GE Industrial Systems

F60 Feeder Management Relay

UR Series Instruction Manual

F60 Revision: 4.9x

Manual P/N: 1601-0093-**M2** (GEK-113206A)

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QMI # 005094
UL # A3775

ADDENDUM

This Addendum contains information that relates to the F60 Feeder Management Relay relay, version 4.9x. This addendum lists a number of information items that appear in the instruction manual GEK-113206A (revision **M2**) but are not included in the current F60 operations.

The following functions/items are not yet available with the current version of the F60 relay:

- Signal Sources SRC 5 and SRC 6

Version 4.0x and higher releases of the F60 relay includes new hardware (CPU and CT/VT modules).

- The new CPU modules are specified with the following order codes: 9E, 9G, 9H, 9J, 9K, 9L, 9M, 9N, 9P, and 9R.
- 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 (Ethernet, Modbus TCP/IP, DNP)
	9D	9H	RS485 and redundant 10Base-F (Ethernet, Modbus TCP/IP, DNP)
	--	9J	RS485 and multi-mode ST 100Base-FX
	--	9K	RS485 and multi-mode ST redundant 100Base-FX
	--	9L	RS485 and single mode SC 100Base-FX
	--	9M	RS485 and single mode SC redundant 100Base-FX
	--	9N	RS485 and 10/100Base-T
	--	9P	RS485 and single mode ST 100Base-FX
	--	9R	RS485 and single mode ST redundant 100Base-FX
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, 9J, 9K, 9L, 9M, 9N, 9P, 9R), 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.

B. MODBUS COMMUNICATIONS

B.1 MODBUS RTU PROTOCOL

B.2 MODBUS FUNCTION CODES

B.3 FILE TRANSFERS

B.4 MEMORY MAPPING

C. IEC 61850 COMMUNICATIONS

C.1 INTRODUCTION

C.2 ACSI CONFORMANCE

C.3 LOGICAL NODES

D. IEC 60870-5-104 COMMUNICATIONS

D.1 IEC 60870-5-104

E. DNP COMMUNICATIONS

E.1 DEVICE PROFILE DOCUMENT

E.2 DNP POINT LISTS

F. MISCELLANEOUS

F.1 CHANGE NOTES

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 CAUTIONS 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.

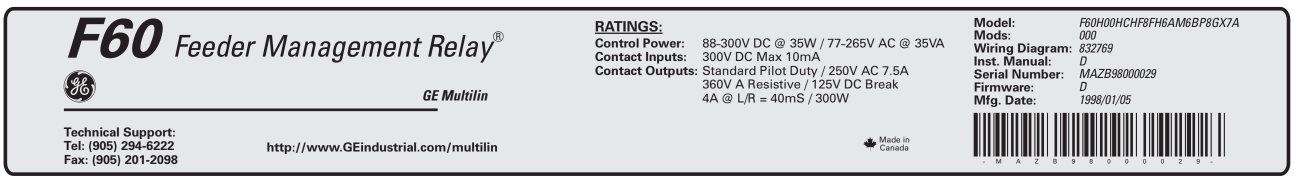

Figure 1–1: REAR NAMEPLATE (EXAMPLE)

- 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:**

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Canada L6E 1B3

TELEPHONE: (905) 294-6222, 1-800-547-8629 (North America only)
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HOME PAGE: http://www.GEindustrial.com/multilin

1.2.1 INTRODUCTION TO THE UR

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

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

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

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

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

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

1.2.2 HARDWARE ARCHITECTURE

a) UR BASIC DESIGN

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

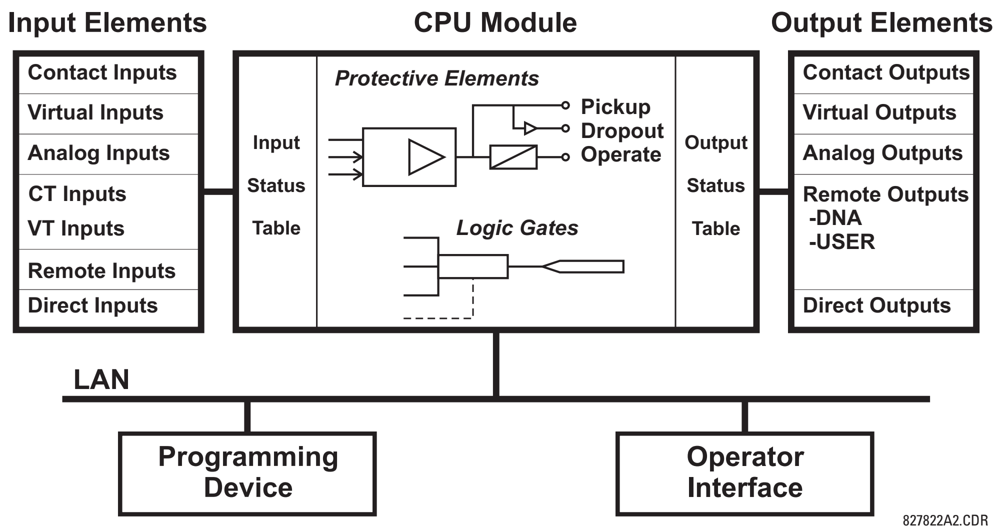


Figure 1–2: UR CONCEPT BLOCK DIAGRAM

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

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

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

b) UR SIGNAL TYPES

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

The **virtual inputs and outputs** are digital signals associated with UR-series internal logic signals. Virtual inputs include signals generated by the local user interface. The virtual outputs are outputs of FlexLogic™ equations used to customize the device. Virtual outputs can also serve as virtual inputs to FlexLogic™ equations.

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

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

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

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

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.

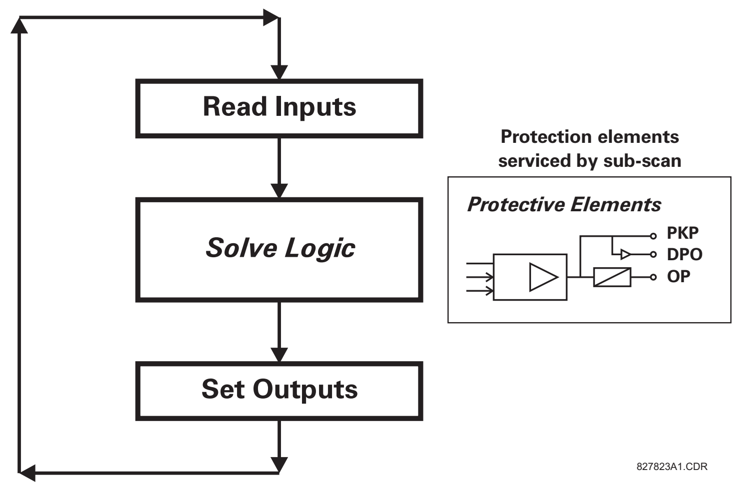


Figure 1–3: UR-SERIES SCAN OPERATION

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.

1.3.1 PC REQUIREMENTS

The faceplate keypad and display or the EnerVista UR Setup software interface can be used to communicate with the relay. The EnerVista UR Setup software interface is the preferred method to edit settings and view actual values because the PC monitor can display more information in a simple comprehensible format.

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

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

The following qualified modems have been tested to be compliant with the F60 and the EnerVista UR Setup software.

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

1.3.2 INSTALLATION

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

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

5. In the enerVista Launch Pad window, click the **Install Software** button and select the “F60 Feeder 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 F60.

6. Select the F60 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.

10. Click **Finish** to end the installation. The F60 device will be added to the list of installed IEDs in the enerVista Launchpad window, as shown below.

1.3.3 CONNECTING ENERVISTA UR SETUP WITH THE F60

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** ⇨ **MODBUS 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 F60 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.

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

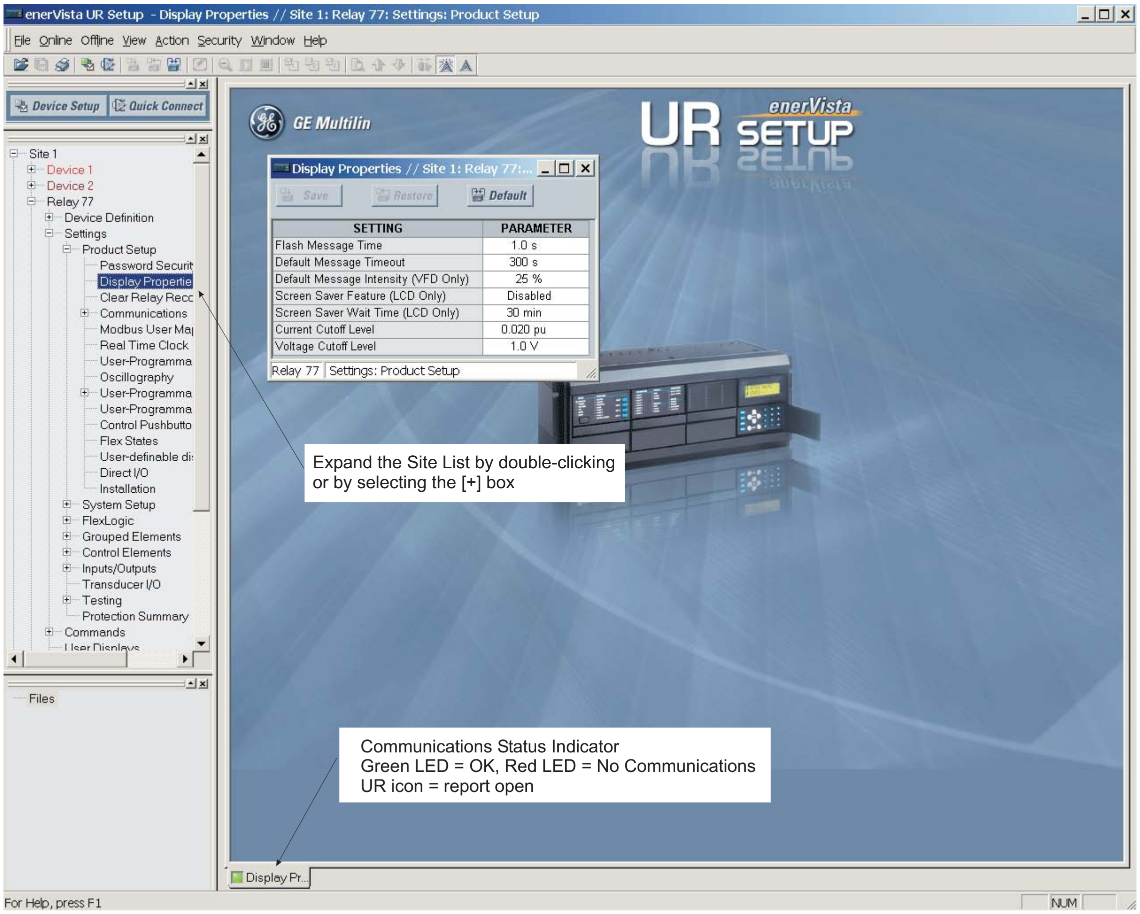
Before starting, verify that the RS232 serial cable is properly connected to the RS232 port on the front panel of the relay.

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 F60 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:



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2. The Display Properties window will open with a status indicator on the lower left of the EnerVista UR Setup window.
3. If the status indicator is red, verify that the Ethernet network cable is properly connected to the Ethernet port on the back of the relay and that the relay has been properly setup for communications (steps A and B earlier).

   If a relay icon appears in place of the status indicator, than a report (such as an oscillography or event record) is open. Close the report to re-display the green status indicator.
4. The Display Properties settings can now be edited, printed, or changed according to user specifications.

NOTE

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

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.

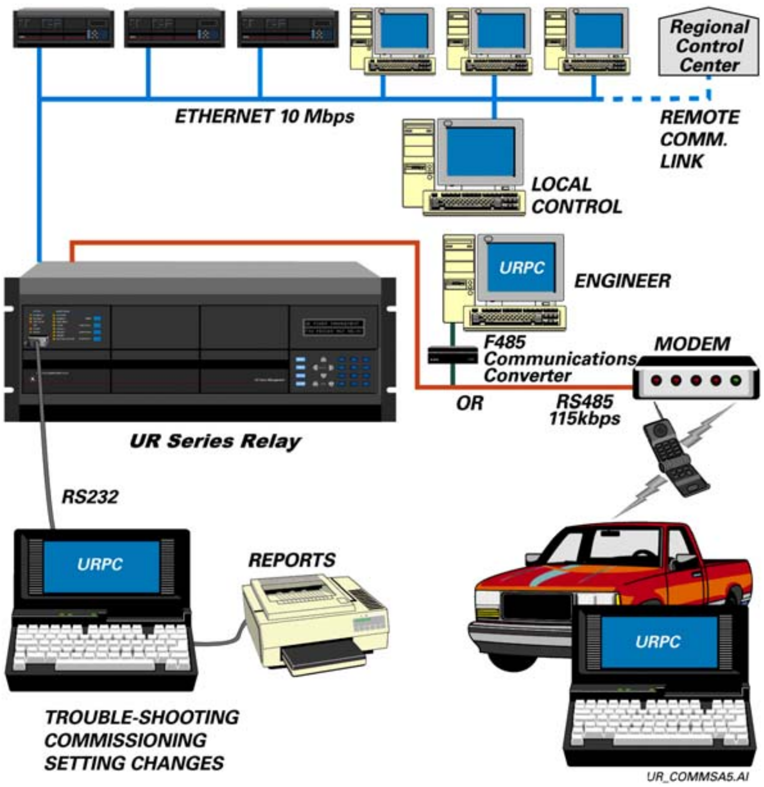


Figure 1–4: RELAY COMMUNICATIONS OPTIONS

To communicate through the F60 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 F60 rear communications port. The converter terminals (+, –, GND) are connected to the F60 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.

1.5.1 FACEPLATE KEYPAD

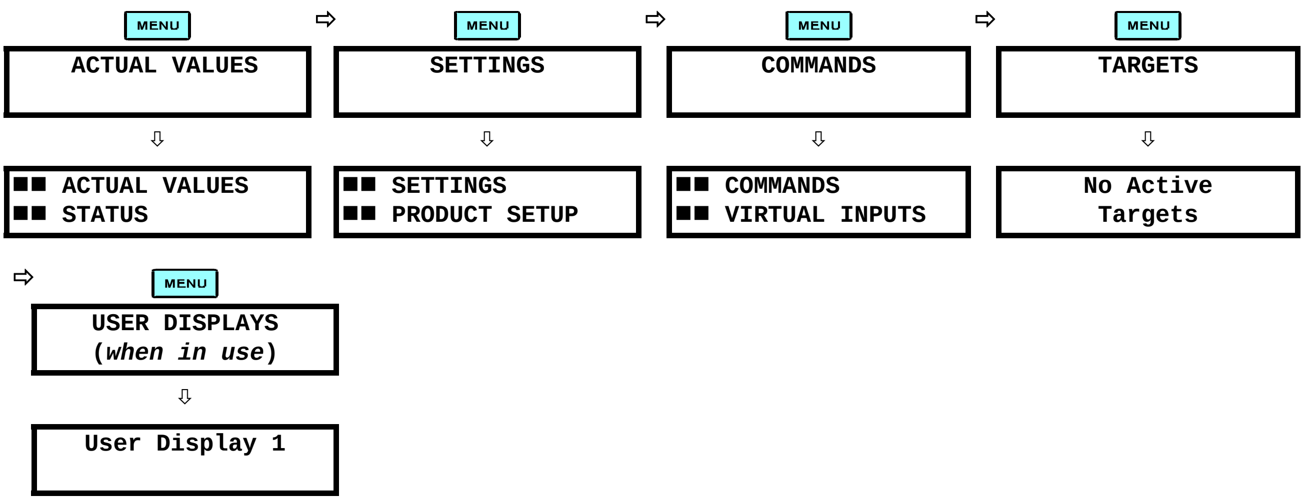
Display messages are organized into ‘pages’ under the following headings: Actual Values, Settings, Commands, and Targets. The MENU key navigates through these pages. Each heading page is broken down further into logical subgroups.

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

The · key initiates and advance to the next character in text edit mode or enters a decimal point. The HELP key may be pressed at any time for context sensitive help messages. The ENTER key stores altered setting values.

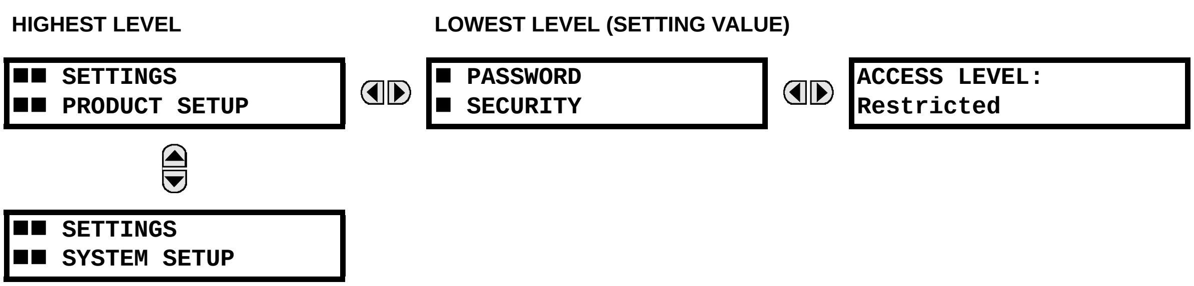
1.5.2 MENU NAVIGATION

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



1.5.3 MENU HIERARCHY

The setting and actual value messages are arranged hierarchically. The header display pages are indicated by double scroll bar characters (■■), while sub-header pages are indicated by single scroll bar characters (■). The header display pages represent the highest level of the hierarchy and the sub-header display pages fall below this level. The MESSAGE ▲ 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.



1.5.4 RELAY ACTIVATION

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

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

```
RELAY SETTINGS:
Not Programmed
```

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

1.5.5 RELAY PASSWORDS

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

1. COMMAND

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

- 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.

1.5.6 FLEXLOGIC™ CUSTOMIZATION

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

1.5.7 COMMISSIONING

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 F60 requires a minimum amount of maintenance when it is commissioned into service. The F60 is a microprocessor-based relay and its characteristics do not change over time. As such no further functional tests are required.

Furthermore the F60 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 F60 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.

2.1.1 OVERVIEW

The F60 Feeder Management Relay is a microprocessor based relay designed for feeder protection.

Overvoltage and undervoltage protection, overfrequency and underfrequency protection, breaker failure protection, directional current supervision, fault diagnostics, RTU, and programmable logic functions are provided. This relay also provides phase, neutral, ground and negative sequence, instantaneous and time overcurrent protection. The time overcurrent function provides multiple curve shapes or FlexCurves™ for optimum co-ordination. Automatic reclosing, synchrocheck, and line fault locator features are also provided. When equipped with a type 8Z CT/VT module, an element for detecting high impedance faults is provided.

