
| D832 | Clear Relay Records Reserved (18 items) | --- | --- | --- | F001 | 0 |
| **Force Contact Inputs (Read/Write Setting)** | | | | | | |
| D8B0 | Force Contact Input x State (96 items) | 0 to 2 | --- | 1 | F144 | 0 (Disabled) |
| **Force Contact Outputs (Read/Write Setting)** | | | | | | |
| D910 | Force Contact Output x State (64 items) | 0 to 3 | --- | 1 | F131 | 0 (Disabled) |
| **Direct Inputs/Outputs (Read/Write Setting)** | | | | | | |
| DB40 | Direct Device ID | 1 to 16 | --- | 1 | F001 | 1 |
| DB41 | Direct I/O Channel 1 Ring Configuration Function | 0 to 1 | --- | 1 | F126 | 0 (No) |
| DB42 | Platform Direct I/O Data Rate | 64 to 128 | kbps | 64 | F001 | 64 |

**Table B–9: MODBUS MEMORY MAP (Sheet 33 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---------------|-------|-------|------|--------|---------|
| DB43 | Direct I/O Channel 2 Ring Configuration Function | 0 to 1 | --- | 1 | F126 | 0 (No) |
| DB44 | Platform Direct I/O Crossover Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| **Direct input/output commands (Read/Write Command)** | | | | | | |
| DB48 | Direct input/output clear counters command | 0 to 1 | --- | 1 | F126 | 0 (No) |
| **Direct inputs (Read/Write Setting) (96 modules)** | | | | | | |
| DB50 | Direct Input 1 Device Number | 0 to 16 | --- | 1 | F001 | 0 |
| DB51 | Direct Input 1 Number | 0 to 96 | --- | 1 | F001 | 0 |
| DB52 | Direct Input 1 Default State | 0 to 3 | --- | 1 | F086 | 0 (Off) |
| DB53 | Direct Input 1 Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| DB54 | ...Repeated for module number 2 | | | | | |
| DB58 | ...Repeated for module number 3 | | | | | |
| DB5C | ...Repeated for module number 4 | | | | | |
| DB60 | ...Repeated for module number 5 | | | | | |
| DB64 | ...Repeated for module number 6 | | | | | |
| DB68 | ...Repeated for module number 7 | | | | | |
| DB6C | ...Repeated for module number 8 | | | | | |
| DB70 | ...Repeated for module number 9 | | | | | |
| DB74 | ...Repeated for module number 10 | | | | | |
| DB78 | ...Repeated for module number 11 | | | | | |
| DB7C | ...Repeated for module number 12 | | | | | |
| DB80 | ...Repeated for module number 13 | | | | | |
| DB84 | ...Repeated for module number 14 | | | | | |
| DB88 | ...Repeated for module number 15 | | | | | |
| DB8C | ...Repeated for module number 16 | | | | | |
| DB90 | ...Repeated for module number 17 | | | | | |
| DB94 | ...Repeated for module number 18 | | | | | |
| DB98 | ...Repeated for module number 19 | | | | | |
| DB9C | ...Repeated for module number 20 | | | | | |
| DBA0 | ...Repeated for module number 21 | | | | | |
| DBA4 | ...Repeated for module number 22 | | | | | |
| DBA8 | ...Repeated for module number 23 | | | | | |
| DBAC | ...Repeated for module number 24 | | | | | |
| DBB0 | ...Repeated for module number 25 | | | | | |
| DBB4 | ...Repeated for module number 26 | | | | | |
| DBB8 | ...Repeated for module number 27 | | | | | |
| DBBC | ...Repeated for module number 28 | | | | | |
| DBC0 | ...Repeated for module number 29 | | | | | |
| DBC4 | ...Repeated for module number 30 | | | | | |
| DBC8 | ...Repeated for module number 31 | | | | | |
| DBCC | ...Repeated for module number 32 | | | | | |
| **Platform Direct Outputs (Read/Write Setting) (96 modules)** | | | | | | |
| DD00 | Direct Output 1 Operand | 0 to 65535 | --- | 1 | F300 | 0 |
| DD01 | Direct Output 1 Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| DD02 | ...Repeated for module number 2 | | | | | |
| DD04 | ...Repeated for module number 3 | | | | | |
| DD06 | ...Repeated for module number 4 | | | | | |
| DD08 | ...Repeated for module number 5 | | | | | |
| DD0A | ...Repeated for module number 6 | | | | | |
| DD0C | ...Repeated for module number 7 | | | | | |
| DD0E | ...Repeated for module number 8 | | | | | |
| DD10 | ...Repeated for module number 9 | | | | | |
| DD12 | ...Repeated for module number 10 | | | | | |
| DD14 | ...Repeated for module number 11 | | | | | |
| DD16 | ...Repeated for module number 12 | | | | | |

**Table B–9: MODBUS MEMORY MAP (Sheet 34 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---------------|-------|-------|------|--------|---------|
| DD18 | ...Repeated for module number 13 | | | | | |
| DD1A | ...Repeated for module number 14 | | | | | |
| DD1C | ...Repeated for module number 15 | | | | | |
| DD1E | ...Repeated for module number 16 | | | | | |
| DD20 | ...Repeated for module number 17 | | | | | |
| DD22 | ...Repeated for module number 18 | | | | | |
| DD24 | ...Repeated for module number 19 | | | | | |
| DD26 | ...Repeated for module number 20 | | | | | |
| DD28 | ...Repeated for module number 21 | | | | | |
| DD2A | ...Repeated for module number 22 | | | | | |
| DD2C | ...Repeated for module number 23 | | | | | |
| DD2E | ...Repeated for module number 24 | | | | | |
| DD30 | ...Repeated for module number 25 | | | | | |
| DD32 | ...Repeated for module number 26 | | | | | |
| DD34 | ...Repeated for module number 27 | | | | | |
| DD36 | ...Repeated for module number 28 | | | | | |
| DD38 | ...Repeated for module number 29 | | | | | |
| DD3A | ...Repeated for module number 30 | | | | | |
| DD3C | ...Repeated for module number 31 | | | | | |
| DD3E | ...Repeated for module number 32 | | | | | |
| **Direct Input/Output Alarms (Read/Write Setting)** | | | | | | |
| DE00 | Direct Input/Output Channel 1 CRC Alarm Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| DE01 | Direct I/O Channel 1 CRC Alarm Message Count | 100 to 10000 | --- | 1 | F001 | 600 |
| DE02 | Direct Input/Output Channel 1 CRC Alarm Threshold | 1 to 1000 | --- | 1 | F001 | 10 |
| DE03 | Direct Input/Output Channel 1 CRC Alarm Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| DE04 | Reserved (4 items) | 1 to 1000 | --- | 1 | F001 | 10 |
| DE08 | Direct Input/Output Channel 2 CRC Alarm Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| DE09 | Direct I/O Channel 2 CRC Alarm Message Count | 100 to 10000 | --- | 1 | F001 | 600 |
| DE0A | Direct Input/Output Channel 2 CRC Alarm Threshold | 1 to 1000 | --- | 1 | F001 | 10 |
| DE0B | Direct Input/Output Channel 2 CRC Alarm Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| DE0C | Reserved (4 items) | 1 to 1000 | --- | 1 | F001 | 10 |
| DE10 | Direct I/O Ch 1 Unreturned Messages Alarm Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| DE11 | Direct I/O Ch 1 Unreturned Messages Alarm Msg Count | 100 to 10000 | --- | 1 | F001 | 600 |
| DE12 | Direct I/O Ch 1 Unreturned Messages Alarm Threshold | 1 to 1000 | --- | 1 | F001 | 10 |
| DE13 | Direct I/O Ch 1 Unreturned Messages Alarm Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| DE14 | Reserved (4 items) | 1 to 1000 | --- | 1 | F001 | 10 |
| DE18 | Direct IO Ch 2 Unreturned Messages Alarm Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| DE19 | Direct I/O Ch 2 Unreturned Messages Alarm Msg Count | 100 to 10000 | --- | 1 | F001 | 600 |
| DE1A | Direct I/O Ch 2 Unreturned Messages Alarm Threshold | 1 to 1000 | --- | 1 | F001 | 10 |
| DE1B | Direct I/O Channel 2 Unreturned Messages Alarm Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| DE1C | Reserved (4 items) | 1 to 1000 | --- | 1 | F001 | 10 |
| **Remote Devices (Read/Write Setting) (16 modules)** | | | | | | |
| E000 | Remote Device 1 ID | --- | --- | --- | F202 | "Remote Device 1 " |
| E00A | ...Repeated for module number 2 | | | | | |
| E014 | ...Repeated for module number 3 | | | | | |
| E01E | ...Repeated for module number 4 | | | | | |
| E028 | ...Repeated for module number 5 | | | | | |
| E032 | ...Repeated for module number 6 | | | | | |
| E03C | ...Repeated for module number 7 | | | | | |
| E046 | ...Repeated for module number 8 | | | | | |
| E050 | ...Repeated for module number 9 | | | | | |
| E05A | ...Repeated for module number 10 | | | | | |
| E064 | ...Repeated for module number 11 | | | | | |
| E06E | ...Repeated for module number 12 | | | | | |

**Table B–9: MODBUS MEMORY MAP (Sheet 35 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|--------------|-------|-------|------|--------|---------|
| E078 | ...Repeated for module number 13 | | | | | |
| E082 | ...Repeated for module number 14 | | | | | |
| E08C | ...Repeated for module number 15 | | | | | |
| E096 | ...Repeated for module number 16 | | | | | |
| **Remote Inputs (Read/Write Setting) (64 modules)** | | | | | | |
| E100 | Remote Input 1 Device | 1 to 16 | --- | 1 | F001 | 1 |
| E101 | Remote Input 1 Bit Pair | 0 to 64 | --- | 1 | F156 | 0 (None) |
| E102 | Remote Input 1 Default State | 0 to 3 | --- | 1 | F086 | 0 (Off) |
| E103 | Remote Input 1 Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| E104 | ...Repeated for module number 2 | | | | | |
| E108 | ...Repeated for module number 3 | | | | | |
| E10C | ...Repeated for module number 4 | | | | | |
| E110 | ...Repeated for module number 5 | | | | | |
| E114 | ...Repeated for module number 6 | | | | | |
| E118 | ...Repeated for module number 7 | | | | | |
| E11C | ...Repeated for module number 8 | | | | | |
| E120 | ...Repeated for module number 9 | | | | | |
| E124 | ...Repeated for module number 10 | | | | | |
| E128 | ...Repeated for module number 11 | | | | | |
| E12C | ...Repeated for module number 12 | | | | | |
| E130 | ...Repeated for module number 13 | | | | | |
| E134 | ...Repeated for module number 14 | | | | | |
| E138 | ...Repeated for module number 15 | | | | | |
| E13C | ...Repeated for module number 16 | | | | | |
| E140 | ...Repeated for module number 17 | | | | | |
| E144 | ...Repeated for module number 18 | | | | | |
| E148 | ...Repeated for module number 19 | | | | | |
| E14C | ...Repeated for module number 20 | | | | | |
| E150 | ...Repeated for module number 21 | | | | | |
| E154 | ...Repeated for module number 22 | | | | | |
| E158 | ...Repeated for module number 23 | | | | | |
| E15C | ...Repeated for module number 24 | | | | | |
| E160 | ...Repeated for module number 25 | | | | | |
| E164 | ...Repeated for module number 26 | | | | | |
| E168 | ...Repeated for module number 27 | | | | | |
| E16C | ...Repeated for module number 28 | | | | | |
| E170 | ...Repeated for module number 29 | | | | | |
| E174 | ...Repeated for module number 30 | | | | | |
| E178 | ...Repeated for module number 31 | | | | | |
| E17C | ...Repeated for module number 32 | | | | | |
| E180 | ...Repeated for module number 33 | | | | | |
| E184 | ...Repeated for module number 34 | | | | | |
| E188 | ...Repeated for module number 35 | | | | | |
| E18C | ...Repeated for module number 36 | | | | | |
| E190 | ...Repeated for module number 37 | | | | | |
| E194 | ...Repeated for module number 38 | | | | | |
| E198 | ...Repeated for module number 39 | | | | | |
| E19C | ...Repeated for module number 40 | | | | | |
| E1A0 | ...Repeated for module number 41 | | | | | |
| E1A4 | ...Repeated for module number 42 | | | | | |
| E1A8 | ...Repeated for module number 43 | | | | | |
| E1AC | ...Repeated for module number 44 | | | | | |
| E1B0 | ...Repeated for module number 45 | | | | | |
| E1B4 | ...Repeated for module number 46 | | | | | |

**Table B–9: MODBUS MEMORY MAP (Sheet 36 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---------------|-------|-------|------|--------|---------|
| E1B8 | ...Repeated for module number 47 | | | | | |
| E1BC | ...Repeated for module number 48 | | | | | |
| E1C0 | ...Repeated for module number 49 | | | | | |
| E1C4 | ...Repeated for module number 50 | | | | | |
| E1C8 | ...Repeated for module number 51 | | | | | |
| E1CC | ...Repeated for module number 52 | | | | | |
| E1D0 | ...Repeated for module number 53 | | | | | |
| E1D4 | ...Repeated for module number 54 | | | | | |
| E1D8 | ...Repeated for module number 55 | | | | | |
| E1DC | ...Repeated for module number 56 | | | | | |
| E1E0 | ...Repeated for module number 57 | | | | | |
| E1E4 | ...Repeated for module number 58 | | | | | |
| E1E8 | ...Repeated for module number 59 | | | | | |
| E1EC | ...Repeated for module number 60 | | | | | |
| E1F0 | ...Repeated for module number 61 | | | | | |
| E1F4 | ...Repeated for module number 62 | | | | | |
| E1F8 | ...Repeated for module number 63 | | | | | |
| E1FC | ...Repeated for module number 64 | | | | | |
| **Remote Output DNA Pairs (Read/Write Setting) (32 modules)** | | | | | | |
| E600 | Remote Output DNA 1 Operand | 0 to 65535 | --- | 1 | F300 | 0 |
| E601 | Remote Output DNA 1 Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| E602 | Remote Output DNA 1 Reserved (2 items) | 0 to 1 | --- | 1 | F001 | 0 |
| E604 | ...Repeated for module number 2 | | | | | |
| E608 | ...Repeated for module number 3 | | | | | |
| E60C | ...Repeated for module number 4 | | | | | |
| E610 | ...Repeated for module number 5 | | | | | |
| E614 | ...Repeated for module number 6 | | | | | |
| E618 | ...Repeated for module number 7 | | | | | |
| E61C | ...Repeated for module number 8 | | | | | |
| E620 | ...Repeated for module number 9 | | | | | |
| E624 | ...Repeated for module number 10 | | | | | |
| E628 | ...Repeated for module number 11 | | | | | |
| E62C | ...Repeated for module number 12 | | | | | |
| E630 | ...Repeated for module number 13 | | | | | |
| E634 | ...Repeated for module number 14 | | | | | |
| E638 | ...Repeated for module number 15 | | | | | |
| E63C | ...Repeated for module number 16 | | | | | |
| E640 | ...Repeated for module number 17 | | | | | |
| E644 | ...Repeated for module number 18 | | | | | |
| E648 | ...Repeated for module number 19 | | | | | |
| E64C | ...Repeated for module number 20 | | | | | |
| E650 | ...Repeated for module number 21 | | | | | |
| E654 | ...Repeated for module number 22 | | | | | |
| E658 | ...Repeated for module number 23 | | | | | |
| E65C | ...Repeated for module number 24 | | | | | |
| E660 | ...Repeated for module number 25 | | | | | |
| E664 | ...Repeated for module number 26 | | | | | |
| E668 | ...Repeated for module number 27 | | | | | |
| E66C | ...Repeated for module number 28 | | | | | |
| E670 | ...Repeated for module number 29 | | | | | |
| E674 | ...Repeated for module number 30 | | | | | |
| E678 | ...Repeated for module number 31 | | | | | |
| E67C | ...Repeated for module number 32 | | | | | |