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 a sequence of records capable of storing 1024 time-tagged events. 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 (F60 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 F60 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
25 (2)	Synchrocheck
27P (2)	Phase Undervoltage
27X	Auxiliary Undervoltage
32	Sensitive Directional Power
50BF / 50NBF (2)	Breaker Failure
50DD	Disturbance Detector
50G (2)	Ground Instantaneous Overcurrent
50N (2)	Neutral Instantaneous Overcurrent
50P (2)	Phase Instantaneous Overcurrent
50_2 (2)	Negative Sequence Instantaneous Overcurrent
51G (2)	Ground Time Overcurrent
51N (2)	Neutral Time Overcurrent
51P (2)	Phase Time Overcurrent

DEVICE NUMBER	FUNCTION
51_2 (2)	Negative Sequence Time Overcurrent
52	AC Circuit Breaker
59N	Neutral Overvoltage
59P	Phase Overvoltage
59X	Auxiliary Overvoltage
59_2	Negative Sequence Overvoltage
67N (2)	Neutral Directional Overcurrent
67P (2)	Phase Directional
67_2 (2)	Negative Sequence Directional Overcurrent
79	Automatic Recloser
81O (4)	Overfrequency
81U (6)	Underfrequency

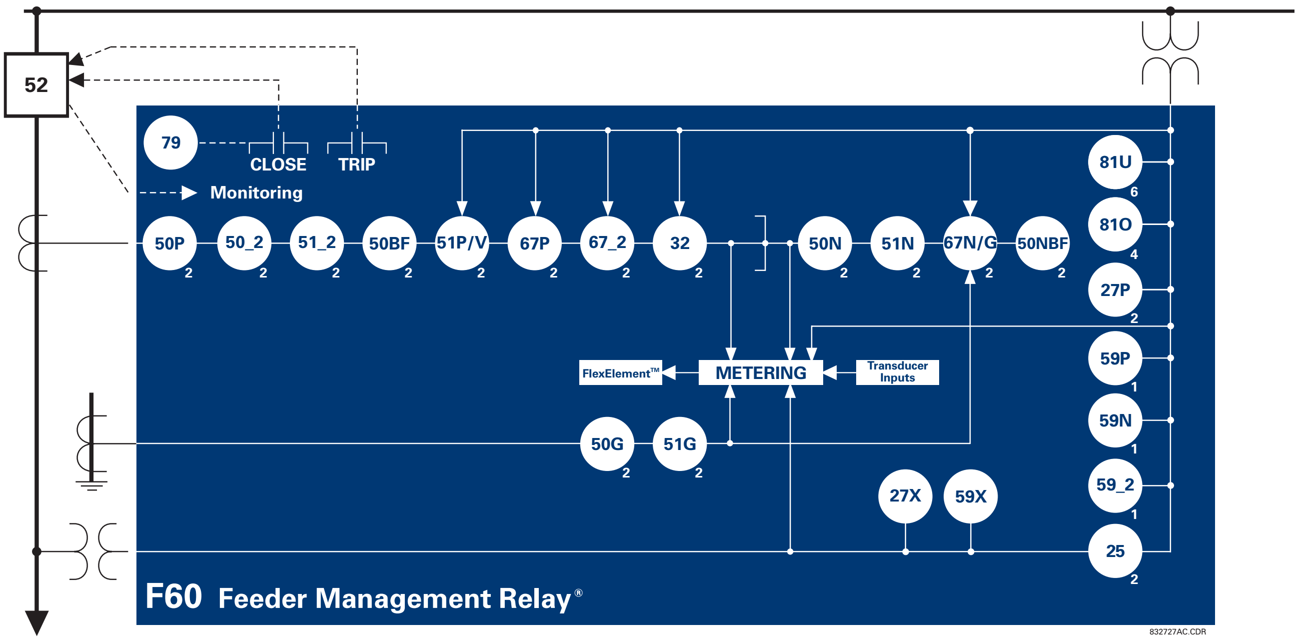


Figure 2–1: SINGLE LINE DIAGRAM

Table 2–2: OTHER DEVICE FUNCTIONS

FUNCTION
Breaker Arcing Current (I^2t)
Breaker Control (2)
Cold Load Pickup (2)
Contact Inputs (up to 96)
Contact Outputs (up to 64)
Control Pushbuttons
Data Logger
Demand
Digital Counters (8)
Digital Elements (48)
Direct Inputs/Outputs (32)
Event Recorder

FUNCTION
Fault Detector and Fault Report
Fault Locator
FlexElements™ (8)
FlexLogic™ Equations
High Impedance Fault Detection (Hi-Z)
IEC 61850 Communications (optional)
Load Encroachment
Metering: Current, Voltage, Power, PF, Energy, Frequency, Harmonics, THD
Modbus User Map
Non-Volatile Latches
Non-Volatile Selector Switch

FUNCTION
Oscillography
Setting Groups (6)
Time Synchronization over SNTP
Transducer Inputs/Outputs
User Definable Displays
User Programmable LEDs
User Programmable Pushbuttons
User Programmable Self-Tests
Virtual Inputs (64)
Virtual Outputs (96)
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 tables (see Chapter 3 for full details of relay modules).

Table 2–3: F60 ORDER CODES (HORIZONTAL UNITS)

	F60	- *	**	- *	*	*	- F **	- H **	- M **	- P **	- U **	- W/X **	Full Size Horizontal Mount
BASE UNIT	F60												Base Unit
CPU		E											RS485 and RS485
		G											RS485 and multi-mode ST 10Base-F
		H											RS485 and multi-mode ST redundant 10Base-F
		J											RS485 and multi-mode ST 100Base-FX
		K											RS485 and multi-mode ST redundant 100Base-FX
		L											RS485 and single mode SC 100Base-FX
		M											RS485 and single mode SC redundant 100Base-FX
		N											RS485 and 10/100Base-T
		P											RS485 and single mode ST 100Base-FX
		R											RS485 and single mode ST redundant 100Base-FX
SOFTWARE			00										No Software Options
			01										Ethernet Global Data (EGD); not available for Type E CPUs
			03										IEC 61850; not available for Type E CPUs
			04										Ethernet Global Data (EGD) and IEC 61850; not available for Type E CPUs
MOUNT/COATING				H									Horizontal (19” rack)
				A									Horizontal (19” rack) with harsh environmental coating
FACEPLATE/ DISPLAY					C								English display
					P								English display with 4 small and 12 large programmable pushbuttons
					A								Chinese display
					B								Chinese display with 4 small and 12 large programmable pushbuttons
					D								French display
					G								French display with 4 small and 12 large programmable pushbuttons
					R								Russian display
					S								Russian display with 4 small and 12 large programmable pushbuttons
POWER SUPPLY (redundant supply must be same type as main supply)						H							125 / 250 V AC/DC power supply
						H						RH	125 / 250 V AC/DC with redundant 125 / 250 V AC/DC power supply
						L							24 to 48 V (DC only) power supply
						L						RL	24 to 48 V (DC only) with redundant 24 to 48 V DC power supply
CT/VT MODULES							8F						Standard 4CT/4VT
							8G						Sensitive Ground 4CT/4VT
							8H						Standard 8CT
							8J						Sensitive Ground 8CT
									8Z				Hi-Z 4CT (required for high-impedance fault detection element)
DIGITAL INPUTS/OUTPUTS								XX	XX	XX	XX	XX	No Module
								4A	4A	4A	4A	4A	4 Solid-State (no monitoring) MOSFET outputs
								4B	4B	4B	4B	4B	4 Solid-State (voltage with optional current) MOSFET outputs
								4C	4C	4C	4C	4C	4 Solid-State (current with optional voltage) MOSFET outputs
								4D	4D	4D	4D	4D	16 digital inputs with Auto-Burnishing
								4L	4L	4L	4L	4L	14 Form-A (no monitoring) Latching outputs
								67	67	67	67	67	8 Form-A (no monitoring) outputs
								6A	6A	6A	6A	6A	2 Form-A (voltage with optional current) and 2 Form-C outputs, 8 digital inputs
								6B	6B	6B	6B	6B	2 Form-A (voltage with optional current) and 4 Form-C outputs, 4 digital inputs
								6C	6C	6C	6C	6C	8 Form-C outputs
								6D	6D	6D	6D	6D	16 digital inputs
								6E	6E	6E	6E	6E	4 Form-C outputs, 8 digital inputs
								6F	6F	6F	6F	6F	8 Fast Form-C outputs
								6G	6G	6G	6G	6G	4 Form-A (voltage with optional current) outputs, 8 digital inputs
								6H	6H	6H	6H	6H	6 Form-A (voltage with optional current) outputs, 4 digital inputs
								6K	6K	6K	6K	6K	4 Form-C and 4 Fast Form-C outputs
								6L	6L	6L	6L	6L	2 Form-A (current with optional voltage) and 2 Form-C outputs, 8 digital inputs
								6M	6M	6M	6M	6M	2 Form-A (current with optional voltage) and 4 Form-C outputs, 4 digital inputs
								6N	6N	6N	6N	6N	4 Form-A (current with optional voltage) outputs, 8 digital inputs
								6P	6P	6P	6P	6P	6 Form-A (current with optional voltage) outputs, 4 digital inputs
								6R	6R	6R	6R	6R	2 Form-A (no monitoring) and 2 Form-C outputs, 8 digital inputs
								6S	6S	6S	6S	6S	2 Form-A (no monitoring) and 4 Form-C outputs, 4 digital inputs
								6T	6T	6T	6T	6T	4 Form-A (no monitoring) outputs, 8 digital inputs
								6U	6U	6U	6U	6U	6 Form-A (no monitoring) outputs, 4 digital inputs
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	2A	C37.94SM, 1300nm single-mode, ELED, 1 channel single-mode
											2B	2B	C37.94SM, 1300nm single-mode, ELED, 2 channel single-mode
											2E	2E	Bi-phase, single channel
											2F	2F	Bi-phase, dual channel
											72	72	1550 nm, single-mode, LASER, 1 Channel
											73	73	1550 nm, single-mode, LASER, 2 Channel
											74	74	Channel 1 - RS422; Channel 2 - 1550 nm, single-mode, LASER
											75	75	Channel 1 - G.703; Channel 2 - 1550 nm, Single-mode LASER
											76	76	IEEE C37.94, 820 nm, multimode, LED, 1 Channel
											77	77	IEEE C37.94, 820 nm, multimode, LED, 2 Channels
											7A	7A	820 nm, multi-mode, LED, 1 Channel
											7B	7B	1300 nm, multi-mode, LED, 1 Channel
											7C	7C	1300 nm, single-mode, ELED, 1 Channel
											7D	7D	1300 nm, single-mode, LASER, 1 Channel
											7E	7E	Channel 1 - G.703; Channel 2 - 820 nm, multi-mode
											7F	7F	Channel 1 - G.703; Channel 2 - 1300 nm, multi-mode
											7G	7G	Channel 1 - G.703; Channel 2 - 1300 nm, single-mode ELED
											7H	7H	820 nm, multi-mode, LED, 2 Channels
											7I	7I	1300 nm, multi-mode, LED, 2 Channels
											7J	7J	1300 nm, single-mode, ELED, 2 Channels
											7K	7K	1300 nm, single-mode, LASER, 2 Channels
											7L	7L	Channel 1 - RS422; Channel 2 - 820 nm, multi-mode, LED
											7M	7M	Channel 1 - RS422; Channel 2 - 1300 nm, multi-mode, LED
											7N	7N	Channel 1 - RS422; Channel 2 - 1300 nm, single-mode, ELED
											7P	7P	Channel 1 - RS422; Channel 2 - 1300 nm, single-mode, LASER
											7Q	7Q	Channel 1 - G.703; Channel 2 - 1300 nm, single-mode LASER
											7R	7R	G.703, 1 Channel
											7S	7S	G.703, 2 Channels
											7T	7T	RS422, 1 Channel
											7W	7W	RS422, 2 Channels

2

Table 2–4: F60 ORDER CODES (REDUCED SIZE VERTICAL UNITS)

	F60	*	**	*	*	*	F **	H **	M **	P/R **	Reduced Size Vertical Mount (see note regarding P/R slot below)
BASE UNIT	F60										Base Unit
CPU		E									RS485 and RS485
		G									RS485 and multi-mode ST 10Base-F
		H									RS485 and multi-mode ST redundant 10Base-F
		J									RS485 and multi-mode ST 100Base-FX
		K									RS485 and multi-mode ST redundant 100Base-FX
		L									RS485 and single mode SC 100Base-FX
		M									RS485 and single mode SC redundant 100Base-FX
		N									RS485 and 10/100Base-T
		P									RS485 and single mode ST 100Base-FX
		R									RS485 and single mode ST redundant 100Base-FX
SOFTWARE			00								No Software Options
			01								Ethernet Global Data (EGD); not available for Type E CPUs
			03								IEC 61850; not available for Type E CPUs
			04								Ethernet Global Data (EGD) and IEC 61850; not available for Type E CPUs
MOUNT/COATING				V							Vertical (3/4 rack)
				B							Vertical (3/4 rack) with harsh environmental coating
FACEPLATE/ DISPLAY					F						English display
					L						English display with 4 small and 6 large programmable pushbuttons
					K						Chinese display
					M						Chinese display with 4 small and 6 large programmable pushbuttons
					H						French display
					N						French display with 4 small and 6 large programmable pushbuttons
					J						Russian display
					Q						Russian display with 4 small and 6 large programmable pushbuttons
POWER SUPPLY						H					125 / 250 V AC/DC power supply
						L					24 to 48 V (DC only) power supply
CT/VT MODULES							8F				Standard 4CT/4VT
							8G				Sensitive Ground 4CT/4VT
							8H				Standard 8CT
							8J				Sensitive Ground 8CT
									8Z		Hi-Z 4CT (required for high-impedance fault detection element)
DIGITAL INPUTS/OUTPUTS								XX	XX	XX	No Module
								4A	4A	4A	4 Solid-State (no monitoring) MOSFET outputs
								4B	4B	4B	4 Solid-State (voltage with optional current) MOSFET outputs
								4C	4C	4C	4 Solid-State (current with optional voltage) MOSFET outputs
								4D	4D	4D	16 digital inputs with Auto-Burnishing
								4L	4L	4L	14 Form-A (no monitoring) Latching outputs
								67	67	67	8 Form-A (no monitoring) outputs
								6A	6A	6A	2 Form-A (voltage with optional current) and 2 Form-C outputs, 8 digital inputs
								6B	6B	6B	2 Form-A (voltage with optional current) and 4 Form-C outputs, 4 digital inputs
								6C	6C	6C	8 Form-C outputs
								6D	6D	6D	16 digital inputs
								6E	6E	6E	4 Form-C outputs, 8 digital inputs
								6F	6F	6F	8 Fast Form-C outputs
								6G	6G	6G	4 Form-A (voltage with optional current) outputs, 8 digital inputs
								6H	6H	6H	6 Form-A (voltage with optional current) outputs, 4 digital inputs
								6K	6K	6K	4 Form-C and 4 Fast Form-C outputs
								6L	6L	6L	2 Form-A (current with optional voltage) and 2 Form-C outputs, 8 digital inputs
								6M	6M	6M	2 Form-A (current with optional voltage) and 4 Form-C outputs, 4 digital inputs
								6N	6N	6N	4 Form-A (current with optional voltage) outputs, 8 digital inputs
								6P	6P	6P	6 Form-A (current with optional voltage) outputs, 4 digital inputs
								6R	6R	6R	2 Form-A (no monitoring) and 2 Form-C outputs, 8 digital inputs
								6S	6S	6S	2 Form-A (no monitoring) and 4 Form-C outputs, 4 digital inputs
								6T	6T	6T	4 Form-A (no monitoring) outputs, 8 digital inputs
								6U	6U	6U	6 Form-A (no monitoring) outputs, 4 digital inputs
TRANSDUCER INPUTS/OUTPUTS (select a maximum of 3 per unit)								5A	5A	5A	4 dcmA inputs, 4 dcmA outputs (only one 5A module is allowed)
								5C	5C	5C	8 RTD inputs
								5D	5D	5D	4 RTD inputs, 4 dcmA outputs (only one 5D module is allowed)
								5E	5E	5E	4 RTD inputs, 4 dcmA inputs
								5F	5F	5F	8 dcmA inputs
INTER-RELAY COMMUNICATIONS (select a maximum of 1 per unit)										2A	C37.94SM, 1300nm single-mode, ELED, 1 channel single-mode
										2B	C37.94SM, 1300nm single-mode, ELED, 2 channel single-mode
										2E	Bi-phase, single channel
										2F	Bi-phase, dual channel
										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 the last module, slot P is used for digital and transducer input/output modules; slot R is used for inter-relay communications modules.

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 2–5: ORDER CODES FOR REPLACEMENT MODULES

	UR - ** - *	
POWER SUPPLY	1H	125 / 250 V AC/DC
(redundant supply only	1L	24 to 48 V (DC only)
available in horizontal units; must	RH	redundant 125 / 250 V AC/DC
be same type as main supply)	RH	redundant 24 to 48 V (DC only)
CPU	9E	RS485 and RS485 (Modbus RTU, DNP 3.0)
	9G	RS485 and 10Base-F (Ethernet, Modbus TCP/IP, DNP 3.0)
	9H	RS485 and Redundant 10Base-F (Ethernet, Modbus TCP/IP, DNP 3.0)
	9J	RS485 and multi-mode ST 100Base-FX (Ethernet, Modbus TCP/IP, DNP 3.0)
	9K	RS485 and multi-mode ST redundant 100Base-FX (Ethernet, Modbus TCP/IP, DNP 3.0)
	9L	RS485 and single mode SC 100Base-FX (Ethernet, Modbus TCP/IP, DNP 3.0)
	9M	RS485 and single mode SC redundant 100Base-FX (Ethernet, Modbus TCP/IP, DNP 3.0)
	9N	RS485 and 10/100Base-T (Ethernet, Modbus TCP/IP, DNP 3.0)
	9P	RS485 and single mode ST 100Base-FX (Ethernet, Modbus TCP/IP, DNP 3.0)
	9R	RS485 and single mode ST redundant 100Base-FX (Ethernet, Modbus TCP/IP, DNP 3.0)
FACEPLATE/DISPLAY	3C	Horizontal faceplate with keypad and English display
	3P	Horizontal faceplate with keypad, user-programmable pushbuttons, and English display
	3R	Horizontal faceplate with keypad and Russian display
	3S	Horizontal faceplate with keypad, user-programmable pushbuttons, and Russian display
	3A	Horizontal faceplate with keypad and Chinese display
	3B	Horizontal faceplate with keypad, user-programmable pushbuttons, and Chinese display
	3D	Horizontal faceplate with keypad and French display
	3G	Horizontal faceplate with keypad, user-programmable pushbuttons, and French display
	3F	Vertical faceplate with keypad and English display
	3L	Vertical faceplate with keypad, user-programmable pushbuttons, and English display
	3K	Vertical faceplate with keypad and Russian display
	3M	Vertical faceplate with keypad, user-programmable pushbuttons, and Russian display
	3H	Vertical faceplate with keypad and Chinese display
	3N	Vertical faceplate with keypad, user-programmable pushbuttons, and Chinese display
	3J	Vertical faceplate with keypad and French display
	3Q	Vertical faceplate with keypad, user-programmable pushbuttons, and French display
DIGITAL INPUTS/OUTPUTS	4A	4 Solid-State (no monitoring) MOSFET outputs
	4B	4 Solid-State (voltage with optional current) MOSFET outputs
	4C	4 Solid-State (current with optional voltage) MOSFET outputs
	4D	16 digital inputs with Auto-Burnishing
	4L	14 Form-A (no monitoring) Latching outputs
	67	8 Form-A (no monitoring) outputs
	6A	2 Form-A (voltage with optional current) and 2 Form-C outputs, 8 digital inputs
	6B	2 Form-A (voltage with optional current) and 4 Form-C outputs, 4 digital inputs
	6C	8 Form-C outputs
	6D	16 digital inputs
	6E	4 Form-C outputs, 8 digital inputs
	6F	8 Fast Form-C outputs
	6G	4 Form-A (voltage with optional current) outputs, 8 digital inputs
	6H	6 Form-A (voltage with optional current) outputs, 4 digital inputs
	6K	4 Form-C and 4 Fast Form-C outputs
	6L	2 Form-A (current with optional voltage) and 2 Form-C outputs, 8 digital inputs
	6M	2 Form-A (current with optional voltage) and 4 Form-C outputs, 4 digital inputs
	6N	4 Form-A (current with optional voltage) outputs, 8 digital inputs
	6P	6 Form-A (current with optional voltage) outputs, 4 digital inputs
	6R	2 Form-A (no monitoring) and 2 Form-C outputs, 8 digital inputs
	6S	2 Form-A (no monitoring) and 4 Form-C outputs, 4 digital inputs
	6T	4 Form-A (no monitoring) outputs, 8 digital inputs
	6U	6 Form-A (no monitoring) outputs, 4 digital inputs
CT/VT	8F	Standard 4CT/4VT
MODULES	8G	Sensitive Ground 4CT/4VT
(NOT AVAILABLE FOR THE C30)	8H	Standard 8CT
	8J	Sensitive Ground 8CT
	8Z	HI-Z 4CT
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

2

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)