**Table B–9: MODBUS MEMORY MAP (Sheet 37 of 37)**

| ADDR | REGISTER NAME | RANGE | UNITS | STEP | FORMAT | DEFAULT |
|------|---------------|-------|-------|------|--------|---------|
| **Remote Output UserSt Pairs (Read/Write Setting) (32 modules)** | | | | | | |
| E680 | Remote Output UserSt 1 Operand | 0 to 65535 | --- | 1 | F300 | 0 |
| E681 | Remote Output UserSt 1 Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| E682 | Remote Output UserSt 1 Reserved (2 items) | 0 to 1 | --- | 1 | F001 | 0 |
| E684 | ...Repeated for module number 2 | | | | | |
| E688 | ...Repeated for module number 3 | | | | | |
| E68C | ...Repeated for module number 4 | | | | | |
| E690 | ...Repeated for module number 5 | | | | | |
| E694 | ...Repeated for module number 6 | | | | | |
| E698 | ...Repeated for module number 7 | | | | | |
| E69C | ...Repeated for module number 8 | | | | | |
| E6A0 | ...Repeated for module number 9 | | | | | |
| E6A4 | ...Repeated for module number 10 | | | | | |
| E6A8 | ...Repeated for module number 11 | | | | | |
| E6AC | ...Repeated for module number 12 | | | | | |
| E6B0 | ...Repeated for module number 13 | | | | | |
| E6B4 | ...Repeated for module number 14 | | | | | |
| E6B8 | ...Repeated for module number 15 | | | | | |
| E6BC | ...Repeated for module number 16 | | | | | |
| E6C0 | ...Repeated for module number 17 | | | | | |
| E6C4 | ...Repeated for module number 18 | | | | | |
| E6C8 | ...Repeated for module number 19 | | | | | |
| E6CC | ...Repeated for module number 20 | | | | | |
| E6D0 | ...Repeated for module number 21 | | | | | |
| E6D4 | ...Repeated for module number 22 | | | | | |
| E6D8 | ...Repeated for module number 23 | | | | | |
| E6DC | ...Repeated for module number 24 | | | | | |
| E6E0 | ...Repeated for module number 25 | | | | | |
| E6E4 | ...Repeated for module number 26 | | | | | |
| E6E8 | ...Repeated for module number 27 | | | | | |
| E6EC | ...Repeated for module number 28 | | | | | |
| E6F0 | ...Repeated for module number 29 | | | | | |
| E6F4 | ...Repeated for module number 30 | | | | | |
| E6F8 | ...Repeated for module number 31 | | | | | |
| E6FC | ...Repeated for module number 32 | | | | | |

**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.

**F082**
**ENUMERATION: AUTORECLOSE SINGLE-PHASE / THREE-**

**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**

**F081**
**ENUMERATION: AUTORECLOSE 1P/3P BKR FAIL OPTION**

0 = Continue, 1 = Lockout

**PHASE BREAKER SEQUENCE**

0 = 1, 1 = 2, 2 = 1 & 2, 3 = 1 – 2, 4 = 2 – 1

**B**

**F083**
**ENUMERATION: SELECTOR MODES**

0 = Time-Out, 1 = Acknowledge

**F084**
**ENUMERATION: SELECTOR POWER UP**

0 = Restore, 1 = Synchronize, 2 = Sync/Restore

**F086**
**ENUMERATION: DIGITAL INPUT DEFAULT STATE**

0 = Off, 1 = On, 2= Latest/Off, 3 = Latest/On

**F090**
**ENUMERATION: LATCHING OUTPUT TYPE**

0 = Operate-dominant, 1 = Reset-dominant

**F100**
**ENUMERATION: VT CONNECTION TYPE**

0 = Wye; 1 = Delta

**F101**
**ENUMERATION: MESSAGE DISPLAY INTENSITY**

0 = 25%, 1 = 50%, 2 = 75%, 3 = 100%

**F102**
**ENUMERATION: DISABLED/ENABLED**

0 = Disabled; 1 = Enabled

**F103**
**ENUMERATION: CURVE SHAPES**

| bitmask | curve shape | | bitmask | curve shape |
|---------|-------------|--|---------|-------------|
| 0 | IEEE Mod Inv | | 9 | IAC Inverse |
| 1 | IEEE Very Inv | | 10 | IAC Short Inv |
| 2 | IEEE Ext Inv | | 11 | I2t |
| 3 | IEC Curve A | | 12 | Definite Time |
| 4 | IEC Curve B | | 13 | FlexCurve™ A |
| 5 | IEC Curve C | | 14 | FlexCurve™ B |
| 6 | IEC Short Inv | | 15 | FlexCurve™ C |
| 7 | IAC Ext Inv | | 16 | FlexCurve™ D |
| 8 | IAC Very Inv | | | |

**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

**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 |
| 16 | Phase Time Overcurrent 1 |
| 17 | Phase Time Overcurrent 2 |
| 140 | Auxiliary Undervoltage 1 |
| 144 | Phase Undervoltage 1 |
| 145 | Phase Undervoltage 2 |
| 156 | Neutral Overvoltage 1 |
| 214 | Sensitive Directional Power 1 |
| 215 | Sensitive Directional Power 2 |
| 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 |
| 272 | Breaker 1 |
| 273 | Breaker 2 |
| 280 | Breaker Failure 1 |
| 281 | Breaker Failure 2 |
| 288 | Breaker Arcing Current 1 |
| 289 | Breaker Arcing Current 2 |
| 290 | Breaker Arcing Current 3 |
| 291 | Breaker Arcing Current 4 |
| 292 | Breaker Arcing Current 5 |
| 293 | Breaker Arcing Current 6 |
| 294 | Breaker 1 Flashover |
| 295 | Breaker 2 Flashover |
| 304 | Autoreclose 1 |
| 305 | Autoreclose 2 |
| 306 | Autoreclose 3 |
| 307 | Autoreclose 4 |
| 308 | Autoreclose 5 |
| 309 | Autoreclose 6 |
| 312 | Synchrocheck 1 |
| 313 | Synchrocheck 2 |
| 336 | Setting Group |
| 337 | Reset |
| 376 | Autoreclose 1P/3P |
| 385 | Selector 1 |
| 386 | 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 |

**B**

**B**

| bitmask | element |
|---------|---------|
| 401 | FlexElement™ 2 |
| 402 | FlexElement™ 3 |
| 403 | FlexElement™ 4 |
| 404 | FlexElement™ 5 |
| 405 | FlexElement™ 6 |
| 406 | FlexElement™ 7 |
| 407 | FlexElement™ 8 |
| 420 | Non-volatile Latch 1 |
| 421 | Non-volatile Latch 2 |
| 422 | Non-volatile Latch 3 |
| 423 | Non-volatile Latch 4 |
| 424 | Non-volatile Latch 5 |
| 425 | Non-volatile Latch 6 |
| 426 | Non-volatile Latch 7 |
| 427 | Non-volatile Latch 8 |
| 428 | Non-volatile Latch 9 |
| 429 | Non-volatile Latch 10 |
| 430 | Non-volatile Latch 11 |
| 431 | Non-volatile Latch 12 |
| 432 | Non-volatile Latch 13 |
| 433 | Non-volatile Latch 14 |
| 434 | Non-volatile Latch 15 |
| 435 | Non-volatile Latch 16 |
| 512 | Digital Element 1 |
| 513 | Digital Element 2 |
| 514 | Digital Element 3 |
| 515 | Digital Element 4 |
| 516 | Digital Element 5 |
| 517 | Digital Element 6 |
| 518 | Digital Element 7 |
| 519 | Digital Element 8 |
| 520 | Digital Element 9 |
| 521 | Digital Element 10 |
| 522 | Digital Element 11 |
| 523 | Digital Element 12 |
| 524 | Digital Element 13 |
| 525 | Digital Element 14 |
| 526 | Digital Element 15 |
| 527 | Digital Element 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 |
| 680 | User-Programmable Pushbutton 1 |
| 681 | User-Programmable Pushbutton 2 |
| 682 | User-Programmable Pushbutton 3 |
| 683 | User-Programmable Pushbutton 4 |
| 684 | User-Programmable Pushbutton 5 |
| 685 | User-Programmable Pushbutton 6 |

| bitmask | element |
|---------|---------|
| 686 | User-Programmable Pushbutton 7 |
| 687 | User-Programmable Pushbutton 8 |
| 688 | User-Programmable Pushbutton 9 |
| 689 | User-Programmable Pushbutton 10 |
| 690 | User-Programmable Pushbutton 11 |
| 691 | User-Programmable Pushbutton 12 |

**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

**F132**
**ENUMERATION: DEMAND INTERVAL**

0 = 5 min, 1 = 10 min, 2 = 15 min, 3 = 20 min, 4 = 30 min,
5 = 60 min

**F133**
**ENUMERATION: PROGRAM STATE**

0 = Not Programmed, 1 = Programmed

**F134**
**ENUMERATION: PASS/FAIL**

0 = Fail, 1 = OK, 2 = n/a

**B**

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**F135**
**ENUMERATION: GAIN CALIBRATION**

0 = 0x1, 1 = 1x16

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**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

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**F138**
**ENUMERATION: OSCILLOGRAPHY FILE TYPE**

0 = Data File, 1 = Configuration File, 2 = Header File

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**F139**
**ENUMERATION: DEMAND CALCULATIONS**

0 = Thermal Exponential, 1 = Block Interval, 2 = Rolling Demand

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**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

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**F141**
**ENUMERATION: SELF TEST ERROR**

| bitmask | error |
|---------|-------|
| 0 | Any Self Tests |
| 1 | IRIG-B Failure |
| 2 | DSP Error |
| 4 | No DSP Interrupts |
| 5 | Unit Not Calibrated |
| 9 | Prototype Firmware |
| 10 | Flexlogic Error Token |
| 11 | Equipment Mismatch |
| 13 | Unit Not Programmed |
| 14 | System Exception |
| 15 | Latching Out Error |
| 18 | SNTP Failure |
| 19 | Battery Failure |
| 20 | Primary Ethernet Failure |
| 21 | Secondary Ethernet Failure |
| 22 | EEPROM Data Error |
| 23 | SRAM Data Error |
| 24 | Program Memory |
| 25 | Watchdog Error |
| 26 | Low On Memory |
| 27 | Remote Device Off |
| 28 | Direct Device Off |

| bitmask | error |
|---------|-------|
| 29 | Direct Ring Break |
| 30 | Any Minor Error |
| 31 | Any Major Error |

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**F142**
**ENUMERATION: EVENT RECORDER ACCESS FILE TYPE**

0 = All Record Data, 1 = Headers Only, 2 = Numeric Event Cause

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**F143**
**UR_UINT32: 32 BIT ERROR CODE (F141 specifies bit number)**

A bit value of 0 = no error, 1 = error

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**F144**
**ENUMERATION: FORCED CONTACT INPUT STATE**

0 = Disabled, 1 = Open, 2 = Closed

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**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 | | |

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**F146**
**ENUMERATION: MISC. 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 |

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**B**

**F151**
**ENUMERATION: RTD SELECTION**

| bitmask | RTD# | bitmask | RTD# | bitmask | RTD# |
|---------|------|---------|------|---------|------|
| 0 | NONE | 17 | RTD 17 | 33 | RTD 33 |
| 1 | RTD 1 | 18 | RTD 18 | 34 | RTD 34 |
| 2 | RTD 2 | 19 | RTD 19 | 35 | RTD 35 |
| 3 | RTD 3 | 20 | RTD 20 | 36 | RTD 36 |
| 4 | RTD 4 | 21 | RTD 21 | 37 | RTD 37 |
| 5 | RTD 5 | 22 | RTD 22 | 38 | RTD 38 |
| 6 | RTD 6 | 23 | RTD 23 | 39 | RTD 39 |
| 7 | RTD 7 | 24 | RTD 24 | 40 | RTD 40 |
| 8 | RTD 8 | 25 | RTD 25 | 41 | RTD 41 |
| 9 | RTD 9 | 26 | RTD 26 | 42 | RTD 42 |
| 10 | RTD 10 | 27 | RTD 27 | 43 | RTD 43 |
| 11 | RTD 11 | 28 | RTD 28 | 44 | RTD 44 |
| 12 | RTD 12 | 29 | RTD 29 | 45 | RTD 45 |
| 13 | RTD 13 | 30 | RTD 30 | 46 | RTD 46 |
| 14 | RTD 14 | 31 | RTD 31 | 47 | RTD 47 |
| 15 | RTD 15 | 32 | RTD 32 | 48 | RTD 48 |
| 16 | RTD 16 | | | | |

**F152**
**ENUMERATION: SETTING GROUP**

0 = Active Group, 1 = Group 1, 2 = Group 2, 3 = Group 3
4 = Group 4, 5 = Group 5, 6 = Group 6

**F155**
**ENUMERATION: REMOTE DEVICE STATE**

0 = Offline, 1 = Online

**F156**
**ENUMERATION: REMOTE INPUT BIT PAIRS**

| bitmask | RTD# | bitmask | RTD# | bitmask | RTD# |
|---------|------|---------|------|---------|------|
| 0 | NONE | 22 | DNA-22 | 44 | UserSt-12 |
| 1 | DNA-1 | 23 | DNA-23 | 45 | UserSt-13 |
| 2 | DNA-2 | 24 | DNA-24 | 46 | UserSt-14 |
| 3 | DNA-3 | 25 | DNA-25 | 47 | UserSt-15 |
| 4 | DNA-4 | 26 | DNA-26 | 48 | UserSt-16 |
| 5 | DNA-5 | 27 | DNA-27 | 49 | UserSt-17 |
| 6 | DNA-6 | 28 | DNA-28 | 50 | UserSt-18 |
| 7 | DNA-7 | 29 | DNA-29 | 51 | UserSt-19 |
| 8 | DNA-8 | 30 | DNA-30 | 52 | UserSt-20 |
| 9 | DNA-9 | 31 | DNA-31 | 53 | UserSt-21 |
| 10 | DNA-10 | 32 | DNA-32 | 54 | UserSt-22 |
| 11 | DNA-11 | 33 | UserSt-1 | 55 | UserSt-23 |
| 12 | DNA-12 | 34 | UserSt-2 | 56 | UserSt-24 |
| 13 | DNA-13 | 35 | UserSt-3 | 57 | UserSt-25 |
| 14 | DNA-14 | 36 | UserSt-4 | 58 | UserSt-26 |
| 15 | DNA-15 | 37 | UserSt-5 | 59 | UserSt-27 |
| 16 | DNA-16 | 38 | UserSt-6 | 60 | UserSt-28 |
| 17 | DNA-17 | 39 | UserSt-7 | 61 | UserSt-29 |
| 18 | DNA-18 | 40 | UserSt-8 | 62 | UserSt-30 |
| 19 | DNA-19 | 41 | UserSt-9 | 63 | UserSt-31 |
| 20 | DNA-20 | 42 | UserSt-10 | 64 | UserSt-32 |
| 21 | DNA-21 | 43 | UserSt-11 | | |

**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: TRANSDUCER DCMA I/O RANGE**

| bitmask | dcmA I/O range |
|---------|----------------|
| 0 | 0 to –1 mA |
| 1 | 0 to 1 mA |
| 2 | –1 to 1 mA |
| 3 | 0 to 5 mA |
| 4 | 0 to 10 mA |
| 5 | 0 to 20 mA |
| 6 | 4 to 20 mA |

**F174**
**ENUMERATION: TRANSDUCER RTD INPUT TYPE**

0 = 100 Ohm Platinum, 1 = 120 Ohm Nickel,
2 = 100 Ohm Nickel, 3 = 10 Ohm Copper

**F175**
**ENUMERATION: PHASE LETTERS**

0 = A, 1 = B, 2 = C

**F176**
**ENUMERATION: SYNCHROCHECK DEAD SOURCE SELECT**

| bitmask | synchrocheck dead source |
|---------|--------------------------|
| 0 | None |
| 1 | LV1 and DV2 |
| 2 | DV1 and LV2 |
| 3 | DV1 or DV2 |
| 4 | DV1 Xor DV2 |
| 5 | DV1 and DV2 |

**F177**
**ENUMERATION: COMMUNICATION PORT**

0 = None, 1 = COM1-RS485, 2 = COM2-RS485,
3 = Front Panel-RS232, 4 = Network

**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

**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 |

**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

**B**

**F190**
**ENUMERATION: SIMULATED KEYPRESS**

| bitmsk | keypress | | bitmsk | keypress |
|--------|----------|---|--------|----------|
| 0 | ---<br>use between real keys | | 21 | Escape |
| | | | 22 | Enter |
| 1 | 1 | | 23 | Reset |
| 2 | 2 | | 24 | User 1 |
| 3 | 3 | | 25 | User 2 |
| 4 | 4 | | 26 | User 3 |
| 5 | 5 | | 27 | User-programmable key 1 |
| 6 | 6 | | 28 | User-programmable key 2 |
| 7 | 7 | | 29 | User-programmable key 3 |
| 8 | 8 | | 30 | User-programmable key 4 |
| 9 | 9 | | 31 | User-programmable key 5 |
| 10 | 0 | | 32 | User-programmable key 6 |
| 11 | Decimal Pt | | 33 | User-programmable key 7 |
| 12 | Plus/Minus | | 34 | User-programmable key 8 |
| 13 | Value Up | | 35 | User-programmable key 9 |
| 14 | Value Down | | 36 | User-programmable key 10 |
| 15 | Message Up | | 37 | User-programmable key 11 |
| 16 | Message Down | | 38 | User-programmable key 12 |
| 17 | Message Left | | 39 | User 4 (control pushbutton) |
| 18 | Message Right | | 40 | User 5 (control pushbutton) |
| 19 | Menu | | 41 | User 6 (control pushbutton) |
| 20 | Help | | 42 | User 7 (control pushbutton) |

**F192**
**ENUMERATION: ETHERNET OPERATION MODE**

0 = Half-Duplex, 1 = Full-Duplex

**F194**
**ENUMERATION: DNP SCALE**

A bitmask of 0 = 0.01, 1 = 0.1, 2 = 1, 3 = 10, 4 = 100, 5 = 1000, 6 = 10000, 7 = 100000, 8 = 0.001

**F197**
**ENUMERATION: DNP BINARY INPUT POINT BLOCK**

| bitmask | Input Point Block |
|---------|-------------------|
| 0 | Not Used |
| 1 | Virtual Inputs 1 to 16 |
| 2 | Virtual Inputs 17 to 32 |
| 3 | Virtual Outputs 1 to 16 |
| 4 | Virtual Outputs 17 to 32 |
| 5 | Virtual Outputs 33 to 48 |
| 6 | Virtual Outputs 49 to 64 |
| 7 | Contact Inputs 1 to 16 |
| 8 | Contact Inputs 17 to 32 |
| 9 | Contact Inputs 33 to 48 |
| 10 | Contact Inputs 49 to 64 |
| 11 | Contact Inputs 65 to 80 |

| bitmask | Input Point Block |
|---------|-------------------|
| 12 | Contact Inputs 81 to 96 |
| 13 | Contact Outputs 1 to 16 |
| 14 | Contact Outputs 17 to 32 |
| 15 | Contact Outputs 33 to 48 |
| 16 | Contact Outputs 49 to 64 |
| 17 | Remote Inputs 1 to 16 |
| 18 | Remote Inputs 17 to 32 |
| 19 | Remote Devs 1 to 16 |
| 20 | Elements 1 to 16 |
| 21 | Elements 17 to 32 |
| 22 | Elements 33 to 48 |
| 23 | Elements 49 to 64 |
| 24 | Elements 65 to 80 |
| 25 | Elements 81 to 96 |
| 26 | Elements 97 to 112 |
| 27 | Elements 113 to 128 |
| 28 | Elements 129 to 144 |
| 29 | Elements 145 to 160 |
| 30 | Elements 161 to 176 |
| 31 | Elements 177 to 192 |
| 32 | Elements 193 to 208 |
| 33 | Elements 209 to 224 |
| 34 | Elements 225 to 240 |
| 35 | Elements 241 to 256 |
| 36 | Elements 257 to 272 |
| 37 | Elements 273 to 288 |
| 38 | Elements 289 to 304 |
| 39 | Elements 305 to 320 |
| 40 | Elements 321 to 336 |
| 41 | Elements 337 to 352 |
| 42 | Elements 353 to 368 |
| 43 | Elements 369 to 384 |
| 44 | Elements 385 to 400 |
| 45 | Elements 401 to 406 |
| 46 | Elements 417 to 432 |
| 47 | Elements 433 to 448 |
| 48 | Elements 449 to 464 |
| 49 | Elements 465 to 480 |
| 50 | Elements 481 to 496 |
| 51 | Elements 497 to 512 |
| 52 | Elements 513 to 528 |
| 53 | Elements 529 to 544 |
| 54 | Elements 545 to 560 |
| 55 | LED States 1 to 16 |
| 56 | LED States 17 to 32 |
| 57 | Self Tests 1 to 16 |
| 58 | Self Tests 17 to 32 |

**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

**F222**
**ENUMERATION: TEST ENUMERATION**

0 = Test Enumeration 0, 1 = Test Enumeration 1

**F231**
**ENUMERATION: POLARIZING VOLTAGE**

0 = Calculated V0, 1 = Measured VX

**F300**
**UR_UINT16: FLEXLOGIC™ BASE TYPE (6-bit type)**

The FlexLogic™ BASE type is 6 bits and is combined with a 9 bit descriptor and 1 bit for protection element to form a 16 bit value. The combined bits are of the form: PTTTTTTDDDDDDDDD,

where P bit if set, indicates that the FlexLogic™ type is associated with a protection element state and T represents bits for the BASE type, and D represents bits for the descriptor.

The values in square brackets indicate the base type with P prefix [PTTTTTT] and the values in round brackets indicate the descriptor range.

[0] Off(0) this is boolean FALSE value
[0] On (1)This is boolean TRUE value
[2] CONTACT INPUTS (1 - 96)
[3] CONTACT INPUTS OFF (1-96)
[4] VIRTUAL INPUTS (1-64)
[6] VIRTUAL OUTPUTS (1-64)
[10] CONTACT OUTPUTS VOLTAGE DETECTED (1-64)
[11] CONTACT OUTPUTS VOLTAGE OFF DETECTED (1-64)
[12] CONTACT OUTPUTS CURRENT DETECTED (1-64)
[13] CONTACT OUTPUTS CURRENT OFF DETECTED (1-64)
[14] REMOTE INPUTS (1-32)
[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 64)
[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 |

**F500**
**UR_UINT16: PACKED BITFIELD**

First register indicates input/output state with bits 0(MSB)-15(LSB) corresponding to input/output state 1-16. The second register indicates input/output state with bits 0-15 corresponding to input/output state 17-32 (if required) The third register indicates input/output state with bits 0-15 corresponding to input/output state 33-48 (if required). The fourth register indicates input/output state with bits 0-15 corresponding to input/output state 49-64 (if required).

The number of registers required is determined by the specific data item. A bit value of 0 = Off, 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

**F506|**
**BITFIELD: 1 PHASE ELEMENT STATE**

0 = Pickup, 1 = Operate

**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

**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**

| bitmask | keypress | bitmask | keypress |
|---|---|---|---|
| 0 | None | 22 | Value Down |
| 1 | Menu | 23 | Reset |
| 2 | Message Up | 24 | User 1 |
| 3 | 7 | 25 | User 2 |
| 4 | 8 | 26 | User 3 |
| 5 | 9 | 31 | User PB 1 |
| 6 | Help | 32 | User PB 2 |
| 7 | Message Left | 33 | User PB 3 |
| 8 | 4 | 34 | User PB 4 |
| 9 | 5 | 35 | User PB 5 |
| 10 | 6 | 36 | User PB 6 |
| 11 | Escape | 37 | User PB 7 |
| 12 | Message Right | 38 | User PB 8 |
| 13 | 1 | 39 | User PB 9 |
| 14 | 2 | 40 | User PB 10 |
| 15 | 3 | 41 | User PB 11 |
| 16 | Enter | 42 | User PB 12 |
| 17 | Message Down | 44 | User 4 |
| 18 | 0 | 45 | User 5 |
| 19 | Decimal | 46 | User 6 |
| 20 | +/– | 47 | User 7 |
| 21 | Value Up | | |

**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)

**B**

This document is adapted from the IEC 60870-5-104 standard. For ths section the boxes indicate the following: ☒ – used in standard direction; ☐ – not used; ■ – cannot be selected in IEC 60870-5-104 standard.

1.  **SYSTEM OR DEVICE:**

☐ System Definition

☐ Controlling Station Definition (Master)

☒ **Controlled Station Definition (Slave)**

2.  **NETWORK CONFIGURATION:**

■ ~~Point to Point~~              ■ ~~Multipoint~~

■ ~~Multiple Point to Point~~      ■ ~~Multipoint Star~~

3.  **PHYSICAL LAYER**

**Transmission Speed (control direction):**

| Unbalanced Interchange Circuit V.24/V.28 Standard: | Unbalanced Interchange Circuit V.24/V.28 Recommended if >1200 bits/s: | Balanced Interchange Circuit X.24/X.27: |
|---|---|---|
| ■ ~~100 bits/sec.~~ | ■ ~~2400 bits/sec.~~ | ■ ~~2400 bits/sec.~~ |
| ■ ~~200 bits/sec.~~ | ■ ~~4800 bits/sec.~~ | ■ ~~4800 bits/sec.~~ |
| ■ ~~300 bits/sec.~~ | ■ ~~9600 bits/sec.~~ | ■ ~~9600 bits/sec.~~ |
| ■ ~~600 bits/sec.~~ | | ■ ~~19200 bits/sec.~~ |
| ■ ~~1200 bits/sec.~~ | | ■ ~~38400 bits/sec.~~ |
| | | ■ ~~56000 bits/sec.~~ |
| | | ■ ~~64000 bits/sec.~~ |

**Transmission Speed (monitor direction):**

| Unbalanced Interchange Circuit V.24/V.28 Standard: | Unbalanced Interchange Circuit V.24/V.28 Recommended if >1200 bits/s: | Balanced Interchange Circuit X.24/X.27: |
|---|---|---|
| ■ ~~100 bits/sec.~~ | ■ ~~2400 bits/sec.~~ | ■ ~~2400 bits/sec.~~ |
| ■ ~~200 bits/sec.~~ | ■ ~~4800 bits/sec.~~ | ■ ~~4800 bits/sec.~~ |
| ■ ~~300 bits/sec.~~ | ■ ~~9600 bits/sec.~~ | ■ ~~9600 bits/sec.~~ |
| ■ ~~600 bits/sec.~~ | | ■ ~~19200 bits/sec.~~ |
| ■ ~~1200 bits/sec.~~ | | ■ ~~38400 bits/sec.~~ |
| | | ■ ~~56000 bits/sec.~~ |
| | | ■ ~~64000 bits/sec.~~ |

4.  **LINK LAYER**

| Link Transmission Procedure: | Address Field of the Link: |
|---|---|
| ■ ~~Balanced Transmision~~ | ■ ~~Not Present (Balanced Transmission Only)~~ |
| ■ ~~Unbalanced Transmission~~ | ■ ~~One Octet~~ |
| | ■ ~~Two Octets~~ |
| | ■ ~~Structured~~ |
| | ■ ~~Unstructured~~ |
| **Frame Length (maximum length, number of octets):  Not selectable in companion IEC 60870-5-104 standard** | |

When using an unbalanced link layer, the following ADSU types are returned in class 2 messages (low priority) with the indicated causes of transmission:

■ ~~The standard assignment of ADSUs to class 2 messages is used as follows~~:

■ ~~A special assignment of ADSUs to class 2 messages is used as follows~~:

**5. APPLICATION LAYER**

**Transmission Mode for Application Data:**
Mode 1 (least significant octet first), as defined in Clause 4.10 of IEC 60870-5-4, is used exclusively in this companion stanadard.

**Common Address of ADSU:**

■ ~~One Octet~~

☒ Two Octets

**Information Object Address:**

■ ~~One Octet~~ ☒ 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**

☒ <1> := Single-point information M_SP_NA_1
■ ~~<2> := Single-point information with time tag~~ ~~M_SP_TA_1~~
☐ <3> := Double-point information M_DP_NA_1
■ ~~<4> := Double-point information with time tag~~ ~~M_DP_TA_1~~
☐ <5> := Step position information M_ST_NA_1
■ ~~<6> := Step position information with time tag~~ ~~M_ST_TA_1~~
☐ <7> := Bitstring of 32 bits M_BO_NA_1
■ ~~<8> := Bitstring of 32 bits with time tag~~ ~~M_BO_TA_1~~
☐ <9> := Measured value, normalized value M_ME_NA_1
■ ~~<10> := Measured value, normalized value with time tag~~ ~~M_NE_TA_1~~
☐ <11> := Measured value, scaled value M_ME_NB_1
■ ~~<12> := Measured value, scaled value with time tag~~ ~~M_NE_TB_1~~
☒ <13> := Measured value, short floating point value M_ME_NC_1
■ ~~<14> := Measured value, short floating point value with time tag~~ ~~M_NE_TC_1~~
☒ <15> := Integrated totals M_IT_NA_1
■ ~~<16> := Integrated totals with time tag~~ ~~M_IT_TA_1~~
■ ~~<17> := Event of protection equipment with time tag~~ ~~M_EP_TA_1~~
■ ~~<18> := Packed start events of protection equipment with time tag~~ ~~M_EP_TB_1~~
■ ~~<19> := Packed output circuit information of protection equipment with time tag~~ ~~M_EP_TC_1~~
☐ <20> := Packed single-point information with status change detection M_SP_NA_1

☐ <21> := Measured value, normalized value without quantity descriptor          M_ME_ND_1

☒ <30> := Single-point information with time tag CP56Time2a                      M_SP_TB_1

☐ <31> := Double-point information wiht time tag CP56Time2a                      M_DP_TB_1

☐ <32> := Step position information with time tag CP56Time2a                     M_ST_TB_1

☐ <33> := Bitstring of 32 bits with time tag CP56Time2a                         M_BO_TB_1

☐ <34> := Measured value, normalized value with time tag CP56Time2a             M_ME_TD_1

☐ <35> := Measured value, scaled value with time tag CP56Time2a                 M_ME_TE_1

☐ <36> := Measured value, short floating point value with time tag CP56Time2a   M_ME_TF_1

☒ <37> := Integrated totals with time tag CP56Time2a                            M_IT_TB_1

☐ <38> := Event of protection equipment with time tag CP56Time2a                M_EP_TD_1

☐ <39> := Packed start events of protection equipment with time tag CP56Time2a  M_EP_TE_1

☐ <40> := Packed output circuit information of protection equipment with time tag CP56Time2a  M_EP_TF_1

Either the ASDUs of the set <2>, <4>, <6>, <8>, <10>, <12>, <14>, <16>, <17>, <18>, and <19> or of the set <30> to <40> are used.

**Process information in control direction**

☒ <45> := Single command                                                        C_SC_NA_1

☐ <46> := Double command                                                        C_DC_NA_1

☐ <47> := Regulating step command                                               C_RC_NA_1

☐ <48> := Set point command, normalized value                                   C_SE_NA_1

☐ <49> := Set point command, scaled value                                       C_SE_NB_1

☐ <50> := Set point command, short floating point value                         C_SE_NC_1

☐ <51> := Bitstring of 32 bits                                                  C_BO_NA_1

☒ <58> := Single command with time tag CP56Time2a                               C_SC_TA_1

☐ <59> := Double command with time tag CP56Time2a                               C_DC_TA_1

☐ <60> := Regulating step command with time tag CP56Time2a                      C_RC_TA_1

☐ <61> := Set point command, normalized value with time tag CP56Time2a          C_SE_TA_1

☐ <62> := Set point command, scaled value with time tag CP56Time2a              C_SE_TB_1

☐ <63> := Set point command, short floating point value with time tag CP56Time2a  C_SE_TC_1

☐ <64> := Bitstring of 32 bits with time tag CP56Time2a                         C_BO_TA_1

Either the ASDUs of the set <45> to <51> or of the set <58> to <64> are used.

**System information in monitor direction**

☒ <70> := End of initialization                                                 M_EI_NA_1

**System information in control direction**

☒ <100> := Interrogation command                                                C_IC_NA_1

☒ <101> := Counter interrogation command                                        C_CI_NA_1

☒ <102> := Read command                                                         C_RD_NA_1

☒ <103> := Clock synchronization command (see Clause 7.6 in standard)           C_CS_NA_1

■ ~~<104> := Test command~~                                                      ~~C_TS_NA_1~~

☒ <105> := Reset process command                                                C_RP_NA_1

■ <106> := Delay acquisition command                                            C_CD_NA_1

☒ <107> := Test command with time tag CP56Time2a                                C_TS_TA_1

**C**

**Parameter in control direction**

☐ <110> := Parameter of measured value, normalized value                 PE_ME_NA_1

☐ <111> := Parameter of measured value, scaled value                     PE_ME_NB_1

☒ <112> := Parameter of measured value, short floating point value       PE_ME_NC_1

☐ <113> := Parameter activation                                          PE_AC_NA_1

**File transfer**

☐ <120> := File Ready                                                    F_FR_NA_1

☐ <121> := Section Ready                                                 F_SR_NA_1

☐ <122> := Call directory, select file, call file, call section          F_SC_NA_1

☐ <123> := Last section, last segment                                    F_LS_NA_1

☐ <124> := Ack file, ack section                                         F_AF_NA_1

☐ <125> := Segment                                                       F_SG_NA_1

☐ <126> := Directory (blank or X, available only in monitor [standard] direction)   C_CD_NA_1

**Type identifier and cause of transmission assignments**
(station-specific parameters)

In the following table:

• Shaded boxes are not required.

• Black boxes are not permitted in this companion standard.

• Blank boxes indicate functions or ASDU not used.