NEGATIVE SEQUENCE TOC

Pickup level: 0.000 to 30.000 pu in steps of 0.001
Dropout level: 97% to 98% of Pickup
Level accuracy: ±0.5% of reading or ±1% of rated (whichever is greater)
  from 0.1 to 2.0 x CT rating
  ±1.5% of reading > 2.0 x CT rating
Curve shapes: IEEE Moderately/Very/Extremely Inverse; IEC (and BS) A/B/C and Short Inverse; GE IAC Inverse, Short/Very/ Extremely Inverse; I^2t; FlexCurves™ (programmable); Definite Time (0.01 s base curve)
Curve multiplier (Time dial): 0.00 to 600.00 in steps of 0.01
Reset type: Instantaneous/Timed (per IEEE) and Linear
Timing accuracy: Operate at > 1.03 × Actual Pickup ±3.5% of operate time or ±½ cycle (whichever is greater)

NEGATIVE SEQUENCE IOC

Pickup level: 0.000 to 30.000 pu in steps of 0.001
Dropout level: 97 to 98% of Pickup
Level accuracy:
  0.1 to 2.0 × CT rating: ±0.5% of reading or ±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: < 20 ms at 3 × Pickup at 60 Hz
Timing accuracy: Operate at 1.5 × Pickup ±3% or ± 4 ms (whichever is greater)

PHASE DIRECTIONAL OVERCURRENT

Relay connection: 90° (quadrature)
Quadrature voltage:
  ABC phase seq.: phase A (V_{BC}), phase B (V_{CA}), phase C (V_{AB})
  ACB phase seq.: phase A (V_{CB}), phase B (V_{AC}), phase C (V_{BA})
Polarizing voltage threshold: 0.000 to 3.000 pu in steps of 0.001
Current sensitivity threshold: 0.05 pu
Characteristic angle: 0 to 359° in steps of 1
Angle accuracy: ±2°
Operation time (FlexLogic™ operands):
  Tripping (reverse load, forward fault):< 12 ms, typically
  Blocking (forward load, reverse fault):< 8 ms, typically

NEUTRAL DIRECTIONAL OVERCURRENT

Directionality:	Co-existing forward and reverse
Polarizing:	Voltage, Current, Dual
Polarizing voltage:	V_0 or VX
Polarizing current:	IG
Operating current:	I_0
Level sensing:	$3 \times (\lvert I\_0\rvert - K \times \lvert I\_1\rvert)$, IG
Restraint, *K*:	0.000 to 0.500 in steps of 0.001
Characteristic angle:	–90 to 90° in steps of 1
Limit angle:	40 to 90° in steps of 1, independent for forward and reverse
Angle accuracy:	±2°
Offset impedance:	0.00 to 250.00 Ω in steps of 0.01
Pickup level:	0.002 to 30.000 pu in steps of 0.01
Dropout level:	97 to 98%
Operation time:	< 16 ms at 3 × Pickup at 60 Hz

NEGATIVE SEQUENCE DIRECTIONAL OC

Directionality:	Co-existing forward and reverse
Polarizing:	Voltage
Polarizing voltage:	V_2
Operating current:	I_2
Level sensing:	
Zero-sequence:	$\lvert I\_0\rvert - K \times \lvert I\_1\rvert$
Negative-sequence:	$\lvert I\_2\rvert - K \times \lvert I\_1\rvert$
Restraint, *K*:	0.000 to 0.500 in steps of 0.001
Characteristic angle:	0 to 90° in steps of 1
Limit angle:	40 to 90° in steps of 1, independent for forward and reverse
Angle accuracy:	±2°
Offset impedance:	0.00 to 250.00 Ω in steps of 0.01
Pickup level:	0.05 to 30.00 pu in steps of 0.01
Dropout level:	97 to 98%
Operation time:	< 16 ms at 3 × Pickup at 60 Hz

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

Voltage:	Phasor only
Pickup level:	0.000 to 3.000 pu in steps of 0.001
Dropout level:	102 to 103% of pickup
Level accuracy:	±0.5% of reading from 10 to 208 V
Curve shapes:	GE IAV Inverse; Definite Time (0.1s base curve)
Curve multiplier:	Time dial = 0.00 to 600.00 in steps of 0.01
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)

PHASE OVERVOLTAGE

Voltage:	Phasor only
Pickup level:	0.000 to 3.000 pu in steps of 0.001
Dropout level:	97 to 98% of Pickup
Level accuracy:	±0.5% of reading from 10 to 208 V
Pickup delay:	0.00 to 600.00 in steps of 0.01 s
Operate time:	< 30 ms at 1.10 × Pickup at 60 Hz
Timing accuracy:	±3% or ±4 ms (whichever is greater)

NEUTRAL OVERVOLTAGE

Pickup level:	0.000 to 3.000 pu in steps of 0.001
Dropout level:	97 to 98% of Pickup
Level accuracy:	±0.5% of reading from 10 to 208 V
Pickup delay:	0.00 to 600.00 s in steps of 0.01 (definite time) or user-defined curve
Reset delay:	0.00 to 600.00 s in steps of 0.01
Timing accuracy:	±3% or ±20 ms (whichever is greater)
Operate time:	< 30 ms at 1.10 × Pickup at 60 Hz

AUXILIARY OVERVOLTAGE

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

NEGATIVE SEQUENCE OVERVOLTAGE

Pickup level:	0.000 to 1.250 pu in steps of 0.001
Dropout level:	97 to 98% of Pickup
Level accuracy:	±0.5% of reading from 10 to 208 V
Pickup delay:	0 to 600.00 s in steps of 0.01
Reset delay:	0 to 600.00 s in steps of 0.01
Time accuracy:	±3% or ±20 ms, whichever is greater
Operate time:	< 30 ms at 1.10 × Pickup at 60 Hz

UNDERFREQUENCY

Minimum signal:	0.10 to 1.25 pu in steps of 0.01
Pickup level:	20.00 to 65.00 Hz in steps of 0.01
Dropout level:	Pickup + 0.03 Hz
Level accuracy:	±0.01 Hz
Time delay:	0 to 65.535 s in steps of 0.001
Timer accuracy:	±3% or 4 ms, whichever is greater

OVERFREQUENCY

Pickup level:	20.00 to 65.00 Hz in steps of 0.01
Dropout level:	Pickup – 0.03 Hz
Level accuracy:	±0.01 Hz
Time delay:	0 to 65.535 s in steps of 0.001
Timer accuracy:	±3% or 4 ms, whichever is greater

RATE OF CHANGE OF FREQUENCY

df/dt trend:	increasing, decreasing, bi-directional
df/dt pickup level:	0.10 to 15.00 Hz/s in steps of 0.01
df/dt dropout level:	96% of pickup
df/dt level accuracy:	80 mHz/s or 3.5%, whichever is greater
Overvoltage supv.:	0.100 to 3.000 pu in steps of 0.001
Overcurrent supv.:	0.000 to 30.000 pu in steps of 0.001
Pickup delay:	0 to 65.535 s in steps of 0.001
Reset delay:	0 to 65.535 s in steps of 0.001
Time accuracy:	±3% or ±4 ms, whichever is greater
95% settling time for df/dt:	< 24 cycles
Operate time:	at 2 × pickup: 12 cycles at 3 × pickup: 8 cycles at 5 × pickup: 6 cycles

BREAKER FAILURE

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

BREAKER ARCING CURRENT

Principle:	accumulates breaker duty (I^2t) and measures fault duration
Initiation:	programmable per phase from any FlexLogic™ operand
Compensation for auxiliary relays:	0 to 65.535 s in steps of 0.001
Alarm threshold:	0 to 50000 kA2-cycle in steps of 1
Fault duration accuracy:	0.25 of a power cycle
Availability:	1 per CT bank with a minimum of 2

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 400000 V in steps of 1
Max angle difference:	0 to 100° in steps of 1
Max freq. difference:	0.00 to 2.00 Hz in steps of 0.01
Hysteresis for max. freq. diff.:	0.00 to 0.10 Hz in steps of 0.01
Dead source function:	None, LV1 & DV2, DV1 & LV2, DV1 or DV2, DV1 xor DV2, DV1 & DV2 (L = Live, D = Dead)

AUTORECLOSURE

Single breaker applications, 3-pole tripping schemes
Up to 4 reclose attempts before lockout
Independent dead time setting before each shot
Possibility of changing protection settings after each shot with FlexLogic™

LOAD ENCROACHMENT

Responds to:	Positive-sequence quantities
Minimum voltage:	0.000 to 3.000 pu in steps of 0.001
Reach (sec. Ω):	0.02 to 250.00 Ω in steps of 0.01
Impedance accuracy:	±5%
Angle:	5 to 50° in steps of 1
Angle accuracy:	±2°
Pickup delay:	0 to 65.535 s in steps of 0.001
Reset delay:	0 to 65.535 s in steps of 0.001
Time accuracy:	±3% or ±4 ms, whichever is greater
Operate time:	< 30 ms at 60 Hz

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

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 or Synch/Restore mode

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

FAULT LOCATOR

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%)

HI-Z

Detections:	Arc Suspected, Arc Detected, Downed Conductor, Phase Identification

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 × 10^9 MWh
Parameters:	3-phase only
Update rate:	50 ms

VAR-HOURS (POSITIVE AND NEGATIVE)

Accuracy:	±2.0% of reading
Range:	±0 to 2 × 10^9 Mvarh
Parameters:	3-phase only
Update rate:	50 ms

CURRENT HARMONICS

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

VOLTAGE HARMONICS

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

FREQUENCY
Accuracy at
V = 0.8 to 1.2 pu: ±0.01 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)

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

2.2.5 INPUTS

AC CURRENT
CT rated primary: 1 to 50000 A
CT rated secondary: 1 A or 5 A by connection
Nominal frequency: 20 to 65 Hz
Relay burden: < 0.2 VA at rated secondary
Conversion range:
Standard CT: 0.02 to 46 × CT rating RMS symmetrical
Sensitive Ground/HI-Z CT module:
0.002 to 4.6 × CT rating RMS symmetrical
Current withstand: 20 ms at 250 times rated
1 sec. at 100 times rated
continuous at 3 times rated

AC VOLTAGE
VT rated secondary: 50.0 to 240.0 V
VT ratio: 1.00 to 24000.00
Nominal frequency: 20 to 65 Hz
Relay burden: < 0.25 VA at 120 V
Conversion range: 1 to 275 V
Voltage withstand: continuous at 260 V to neutral
1 min./hr at 420 V to neutral

CONTACT INPUTS
Dry contacts: 1000 Ω maximum
Wet contacts: 300 V DC maximum
Selectable thresholds: 17 V, 33 V, 84 V, 166 V
Tolerance: ±10%
Contacts per common return: 4
Recognition time: < 1 ms
Debounce time: 0.0 to 16.0 ms in steps of 0.5
Continuous current draw: 3 mA (when energized)

CONTACT INPUTS WITH AUTO-BURNISHING
Dry contacts: 1000 Ω maximum
Wet contacts: 300 V DC maximum
Selectable thresholds: 17 V, 33 V, 84 V, 166 V
Tolerance: ±10%
Contacts per common return: 2
Recognition time: < 1 ms
Debounce time: 0.0 to 16.0 ms in steps of 0.5
Continuous current draw: 3 mA (when energized)
Auto-burnish impulse current: 50 to 70 mA
Duration of auto-burnish impulse: 25 to 50 ms

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

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

IRIG-B INPUT
Amplitude modulation: 1 to 10 V pk-pk
DC shift: TTL
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

TELEPROTECTION
Number of input points: 16
No. of remote devices: 3
Default states on loss of comms.: On, Off, Latest/Off, Latest/On
Ring configuration: No
Data rate: 64 or 128 kbps
CRC: 32-bit

2.2.6 POWER SUPPLY

LOW RANGE
Nominal DC voltage: 24 to 48 V
Min/max DC voltage: 20 / 60 V
Voltage loss hold-up: 20 ms duration at nominal
NOTE: Low range is DC only.

HIGH RANGE
Nominal DC voltage: 125 to 250 V
Min/max DC voltage: 88 / 300 V
Nominal AC voltage: 100 to 240 V at 50/60 Hz
Min/max AC voltage: 88 / 265 V at 25 to 100 Hz
Voltage loss hold-up: 200 ms duration at nominal

ALL RANGES
Volt withstand: 2 × Highest Nominal Voltage for 10 ms
Power consumption: typical = 15 to 20 W/VA
maximum = 50 W/VA
contact factory for exact order code consumption

INTERNAL FUSE
RATINGS
Low range power supply: 8 A / 250 V
High range power supply: 4 A / 250 V
INTERRUPTING CAPACITY
AC: 100 000 A RMS symmetrical
DC: 10 000 A

2.2.7 OUTPUTS

FORM-A RELAY
Make and carry for 0.2 s: 30 A as per ANSI C37.90
Carry continuous: 6 A
Break (DC inductive, L/R = 40 ms):

VOLTAGE	CURRENT
24 V	1 A
48 V	0.5 A
125 V	0.3 A
250 V	0.2 A

Operate time: < 4 ms
Contact material: silver alloy

LATCHING RELAY
Make and carry for 0.2 s: 30 A as per ANSI C37.90
Carry continuous: 6 A
Break at L/R of 40 ms: 0.25 A DC max.
Operate time: < 4 ms
Contact material: silver alloy
Control: separate operate and reset inputs
Control mode: operate-dominant or reset-dominant

FORM-A VOLTAGE MONITOR
Applicable voltage: approx. 15 to 250 V DC
Trickle current: approx. 1 to 2.5 mA

FORM-A CURRENT MONITOR
Threshold current: approx. 80 to 100 mA

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

VOLTAGE	CURRENT
24 V	1 A
48 V	0.5 A
125 V	0.3 A
250 V	0.2 A

Operate time: < 8 ms
Contact material: silver alloy

FAST FORM-C RELAY
Make and carry: 0.1 A max. (resistive load)
Minimum load impedance:

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

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

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

SOLID-STATE OUTPUT RELAY
Operate and release time: <100 μs
Maximum voltage: 265 V DC
Maximum continuous current: 5 A at 45°C; 4 A at 65°C
Make and carry:
for 0.2 s: 30 A as per ANSI C37.90
for 0.03 s 300 A
Breaking capacity:

	UL508	Utility application (autoreclose scheme)	Industrial application
Operations/ interval	5000 ops / 1 s-On, 9 s-Off	5 ops / 0.2 s-On, 0.2 s-Off within 1 minute	10000 ops / 0.2 s-On, 30 s-Off
	1000 ops / 0.5 s-On, 0.5 s-Off		
Break capability (0 to 250 V DC)	3.2 A L/R = 10 ms	10 A L/R = 40 ms	10 A L/R = 40 ms
	1.6 A L/R = 20 ms		
	0.8 A L/R = 40 ms		

IRIG-B OUTPUT

Amplitude: 10 V peak-peak RS485 level
Maximum load: 100 ohms
Time delay: 1 ms for AM input
40 µs for DC-shift input
Isolation: 2 kV

CONTROL POWER EXTERNAL OUTPUT (FOR DRY CONTACT INPUT)

Capacity: 100 mA DC at 48 V DC
Isolation: ±300 Vpk

REMOTE OUTPUTS (IEC 61850 GSSE/GOOSE)

Standard output points: 32
User output points: 32

DIRECT OUTPUTS

Output points: 32

DCMA OUTPUTS

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

2

2.2.8 COMMUNICATIONS

RS232

Front port: 19.2 kbps, Modbus® RTU

RS485

1 or 2 rear ports: Up to 115 kbps, Modbus® RTU, isolated together at 36 Vpk
Typical distance: 1200 m
Isolation: 2 kV

ETHERNET (FIBER)

PARAMETER	FIBER TYPE		
	10MB MULTI-MODE	100MB MULTI-MODE	100MB SINGLE-MODE
Wavelength	820 nm	1310 nm	1310 nm
Connector	ST	ST	SC
Transmit power	–20 dBm	–20 dBm	–15 dBm
Receiver sensitivity	–30 dBm	–30 dBm	–30 dBm
Power budget	10 dB	10 dB	15 dB
Maximum input power	–7.6 dBm	–14 dBm	–7 dBm
Typical distance	1.65 km	2 km	15 km
Duplex	full/half	full/half	full/half
Redundancy	yes	yes	yes

ETHERNET (COPPER)

Modes: 10 MB, 10/100 MB (auto-detect)
Connector: RJ45
SNTP clock synchronization error: <10 ms (typical)

2.2.9 INTER-RELAY COMMUNICATIONS

SHIELDED TWISTED-PAIR INTERFACE OPTIONS

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

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

LINK POWER BUDGET

EMITTER, FIBER TYPE	TRANSMIT POWER	RECEIVED SENSITIVITY	POWER BUDGET
820 nm LED, Multimode	–20 dBm	–30 dBm	10 dB
1300 nm LED, Multimode	–21 dBm	–30 dBm	9 dB
1300 nm ELED, Singlemode	–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

2.2.10 ENVIRONMENTAL

AMBIENT TEMPERATURES

Operating: –40 to 60°C
Storage: –40 to 80°C

NOTE: The LCD contrast may be impaired at temperatures less than –20°C.

OTHER

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

2.2.11 TYPE TESTS

Electrical fast transient: ANSI/IEEE C37.90.1
IEC 61000-4-4
IEC 60255-22-4

Oscillatory transient: ANSI/IEEE C37.90.1
IEC 61000-4-12

Insulation resistance: IEC 60255-5

Dielectric strength: IEC 60255-6
ANSI/IEEE C37.90

Electrostatic discharge: EN 61000-4-2

Surge immunity: EN 61000-4-5

RFI susceptibility: ANSI/IEEE C37.90.2
IEC 61000-4-3
IEC 60255-22-3
Ontario Hydro C-5047-77

Conducted RFI: IEC 61000-4-6

Voltage dips/interruptions/variations:
IEC 61000-4-11
IEC 60255-11

Power frequency magnetic field immunity:
IEC 61000-4-8

Pulse magnetic field immunity: IEC 61000-4-9

Vibration test (sinusoidal): IEC 60255-21-1

Shock and bump: IEC 60255-21-2

Seismic: IEC 60255-21-3
IEEE C37.98

Cold: IEC 60028-2-1, 16 h at –40°C

Dry heat: IEC 60028-2-2, 16 h at 85°C

NOTE

Type test report available upon request.

2.2.12 PRODUCTION TESTS

THERMAL

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

2.2.13 APPROVALS

APPROVALS

UL Listed for the USA and Canada

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

2.2.14 MAINTENANCE

MOUNTING

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

CLEANING

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

NOTE

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

3.1.1 PANEL CUTOUT

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.

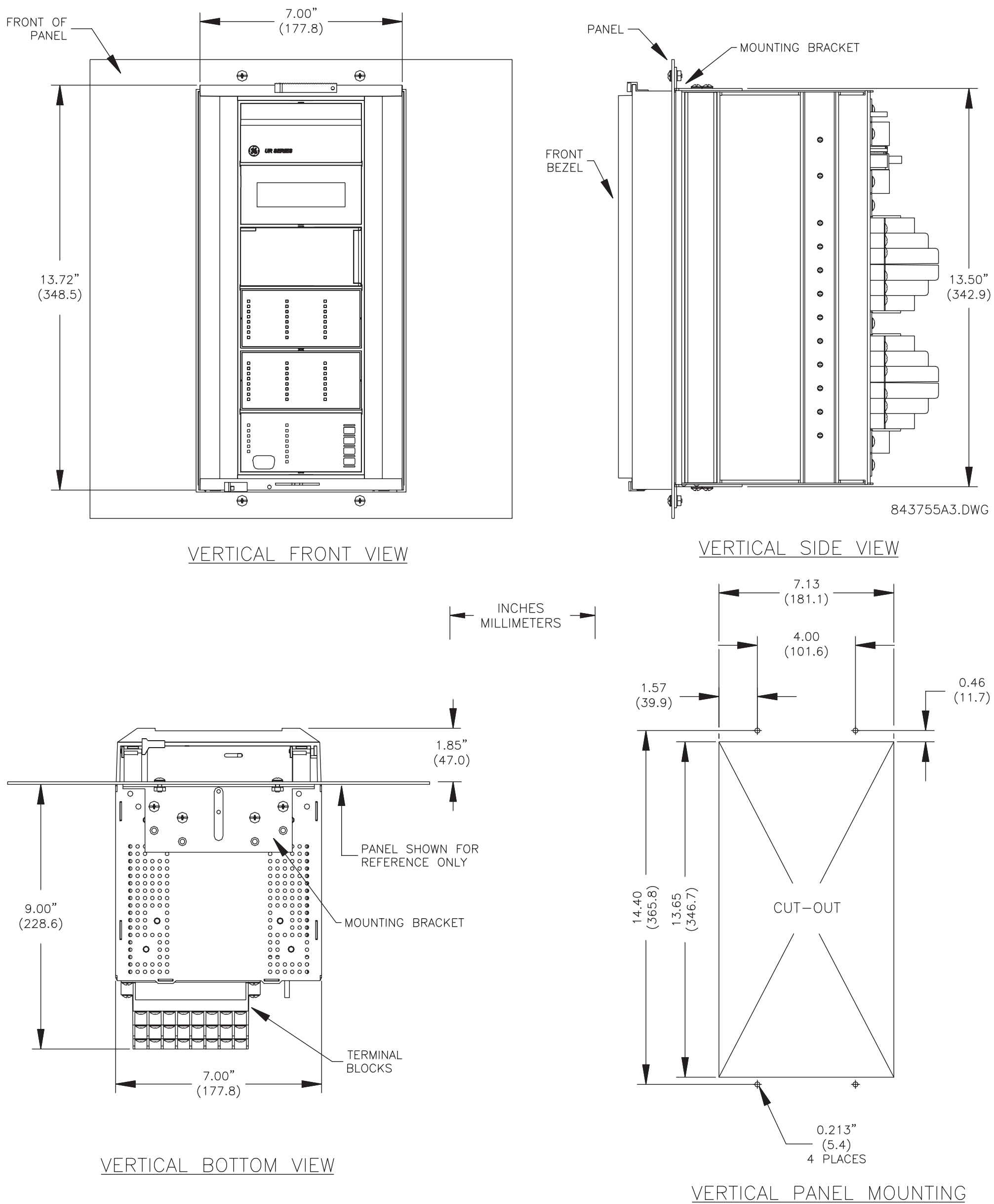


Figure 3–1: F60 VERTICAL MOUNTING AND DIMENSIONS

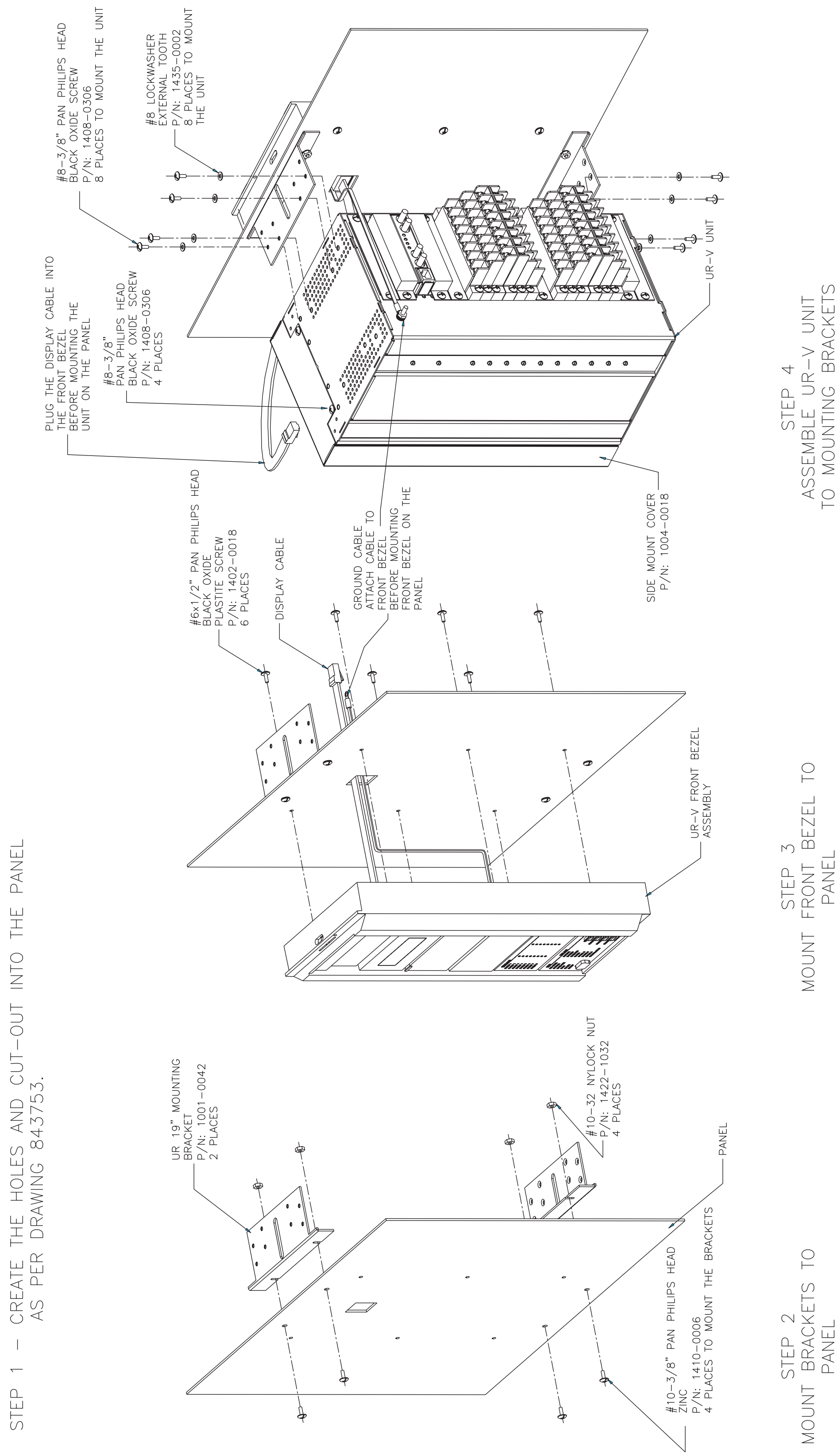


Figure 3–2: F60 VERTICAL SIDE MOUNTING INSTALLATION

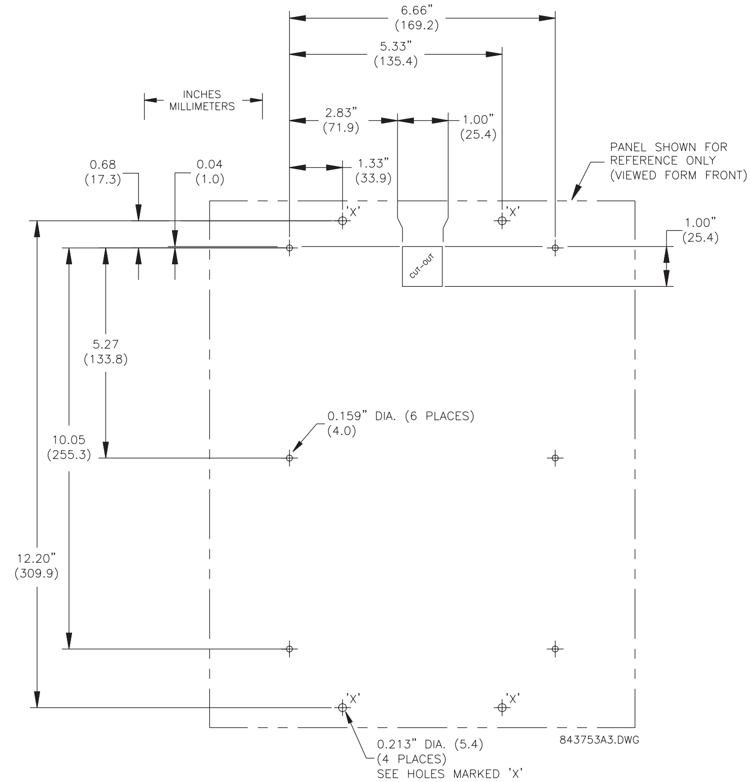


Figure 3–3: F60 VERTICAL SIDE MOUNTING REAR DIMENSIONS

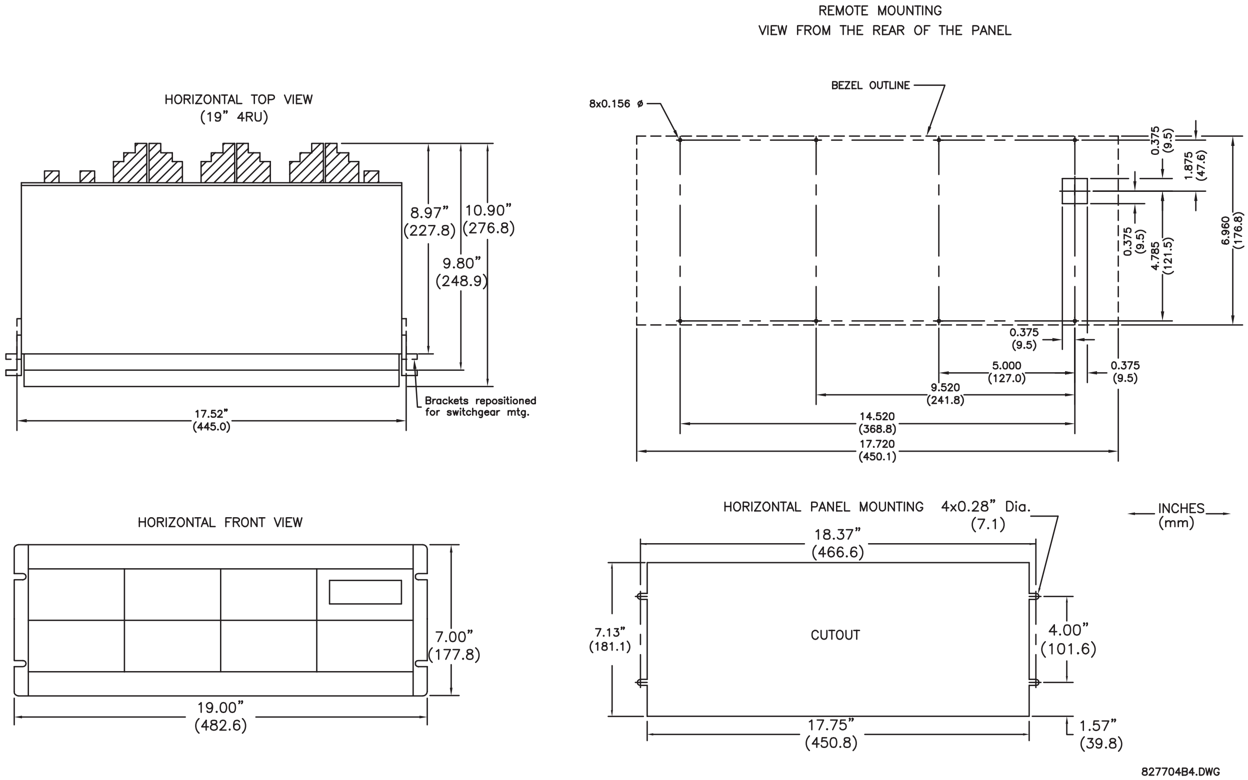


Figure 3–4: F60 HORIZONTAL MOUNTING AND DIMENSIONS

3.1.2 MODULE WITHDRAWAL AND INSERTION

WARNING

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

WARNING

Proper electrostatic discharge protection (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

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

NOTE

The version 4.0 release of the F60 relay includes new hardware (CPU and CT/VT modules). The new CPU modules are specified with the following order codes: 9E, 9G, 9H, 9J, 9K, 9L, 9M, 9N, 9P, 9R. 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 new CPUs (9E, 9G, 9H, 9J, 9K, 9L, 9M, 9N, 9P, 9R); similarly, old CT/VT modules (8A, 8B, 8C, 8D) can only be used with old CPUs (9A, 9C, 9D). To prevent hardware mismatches, the new 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.

3.1.3 REAR TERMINAL LAYOUT

832768A1.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.

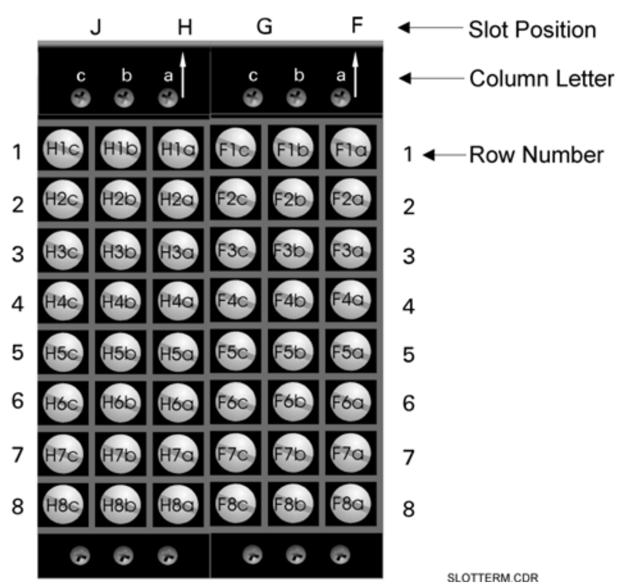
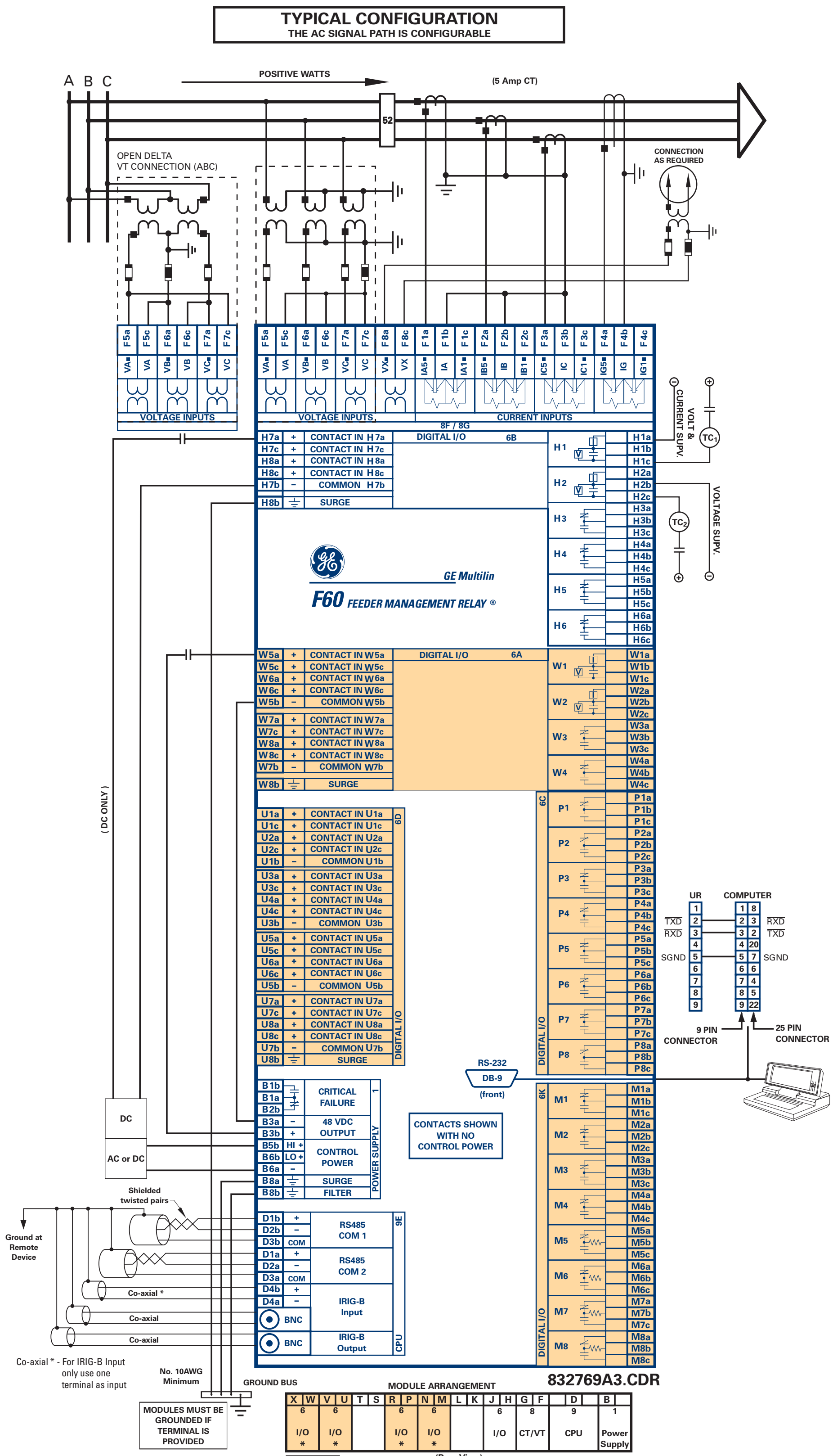


Figure 3–7: EXAMPLE OF MODULES IN F AND H SLOTS

3.2.1 TYPICAL WIRING



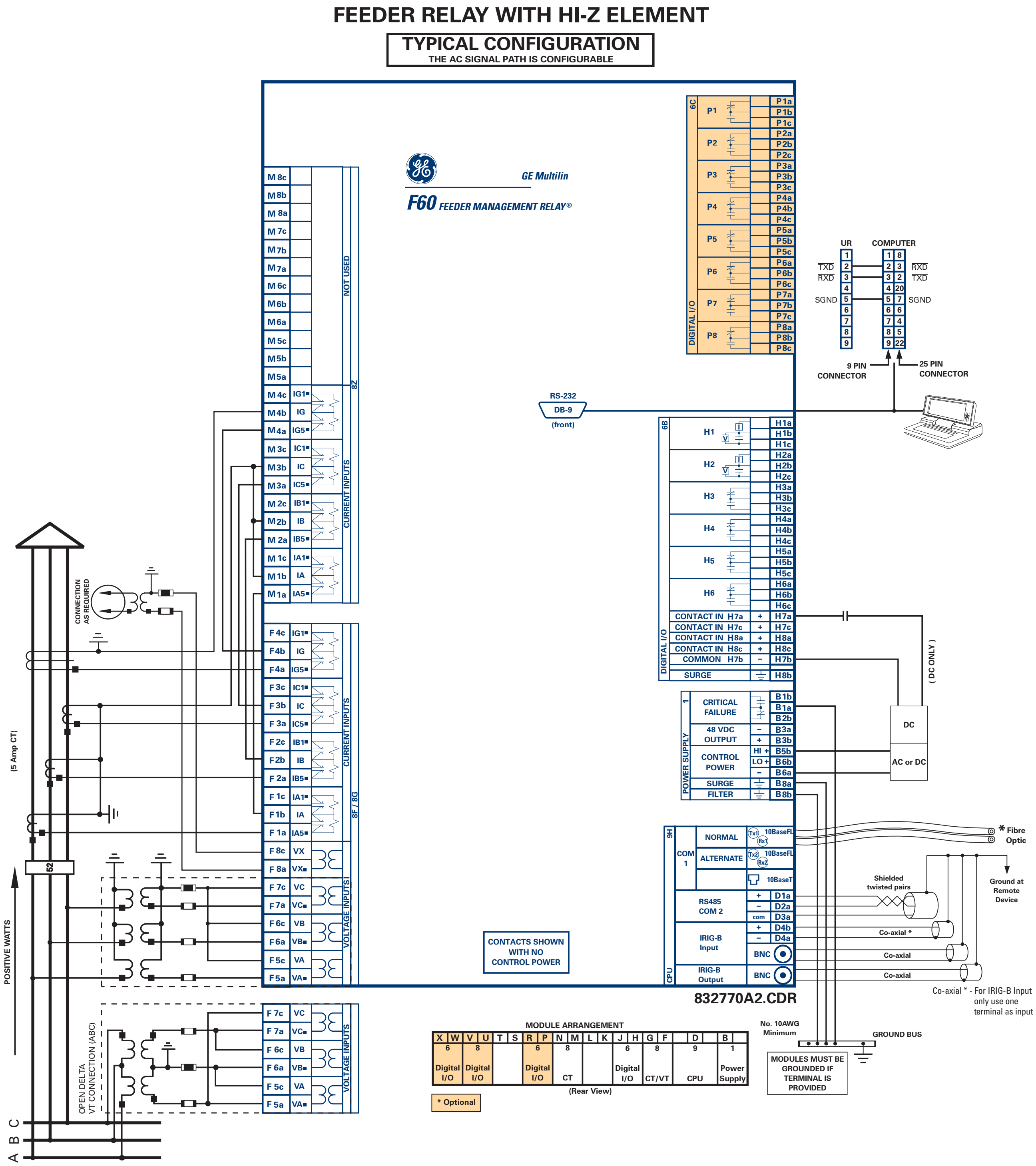
This diagram is based on the following order code: F60-E00-HCH-F8F-H6B-M6K-P6C-U6D-W6A.