• '**X**' if only used in the standard direction

| TYPE IDENTIFICATION | | CAUSE OF TRANSMISSION | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PERIODIC, CYCLIC | BACKGROUND SCAN | SPONTANEOUS | INITIALIZED | REQUEST OR REQUESTED | ACTIVATION | ACTIVATION CONFIRMATION | DEACTIVATION | DEACTIVATION CONFIRMATION | ACTIVATION TERMINATION | RETURN INFO CAUSED BY LOCAL CMD | FILE TRANSFER | INTERROGATED BY GROUP <NUMBER> | REQUEST BY GROUP <N> COUNTER REQ | UNKNOWN TYPE IDENTIFICATION | UNKNOWN CAUSE OF TRANSMISSION | UNKNOWN COMMON ADDRESS OF ADSU | UNKNOWN INFORMATION OBJECT ADDR | UNKNOWN INFORMATION OBJECT ADDR |
| NO. | MNEMONIC | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 20 to 36 | 37 to 41 | 44 | 45 | 46 | 47 |
| <1> | M_SP_NA_1 | | | X | | X | | | | | | X | X | | X | | | | | |
| <2> | M_SP_TA_1 | | | | | | | | | | | | | | | | | | | |
| <3> | M_DP_NA_1 | | | | | | | | | | | | | | | | | | | |
| <4> | M_DP_TA_1 | | | | | | | | | | | | | | | | | | | |
| <5> | M_ST_NA_1 | | | | | | | | | | | | | | | | | | | |
| <6> | M_ST_TA_1 | | | | | | | | | | | | | | | | | | | |
| <7> | M_BO_NA_1 | | | | | | | | | | | | | | | | | | | |
| <8> | M_BO_TA_1 | | | | | | | | | | | | | | | | | | | |

| 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 | UNKNOWN COMMON ADDRESS OF ADSU | UNKNOWN INFORMATION OBJECT ADDR | UNKNOWN INFORMATION OBJECT ADDR |
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 20 to 36 | 37 to 41 | 44 | 45 | 46 | 47 |
| \<9\> | M_ME_NA_1 | | | | | | | | | | | | | | | | | | | |
| \<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 | | | | | | | | | | | | | | | | | | | |

| 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 | UNKNOWN COMMON ADDRESS OF ADSU | UNKNOWN INFORMATION OBJECT ADDR | UNKNOWN INFORMATION OBJECT ADDR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 20 to 36 | 37 to 41 | 44 | 45 | 46 | 47 |
| <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 | | | | | | | | | | | | | | | | | | | |
| <61> | C_SE_TA_1 | | | | | | | | | | | | | | | | | | | |
| <62> | C_SE_TB_1 | | | | | | | | | | | | | | | | | | | |
| <63> | C_SE_TC_1 | | | | | | | | | | | | | | | | | | | |
| <64> | C_BO_TA_1 | | | | | | | | | | | | | | | | | | | |
| <70> | M_EI_NA_1*) | | | | X | | | | | | | | | | | | | | | |
| <100> | C_IC_NA_1 | | | | | | X | X | X | X | X | | | | | | | | | |
| <101> | C_CI_NA_1 | | | | | | X | X | | | X | | | | | | | | | |
| <102> | C_RD_NA_1 | | | | | X | | | | | | | | | | | | | | |
| <103> | C_CS_NA_1 | | | X | | | X | X | | | | | | | | | | | | |
| <104> | C_TS_NA_1 | | | | | | | | | | | | | | | | | | | |
| <105> | C_RP_NA_1 | | | | | | X | X | | | | | | | | | | | | |
| <106> | C_CD_NA_1 | | | | | | | | | | | | | | | | | | | |
| <107> | C_TS_TA_1 | | | | | | | | | | | | | | | | | | | |
| <110> | P_ME_NA_1 | | | | | | | | | | | | | | | | | | | |
| <111> | P_ME_NB_1 | | | | | | | | | | | | | | | | | | | |
| <112> | P_ME_NC_1 | | | | | | X | X | | | | | | | X | | | | | |
| <113> | P_AC_NA_1 | | | | | | | | | | | | | | | | | | | |
| <120> | F_FR_NA_1 | | | | | | | | | | | | | | | | | | | |
| <121> | F_SR_NA_1 | | | | | | | | | | | | | | | | | | | |
| <122> | F_SC_NA_1 | | | | | | | | | | | | | | | | | | | |
| <123> | F_LS_NA_1 | | | | | | | | | | | | | | | | | | | |
| <124> | F_AF_NA_1 | | | | | | | | | | | | | | | | | | | |
| <125> | F_SG_NA_1 | | | | | | | | | | | | | | | | | | | |
| <126> | F_DR_TA_1*) | | | | | | | | | | | | | | | | | | | |

**C**

6.  **BASIC APPLICATION FUNCTIONS**

**Station Initialization:**

☒ Remote initialization

**Cyclic Data Transmission:**

☒ Cyclic data transmission

**Read Procedure:**

☒ Read procedure

**Spontaneous Transmission:**

☒ Spontaneous transmission

**Double transmission of information objects with cause of transmission spontaneous:**

The following type identifications may be transmitted in succession caused by a single status change of an information object. The particular information object addresses for which double transmission is enabled are defined in a project-specific list.

☐ Single point information: M_SP_NA_1, M_SP_TA_1, M_SP_TB_1, and M_PS_NA_1

☐ Double point information: M_DP_NA_1, M_DP_TA_1, and M_DP_TB_1

☐ Step position information: M_ST_NA_1, M_ST_TA_1, and M_ST_TB_1

☐ Bitstring of 32 bits: M_BO_NA_1, M_BO_TA_1, and M_BO_TB_1 (if defined for a specific project)

☐ Measured value, normalized value: M_ME_NA_1, M_ME_TA_1, M_ME_ND_1, and M_ME_TD_1

☐ Measured value, scaled value: M_ME_NB_1, M_ME_TB_1, and M_ME_TE_1

☐ Measured value, short floating point number: M_ME_NC_1, M_ME_TC_1, and M_ME_TF_1

**Station interrogation:**

☒ Global

☒ Group 1          ☒ Group 5          ☒ Group 9          ☒ Group 13

☒ Group 2          ☒ Group 6          ☒ Group 10         ☒ Group 14

☒ Group 3          ☒ Group 7          ☒ Group 11         ☒ Group 15

☒ Group 4          ☒ Group 8          ☒ Group 12         ☒ Group 16

**Clock synchronization:**

☒ Clock synchronization (optional, see Clause 7.6)

**Command transmission:**

☒ Direct command transmission

☐ Direct setpoint command transmission

☒ Select and execute command

☐ Select and execute setpoint command

☒ C_SE ACTTERM used

☒ No additional definition

☒ Short pulse duration (duration determined by a system parameter in the outstation)

☒ Long pulse duration (duration determined by a system parameter in the outstation)

☒ Persistent output

☒ Supervision of maximum delay in command direction of commands and setpoint commands

Maximum allowable delay of commands and setpoint commands: **10 s**

**Transmission of integrated totals:**

☒ Mode A: Local freeze with spontaneous transmission

☒ Mode B: Local freeze with counter interrogation

☒ Mode C: Freeze and transmit by counter-interrogation commands

☒ Mode D: Freeze by counter-interrogation command, frozen values reported simultaneously

☒ Counter read

☒ Counter freeze without reset

☒ Counter freeze with reset

☒ Counter reset

☒ General request counter

☒ Request counter group 1

☒ Request counter group 2

☒ Request counter group 3

☒ Request counter group 4

**Parameter loading:**

☒ Threshold value

☐ Smoothing factor

☐ Low limit for transmission of measured values

☐ High limit for transmission of measured values

**Parameter activation:**

☐ Activation/deactivation of persistent cyclic or periodic transmission of the addressed object

**Test procedure:**

☐ Test procedure

**File transfer:**

File transfer in monitor direction:

☐ Transparent file

☐ Transmission of disturbance data of protection equipment

☐ Transmission of sequences of events

☐ Transmission of sequences of recorded analog values

File transfer in control direction:

☐ Transparent file

**Background scan:**

☐ Background scan

**Acquisition of transmission delay:**

■ ~~Acquisition of transmission delay~~

**Definition of time outs:**

| PARAMETER | DEFAULT VALUE | REMARKS | SELECTED VALUE |
|---|---|---|---|
| $t_0$ | 30 s | Timeout of connection establishment | 120 s |
| $t_1$ | 15 s | Timeout of send or test APDUs | 15 s |
| $t_2$ | 10 s | Timeout for acknowlegements in case of no data messages $t_2 < t_1$ | 10 s |
| $t_3$ | 20 s | Timeout for sending test frames in case of a long idle state | 20 s |

Maximum range of values for all time outs: 1 to 255 s, accuracy 1 s

**Maximum number of outstanding I-format APDUs $k$ and latest acknowledge APDUs ($w$):**

| PARAMETER | DEFAULT VALUE | REMARKS | SELECTED VALUE |
|---|---|---|---|
| $k$ | 12 APDUs | Maximum difference receive sequence number to send state variable | 12 APDUs |
| $w$ | 8 APDUs | Latest acknowledge after receiving $w$ I-format APDUs | 8 APDUs |

Maximum range of values $k$:      1 to 32767 ($2^{15} - 1$) APDUs, accuracy 1 APDU

Maximum range of values $w$:      1 to 32767 APDUs, accuracy 1 APDU
                                              Recommendation: $w$ should not exceed two-thirds of $k$.

**Portnumber:**

| PARAMETER | VALUE | REMARKS |
|---|---|---|
| Portnumber | 2404 | In all cases |

**RFC 2200 suite:**

RFC 2200 is an official Internet Standard which describes the state of standardization of protocols used in the Internet as determined by the Internet Architecture Board (IAB). It offers a broad spectrum of actual standards used in the Internet. The suitable selection of documents from RFC 2200 defined in this standard for given projects has to be chosen by the user of this standard.

☒ Ethernet 802.3

☐ Serial X.21 interface

☐ Other selection(s) from RFC 2200 (list below if selected)

Only Source 1 data points are shown in the following table. If the **NUMBER OF SOURCES IN MMENC1 LIST** setting is increased, data points for subsequent sources will be added to the list immediately following the Source 1 data points.

**Table C–1: IEC 60840-5-104 POINTS (Sheet 1 of 4)**

| POINT | DESCRIPTION | UNITS |
|---|---|---|
| **M_ME_NC_1 Points** | | |
| 2000 | SRC 1 Phase A Current RMS | A |
| 2001 | SRC 1 Phase B Current RMS | A |
| 2002 | SRC 1 Phase C Current RMS | A |
| 2003 | SRC 1 Neutral Current RMS | A |
| 2004 | SRC 1 Phase A Current Magnitude | A |
| 2005 | SRC 1 Phase A Current Angle | degrees |
| 2006 | SRC 1 Phase B Current Magnitude | A |
| 2007 | SRC 1 Phase B Current Angle | degrees |
| 2008 | SRC 1 Phase C Current Magnitude | A |
| 2009 | SRC 1 Phase C Current Angle | degrees |
| 2010 | SRC 1 Neutral Current Magnitude | A |
| 2011 | SRC 1 Neutral Current Angle | degrees |
| 2012 | SRC 1 Ground Current RMS | A |
| 2013 | SRC 1 Ground Current Magnitude | A |
| 2014 | SRC 1 Ground Current Angle | degrees |
| 2015 | SRC 1 Zero Sequence Current Magnitude | A |
| 2016 | SRC 1 Zero Sequence Current Angle | degrees |
| 2017 | SRC 1 Positive Sequence Current Magnitude | A |
| 2018 | SRC 1 Positive Sequence Current Angle | degrees |
| 2019 | SRC 1 Negative Sequence Current Magnitude | A |
| 2020 | SRC 1 Negative Sequence Current Angle | degrees |
| 2021 | SRC 1 Differential Ground Current Magnitude | A |
| 2022 | SRC 1 Differential Ground Current Angle | degrees |
| 2023 | SRC 1 Phase AG Voltage RMS | V |
| 2024 | SRC 1 Phase BG Voltage RMS | V |
| 2025 | SRC 1 Phase CG Voltage RMS | V |
| 2026 | SRC 1 Phase AG Voltage Magnitude | V |
| 2027 | SRC 1 Phase AG Voltage Angle | degrees |
| 2028 | SRC 1 Phase BG Voltage Magnitude | V |
| 2029 | SRC 1 Phase BG Voltage Angle | degrees |
| 2030 | SRC 1 Phase CG Voltage Magnitude | V |
| 2031 | SRC 1 Phase CG Voltage Angle | degrees |
| 2032 | SRC 1 Phase AB Voltage RMS | V |
| 2033 | SRC 1 Phase BC Voltage RMS | V |
| 2034 | SRC 1 Phase CA Voltage RMS | V |
| 2035 | SRC 1 Phase AB Voltage Magnitude | V |
| 2036 | SRC 1 Phase AB Voltage Angle | degrees |
| 2037 | SRC 1 Phase BC Voltage Magnitude | V |
| 2038 | SRC 1 Phase BC Voltage Angle | degrees |
| 2039 | SRC 1 Phase CA Voltage Magnitude | V |
| 2040 | SRC 1 Phase CA Voltage Angle | degrees |
| 2041 | SRC 1 Auxiliary Voltage RMS | V |
| 2042 | SRC 1 Auxiliary Voltage Magnitude | V |
| 2043 | SRC 1 Auxiliary Voltage Angle | degrees |
| 2044 | SRC 1 Zero Sequence Voltage Magnitude | V |

**Table C–1: IEC 60840-5-104 POINTS (Sheet 2 of 4)**

| POINT | DESCRIPTION | UNITS |
|---|---|---|
| 2045 | SRC 1 Zero Sequence Voltage Angle | degrees |
| 2046 | SRC 1 Positive Sequence Voltage Magnitude | V |
| 2047 | SRC 1 Positive Sequence Voltage Angle | degrees |
| 2048 | SRC 1 Negative Sequence Voltage Magnitude | V |
| 2049 | SRC 1 Negative Sequence Voltage Angle | degrees |
| 2050 | SRC 1 Three Phase Real Power | W |
| 2051 | SRC 1 Phase A Real Power | W |
| 2052 | SRC 1 Phase B Real Power | W |
| 2053 | SRC 1 Phase C Real Power | W |
| 2054 | SRC 1 Three Phase Reactive Power | var |
| 2055 | SRC 1 Phase A Reactive Power | var |
| 2056 | SRC 1 Phase B Reactive Power | var |
| 2057 | SRC 1 Phase C Reactive Power | var |
| 2058 | SRC 1 Three Phase Apparent Power | VA |
| 2059 | SRC 1 Phase A Apparent Power | VA |
| 2060 | SRC 1 Phase B Apparent Power | VA |
| 2061 | SRC 1 Phase C Apparent Power | VA |
| 2062 | SRC 1 Three Phase Power Factor | none |
| 2063 | SRC 1 Phase A Power Factor | none |
| 2064 | SRC 1 Phase B Power Factor | none |
| 2065 | SRC 1 Phase C Power Factor | none |
| 2066 | SRC 1 Positive Watthour | Wh |
| 2067 | SRC 1 Negative Watthour | Wh |
| 2068 | SRC 1 Positive Varhour | varh |
| 2069 | SRC 1 Negative Varhour | varh |
| 2070 | SRC 1 Frequency | Hz |
| 2071 | SRC 1 Demand Ia | A |
| 2072 | SRC 1 Demand Ib | A |
| 2073 | SRC 1 Demand Ic | A |
| 2074 | SRC 1 Demand Watt | W |
| 2075 | SRC 1 Demand Var | var |
| 2076 | SRC 1 Demand Va | VA |
| 2077 | Sens Dir Power 1 Actual | W |
| 2078 | Sens Dir Power 2 Actual | W |
| 2079 | Breaker 1 Arcing Amp Phase A | kA2-cyc |
| 2080 | Breaker 1 Arcing Amp Phase B | kA2-cyc |
| 2081 | Breaker 1 Arcing Amp Phase C | kA2-cyc |
| 2082 | Breaker 2 Arcing Amp Phase A | kA2-cyc |
| 2083 | Breaker 2 Arcing Amp Phase B | kA2-cyc |
| 2084 | Breaker 2 Arcing Amp Phase C | kA2-cyc |
| 2085 | Fault 1 Prefault Phase A Current Magnitude | A |
| 2086 | Fault 1 Prefault Phase A Current Angle | degrees |
| 2087 | Fault 1 Prefault Phase B Current Magnitude | A |
| 2088 | Fault 1 Prefault Phase B Current Angle | degrees |
| 2089 | Fault 1 Prefault Phase C Current Magnitude | A |
| 2090 | Fault 1 Prefault Phase C Current Angle | degrees |

**Table C–1: IEC 60840-5-104 POINTS (Sheet 3 of 4)**

| POINT | DESCRIPTION | UNITS |
|---|---|---|
| 2091 | Fault 1 Prefault Phase A Voltage Magnitude | V |
| 2092 | Fault 1 Prefault Phase A Voltage Angle | degrees |
| 2093 | Fault 1 Prefault Phase B Voltage Magnitude | V |
| 2094 | Fault 1 Prefault Phase B Voltage Angle | degrees |
| 2095 | Fault 1 Prefault Phase C Voltage Magnitude | V |
| 2096 | Fault 1 Prefault Phase C Voltage Angle | degrees |
| 2097 | Fault 1 Postfault Phase A Current Magnitude | A |
| 2098 | Fault 1 Postfault Phase A Current Angle | degrees |
| 2099 | Fault 1 Postfault Phase B Current Magnitude | A |
| 2100 | Fault 1 Postfault Phase B Current Angle | degrees |
| 2101 | Fault 1 Postfault Phase C Current Magnitude | A |
| 2102 | Fault 1 Postfault Phase C Current Angle | degrees |
| 2103 | Fault 1 Postfault Phase A Voltage Magnitude | V |
| 2104 | Fault 1 Postfault Phase A Voltage Angle | degrees |
| 2105 | Fault 1 Postfault Phase B Voltage Magnitude | V |
| 2106 | Fault 1 Postfault Phase B Voltage Angle | degrees |
| 2107 | Fault 1 Postfault Phase C Voltage Magnitude | V |
| 2108 | Fault 1 Postfault Phase C Voltage Angle | degrees |
| 2109 | Fault 1 Type | none |
| 2110 | Fault 1 Location | none |
| 2111 | Synchrocheck 1 Delta Voltage | V |
| 2112 | Synchrocheck 1 Delta Frequency | Hz |
| 2113 | Synchrocheck 1 Delta Phase | degrees |
| 2114 | Synchrocheck 2 Delta Voltage | V |
| 2115 | Synchrocheck 2 Delta Frequency | Hz |
| 2116 | Synchrocheck 2 Delta Phase | degrees |
| 2117 | DCMA Inputs 1 Value | none |
| 2118 | DCMA Inputs 2 Value | none |
| 2119 | DCMA Inputs 3 Value | none |
| 2120 | DCMA Inputs 4 Value | none |
| 2121 | RTD Inputs 1 Value | degreesC |
| 2122 | RTD Inputs 2 Value | degreesC |
| 2123 | RTD Inputs 3 Value | degreesC |
| 2124 | RTD Inputs 4 Value | degreesC |
| 2125 | Tracking Frequency | Hz |
| 2126 | FlexElement 1 Actual | none |
| 2127 | FlexElement 2 Actual | none |
| 2128 | FlexElement 3 Actual | none |
| 2129 | FlexElement 4 Actual | none |
| 2130 | FlexElement 5 Actual | none |
| 2131 | FlexElement 6 Actual | none |
| 2132 | FlexElement 7 Actual | none |
| 2133 | FlexElement 8 Actual | none |
| 2134 | Current Setting Group | none |
| **P_ME_NC_1 Points** | | |
| 5000 - 5133 | Threshold values for M_ME_NC_1 points | - |
| **M_SP_NA_1 Points** | | |
| 100 - 115 | Virtual Input States[0] | - |
| 116 - 131 | Virtual Input States[1] | - |
| 132 - 147 | Virtual Output States[0] | - |
| 148 - 163 | Virtual Output States[1] | - |