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

3.2.2 TYPICAL WIRING WITH HI-Z



WARNING This wiring diagram is based on the following order code: F60-H00-HCH-F8F-H6B-M8Z-P6C-Uxx-Wxx. This diagram provides 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.

Figure 3–9: TYPICAL WIRING DIAGRAM WITH HI-Z

3.2.3 DIELECTRIC STRENGTH

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

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

MODULE TYPE	MODULE FUNCTION	TERMINALS		DIELECTRIC STRENGTH (AC)
		FROM	TO	
1	Power Supply	High (+); Low (+); (–)	Chassis	2000 V AC for 1 minute
1	Power Supply	48 V DC (+) and (–)	Chassis	2000 V AC for 1 minute
1	Power Supply	Relay Terminals	Chassis	2000 V AC for 1 minute
2	Reserved	N/A	N/A	N/A
3	Reserved	N/A	N/A	N/A
4	Reserved	N/A	N/A	N/A
5	Analog Inputs/Outputs	All except 8b	Chassis	< 50 V DC
6	Digital Inputs/Outputs	All	Chassis	2000 V AC for 1 minute
7	G.703	All except 2b, 3a, 7b, 8a	Chassis	2000 V AC for 1 minute
	RS422	All except 6a, 7b, 8a	Chassis	< 50 V DC
8	CT/VT	All	Chassis	2000 V AC for 1 minute
9	CPU	All	Chassis	2000 V AC for 1 minute

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

3.2.4 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 F60 relay, like almost all electronic relays, contains electrolytic capacitors. These capacitors are well known to be subject to deterioration over time if voltage is not applied periodically. Deterioration can be avoided by powering the relays up once a year.**

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

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.

For high reliability systems, the F60 has a redundant option in which two F60 power supplies are placed in parallel on the bus. If one of the power supplies become faulted, the second power supply will assume the full load of the relay without any interruptions. Each power supply has a green LED on the front of the module to indicate it is functional. The critical fail relay of the module will also indicate a faulted power supply.

An LED on the front of the module shows the status of the power supply:

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

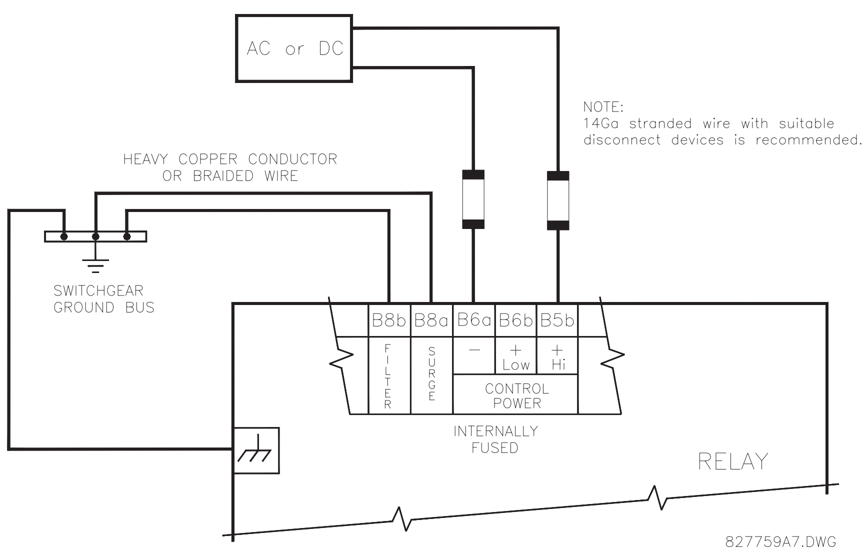


Figure 3–10: CONTROL POWER CONNECTION

3.2.5 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.

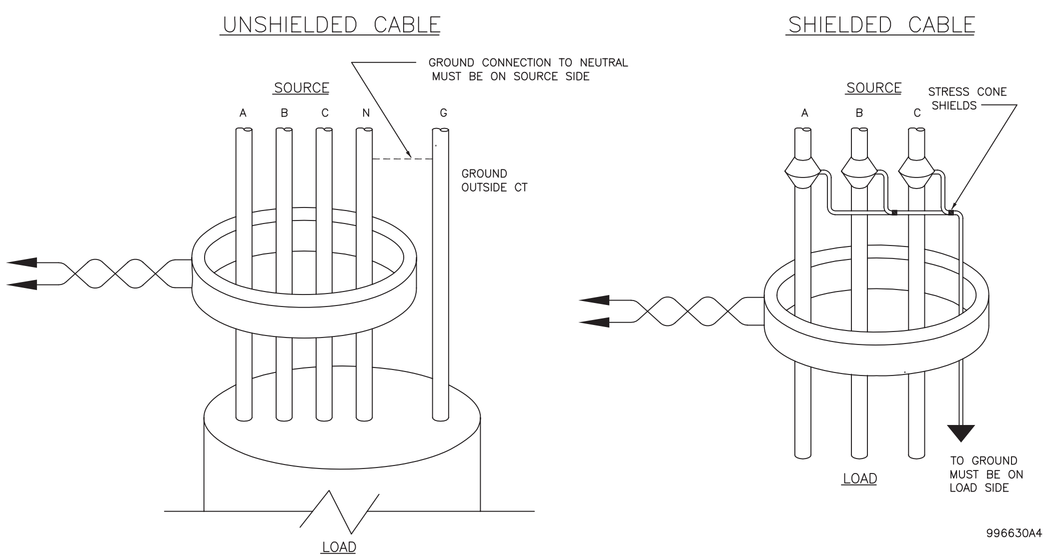


Figure 3–11: ZERO-SEQUENCE CORE BALANCE CT INSTALLATION

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.

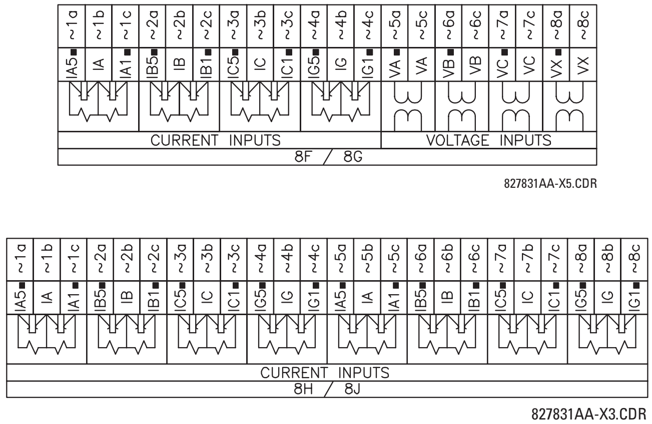


Figure 3–12: CT/VT MODULE WIRING

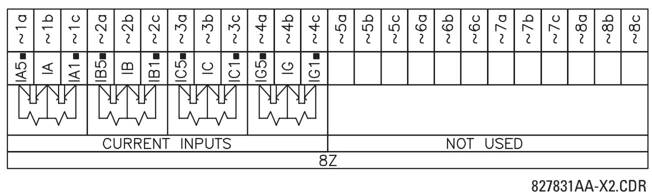


Figure 3–13: CT HI-Z MODULE WIRING

NOTE

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

NOTE

A feeder relay with the high impedance fault detection (Hi-Z) element typically includes two CT/VT modules: one Type 8F or 8G and one Type 8Z. For correct operation of the Hi-Z element, the ground current terminals of the two CT modules must be connected to a ground current source, either a zero-sequence CT (see the *Typical Wiring Diagram with Hi-Z* earlier in this chapter) or, if a zero-sequence CT is not available, to the neutral conductor of the Phase CTs (see the following diagram).

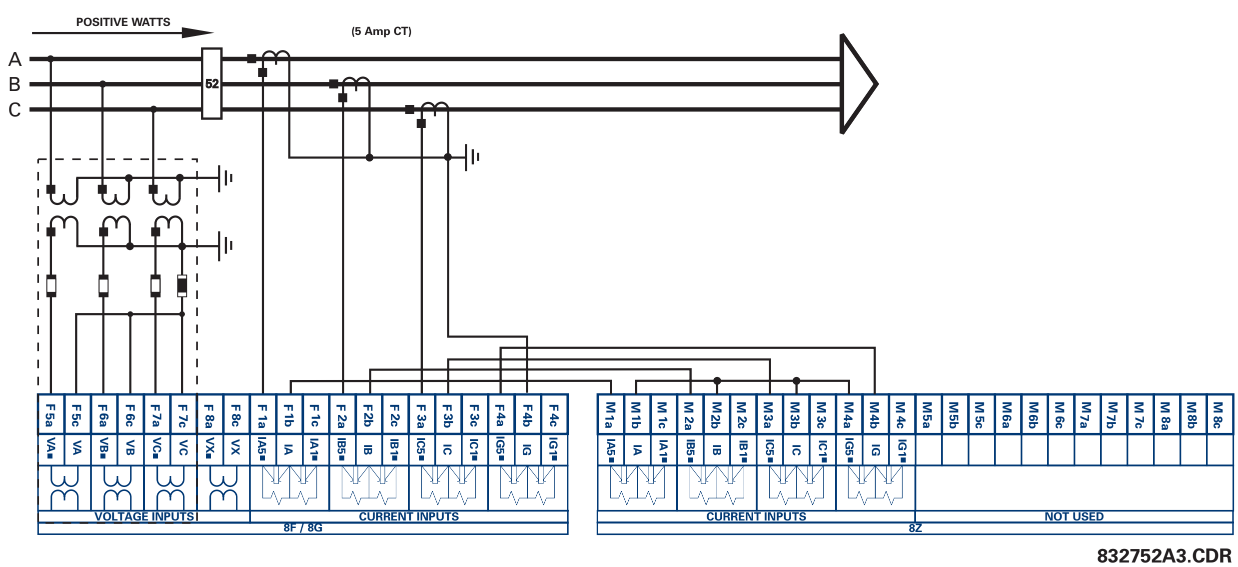


Figure 3–14: TYPICAL 8Z MODULE WIRING WITH PHASE CTS

3.2.6 CONTACT INPUTS/OUTPUTS

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

The digital inputs are grouped with a common return. The F60 has two versions of grouping: four inputs per common return and two inputs per common return. When a digital input/output module is ordered, four inputs per common is used. The four inputs per common allows for high-density inputs in combination with outputs, with a compromise of four inputs sharing one common. If the inputs must be isolated per row, then two inputs per common return should be selected (4D module).

3

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

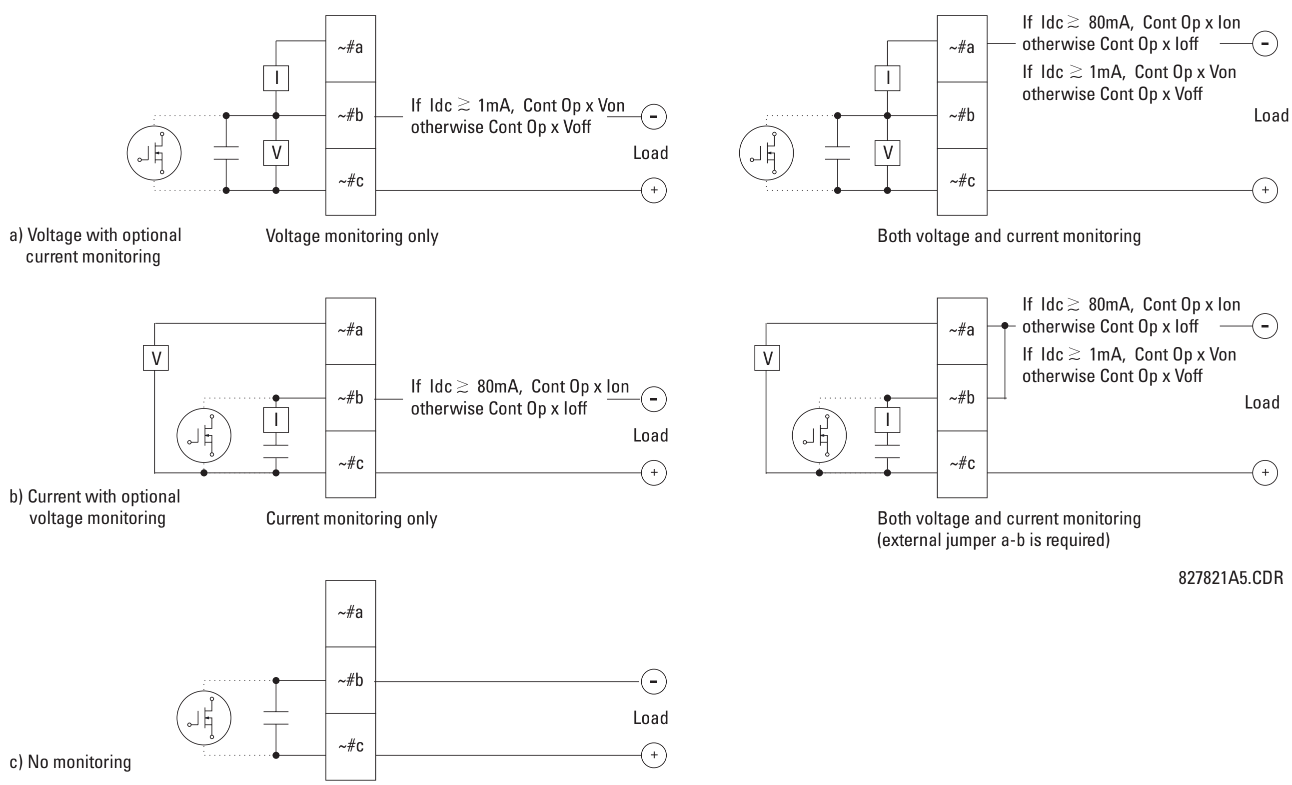


Figure 3–15: FORM-A /SOLID STATE CONTACT FUNCTIONS

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

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

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

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

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

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

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

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

3

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

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

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

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

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

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

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

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

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

~67 MODULE	
TERMINAL ASSIGNMENT	OUTPUT
~1	Form-A
~2	Form-A
~3	Form-A
~4	Form-A
~5	Form-A
~6	Form-A
~7	Form-A
~8	Form-A

~4A MODULE	
TERMINAL ASSIGNMENT	OUTPUT
~1	Not Used
~2	Solid-State
~3	Not Used
~4	Solid-State
~5	Not Used
~6	Solid-State
~7	Not Used
~8	Solid-State

~4B MODULE	
TERMINAL ASSIGNMENT	OUTPUT
~1	Not Used
~2	Solid-State
~3	Not Used
~4	Solid-State
~5	Not Used
~6	Solid-State
~7	Not Used
~8	Solid-State

~4C MODULE	
TERMINAL ASSIGNMENT	OUTPUT
~1	Not Used
~2	Solid-State
~3	Not Used
~4	Solid-State
~5	Not Used
~6	Solid-State
~7	Not Used
~8	Solid-State

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

~4L MODULE	
TERMINAL ASSIGNMENT	OUTPUT
~1	2 Outputs
~2	2 Outputs
~3	2 Outputs
~4	2 Outputs
~5	2 Outputs
~6	2 Outputs
~7	2 Outputs
~8	Not Used

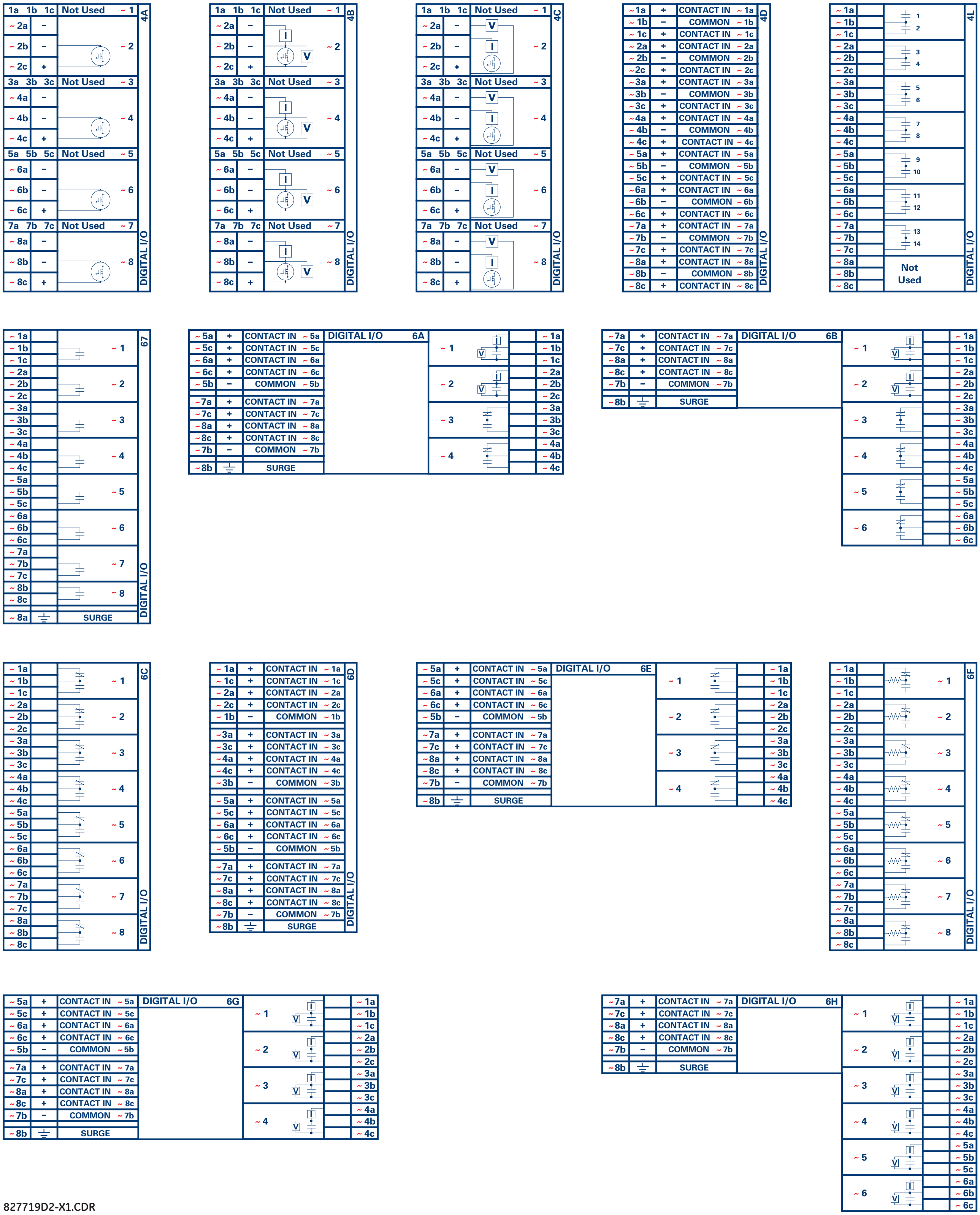


Figure 3–16: DIGITAL INPUT/OUTPUT MODULE WIRING (1 of 2)

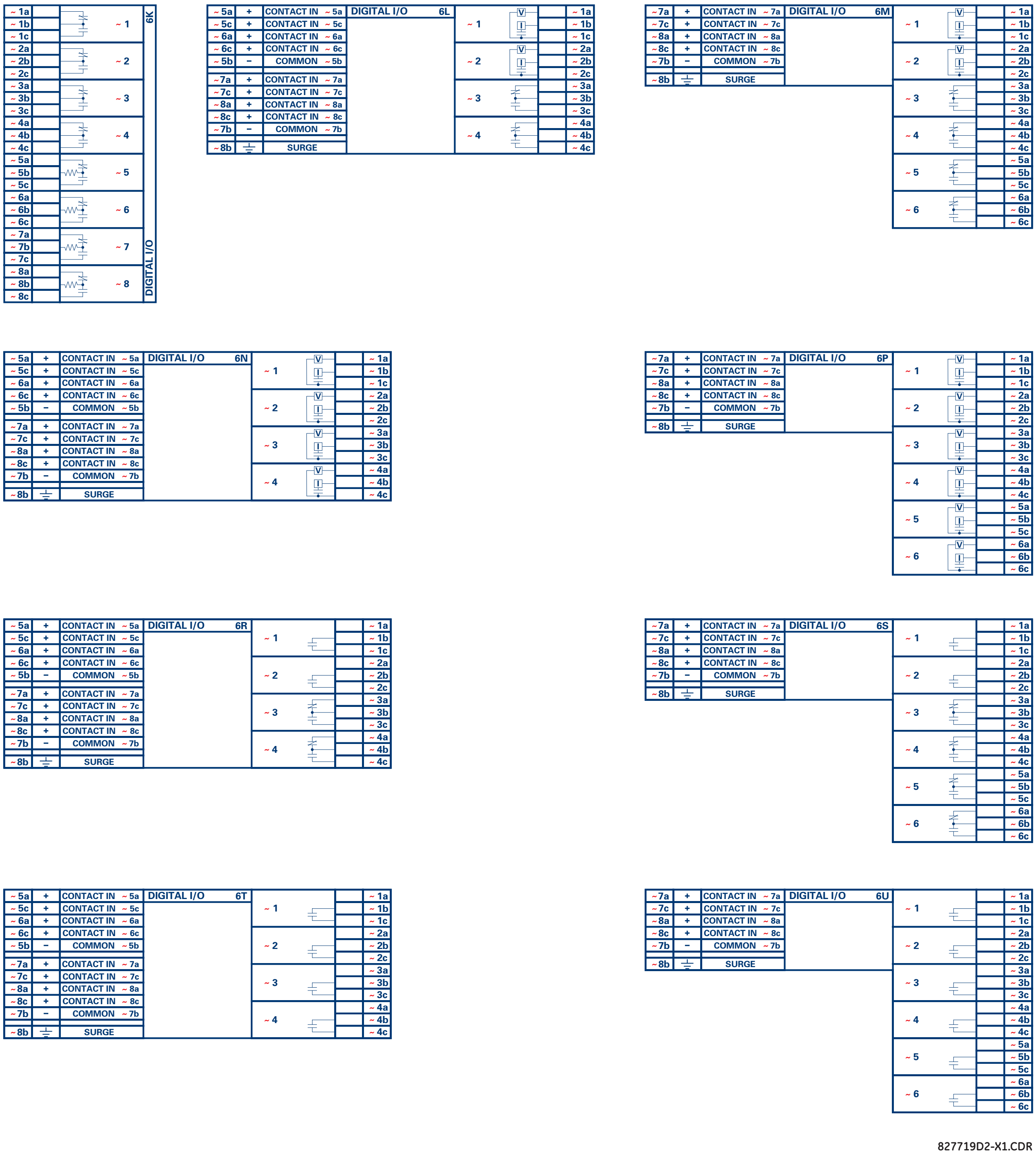


Figure 3–17: DIGITAL INPUT/OUTPUT MODULE WIRING (2 of 2)

CAUTION

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

CONTACT INPUTS:

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

A wet contact has one side connected to the positive terminal of an external DC power supply. The other side of this contact is connected to the required contact input terminal. 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.

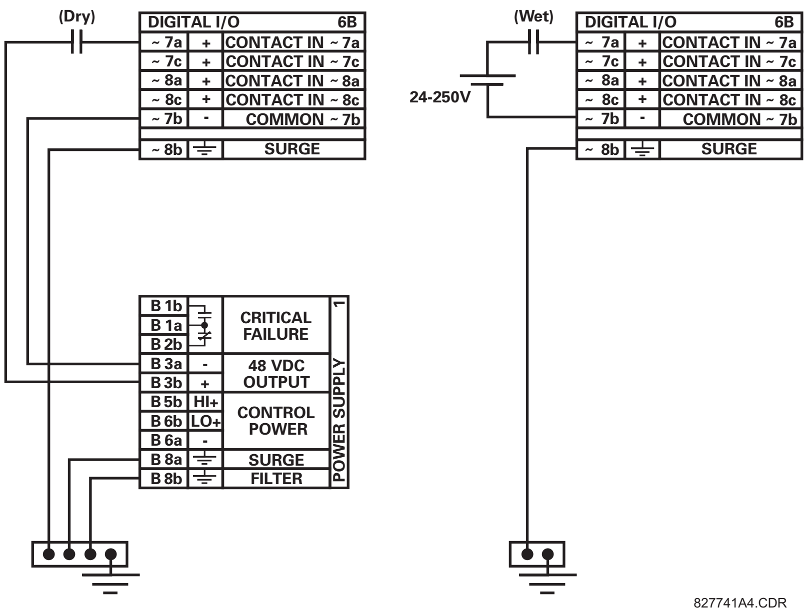


Figure 3–18: DRY AND WET CONTACT INPUT CONNECTIONS

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

CONTACT OUTPUTS:

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

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

USE OF CONTACT INPUTS WITH AUTO-BURNISHING:

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

The contact inputs with auto-burnish create a high current impulse when the threshold is reached to burn off this oxidation layer as a maintenance to the contacts. Afterwards the contact input current is reduced to a steady-state current. The impulse will have a 5 second delay after a contact input changes state.

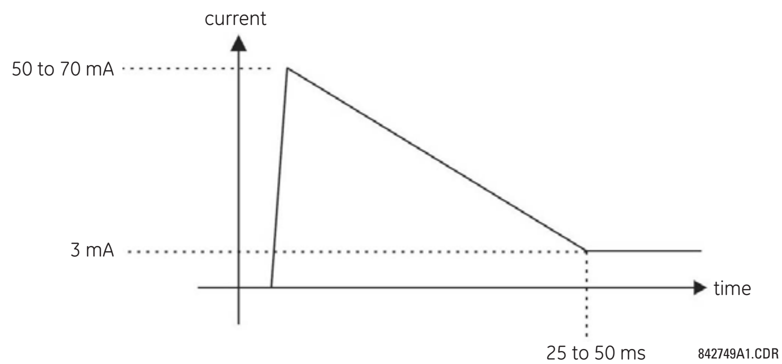


Figure 3–19: CURRENT THROUGH CONTACT INPUTS WITH AUTO-BURNISHING

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

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

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

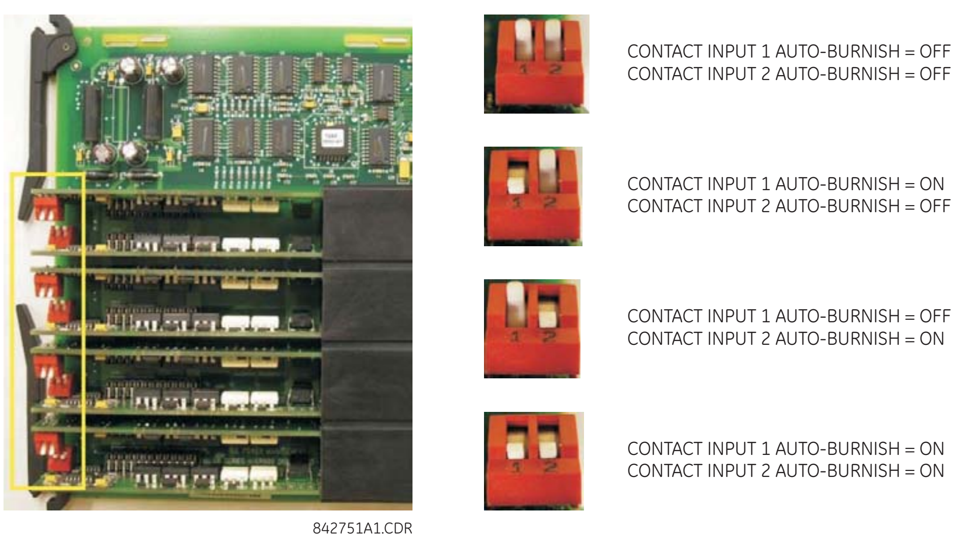


Figure 3–20: AUTO-BURNISH DIP SWITCHES

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

3.2.7 TRANSDUCER INPUTS/OUTPUTS

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

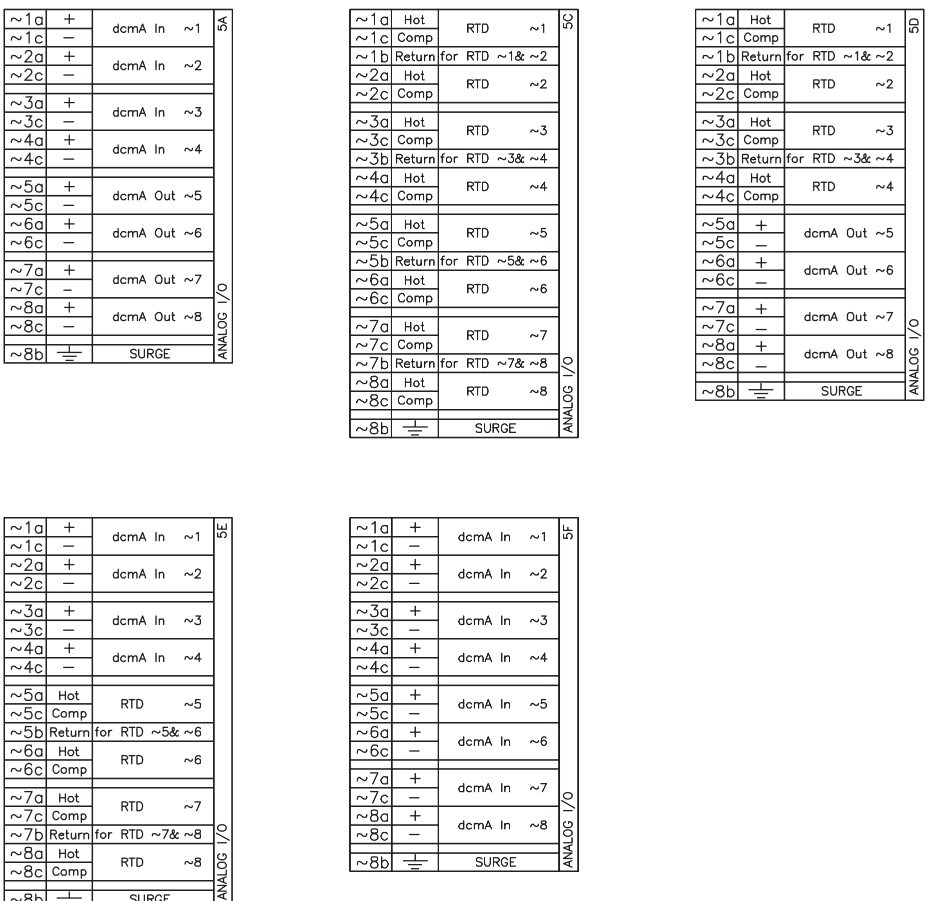
Transducer output modules provide DC current outputs in several standard dcmA ranges. Software is provided to configure virtually any analog quantity used in the relay to drive the analog outputs.

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

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

NOTE

Wherever a tilde “~” symbol appears, substitute with the Slot Position of the module.



827831AB-X1.CDR

Figure 3–21: TRANSDUCER INPUT/OUTPUT MODULE WIRING

3.2.8 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.

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

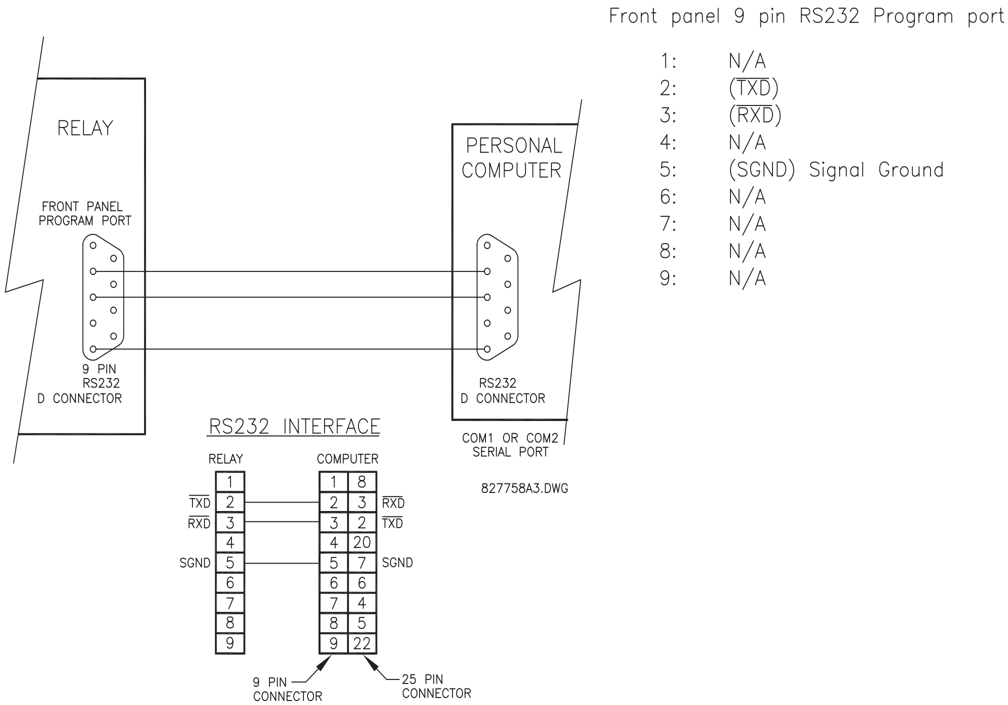


Figure 3–22: RS232 FACEPLATE PORT CONNECTION

3.2.9 CPU COMMUNICATION PORTS

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 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
9J	10Base-FX	RS485
9K	Redundant 10Base-FX	RS485
9L	100Base-FX	RS485
9M	Redundant 100Base-FX	RS485
9N	10/100Base-T	RS485
9P	100Base-FX	RS485
9R	Redundant 100Base-FX	RS485

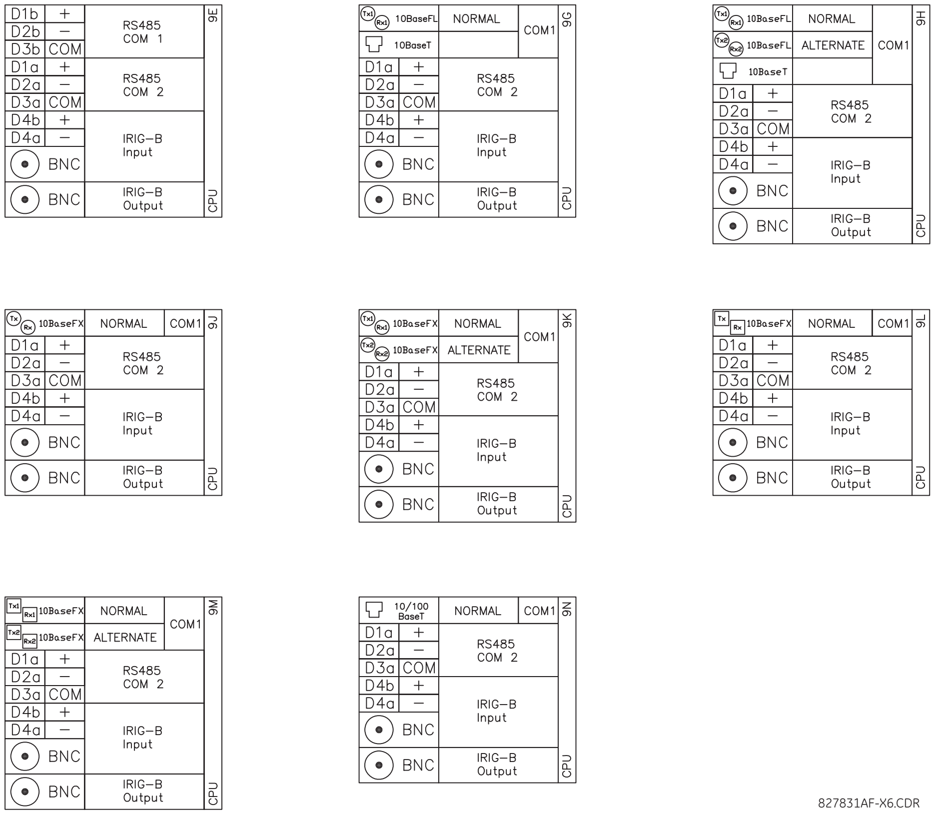


Figure 3–23: CPU MODULE COMMUNICATIONS WIRING

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.

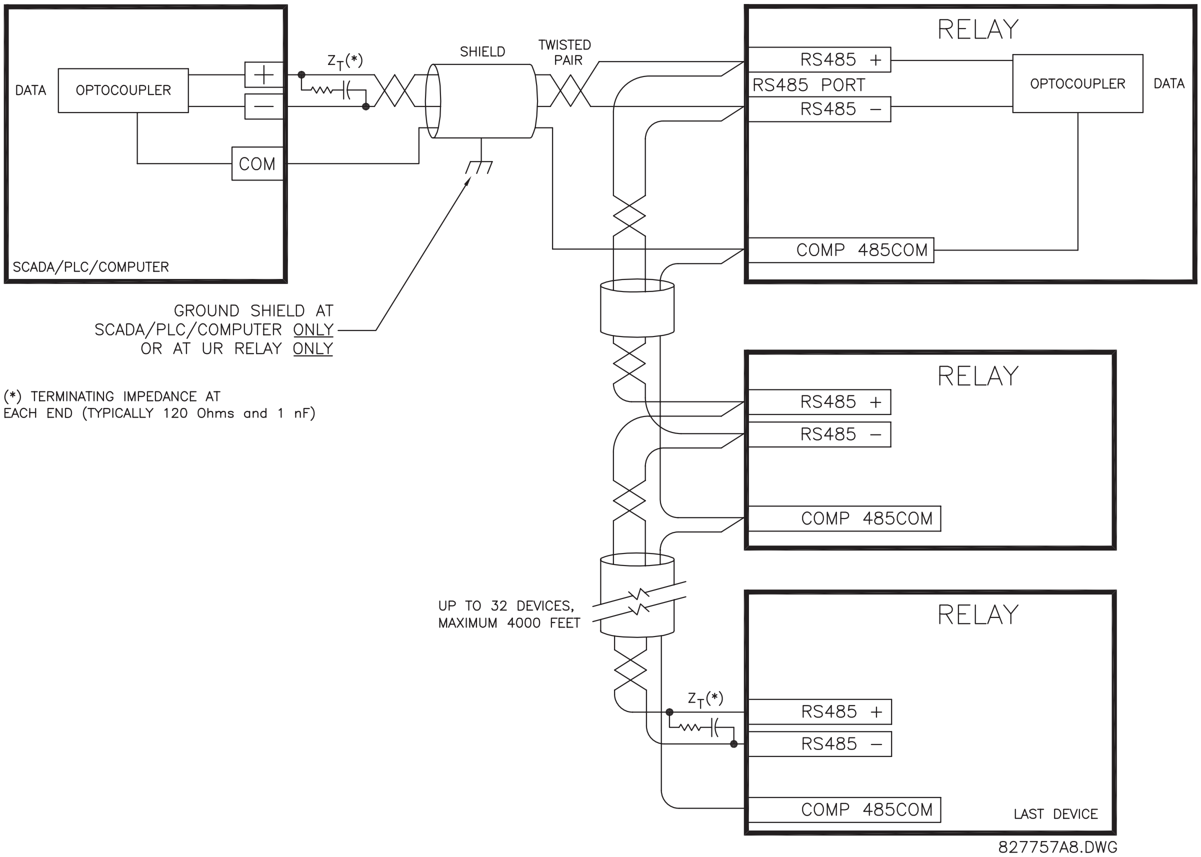


Figure 3–24: RS485 SERIAL CONNECTION

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

CAUTION

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

CAUTION

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

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

The optical fiber sizes supported include 50/125 µm, 62.5/125 µm and 100/140 µm for 10 Mbps. The fiber optic port is designed such that the response times will not vary for any core that is 100 µm or less in diameter, 62.5 µm for 100 Mbps. For optical power budgeting, splices are required every 1 km for the transmitter/receiver pair. When splicing optical fibers, the diameter and numerical aperture of each fiber must be the same. In order to engage or disengage the ST type connector, only a quarter turn of the coupling is required.