**Table C–1: IEC 60840-5-104 POINTS (Sheet 4 of 4)**

| POINT | DESCRIPTION | UNITS |
|---|---|---|
| 164 - 179 | Virtual Output States[2] | - |
| 180 - 195 | Virtual Output States[3] | - |
| 196 - 211 | Contact Input States[0] | - |
| 212 - 227 | Contact Input States[1] | - |
| 228 - 243 | Contact Input States[2] | - |
| 244 - 259 | Contact Input States[3] | - |
| 260 - 275 | Contact Input States[4] | - |
| 276 - 291 | Contact Input States[5] | - |
| 292 - 307 | Contact Output States[0] | - |
| 308 - 323 | Contact Output States[1] | - |
| 324 - 339 | Contact Output States[2] | - |
| 340 - 355 | Contact Output States[3] | - |
| 356 - 371 | Remote Input 1 States[0] | - |
| 372 - 387 | Remote Input 1 States[1] | - |
| 388 - 403 | Remote Device 1 States | - |
| 404 - 419 | LED Column 1 State[0] | - |
| 420 - 435 | LED Column 1 State[1] | - |
| **C_SC_NA_1 Points** | | |
| 1100 - 1115 | Virtual Input States[0] - No Select Required | - |
| 1116 - 1131 | Virtual Input States[1] - Select Required | - |
| **M_IT_NA_1 Points** | | |
| 4000 | Digital Counter 1 Value | - |
| 4001 | Digital Counter 2 Value | - |
| 4002 | Digital Counter 3 Value | - |
| 4003 | Digital Counter 4 Value | - |
| 4004 | Digital Counter 5 Value | - |
| 4005 | Digital Counter 6 Value | - |
| 4006 | Digital Counter 7 Value | - |
| 4007 | Digital Counter 8 Value | - |

**C**

**C**

The following table provides a 'Device Profile Document' in the standard format defined in the DNP 3.0 Subset Definitions Document.

**Table D–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:**<br><br>    For Requests:     **Level 2**<br>    For Responses:   **Level 2** | **Device Function:**<br><br>  ☐  Master<br>  ☒  **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):<br><br>    **Binary Inputs (Object 1)**<br><br>    **Binary Input Changes (Object 2)**<br><br>    **Binary Outputs (Object 10)**<br><br>    **Binary Counters (Object 20)**<br><br>    **Frozen Counters (Object 21)**<br><br>    **Counter Change Event (Object 22)**<br><br>    **Frozen Counter Event (Object 23)**<br><br>    **Analog Inputs (Object 30)**<br><br>    **Analog Input Changes (Object 32)**<br><br>    **Analog Deadbands (Object 34)** | |
| **Maximum Data Link Frame Size (octets):**<br><br>    Transmitted:  **292**<br>    Received:      **292** | **Maximum Application Fragment Size (octets):**<br><br>    Transmitted:  **240**<br>    Received:      **2048** |
| **Maximum Data Link Re-tries:**<br><br>  ☐  **None**<br>  ☒  Fixed at 2<br>  ☐  Configurable | **Maximum Application Layer Re-tries:**<br><br>  ☒  None<br>  ☐  Configurable |
| **Requires Data Link Layer Confirmation:**<br><br>  ☒  Never<br>  ☐  Always<br>  ☐  Sometimes<br>  ☐  Configurable | |

**D**

**Table D–1: DNP V3.00 DEVICE PROFILE (Sheet 2 of 3)**

**Requires Application Layer Confirmation:**

☐ Never
☐ Always
☒ When reporting Event Data
☒ When sending multi-fragment responses
☐ Sometimes
☐ Configurable

**Timeouts while waiting for:**

| | | | | |
|---|---|---|---|---|
| Data Link Confirm: | ☐ None | ☒ **Fixed at 3 s** | ☐ Variable | ☐ Configurable |
| Complete Appl. Fragment: | ☒ **None** | ☐ Fixed at ____ | ☐ Variable | ☐ Configurable |
| Application Confirm: | ☐ None | ☒ **Fixed at 4 s** | ☐ Variable | ☐ Configurable |
| Complete Appl. Response: | ☒ **None** | ☐ Fixed at ____ | ☐ Variable | ☐ Configurable |

**Others:**

| | |
|---|---|
| Transmission Delay: | **No intentional delay** |
| Inter-character Timeout: | **50 ms** |
| Need Time Delay: | **Configurable (default = 24 hrs.)** |
| Select/Operate Arm Timeout: | **10 s** |
| Binary input change scanning period: | **8 times per power system cycle** |
| Packed binary change process period: | **1 s** |
| Analog input change scanning period: | **500 ms** |
| Counter change scanning period: | **500 ms** |
| Frozen counter event scanning period: | **500 ms** |
| Unsolicited response notification delay: | **500 ms** |
| Unsolicited response retry delay | **configurable 0 to 60 sec.** |

**Sends/Executes Control Operations:**

| | | | | |
|---|---|---|---|---|
| WRITE Binary Outputs | ☒ **Never** | ☐ Always | ☐ Sometimes | ☐ Configurable |
| SELECT/OPERATE | ☐ Never | ☒ **Always** | ☐ Sometimes | ☐ Configurable |
| DIRECT OPERATE | ☐ Never | ☒ **Always** | ☐ Sometimes | ☐ Configurable |
| DIRECT OPERATE – NO ACK | ☐ Never | ☒ **Always** | ☐ Sometimes | ☐ Configurable |

| | | | | |
|---|---|---|---|---|
| Count > 1 | ☒ **Never** | ☐ Always | ☐ Sometimes | ☐ Configurable |
| Pulse On | ☐ Never | ☐ Always | ☒ **Sometimes** | ☐ Configurable |
| Pulse Off | ☐ Never | ☐ Always | ☒ **Sometimes** | ☐ Configurable |
| Latch On | ☐ Never | ☐ Always | ☒ **Sometimes** | ☐ Configurable |
| Latch Off | ☐ Never | ☐ Always | ☒ **Sometimes** | ☐ Configurable |

| | | | | |
|---|---|---|---|---|
| Queue | ☒ **Never** | ☐ Always | ☐ Sometimes | ☐ Configurable |
| Clear Queue | ☒ **Never** | ☐ Always | ☐ Sometimes | ☐ Configurable |

**Explanation of 'Sometimes':** Object 12 points are mapped to UR Virtual Inputs. The persistence of Virtual Inputs is determined by the **VIRTUAL INPUT X TYPE** settings. Both "Pulse On" and "Latch On" operations perform the same function in the UR; that is, the appropriate Virtual Input is put into the "On" state. If the Virtual Input is set to "Self-Reset", it will reset after one pass of FlexLogic™. The On/Off times and Count value are ignored. "Pulse Off" and "Latch Off" operations put the appropriate Virtual Input into the "Off" state. "Trip" and "Close" operations both put the appropriate Virtual Input into the "On" state.

**Table D–1: DNP V3.00 DEVICE PROFILE (Sheet 3 of 3)**

| | |
|---|---|
| **Reports Binary Input Change Events when no specific variation requested:**<br><br>☐ Never<br>☒ **Only time-tagged**<br>☐ Only non-time-tagged<br>☐ Configurable | **Reports time-tagged Binary Input Change Events when no specific variation requested:**<br><br>☐ Never<br>☒ Binary Input Change With Time<br>☐ Binary Input Change With Relative Time<br>☐ Configurable (attach explanation) |
| **Sends Unsolicited Responses:**<br><br>☐ **Never**<br>☒ Configurable<br>☐ Only certain objects<br>☐ Sometimes (attach explanation)<br>☒ ENABLE/DISABLE unsolicited Function codes supported | **Sends Static Data in Unsolicited Responses:**<br><br>☒ Never<br>☐ When Device Restarts<br>☐ When Status Flags Change<br><br>No other options are permitted. |
| **Default Counter Object/Variation:**<br><br>☐ No Counters Reported<br>☐ Configurable (attach explanation)<br>☒ **Default Object:      20**<br>     **Default Variation:    1**<br>☒ **Point-by-point list attached** | **Counters Roll Over at:**<br><br>☐ No Counters Reported<br>☐ Configurable (attach explanation)<br>☒ **16 Bits (Counter 8)**<br>☒ **32 Bits (Counters 0 to 7, 9)**<br>☐ Other Value: _____<br>☒ **Point-by-point list attached** |
| **Sends Multi-Fragment Responses:**<br><br>☒ **Yes**<br>☐ No | |

**D**

The following table identifies the variations, function codes, and qualifiers supported by the C60 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 D–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 (parse only) | 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 C60 is not restarted, but the DNP process is restarted.

**Table D–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)<br>7 (freeze)<br>8 (freeze noack)<br>9 (freeze clear)<br>10 (frz. cl. noack)<br>22 (assign class) | 00, 01 (start-stop)<br>06 (no range, or all)<br>07, 08 (limited quantity)<br>17, 28 (index) | 129 (response) | 00, 01 (start-stop)<br>17, 28 (index)<br>*(see Note 2)* |
| | 5 | 32-Bit Binary Counter without Flag | 1 (read)<br>7 (freeze)<br>8 (freeze noack)<br>9 (freeze clear)<br>10 (frz. cl. noack)<br>22 (assign class) | 00, 01 (start-stop)<br>06 (no range, or all)<br>07, 08 (limited quantity)<br>17, 28 (index) | 129 (response) | 00, 01 (start-stop)<br>17, 28 (index)<br>*(see Note 2)* |
| | 6 | 16-Bit Binary Counter without Flag | 1 (read)<br>7 (freeze)<br>8 (freeze noack)<br>9 (freeze clear)<br>10 (frz. cl. noack)<br>22 (assign class) | 00, 01 (start-stop)<br>06 (no range, or all)<br>07, 08 (limited quantity)<br>17, 28 (index) | 129 (response) | 00, 01 (start-stop)<br>17, 28 (index)<br>*(see Note 2)* |
| 21 | 0 | Frozen Counter<br>(Variation 0 is used to request default variation) | 1 (read)<br>22 (assign class) | 00, 01 (start-stop)<br>06 (no range, or all)<br>07, 08 (limited quantity)<br>17, 28 (index) | | |
| | 1 | 32-Bit Frozen Counter | 1 (read)<br>22 (assign class) | 00, 01 (start-stop)<br>06 (no range, or all)<br>07, 08 (limited quantity)<br>17, 28 (index) | 129 (response) | 00, 01 (start-stop)<br>17, 28 (index)<br>*(see Note 2)* |
| | 2 | 16-Bit Frozen Counter | 1 (read)<br>22 (assign class) | 00, 01 (start-stop)<br>06 (no range, or all)<br>07, 08 (limited quantity)<br>17, 28 (index) | 129 (response) | 00, 01 (start-stop)<br>17, 28 (index)<br>*(see Note 2)* |
| | 9 | 32-Bit Frozen Counter without Flag | 1 (read)<br>22 (assign class) | 00, 01 (start-stop)<br>06 (no range, or all)<br>07, 08 (limited quantity)<br>17, 28 (index) | 129 (response) | 00, 01 (start-stop)<br>17, 28 (index)<br>*(see Note 2)* |
| | 10 | 16-Bit Frozen Counter without Flag | 1 (read)<br>22 (assign class) | 00, 01 (start-stop)<br>06 (no range, or all)<br>07, 08 (limited quantity)<br>17, 28 (index) | 129 (response) | 00, 01 (start-stop)<br>17, 28 (index)<br>*(see Note 2)* |
| 22 | 0 | Counter Change Event (Variation 0 is used to request default variation) | 1 (read) | 06 (no range, or all)<br>07, 08 (limited quantity) | | |
| | 1 | 32-Bit Counter Change Event | 1 (read) | 06 (no range, or all)<br>07, 08 (limited quantity) | 129 (response)<br>130 (unsol. resp.) | 17, 28 (index) |
| | 2 | 16-Bit Counter Change Event | 1 (read) | 06 (no range, or all)<br>07, 08 (limited quantity) | 129 (response)<br>130 (unsol. resp.) | 17, 28 (index) |
| | 5 | 32-Bit Counter Change Event with Time | 1 (read) | 06 (no range, or all)<br>07, 08 (limited quantity) | 129 (response)<br>130 (unsol. resp.) | 17, 28 (index) |
| | 6 | 16-Bit Counter Change Event with Time | 1 (read) | 06 (no range, or all)<br>07, 08 (limited quantity) | 129 (response)<br>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)<br>07, 08 (limited quantity) | | |
| | 1 | 32-Bit Frozen Counter Event | 1 (read) | 06 (no range, or all)<br>07, 08 (limited quantity) | 129 (response)<br>130 (unsol. resp.) | 17, 28 (index) |
| | 2 | 16-Bit Frozen Counter Event | 1 (read) | 06 (no range, or all)<br>07, 08 (limited quantity) | 129 (response)<br>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 C60 is not restarted, but the DNP process is restarted.

**D**

**Table D–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 C60 is not restarted, but the DNP process is restarted.

**Table D–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 | 0 | Time and Date | 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)* |
| | 1 | Time and Date (default – see Note 1) | 1 (read) 2 (write) | 00, 01 (start-stop) 06 (no range, or all) 07 (limited qty=1) 08 (limited quantity) 17, 28 (index) | 129 (response) | 00, 01 (start-stop) 17, 28 (index) *(see Note 2)* |
| 52 | 2 | Time Delay Fine | | | 129 (response) | 07 (limited quantity) (quantity = 1) |
| 60 | 0 | Class 0, 1, 2, and 3 Data | 1 (read) 20 (enable unsol) 21 (disable unsol) 22 (assign class) | 06 (no range, or all) | | |
| | 1 | Class 0 Data | 1 (read) 22 (assign class) | 06 (no range, or all) | | |
| | 2 | Class 1 Data | 1 (read) 20 (enable unsol) 21 (disable unsol) 22 (assign class) | 06 (no range, or all) 07, 08 (limited quantity) | | |
| | 3 | Class 2 Data | 1 (read) 20 (enable unsol) 21 (disable unsol) 22 (assign class) | 06 (no range, or all) 07, 08 (limited quantity) | | |
| | 4 | Class 3 Data | 1 (read) 20 (enable unsol) 21 (disable unsol) 22 (assign class) | 06 (no range, or all) 07, 08 (limited quantity) | | |
| 80 | 1 | Internal Indications | 2 (write) | 00 (start-stop) (index must =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 C60 is not restarted, but the DNP process is restarted.

**D**

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.