3.2.10 IRIG-B

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

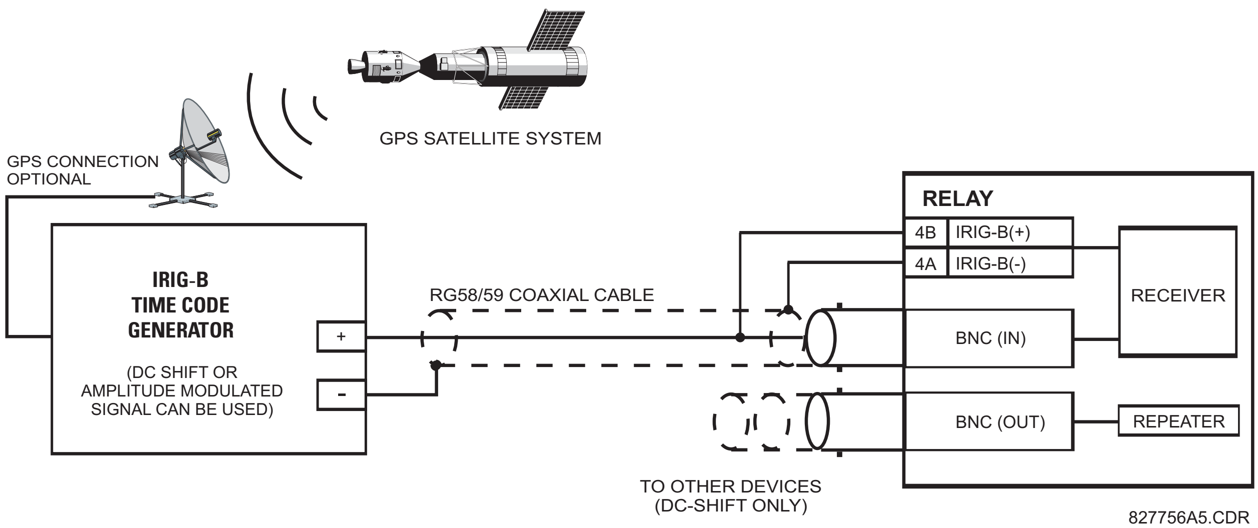


Figure 3–25: IRIG-B CONNECTION

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.

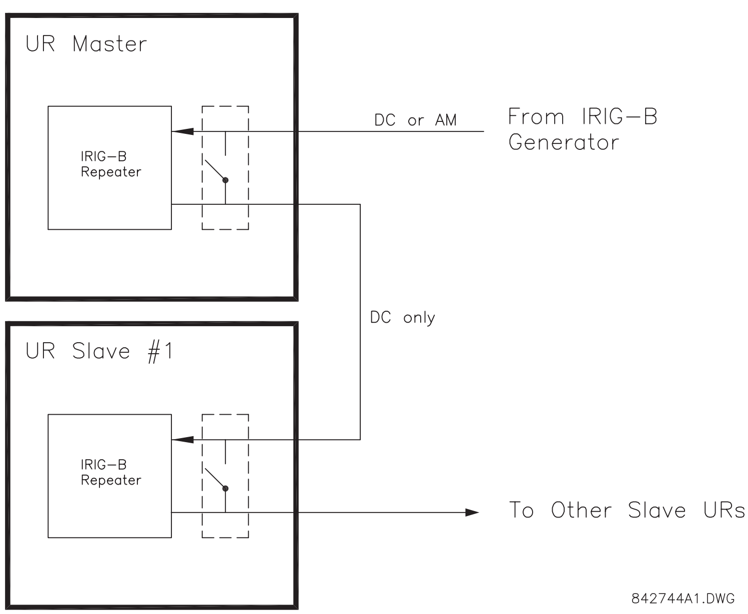


Figure 3–26: IRIG-B REPEATER

3.3.1 DESCRIPTION

The F60 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 sixteen (16) UR-series relays can be connected in a single ring

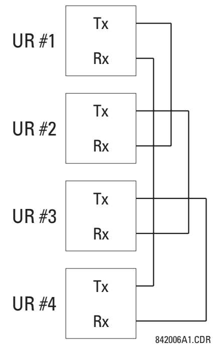


Figure 3–27: DIRECT INPUT/OUTPUT SINGLE CHANNEL CONNECTION

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

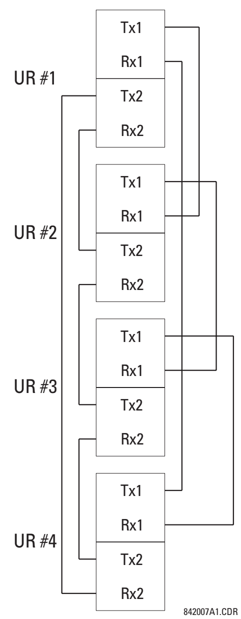


Figure 3–28: DIRECT INPUT/OUTPUT DUAL CHANNEL CONNECTION

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 'cross-over' from Channel 1 to Channel 2 on UR2, the **DIRECT I/O CHANNEL CROSSOVER** setting should be "Enabled" on UR2. This forces UR2 to forward messages received on Rx1 out Tx2, and messages received on Rx2 out Tx1.

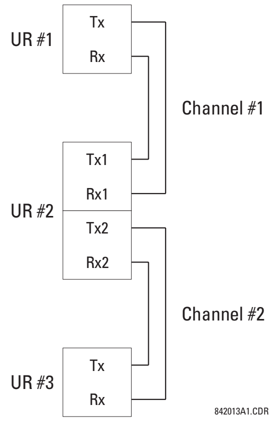


Figure 3–29: DIRECT INPUT/OUTPUT SINGLE/DUAL CHANNEL COMBINATION CONNECTION

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 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
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

CAUTION

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

3.3.2 FIBER: LED AND ELED TRANSMITTERS

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

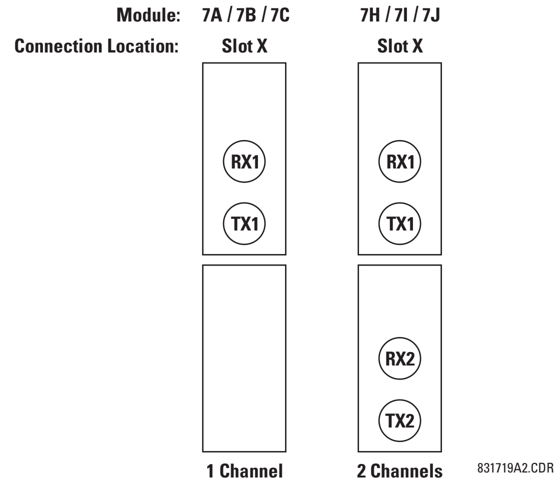


Figure 3–30: LED AND ELED FIBER MODULES

3.3.3 FIBER-LASER TRANSMITTERS

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

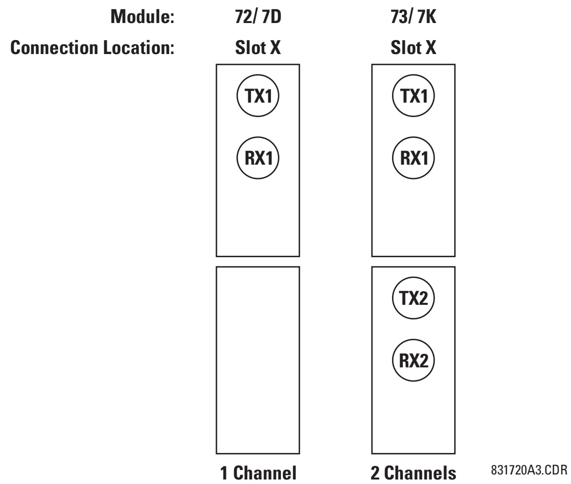


Figure 3–31: LASER FIBER MODULES

WARNING

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

3.3.4 G.703 INTERFACE

a) DESCRIPTION

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

NOTE

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

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

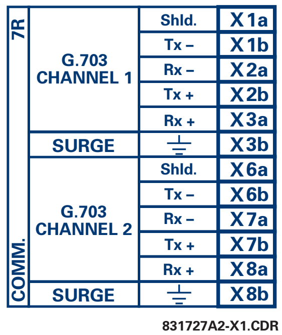


Figure 3–32: G.703 INTERFACE CONFIGURATION

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

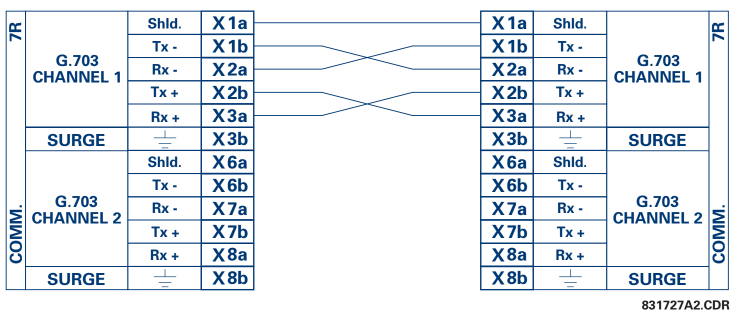


Figure 3–33: TYPICAL PIN INTERCONNECTION BETWEEN TWO G.703 INTERFACES

NOTE

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

b) G.703 SELECTION SWITCH PROCEDURES

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

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

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

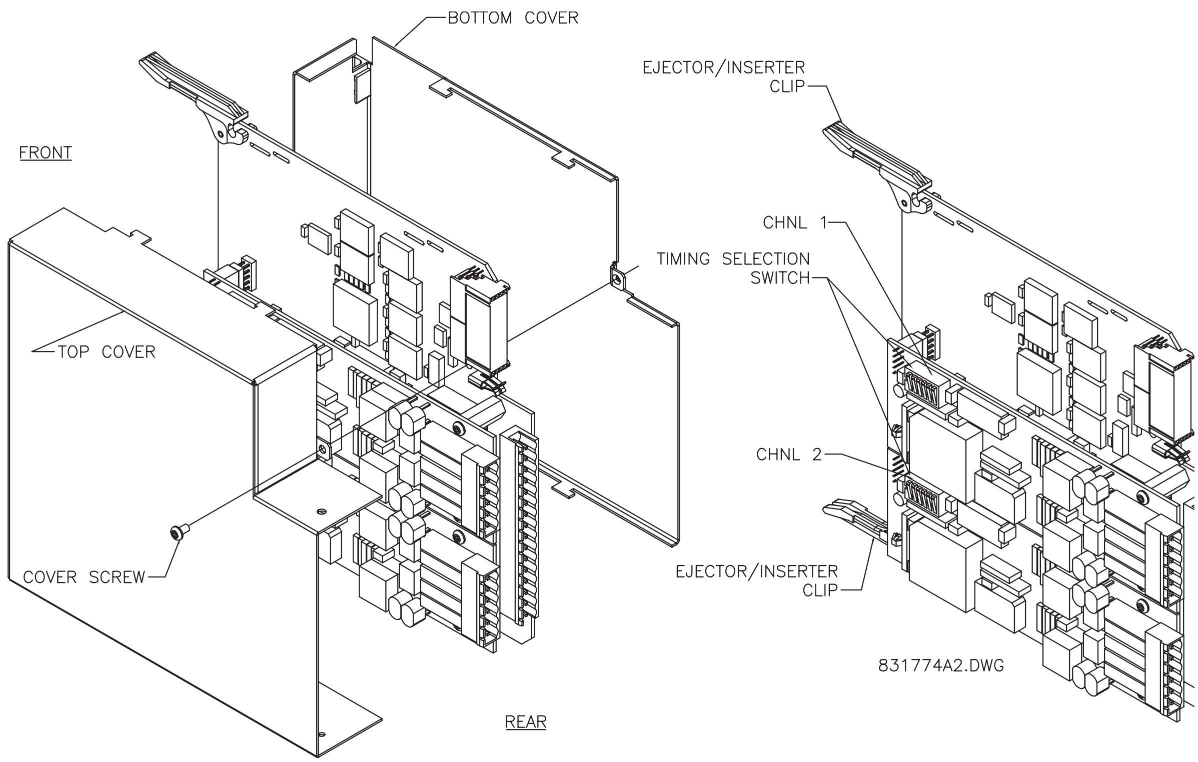


Figure 3–34: G.703 TIMING SELECTION SWITCH SETTING

Table 3–4: G.703 TIMING SELECTIONS

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

c) OCTET TIMING (SWITCH S1)

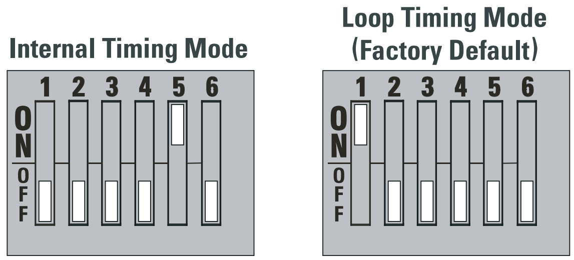
If Octet Timing is enabled (ON), this 8 kHz signal will be asserted during the violation of Bit 8 (LSB) necessary for connecting to higher order systems. When F60s are connected back to back, Octet Timing should be disabled (OFF).

d) TIMING MODES (SWITCHES S5 AND S6)

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

- **Internal Timing Mode:** The system clock is generated internally. Therefore, the G.703 timing selection should be in the Internal Timing Mode for back-to-back (UR-to-UR) connections. For back-to-back connections, set for Octet Timing (S1 = OFF) and Timing Mode = 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).

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



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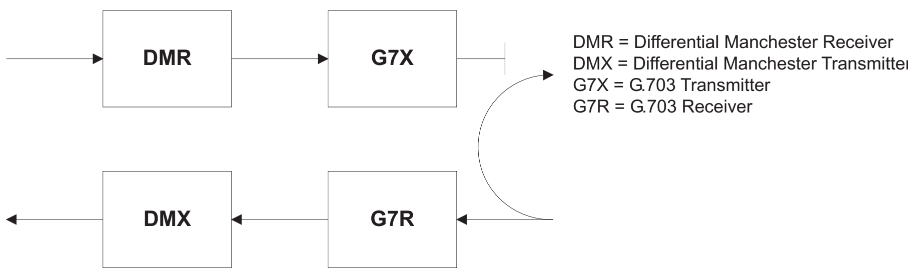
e) TEST MODES (SWITCHES S5 AND S6)

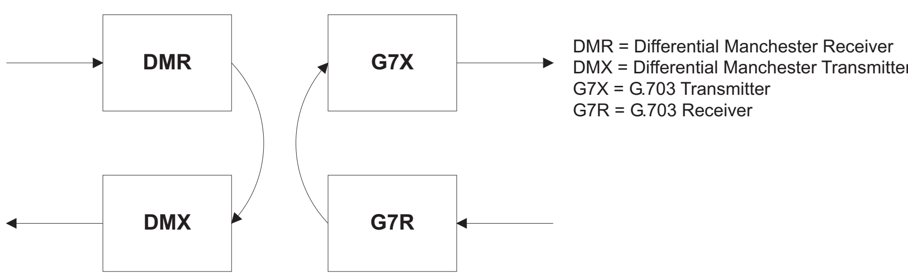
MINIMUM REMOTE LOOPBACK MODE:

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.



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.



3.3.5 RS422 INTERFACE

a) DESCRIPTION

The following figure shows the RS422 2-terminal interface configuration at 64 kbps. AWG 24 twisted shielded pair is recommended for external connections. This interface module is protected by surge suppression devices which optically isolated.

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.

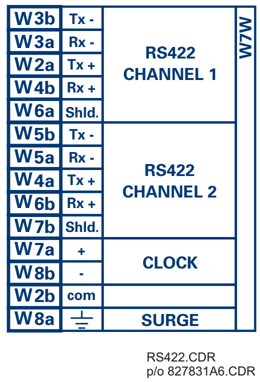


Figure 3–35: RS422 INTERFACE CONFIGURATION

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.

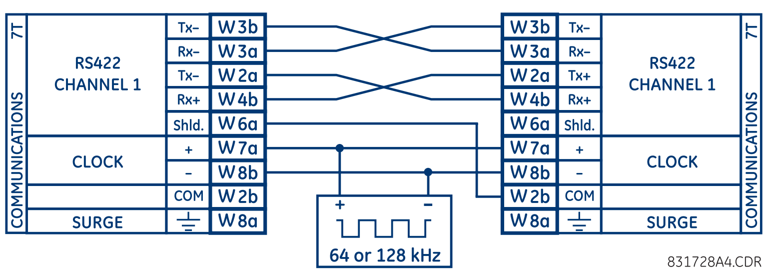


Figure 3–36: TYPICAL PIN INTERCONNECTION BETWEEN TWO RS422 INTERFACES

b) TWO CHANNEL APPLICATIONS VIA MULTIPLEXERS

The RS422 Interface may be used for single or two channel applications over SONET/SDH and/or multiplexed systems. When used in single channel applications, the RS422 interface links to higher order systems in a typical fashion observing transmit (Tx), receive (Rx), and send timing (ST) connections. However, when used in two channel applications, certain criteria must be followed since there is one clock input for the two RS422 channels. The system will function correctly if the following connections are observed and your data module has a terminal timing feature. Terminal timing is a common feature to most synchronous data units that allows the module to accept timing from an external source. Using the terminal timing feature, two channel applications can be achieved if these connections are followed: The send timing outputs from the multiplexer (data module 1), will connect to the Clock inputs of the UR–RS422 interface in the usual fashion. In addition, the send timing outputs of data module 1 will also be paralleled to the terminal timing inputs of data module 2. By using this configuration, the timing for both data modules and both UR–RS422 channels will be derived from a single clock source. As a result, data sampling for both of the UR–RS422 channels will be synchronized via the send timing leads on data module 1 as shown below. If the terminal timing feature is not available or this type of connection is not desired, the G.703 interface is a viable option that does not impose timing restrictions.

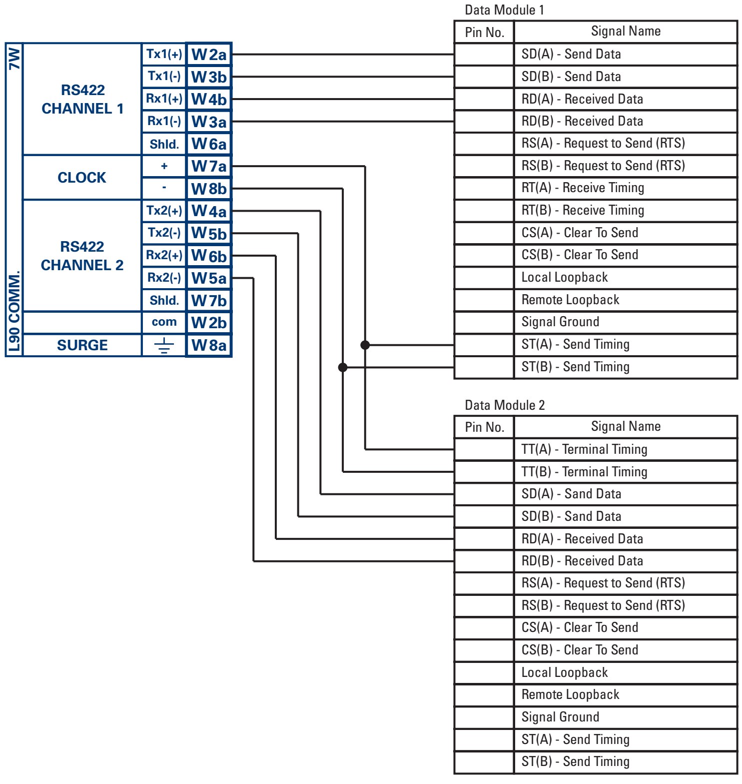


Figure 3–37: TIMING CONFIGURATION FOR RS422 TWO-CHANNEL, 3-TERMINAL APPLICATION

Data module 1 provides timing to the F60 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.