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**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)**

Change Event Variation reported when variation 0 requested: **2 (Binary Input Change with Time)**

Change Event Scan Rate: **8 times per power system cycle**

Change Event Buffer Size: **1000**

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**D**

**Table D–3: BINARY INPUTS (Sheet 1 of 11)**

| point | name/description | change event class |
|---|---|---|
| 0 | Virtual Input 1 | 2 |
| 1 | Virtual Input 2 | 2 |
| 2 | Virtual Input 3 | 2 |
| 3 | Virtual Input 4 | 2 |
| 4 | Virtual Input 5 | 2 |
| 5 | Virtual Input 6 | 2 |
| 6 | Virtual Input 7 | 2 |
| 7 | Virtual Input 8 | 2 |
| 8 | Virtual Input 9 | 2 |
| 9 | Virtual Input 10 | 2 |
| 10 | Virtual Input 11 | 2 |
| 11 | Virtual Input 12 | 2 |
| 12 | Virtual Input 13 | 2 |
| 13 | Virtual Input 14 | 2 |
| 14 | Virtual Input 15 | 2 |
| 15 | Virtual Input 16 | 2 |
| 16 | Virtual Input 17 | 2 |
| 17 | Virtual Input 18 | 2 |
| 18 | Virtual Input 19 | 2 |
| 19 | Virtual Input 20 | 2 |
| 20 | Virtual Input 21 | 2 |
| 21 | Virtual Input 22 | 2 |
| 22 | Virtual Input 23 | 2 |
| 23 | Virtual Input 24 | 2 |
| 24 | Virtual Input 25 | 2 |
| 25 | Virtual Input 26 | 2 |
| 26 | Virtual Input 27 | 2 |
| 27 | Virtual Input 28 | 2 |
| 28 | Virtual Input 29 | 2 |
| 29 | Virtual Input 30 | 2 |

**Table D–3: BINARY INPUTS (Sheet 2 of 11)**

| point | name/description | change event class |
|---|---|---|
| 30 | Virtual Input 31 | 2 |
| 31 | Virtual Input 32 | 2 |
| 32 | Virtual Output 1 | 2 |
| 33 | Virtual Output 2 | 2 |
| 34 | Virtual Output 3 | 2 |
| 35 | Virtual Output 4 | 2 |
| 36 | Virtual Output 5 | 2 |
| 37 | Virtual Output 6 | 2 |
| 38 | Virtual Output 7 | 2 |
| 39 | Virtual Output 8 | 2 |
| 40 | Virtual Output 9 | 2 |
| 41 | Virtual Output 10 | 2 |
| 42 | Virtual Output 11 | 2 |
| 43 | Virtual Output 12 | 2 |
| 44 | Virtual Output 13 | 2 |
| 45 | Virtual Output 14 | 2 |
| 46 | Virtual Output 15 | 2 |
| 47 | Virtual Output 16 | 2 |
| 48 | Virtual Output 17 | 2 |
| 49 | Virtual Output 18 | 2 |
| 50 | Virtual Output 19 | 2 |
| 51 | Virtual Output 20 | 2 |
| 52 | Virtual Output 21 | 2 |
| 53 | Virtual Output 22 | 2 |
| 54 | Virtual Output 23 | 2 |
| 55 | Virtual Output 24 | 2 |
| 56 | Virtual Output 25 | 2 |
| 57 | Virtual Output 26 | 2 |
| 58 | Virtual Output 27 | 2 |
| 59 | Virtual Output 28 | 2 |

**Table D–3: BINARY INPUTS (Sheet 3 of 11)**

| point | name/description | change event class |
|-------|------------------|---------------------|
| 60 | Virtual Output 29 | 2 |
| 61 | Virtual Output 30 | 2 |
| 62 | Virtual Output 31 | 2 |
| 63 | Virtual Output 32 | 2 |
| 64 | Virtual Output 33 | 2 |
| 65 | Virtual Output 34 | 2 |
| 66 | Virtual Output 35 | 2 |
| 67 | Virtual Output 36 | 2 |
| 68 | Virtual Output 37 | 2 |
| 69 | Virtual Output 38 | 2 |
| 70 | Virtual Output 39 | 2 |
| 71 | Virtual Output 40 | 2 |
| 72 | Virtual Output 41 | 2 |
| 73 | Virtual Output 42 | 2 |
| 74 | Virtual Output 43 | 2 |
| 75 | Virtual Output 44 | 2 |
| 76 | Virtual Output 45 | 2 |
| 77 | Virtual Output 46 | 2 |
| 78 | Virtual Output 47 | 2 |
| 79 | Virtual Output 48 | 2 |
| 80 | Virtual Output 49 | 2 |
| 81 | Virtual Output 50 | 2 |
| 82 | Virtual Output 51 | 2 |
| 83 | Virtual Output 52 | 2 |
| 84 | Virtual Output 53 | 2 |
| 85 | Virtual Output 54 | 2 |
| 86 | Virtual Output 55 | 2 |
| 87 | Virtual Output 56 | 2 |
| 88 | Virtual Output 57 | 2 |
| 89 | Virtual Output 58 | 2 |
| 90 | Virtual Output 59 | 2 |
| 91 | Virtual Output 60 | 2 |
| 92 | Virtual Output 61 | 2 |
| 93 | Virtual Output 62 | 2 |
| 94 | Virtual Output 63 | 2 |
| 95 | Virtual Output 64 | 2 |
| 96 | Contact Input 1 | 1 |
| 97 | Contact Input 2 | 1 |
| 98 | Contact Input 3 | 1 |
| 99 | Contact Input 4 | 1 |
| 100 | Contact Input 5 | 1 |
| 101 | Contact Input 6 | 1 |
| 102 | Contact Input 7 | 1 |
| 103 | Contact Input 8 | 1 |
| 104 | Contact Input 9 | 1 |
| 105 | Contact Input 10 | 1 |
| 106 | Contact Input 11 | 1 |

**Table D–3: BINARY INPUTS (Sheet 4 of 11)**

| point | name/description | change event class |
|-------|------------------|---------------------|
| 107 | Contact Input 12 | 1 |
| 108 | Contact Input 13 | 1 |
| 109 | Contact Input 14 | 1 |
| 110 | Contact Input 15 | 1 |
| 111 | Contact Input 16 | 1 |
| 112 | Contact Input 17 | 1 |
| 113 | Contact Input 18 | 1 |
| 114 | Contact Input 19 | 1 |
| 115 | Contact Input 20 | 1 |
| 116 | Contact Input 21 | 1 |
| 117 | Contact Input 22 | 1 |
| 118 | Contact Input 23 | 1 |
| 119 | Contact Input 24 | 1 |
| 120 | Contact Input 25 | 1 |
| 121 | Contact Input 26 | 1 |
| 122 | Contact Input 27 | 1 |
| 123 | Contact Input 28 | 1 |
| 124 | Contact Input 29 | 1 |
| 125 | Contact Input 30 | 1 |
| 126 | Contact Input 31 | 1 |
| 127 | Contact Input 32 | 1 |
| 128 | Contact Input 33 | 1 |
| 129 | Contact Input 34 | 1 |
| 130 | Contact Input 35 | 1 |
| 131 | Contact Input 36 | 1 |
| 132 | Contact Input 37 | 1 |
| 133 | Contact Input 38 | 1 |
| 134 | Contact Input 39 | 1 |
| 135 | Contact Input 40 | 1 |
| 136 | Contact Input 41 | 1 |
| 137 | Contact Input 42 | 1 |
| 138 | Contact Input 43 | 1 |
| 139 | Contact Input 44 | 1 |
| 140 | Contact Input 45 | 1 |
| 141 | Contact Input 46 | 1 |
| 142 | Contact Input 47 | 1 |
| 143 | Contact Input 48 | 1 |
| 144 | Contact Input 49 | 1 |
| 145 | Contact Input 50 | 1 |
| 146 | Contact Input 51 | 1 |
| 147 | Contact Input 52 | 1 |
| 148 | Contact Input 53 | 1 |
| 149 | Contact Input 54 | 1 |
| 150 | Contact Input 55 | 1 |
| 151 | Contact Input 56 | 1 |
| 152 | Contact Input 57 | 1 |
| 153 | Contact Input 58 | 1 |

**D**

**Table D–3: BINARY INPUTS (Sheet 5 of 11)**

| point | name/description | change event class |
|-------|------------------|--------------------|
| 154 | Contact Input 59 | 1 |
| 155 | Contact Input 60 | 1 |
| 156 | Contact Input 61 | 1 |
| 157 | Contact Input 62 | 1 |
| 158 | Contact Input 63 | 1 |
| 159 | Contact Input 64 | 1 |
| 160 | Contact Input 65 | 1 |
| 161 | Contact Input 66 | 1 |
| 162 | Contact Input 67 | 1 |
| 163 | Contact Input 68 | 1 |
| 164 | Contact Input 69 | 1 |
| 165 | Contact Input 70 | 1 |
| 166 | Contact Input 71 | 1 |
| 167 | Contact Input 72 | 1 |
| 168 | Contact Input 73 | 1 |
| 169 | Contact Input 74 | 1 |
| 170 | Contact Input 75 | 1 |
| 171 | Contact Input 76 | 1 |
| 172 | Contact Input 77 | 1 |
| 173 | Contact Input 78 | 1 |
| 174 | Contact Input 79 | 1 |
| 175 | Contact Input 80 | 1 |
| 176 | Contact Input 81 | 1 |
| 177 | Contact Input 82 | 1 |
| 178 | Contact Input 83 | 1 |
| 179 | Contact Input 84 | 1 |
| 180 | Contact Input 85 | 1 |
| 181 | Contact Input 86 | 1 |
| 182 | Contact Input 87 | 1 |
| 183 | Contact Input 88 | 1 |
| 184 | Contact Input 89 | 1 |
| 185 | Contact Input 90 | 1 |
| 186 | Contact Input 91 | 1 |
| 187 | Contact Input 92 | 1 |
| 188 | Contact Input 93 | 1 |
| 189 | Contact Input 94 | 1 |
| 190 | Contact Input 95 | 1 |
| 191 | Contact Input 96 | 1 |
| 192 | Contact Output 1 | 1 |
| 193 | Contact Output 2 | 1 |
| 194 | Contact Output 3 | 1 |
| 195 | Contact Output 4 | 1 |
| 196 | Contact Output 5 | 1 |
| 197 | Contact Output 6 | 1 |
| 198 | Contact Output 7 | 1 |
| 199 | Contact Output 8 | 1 |
| 200 | Contact Output 9 | 1 |

**Table D–3: BINARY INPUTS (Sheet 6 of 11)**

| point | name/description | change event class |
|-------|------------------|--------------------|
| 201 | Contact Output 10 | 1 |
| 202 | Contact Output 11 | 1 |
| 203 | Contact Output 12 | 1 |
| 204 | Contact Output 13 | 1 |
| 205 | Contact Output 14 | 1 |
| 206 | Contact Output 15 | 1 |
| 207 | Contact Output 16 | 1 |
| 208 | Contact Output 17 | 1 |
| 209 | Contact Output 18 | 1 |
| 210 | Contact Output 19 | 1 |
| 211 | Contact Output 20 | 1 |
| 212 | Contact Output 21 | 1 |
| 213 | Contact Output 22 | 1 |
| 214 | Contact Output 23 | 1 |
| 215 | Contact Output 24 | 1 |
| 216 | Contact Output 25 | 1 |
| 217 | Contact Output 26 | 1 |
| 218 | Contact Output 27 | 1 |
| 219 | Contact Output 28 | 1 |
| 220 | Contact Output 29 | 1 |
| 221 | Contact Output 30 | 1 |
| 222 | Contact Output 31 | 1 |
| 223 | Contact Output 32 | 1 |
| 224 | Contact Output 33 | 1 |
| 225 | Contact Output 34 | 1 |
| 226 | Contact Output 35 | 1 |
| 227 | Contact Output 36 | 1 |
| 228 | Contact Output 37 | 1 |
| 229 | Contact Output 38 | 1 |
| 230 | Contact Output 39 | 1 |
| 231 | Contact Output 40 | 1 |
| 232 | Contact Output 41 | 1 |
| 233 | Contact Output 42 | 1 |
| 234 | Contact Output 43 | 1 |
| 235 | Contact Output 44 | 1 |
| 236 | Contact Output 45 | 1 |
| 237 | Contact Output 46 | 1 |
| 238 | Contact Output 47 | 1 |
| 239 | Contact Output 48 | 1 |
| 240 | Contact Output 49 | 1 |
| 241 | Contact Output 50 | 1 |
| 242 | Contact Output 51 | 1 |
| 243 | Contact Output 52 | 1 |
| 244 | Contact Output 53 | 1 |
| 245 | Contact Output 54 | 1 |
| 246 | Contact Output 55 | 1 |
| 247 | Contact Output 56 | 1 |

**D**

**Table D–3: BINARY INPUTS (Sheet 7 of 11)**

| point | name/description | change event class |
|-------|------------------|--------------------|
| 248 | Contact Output 57 | 1 |
| 249 | Contact Output 58 | 1 |
| 250 | Contact Output 59 | 1 |
| 251 | Contact Output 60 | 1 |
| 252 | Contact Output 61 | 1 |
| 253 | Contact Output 62 | 1 |
| 254 | Contact Output 63 | 1 |
| 255 | Contact Output 64 | 1 |
| 256 | Remote Input 1 | 1 |
| 257 | Remote Input 2 | 1 |
| 258 | Remote Input 3 | 1 |
| 259 | Remote Input 4 | 1 |
| 260 | Remote Input 5 | 1 |
| 261 | Remote Input 6 | 1 |
| 262 | Remote Input 7 | 1 |
| 263 | Remote Input 8 | 1 |
| 264 | Remote Input 9 | 1 |
| 265 | Remote Input 10 | 1 |
| 266 | Remote Input 11 | 1 |
| 267 | Remote Input 12 | 1 |
| 268 | Remote Input 13 | 1 |
| 269 | Remote Input 14 | 1 |
| 270 | Remote Input 15 | 1 |
| 271 | Remote Input 16 | 1 |
| 272 | Remote Input 17 | 1 |
| 273 | Remote Input 18 | 1 |
| 274 | Remote Input 19 | 1 |
| 275 | Remote Input 20 | 1 |
| 276 | Remote Input 21 | 1 |
| 277 | Remote Input 22 | 1 |
| 278 | Remote Input 23 | 1 |
| 279 | Remote Input 24 | 1 |
| 280 | Remote Input 25 | 1 |
| 281 | Remote Input 26 | 1 |
| 282 | Remote Input 27 | 1 |
| 283 | Remote Input 28 | 1 |
| 284 | Remote Input 29 | 1 |
| 285 | Remote Input 30 | 1 |
| 286 | Remote Input 31 | 1 |
| 287 | Remote Input 32 | 1 |
| 288 | Remote Device 1 | 1 |
| 289 | Remote Device 2 | 1 |
| 290 | Remote Device 3 | 1 |
| 291 | Remote Device 4 | 1 |
| 292 | Remote Device 5 | 1 |
| 293 | Remote Device 6 | 1 |
| 294 | Remote Device 7 | 1 |

**Table D–3: BINARY INPUTS (Sheet 8 of 11)**

| point | name/description | change event class |
|-------|------------------|--------------------|
| 295 | Remote Device 8 | 1 |
| 296 | Remote Device 9 | 1 |
| 297 | Remote Device 10 | 1 |
| 298 | Remote Device 11 | 1 |
| 299 | Remote Device 12 | 1 |
| 300 | Remote Device 13 | 1 |
| 301 | Remote Device 14 | 1 |
| 302 | Remote Device 15 | 1 |
| 303 | Remote Device 16 | 1 |
| 304 | Phase Instantaneous Overcurrent 1 | 1 |
| 305 | Phase Instantaneous Overcurrent 2 | 1 |
| 320 | Phase Time Overcurrent 1 | 1 |
| 321 | Phase Time Overcurrent 2 | 1 |
| 444 | Auxiliary Undervoltage 1 | 1 |
| 448 | Phase Undervoltage 1 | 1 |
| 449 | Phase Undervoltage 2 | 1 |
| 460 | Neutral Overvoltage 1 | 1 |
| 518 | Sensitive Directional Power 1 | 1 |
| 519 | Sensitive Directional Power 1 | 1 |
| 528 | Source 1 VT Fuse Failure | 1 |
| 529 | Source 2 VT Fuse Failure | 1 |
| 530 | Source 3 VT Fuse Failure | 1 |
| 531 | Source 4 VT Fuse Failure | 1 |
| 576 | Breaker Control 1 | 1 |
| 577 | Breaker Control 2 | 1 |
| 584 | Breaker Failure 1 | 1 |
| 585 | Breaker Failure 2 | 1 |
| 592 | Breaker Arcing Current 1 | 1 |
| 593 | Breaker Arcing Current 2 | 1 |
| 594 | Breaker Arcing Current 3 | 1 |
| 595 | Breaker Arcing Current 4 | 1 |
| 598 | Breaker Flashover 1 | 1 |
| 599 | Breaker Flashover 2 | 1 |
| 616 | Synchrocheck 1 | 1 |
| 617 | Synchrocheck 2 | 1 |
| 640 | Setting Group | 1 |
| 641 | Reset | 1 |
| 679 | Autoreclose 1P/3P | 1 |
| 689 | Selector Switch 1 | 1 |
| 690 | Selector Switch 2 | 1 |
| 694 | Control Pushbutton 1 | 1 |
| 695 | Control Pushbutton 2 | 1 |
| 696 | Control Pushbutton 3 | 1 |
| 697 | Control Pushbutton 4 | 1 |
| 698 | Control Pushbutton 5 | 1 |
| 699 | Control Pushbutton 6 | 1 |
| 700 | Control Pushbutton 7 | 1 |

**D**

**Table D–3: BINARY INPUTS (Sheet 9 of 11)**

| point | name/description | change event class |
|---|---|---|
| 704 | FlexElement™ 1 | 1 |
| 705 | FlexElement™ 2 | 1 |
| 706 | FlexElement™ 3 | 1 |
| 707 | FlexElement™ 4 | 1 |
| 708 | FlexElement™ 5 | 1 |
| 709 | FlexElement™ 6 | 1 |
| 710 | FlexElement™ 7 | 1 |
| 711 | FlexElement™ 8 | 1 |
| 724 | Non-Volatile Latch 1 | 1 |
| 725 | Non-Volatile Latch 2 | 1 |
| 726 | Non-Volatile Latch 3 | 1 |
| 727 | Non-Volatile Latch 4 | 1 |
| 728 | Non-Volatile Latch 5 | 1 |
| 729 | Non-Volatile Latch 6 | 1 |
| 730 | Non-Volatile Latch 7 | 1 |
| 731 | Non-Volatile Latch 8 | 1 |
| 732 | Non-Volatile Latch 9 | 1 |
| 733 | Non-Volatile Latch 10 | 1 |
| 734 | Non-Volatile Latch 11 | 1 |
| 735 | Non-Volatile Latch 12 | 1 |
| 736 | Non-Volatile Latch 13 | 1 |
| 737 | Non-Volatile Latch 14 | 1 |
| 738 | Non-Volatile Latch 15 | 1 |
| 739 | Non-Volatile Latch 16 | 1 |
| 816 | Digital Element 1 | 1 |
| 817 | Digital Element 2 | 1 |
| 818 | Digital Element 3 | 1 |
| 819 | Digital Element 4 | 1 |
| 820 | Digital Element 5 | 1 |
| 821 | Digital Element 6 | 1 |
| 822 | Digital Element 7 | 1 |
| 823 | Digital Element 8 | 1 |
| 824 | Digital Element 9 | 1 |
| 825 | Digital Element 10 | 1 |
| 826 | Digital Element 11 | 1 |
| 827 | Digital Element 12 | 1 |
| 828 | Digital Element 13 | 1 |
| 829 | Digital Element 14 | 1 |
| 830 | Digital Element 15 | 1 |
| 831 | Digital Element 16 | 1 |
| 840 | Eight-Bit Switch 1 | 1 |
| 841 | Eight-Bit Switch 2 | 1 |
| 842 | Eight-Bit Switch 3 | 1 |
| 843 | Eight-Bit Switch 4 | 1 |
| 844 | Eight-Bit Switch 5 | 1 |
| 845 | Eight-Bit Switch 6 | 1 |
| 848 | Digital Counter 1 | 1 |

**Table D–3: BINARY INPUTS (Sheet 10 of 11)**

| point | name/description | change event class |
|---|---|---|
| 849 | Digital Counter 2 | 1 |
| 850 | Digital Counter 3 | 1 |
| 851 | Digital Counter 4 | 1 |
| 852 | Digital Counter 5 | 1 |
| 853 | Digital Counter 6 | 1 |
| 854 | Digital Counter 7 | 1 |
| 855 | Digital Counter 8 | 1 |
| 864 | LED State 1 (IN SERVICE) | 1 |
| 865 | LED State 2 (TROUBLE) | 1 |
| 866 | LED State 3 (TEST MODE) | 1 |
| 867 | LED State 4 (TRIP) | 1 |
| 868 | LED State 5 (ALARM) | 1 |
| 869 | LED State 6 (PICKUP) | 1 |
| 880 | LED State 9 (VOLTAGE) | 1 |
| 881 | LED State 10 (CURRENT) | 1 |
| 882 | LED State 11 (FREQUENCY) | 1 |
| 883 | LED State 12 (OTHER) | 1 |
| 884 | LED State 13 (PHASE A) | 1 |
| 885 | LED State 14 (PHASE B) | 1 |
| 886 | LED State 15 (PHASE C) | 1 |
| 887 | LED State 16 (NTL/GROUND) | 1 |
| 898 | SNTP FAILURE | 1 |
| 899 | BATTERY FAIL | 1 |
| 900 | PRI ETHERNET FAIL | 1 |
| 901 | SEC ETHERNET FAIL | 1 |
| 902 | EEPROM DATA ERROR | 1 |
| 903 | SRAM DATA ERROR | 1 |
| 904 | PROGRAM MEMORY | 1 |
| 905 | WATCHDOG ERROR | 1 |
| 906 | LOW ON MEMORY | 1 |
| 907 | REMOTE DEVICE OFF | 1 |
| 908 | DIRECT DEVICE OFF | |
| 909 | DIRECT RING BREAK | |
| 910 | ANY MINOR ERROR | 1 |
| 911 | ANY MAJOR ERROR | 1 |
| 912 | ANY SELF-TESTS | 1 |
| 913 | IRIG-B FAILURE | 1 |
| 914 | DSP ERROR | 1 |
| 916 | NO DSP INTERUPTS | 1 |
| 917 | UNIT NOT CALIBRATED | 1 |
| 921 | PROTOTYPE FIRMWARE | 1 |
| 922 | FLEXLOGIC ERR TOKEN | 1 |
| 923 | EQUIPMENT MISMATCH | 1 |
| 925 | UNIT NOT PROGRAMMED | 1 |
| 926 | SYSTEM EXCEPTION | 1 |
| 927 | LATCHING OUT ERROR | 1 |
| 984 | User-Programmable Pushbutton 1 | 1 |

**Table D–3: BINARY INPUTS (Sheet 11 of 11)**

| point | name/description | change event class |
|-------|------------------|--------------------|
| 985 | User-Programmable Pushbutton 2 | 1 |
| 986 | User-Programmable Pushbutton 3 | 1 |
| 987 | User-Programmable Pushbutton 4 | 1 |
| 988 | User-Programmable Pushbutton 5 | 1 |
| 989 | User-Programmable Pushbutton 6 | 1 |
| 990 | User-Programmable Pushbutton 7 | 1 |
| 991 | User-Programmable Pushbutton 8 | 1 |
| 992 | User-Programmable Pushbutton 9 | 1 |
| 993 | User-Programmable Pushbutton 10 | 1 |
| 994 | User-Programmable Pushbutton 11 | 1 |
| 995 | User-Programmable Pushbutton 12 | 1 |

**D**

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 D–4: 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 |

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: **2**

**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: **2**

---

**Table D–5: 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. C60 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.

The following table lists Analog Inputs (Object 30). 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.

When using the C60 in DNP systems with limited memory, the Analog Input Points below may be replaced with a user-definable list. This user-definable list uses the same settings as the Modbus User Map and can be configured with the Modbus User Map settings. When used with DNP, each entry in the Modbus User Map represents the starting Modbus address of a data item available as a DNP Analog Input point. To enable use of the Modbus User Map for DNP Analog Input points, set the **USER MAP FOR DNP ANALOGS** setting to Enabled (this setting is in the **PRODUCT SETUP** ⇨⇩ **COMMUNICATIONS** ⇨⇩ **DNP PROTOCOL** menu). The new DNP Analog points list can be checked via the "DNP Analog Input Points List" webpage, accessible from the "Device Information menu" webpage.

> **NOTE**
>
> After changing the **USER MAP FOR DNP ANALOGS** setting, the relay must be powered off and then back on for the setting to take effect.

Only Source 1 data points are shown in the following table. If the **NUMBER OF SOURCES IN ANALOG LIST** setting is increased, data points for subsequent sources will be added to the list immediately following the Source 1 data points.

Units for Analog Input points are as follows:

- Current:           A (amps)
- Voltage:           V (volts)
- Real Power:        W (watts)
- Reactive Power:    var (vars)
- Apparent Power:    VA (volt-amps)
- Energy             Wh, varh (watt-hours, var-hours)

- Frequency:         Hz (hertz)
- Angle:             degrees
- Ohm Input:         ohms
- RTD Input:         °C (degrees Celsius)

---

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: **800**

Default Class for all Points: **1**

---

**Table D–6: ANALOG INPUT POINTS (Sheet 1 of 3)**

| POINT | DESCRIPTION |
|---|---|
| 0 | SRC 1 Phase A Current RMS |
| 1 | SRC 1 Phase B Current RMS |
| 2 | SRC 1 Phase C Current RMS |
| 3 | SRC 1 Neutral Current RMS |
| 4 | SRC 1 Phase A Current Magnitude |
| 5 | SRC 1 Phase A Current Angle |
| 6 | SRC 1 Phase B Current Magnitude |
| 7 | SRC 1 Phase B Current Angle |
| 8 | SRC 1 Phase C Current Magnitude |
| 9 | SRC 1 Phase C Current Angle |
| 10 | SRC 1 Neutral Current Magnitude |
| 11 | SRC 1 Neutral Current Angle |
| 12 | SRC 1 Ground Current RMS |
| 13 | SRC 1 Ground Current Magnitude |
| 14 | SRC 1 Ground Current Angle |
| 15 | SRC 1 Zero Sequence Current Magnitude |
| 16 | SRC 1 Zero Sequence Current Angle |
| 17 | SRC 1 Positive Sequence Current Magnitude |
| 18 | SRC 1 Positive Sequence Current Angle |
| 19 | SRC 1 Negative Sequence Current Magnitude |
| 20 | SRC 1 Negative Sequence Current Angle |
| 21 | SRC 1 Differential Ground Current Magnitude |
| 22 | SRC 1 Differential Ground Current Angle |
| 23 | SRC 1 Phase AG Voltage RMS |
| 24 | SRC 1 Phase BG Voltage RMS |
| 25 | SRC 1 Phase CG Voltage RMS |
| 26 | SRC 1 Phase AG Voltage Magnitude |
| 27 | SRC 1 Phase AG Voltage Angle |
| 28 | SRC 1 Phase BG Voltage Magnitude |
| 29 | SRC 1 Phase BG Voltage Angle |
| 30 | SRC 1 Phase CG Voltage Magnitude |
| 31 | SRC 1 Phase CG Voltage Angle |
| 32 | SRC 1 Phase AB Voltage RMS |
| 33 | SRC 1 Phase BC Voltage RMS |
| 34 | SRC 1 Phase CA Voltage RMS |
| 35 | SRC 1 Phase AB Voltage Magnitude |
| 36 | SRC 1 Phase AB Voltage Angle |
| 37 | SRC 1 Phase BC Voltage Magnitude |
| 38 | SRC 1 Phase BC Voltage Angle |
| 39 | SRC 1 Phase CA Voltage Magnitude |
| 40 | SRC 1 Phase CA Voltage Angle |
| 41 | SRC 1 Auxiliary Voltage RMS |
| 42 | SRC 1 Auxiliary Voltage Magnitude |
| 43 | SRC 1 Auxiliary Voltage Angle |
| 44 | SRC 1 Zero Sequence Voltage Magnitude |
| 45 | SRC 1 Zero Sequence Voltage Angle |
| 46 | SRC 1 Positive Sequence Voltage Magnitude |
| 47 | SRC 1 Positive Sequence Voltage Angle |
| 48 | SRC 1 Negative Sequence Voltage Magnitude |
| 49 | SRC 1 Negative Sequence Voltage Angle |
| 50 | SRC 1 Three Phase Real Power |
| 51 | SRC 1 Phase A Real Power |

**Table D–6: ANALOG INPUT POINTS (Sheet 2 of 3)**

| POINT | DESCRIPTION |
|---|---|
| 52 | SRC 1 Phase B Real Power |
| 53 | SRC 1 Phase C Real Power |
| 54 | SRC 1 Three Phase Reactive Power |
| 55 | SRC 1 Phase A Reactive Power |
| 56 | SRC 1 Phase B Reactive Power |
| 57 | SRC 1 Phase C Reactive Power |
| 58 | SRC 1 Three Phase Apparent Power |
| 59 | SRC 1 Phase A Apparent Power |
| 60 | SRC 1 Phase B Apparent Power |
| 61 | SRC 1 Phase C Apparent Power |
| 62 | SRC 1 Three Phase Power Factor |
| 63 | SRC 1 Phase A Power Factor |
| 64 | SRC 1 Phase B Power Factor |
| 65 | SRC 1 Phase C Power Factor |
| 66 | SRC 1 Positive Watthour |
| 67 | SRC 1 Negative Watthour |
| 68 | SRC 1 Positive Varhour |
| 69 | SRC 1 Negative Varhour |
| 70 | SRC 1 Frequency |
| 71 | SRC 1 Demand Ia |
| 72 | SRC 1 Demand Ib |
| 73 | SRC 1 Demand Ic |
| 74 | SRC 1 Demand Watt |
| 75 | SRC 1 Demand Var |
| 76 | SRC 1 Demand Va |
| 77 | Sens Dir Power 1 Actual |
| 78 | Sens Dir Power 2 Actual |
| 79 | Breaker 1 Arcing Amp Phase A |
| 80 | Breaker 1 Arcing Amp Phase B |
| 81 | Breaker 1 Arcing Amp Phase C |
| 82 | Breaker 2 Arcing Amp Phase A |
| 83 | Breaker 2 Arcing Amp Phase B |
| 84 | Breaker 2 Arcing Amp Phase C |
| 85 | Fault 1 Prefault Phase A Current Magnitude |
| 86 | Fault 1 Prefault Phase A Current Angle |
| 87 | Fault 1 Prefault Phase B Current Magnitude |
| 88 | Fault 1 Prefault Phase B Current Angle |
| 89 | Fault 1 Prefault Phase C Current Magnitude |
| 90 | Fault 1 Prefault Phase C Current Angle |
| 91 | Fault 1 Prefault Phase A Voltage Magnitude |
| 92 | Fault 1 Prefault Phase A Voltage Angle |
| 93 | Fault 1 Prefault Phase B Voltage Magnitude |
| 94 | Fault 1 Prefault Phase B Voltage Angle |
| 95 | Fault 1 Prefault Phase C Voltage Magnitude |
| 96 | Fault 1 Prefault Phase C Voltage Angle |
| 97 | Fault 1 Postfault Phase A Current Magnitude |
| 98 | Fault 1 Postfault Phase A Current Angle |
| 99 | Fault 1 Postfault Phase B Current Magnitude |
| 100 | Fault 1 Postfault Phase B Current Angle |
| 101 | Fault 1 Postfault Phase C Current Magnitude |
| 102 | Fault 1 Postfault Phase C Current Angle |
| 103 | Fault 1 Postfault Phase A Voltage Magnitude |

**Table D–6: ANALOG INPUT POINTS (Sheet 3 of 3)**

| POINT | DESCRIPTION |
|---|---|
| 104 | Fault 1 Postfault Phase A Voltage Angle |
| 105 | Fault 1 Postfault Phase B Voltage Magnitude |
| 106 | Fault 1 Postfault Phase B Voltage Angle |
| 107 | Fault 1 Postfault Phase C Voltage Magnitude |
| 108 | Fault 1 Postfault Phase C Voltage Angle |
| 109 | Fault 1 Type |
| 110 | Fault 1 Location |
| 111 | Synchrocheck 1 Delta Voltage |
| 112 | Synchrocheck 1 Delta Frequency |
| 113 | Synchrocheck 1 Delta Phase |
| 114 | Synchrocheck 2 Delta Voltage |
| 115 | Synchrocheck 2 Delta Frequency |
| 116 | Synchrocheck 2 Delta Phase |
| 117 | DCMA Inputs 1 Value |
| 118 | DCMA Inputs 2 Value |
| 119 | DCMA Inputs 3 Value |
| 120 | DCMA Inputs 4 Value |
| 121 | RTD Inputs 1 Value |
| 122 | RTD Inputs 2 Value |
| 123 | RTD Inputs 3 Value |
| 124 | RTD Inputs 4 Value |
| 125 | Tracking Frequency |
| 126 | FlexElement 1 Actual |
| 127 | FlexElement 2 Actual |
| 128 | FlexElement 3 Actual |
| 129 | FlexElement 4 Actual |
| 130 | FlexElement 5 Actual |
| 131 | FlexElement 6 Actual |
| 132 | FlexElement 7 Actual |
| 133 | FlexElement 8 Actual |
| 134 | Current Setting Group |

**D**

**Table E–1: REVISION HISTORY**

| MANUAL P/N | C60 REVISION | RELEASE DATE | ECO |
|---|---|---|---|
| 1601-0100-A1 | 1.6x | 11 August 1999 | --- |
| 1601-0100-A2 | 1.8x | 29 October 1999 | URC-005 |
| 1601-0100-A3 | 1.8x | 15 November 1999 | URC-007 |
| 1601-0100-A4 | 2.0x | 17 December 1999 | URC-010 |
| 1601-0100-A5 | 2.2x | 12 May 2000 | URC-012 |
| 1601-0100-A6 | 2.2x | 14 June 2000 | URC-014 |
| 1601-0100-A6a | 2.2x | 28 June 2000 | URC-014a |
| 1601-0100-B1 | 2.4x | 08 September 2000 | URC-016 |
| 1601-0100-B2 | 2.4x | 03 November 2000 | URC-018 |
| 1601-0100-B3 | 2.6x | 09 March 2001 | URC-020 |
| 1601-0100-B4 | 2.8x | 11 October 2001 | URC-023 |
| 1601-0100-B5 | 2.9x | 03 December 2001 | URC-025 |
| 1601-0100-B6 | 2.6x | 27 February 2004 | URX-120 |
| 1601-0100-C1 | 3.0x | 02 July 2002 | URC-027 |
| 1601-0100-C2 | 3.1x | 30 August 2002 | URC-029 |
| 1601-0100-C3 | 3.0x | 18 November 2002 | URC-032 |
| 1601-0100-C4 | 3.1x | 18 November 2002 | URC-033 |
| 1601-0100-C5 | 3.0x | 11 February 2003 | URC-036 |
| 1601-0100-C6 | 3.1x | 11 February 2003 | URC-037 |
| 1601-0100-D1 | 3.2x | 11 February 2003 | URC-039 |
| 1601-0100-D2 | 3.2x | 02 June 2003 | URX-084 |
| 1601-0100-E1 | 3.3x | 01 May 2003 | URX-080 |
| 1601-0100-E2 | 3.3x | 29 May 2003 | URX-083 |
| 1601-0100-F1 | 3.4x | 10 December 2003 | URX-111 |
| 1601-0100-F2 | 3.4x | 09 February 2004 | URX-115 |
| 1601-0100-G1 | 4.0x | 23 March 2004 | URX-123 |
| 1601-0100-G2 | 4.0x | 17 May 2004 | URX-136 |
| 1601-0100-H1 | 4.2x | 30 June 2004 | URX-145 |
| 1601-0100-H2 | 4.2x | 23 July 2004 | URX-151 |
| 1601-0100-J1 | 4.4x | 15 September 2004 | URX-156 |
| 1601-0100-J2 | 4.4x | 05 January 2005 | URX-173 |

**E.1.2 CHANGES TO THE C60 MANUAL**

**Table E–2: MAJOR UPDATES FOR C60 MANUAL REVISION J2**

| PAGE (J1) | PAGE (J2) | CHANGE | DESCRIPTION |
|---|---|---|---|
| Title | Title | Update | Manual part number to 1601-0100-J2 |
| | | | |
| 3-19 | 3-19 | Update | Updated RS485 SERIAL CONNECTION diagram to 827757A7 |

### Table E–3: MAJOR UPDATES FOR C60 MANUAL REVISION J1

| PAGE (H2) | PAGE (J1) | CHANGE | DESCRIPTION |
|---|---|---|---|
| Title | Title | Update | Manual part number to 1601-0100-J1 |
| | | | |
| 5-15 | --- | Remove | Removed UCA/MMS PROTOCOL sub-section |
| --- | 5-15 | Add | Added IEC 61850 PROTOCOL sub-section |
| 5-45 | 5-45 | Update | Updated BREAKERS sub-section |
| 5-145 | 5-142 | Update | Updated VIRTUAL INPUTS sub-section |
| | | | |
| B-8 | B-8 | Update | Updated MODBUS MEMORY MAP for firrmware revision 4.4x |
| | | | |
| C-1 | --- | Remove | Removed UCA/MMS COMMUNICATIONS appendix |

### Table E–4: MAJOR UPDATES FOR C60 MANUAL REVISION H2

| PAGE (H1) | PAGE (H2) | CHANGE | DESCRIPTION |
|---|---|---|---|
| Title | Title | Update | Manual part number to 1601-0100-H2 |
| | | | |
| 3-22 | 3-22 | Update | Updated CHANNEL COMMUNICATION OPTIONS table |

### Table E–5: MAJOR UPDATES FOR C60 MANUAL REVISION H1

| PAGE (G2) | PAGE (H1) | CHANGE | DESCRIPTION |
|---|---|---|---|
| Title | Title | Update | Manual part number to 1601-0100-H1. |
| | | | |
| 1-12 | 1-13 | Update | Updated COMMISSIONING section |
| | | | |
| 2-2 | 2-2 | Update | Updated C60 ORDER CODES table |
| 2-5 | 2-5 | Update | Updated PROTECTION ELEMENTS specifications for Breaker Flashover |
| | | | |
| 3-10 | 3-10 | Update | Updated FORM-A CONTACT FUNCTIONS diagram to 827821A5 |
| | | | |
| 5-13 | 5-13 | Update | Updated DNP PROTOCOL sub-section to reflect new settings |
| 5-20 | 5-20 | Update | Updated FAULT REPORTS section |
| 5-57 | 5-57 | Update | Updated FLEXLOGIC™ OPERANDS table for firmware release 4.2x |
| 5-116 | 5-116 | Update | Updated AUTORECLOSE section |
| --- | 5-135 | Add | Added BREAKER FLASHOVER section |
| | | | |
| B-8 | B-8 | Update | Updated MODBUS MEMORY MAP for firmware release 4.2x |

### Table E–6: MAJOR UPDATES FOR C60 MANUAL REVISION G2

| PAGE (G1) | PAGE (G2) | CHANGE | DESCRIPTION |
|---|---|---|---|
| Title | Title | Update | Manual part number to 1601-0100-G2. |
| | | | |
| 3-6 | 3-6 | Update | Updated TYPICAL WIRING DIAGRAM to 834723A2. |

**Table E–7: MAJOR UPDATES FOR C60 MANUAL REVISION G1**

| PAGE (F2) | PAGE (G1) | CHANGE | DESCRIPTION |
|---|---|---|---|
| Title | Title | Update | Manual part number to 1601-0100-G1. |
| | | | |
| 2-3 | 2-3 | Update | Updated C60 ORDER CODES table |
| 2-4 | 2-4 | Update | Updated ORDER CODES FOR REPLACEMENT MODULES table |
| 2-9 | 2-9 | Add | Added dcmA and IRIG-B outputs specifications to OUTPUTS section |
| | | | |
| 3-4 | 3-4 | Update | Updated MODULE WITHDRAWAL AND INSERTION section to reflect new hardware |
| 3-7 | 3-7 | Update | Updated DIELECTRIC STRENGTH section |
| 3-8 | 3-8 | Update | Updated CT/VT MODULES section for new hardware |
| 3-16 | 3-16 | Update | Updated drawings and description in TRANSDUCER INPUTS/OUTPUTS section |
| 3-17 | 3-18 | Update | Updated drawings and description in CPU COMMUNICATIONS PORTS section |
| 3-19 | 3-20 | Update | Updated IRIG-B section to indicate updated functionality |
| | | | |
| 5-17 | 5-17 | Add | Added EGD PROTOCOL sub-section for Ethernet Global Data protocol |
| 5-17 | 5-19 | Update | Updated REAL TIME CLOCK section |
| 5-18 | 5-20 | Update | Updated FAULT REPORTS section to indicate settings moved from deleted LINE section |
| 5-42 | --- | Remove | Removed LINE section. These settings are now part of the FAULT REPORTS section |
| 5-55 | 5-57 | Update | Updated FLEXLOGIC™ OPERANDS table |
| 5-67 | 5-69 | Update | Updated FLEXELEMENT™ SCHEME LOGIC diagram to 842004A3 |
| 5-68 | 5-70 | Update | Updated FLEXELEMENT™ INPUT MODE SETTING diagram to 842706A2 |
| 5-147 | 5-149 | Add | Added DCMA OUTPUTS section |
| | | | |
| 6-7 | 6-7 | Add | Added EGD PROTOCOL STATUS section |
| 6-17 | 6-17 | Update | Updated FAULT REPORTS section |
| | | | |
| B-8 | B-8 | Update | Updated MODBUS MEMORY MAP for firmware release 4.0x |

**E**

A.................... Ampere
AC ................. Alternating Current
A/D ................ Analog to Digital
AE ................. Accidental Energization, Application Entity
AMP .............. Ampere
ANG .............. Angle
ANSI.............. American National Standards Institute
AR ................. Automatic Reclosure
ASDU ............ Application-layer Service Data Unit
ASYM............. Asymmetry
AUTO ............ Automatic
AUX............... Auxiliary
AVG............... Average

BER............... Bit Error Rate
BF.................. Breaker Fail
BFI................. Breaker Failure Initiate
BKR............... Breaker
BLK .............. Block
BLKG............. Blocking
BPNT............. Breakpoint of a characteristic
BRKR ............ Breaker

CAP............... Capacitor
CC ................. Coupling Capacitor
CCVT ............ Coupling Capacitor Voltage Transformer
CFG............... Configure / Configurable
.CFG.............. Filename extension for oscillography files
CHK............... Check
CHNL ............ Channel
CLS ............... Close
CLSD............. Closed
CMND ........... Command
CMPRSN........ Comparison
CO................. Contact Output
COM.............. Communication
COMM........... Communications
COMP ........... Compensated, Comparison
CONN........... Connection
CONT............ Continuous, Contact
CO-ORD......... Coordination
CPU............... Central Processing Unit
CRC .............. Cyclic Redundancy Code
CRT, CRNT .... Current
CSA............... Canadian Standards Association
CT ................. Current Transformer
CVT ............... Capacitive Voltage Transformer

D/A ................ Digital to Analog
DC (dc).......... Direct Current
DD ................. Disturbance Detector
DFLT ............. Default
DGNST........... Diagnostics
DI.................... Digital Input
DIFF .............. Differential
DIR ................ Directional
DISCREP ....... Discrepancy
DIST .............. Distance
DMD .............. Demand
DNP................ Distributed Network Protocol
DPO .............. Dropout
DSP............... Digital Signal Processor
dt ................... Rate of Change
DTT ............... Direct Transfer Trip
DUTT............. Direct Under-reaching Transfer Trip

ENCRMNT ..... Encroachment
EPRI............... Electric Power Research Institute
.EVT .............. Filename extension for event recorder files
EXT ............... Extension, External

F .................... Field
FAIL................ Failure
FD ................. Fault Detector
FDH............... Fault Detector high-set
FDL ............... Fault Detector low-set
FLA................. Full Load Current
FO ................. Fiber Optic

FREQ............. Frequency
FSK............... Frequency-Shift Keying
FTP ............... File Transfer Protocol
FxE ............... FlexElement™
FWD.............. Forward

G ................... Generator
GE................. General Electric
GND.............. Ground
GNTR............ Generator
GOOSE......... General Object Oriented Substation Event
GPS .............. Global Positioning System

HARM ........... Harmonic / Harmonics
HCT .............. High Current Time
HGF .............. High-Impedance Ground Fault (CT)
HIZ ............... High-Impedance and Arcing Ground
HMI ............... Human-Machine Interface
HTTP ............ Hyper Text Transfer Protocol
HYB .............. Hybrid

I...................... Instantaneous
I_0................. Zero Sequence current
I_1 ................. Positive Sequence current
I_2 ................. Negative Sequence current
IA .................. Phase A current
IAB ............... Phase A minus B current
IB .................. Phase B current
IBC................ Phase B minus C current
IC .................. Phase C current
ICA................ Phase C minus A current
ID .................. Identification
IED................ Intelligent Electronic Device
IEC................ International Electrotechnical Commission
IEEE.............. Institute of Electrical and Electronic Engineers
IG .................. Ground (not residual) current
Igd ................. Differential Ground current
IN .................. CT Residual Current (3Io) or Input
INC SEQ ........ Incomplete Sequence
INIT ............... Initiate
INST.............. Instantaneous
INV ............... Inverse
I/O ................. Input/Output
IOC ............... Instantaneous Overcurrent
IOV................ Instantaneous Overvoltage
IRIG .............. Inter-Range Instrumentation Group
ISO................ International Standards Organization
IUV................ Instantaneous Undervoltage

K0 ................. Zero Sequence Current Compensation
kA.................. kiloAmpere
kV.................. kiloVolt

LED................ Light Emitting Diode
LEO............... Line End Open
LFT BLD ........ Left Blinder
LOOP............ Loopback
LPU............... Line Pickup
LRA................ Locked-Rotor Current
LTC ............... Load Tap-Changer

M ................... Machine
mA ................ MilliAmpere
MAG.............. Magnitude
MAN.............. Manual / Manually
MAX .............. Maximum
MIC ............... Model Implementation Conformance
MIN ............... Minimum, Minutes
MMI............... Man Machine Interface
MMS ............. Manufacturing Message Specification
MRT .............. Minimum Response Time
MSG.............. Message
MTA............... Maximum Torque Angle
MTR .............. Motor
MVA .............. MegaVolt-Ampere (total 3-phase)
MVA_A .......... MegaVolt-Ampere (phase A)
MVA_B .......... MegaVolt-Ampere (phase B)
MVA_C.......... MegaVolt-Ampere (phase C)

MVAR ............ MegaVar (total 3-phase)
MVAR_A......... MegaVar (phase A)
MVAR_B......... MegaVar (phase B)
MVAR_C ........ MegaVar (phase C)
MVARH ......... MegaVar-Hour
MW................ MegaWatt (total 3-phase)
MW_A ........... MegaWatt (phase A)
MW_B ........... MegaWatt (phase B)
MW_C ........... MegaWatt (phase C)
MWH .............. MegaWatt-Hour

N..................... Neutral
N/A, n/a .......... Not Applicable
NEG .............. Negative
NMPLT .......... Nameplate
NOM.............. Nominal
NSAP ............ Network Service Access Protocol
NTR............... Neutral

O ................... Over
OC, O/C ......... Overcurrent
O/P, Op........... Output
OP ................. Operate
OPER ............ Operate
OPERATG...... Operating
O/S ................ Operating System
OSI................ Open Systems Interconnect
OSB............... Out-of-Step Blocking
OUT............... Output
OV ................. Overvoltage
OVERFREQ ... Overfrequency
OVLD ............ Overload

P..................... Phase
PC ................. Phase Comparison, Personal Computer
PCNT ............ Percent
PF................... Power Factor (total 3-phase)
PF_A ............. Power Factor (phase A)
PF_B ............. Power Factor (phase B)
PF_C ............. Power Factor (phase C)
PFLL............... Phase and Frequency Lock Loop
PHS............... Phase
PICS.............. Protocol Implementation & Conformance
                Statement
PKP ............... Pickup
PLC ............... Power Line Carrier
POS............... Positive
POTT............. Permissive Over-reaching Transfer Trip
PRESS .......... Pressure
PRI ................ Primary
PROT ............ Protection
PSEL ............. Presentation Selector
pu .................. Per Unit
PUIB.............. Pickup Current Block
PUIT .............. Pickup Current Trip
PUSHBTN ...... Pushbutton
PUTT............. Permissive Under-reaching Transfer Trip
PWM ............. Pulse Width Modulated
PWR.............. Power

QUAD............ Quadrilateral

R..................... Rate, Reverse
RCA................ Reach Characteristic Angle
REF ............... Reference
REM .............. Remote
REV............... Reverse
RI................... Reclose Initiate
RIP ................ Reclose In Progress
RGT BLD........ Right Blinder
ROD .............. Remote Open Detector
RST ............... Reset
RSTR ............ Restrained
RTD............... Resistance Temperature Detector
RTU............... Remote Terminal Unit
RX (Rx) ......... Receive, Receiver

s .................... second
S..................... Sensitive

SAT ............... CT Saturation
SBO .............. Select Before Operate
SCADA .......... Supervisory Control and Data Acquisition
SEC .............. Secondary
SEL ............... Select / Selector / Selection
SENS ............ Sensitive
SEQ .............. Sequence
SIR................ Source Impedance Ratio
SNTP ............ Simple Network Time Protocol
SRC .............. Source
SSB............... Single Side Band
SSEL.............. Session Selector
STATS ........... Statistics
SUPN............ Supervision
SUPV ............ Supervise / Supervision
SV ................. Supervision, Service
SYNC............ Synchrocheck
SYNCHCHK... Synchrocheck

T..................... Time, transformer
TC ................. Thermal Capacity
TCP............... Transmission Control Protocol
TCU .............. Thermal Capacity Used
TD MULT........ Time Dial Multiplier
TEMP............ Temperature
TFTP ............. Trivial File Transfer Protocol
THD .............. Total Harmonic Distortion
TMR .............. Timer
TOC .............. Time Overcurrent
TOV............... Time Overvoltage
TRANS.......... Transient
TRANSF ........ Transfer
TSEL.............. Transport Selector
TUC .............. Time Undercurrent
TUV............... Time Undervoltage
TX (Tx)........... Transmit, Transmitter

U ................... Under
UC................. Undercurrent
UCA .............. Utility Communications Architecture
UDP .............. User Datagram Protocol
UL ................. Underwriters Laboratories
UNBAL........... Unbalance
UR................. Universal Relay
URC .............. Universal Recloser Control
.URS ............. Filename extension for settings files
UV ................. Undervoltage

V/Hz .............. Volts per Hertz
V_0 ............... Zero Sequence voltage
V_1 ............... Positive Sequence voltage
V_2 ............... Negative Sequence voltage
VA ................. Phase A voltage
VAB ............... Phase A to B voltage
VAG............... Phase A to Ground voltage
VARH ............ Var-hour voltage
VB ................. Phase B voltage
VBA............... Phase B to A voltage
VBG .............. Phase B to Ground voltage
VC................. Phase C voltage
VCA .............. Phase C to A voltage
VCG .............. Phase C to Ground voltage
VF ................. Variable Frequency
VIBR .............. Vibration
VT ................. Voltage Transformer
VTFF ............. Voltage Transformer Fuse Failure
VTLOS .......... Voltage Transformer Loss Of Signal

WDG ............. Winding
WH................. Watt-hour
w/ opt ............ With Option
WRT.............. With Respect To

X ................... Reactance
XDUCER........ Transducer
XFMR............ Transformer

Z..................... Impedance, Zone

**E**

**E**

# 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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