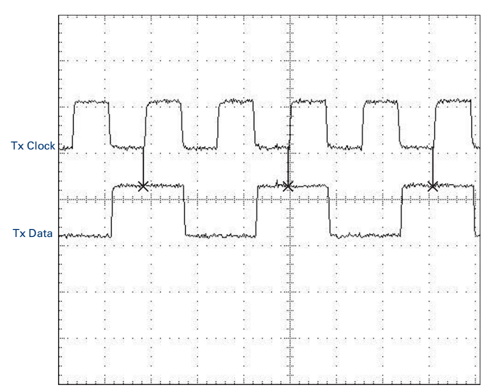


Figure 3–38: CLOCK AND DATA TRANSITIONS

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

3

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 24 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.

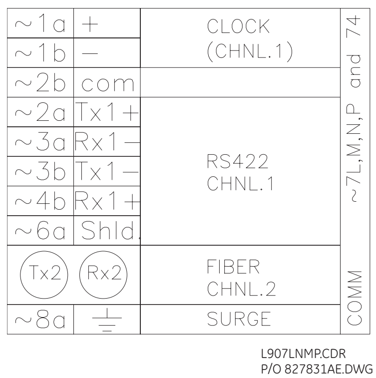


Figure 3–39: RS422 AND FIBER INTERFACE CONNECTION

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 24 twisted shielded pair is recommended for external G.703 connections connecting the shield to Pin 1A at one end only. For the direct fiber channel, 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.

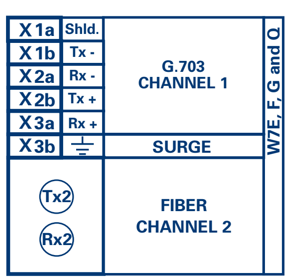


Figure 3–40: G.703 AND FIBER INTERFACE CONNECTION

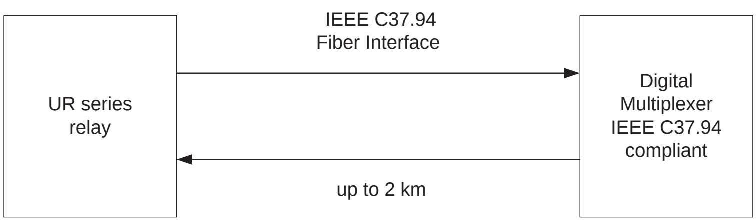
3.3.8 IEEE C37.94 INTERFACE

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.

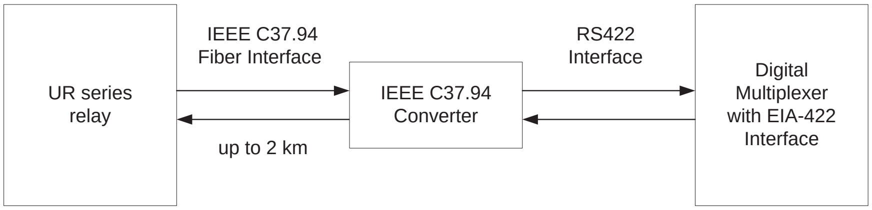
The specifications for the module are as follows:

IEEE standard: C37.94 for 1 × 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.

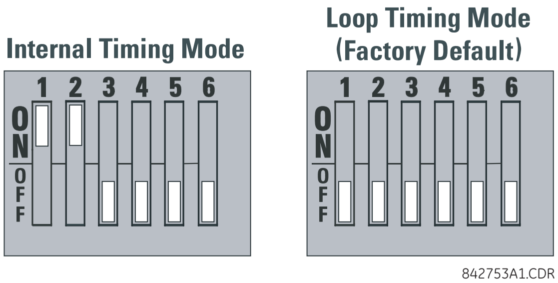
The UR-series C37.94 communication module can be connected directly to any compliant digital multiplexer that supports the IEEE C37.94 standard as shown below.



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.



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.

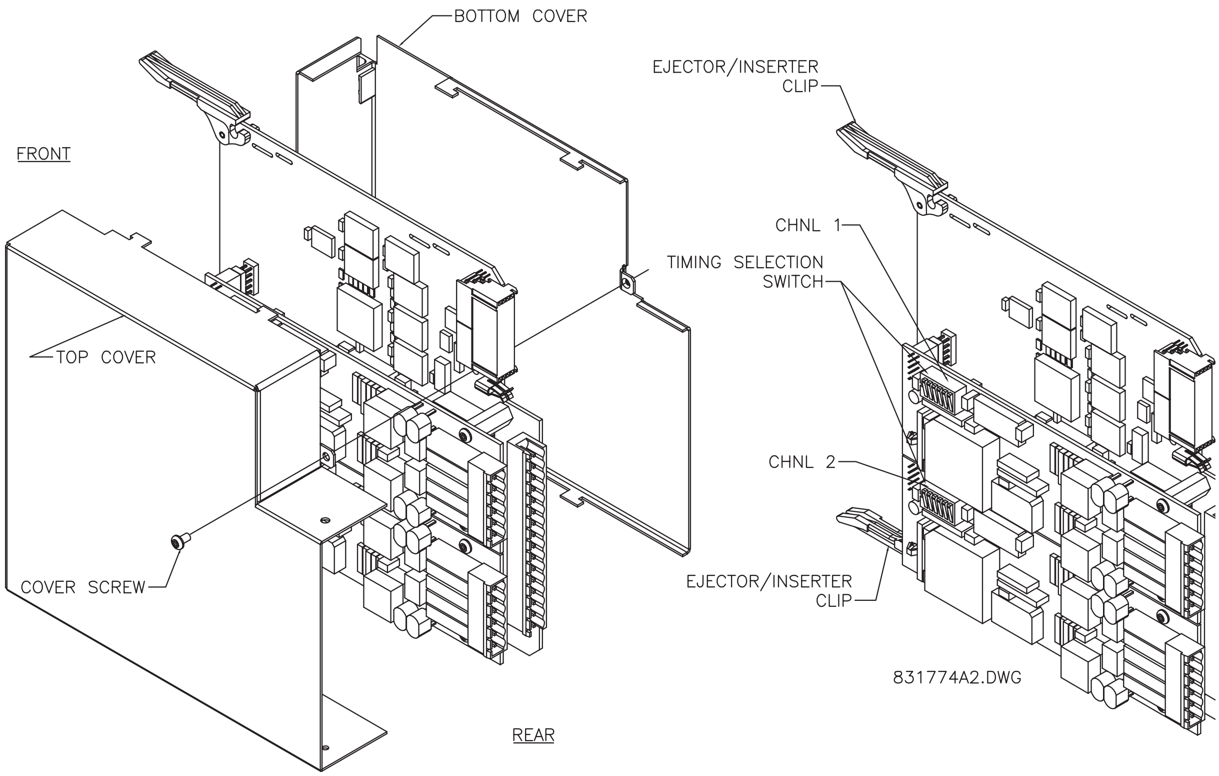


Figure 3–41: IEEE C37.94 TIMING SELECTION SWITCH SETTING

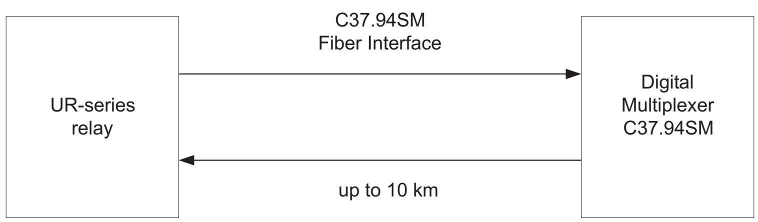
3.3.9 C37.94SM INTERFACE

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

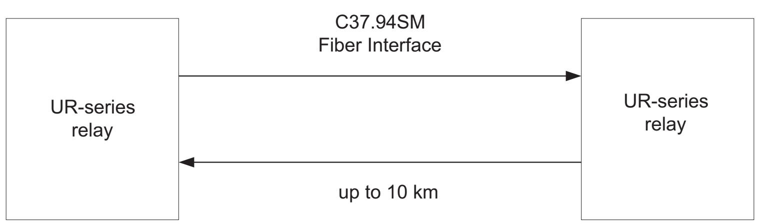
The specifications for the module are as follows:

Emulated IEEE standard: emulates C37.94 for 1 × 64 kbps optical fiber interface (modules set to *n* = 1 or 64 kbps)
Fiber optic cable type: 9/125 µm core diameter optical fiber
Fiber optic mode: single-mode, ELED compatible with HP HFBR-1315T transmitter and HP HFBR-2316T receiver
Fiber optic cable length: up to 10 km
Fiber optic connector: type ST
Wavelength: 1300 ±40 nm
Connection: as per all fiber optic connections, a Tx to Rx connection is required.

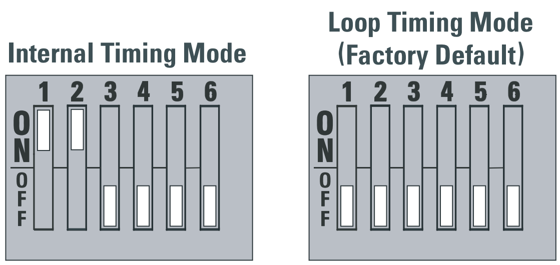
The UR-series C37.94SM communication module can be connected **directly** to any compliant digital multiplexer that supports C37.94SM as shown below.



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



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



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

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

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

1. Remove the C37.94SM module (modules 2A or 2B):

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

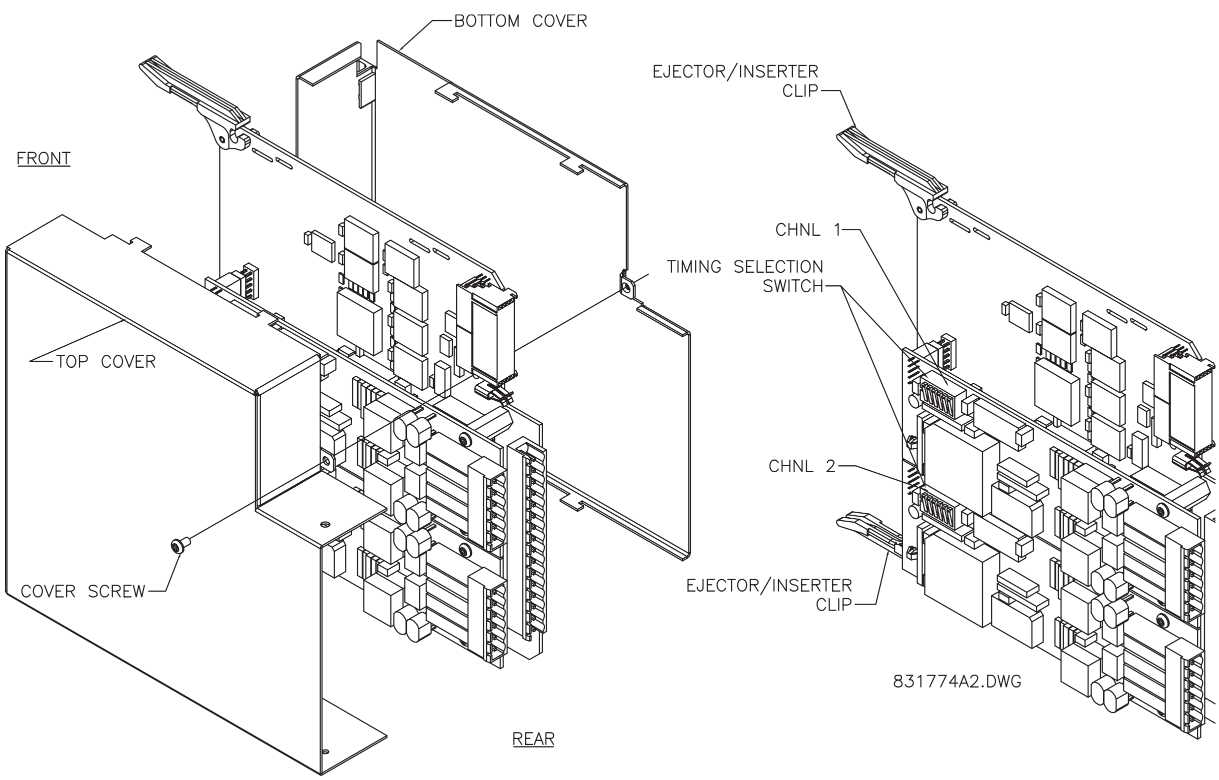


Figure 3–42: C37.94SM TIMING SELECTION SWITCH SETTING

4.1.1 INTRODUCTION

The EnerVista UR Setup software provides a graphical user interface (GUI) as one of two human interfaces to a UR device. The alternate human interface is implemented via the device's faceplate keypad and display (see 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 F60 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 F60* 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 AND EDITING FLEXLOGIC™

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

d) VIEWING ACTUAL VALUES

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

e) VIEWING TRIGGERED EVENTS

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

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

f) FILE SUPPORT

- **Execution:** Any EnerVista UR Setup file which is double clicked or opened will launch the application, or provide focus to the already opened application. If the file was a settings file (has a URS extension) which had been removed from the Settings List tree menu, it will be added back to the Settings List tree menu.
- **Drag and Drop:** The Site List and Settings List control bar windows are each mutually a drag source and a drop target for device-order-code-compatible files or individual menu items. Also, the Settings List control bar window and any Windows Explorer directory folder are each mutually a file drag source and drop target.

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

g) FIRMWARE UPGRADES

The firmware of a F60 device can be upgraded, locally or remotely, via the EnerVista UR Setup software. The corresponding instructions are provided by the EnerVista UR Setup Help file under the topic “Upgrading Firmware”.

NOTE

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

4.1.4 ENERVISTA UR SETUP SOFTWARE MAIN WINDOW

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

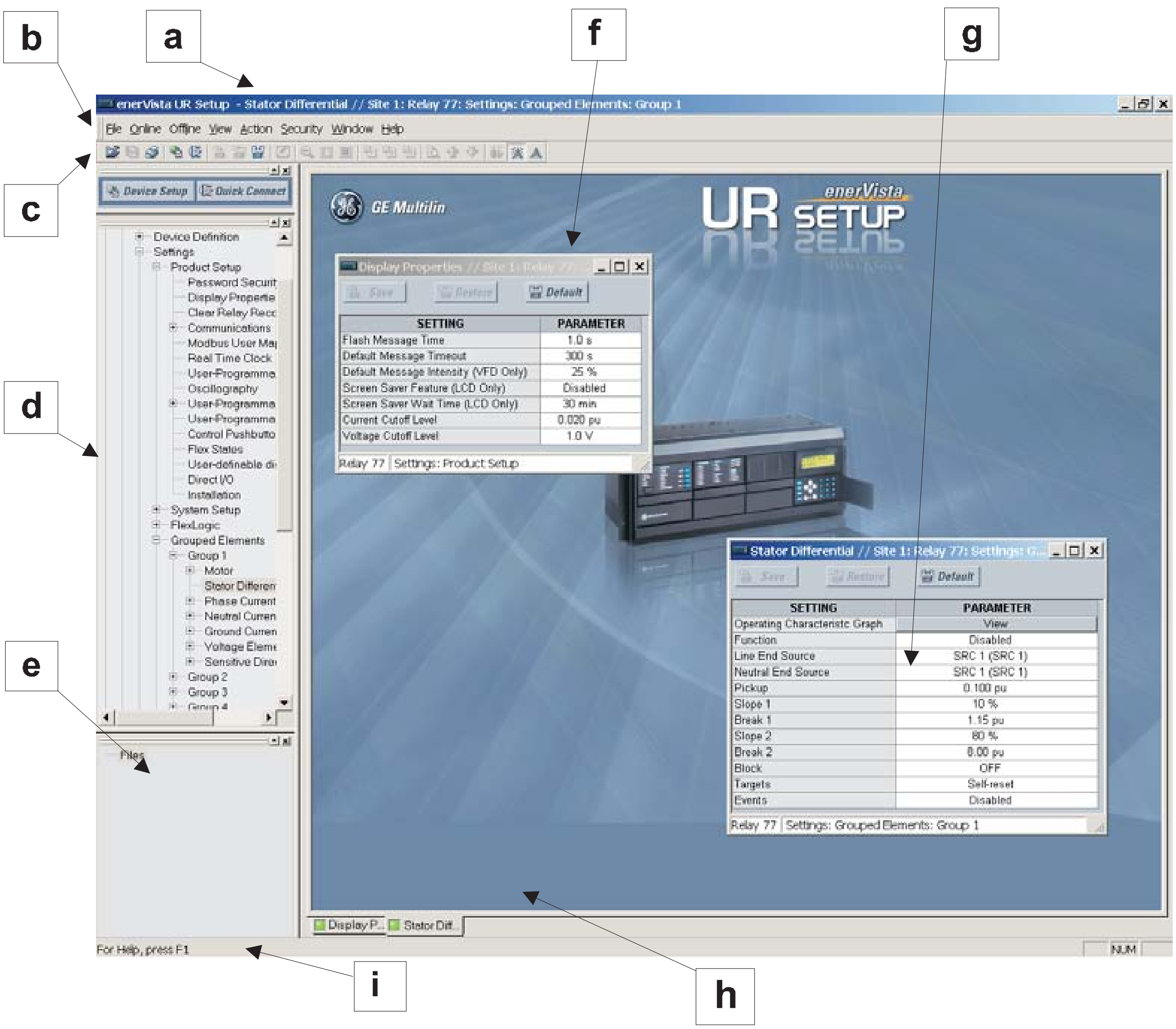


Figure 4–1: ENERVISTA UR SETUP SOFTWARE MAIN WINDOW

4.2.1 FACEPLATE

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.

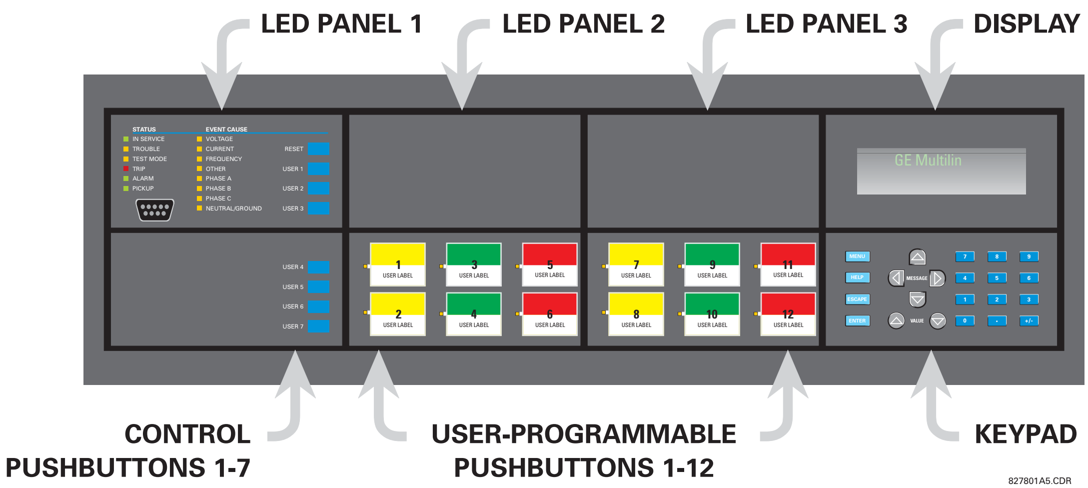


Figure 4–2: UR-SERIES HORIZONTAL FACEPLATE PANELS

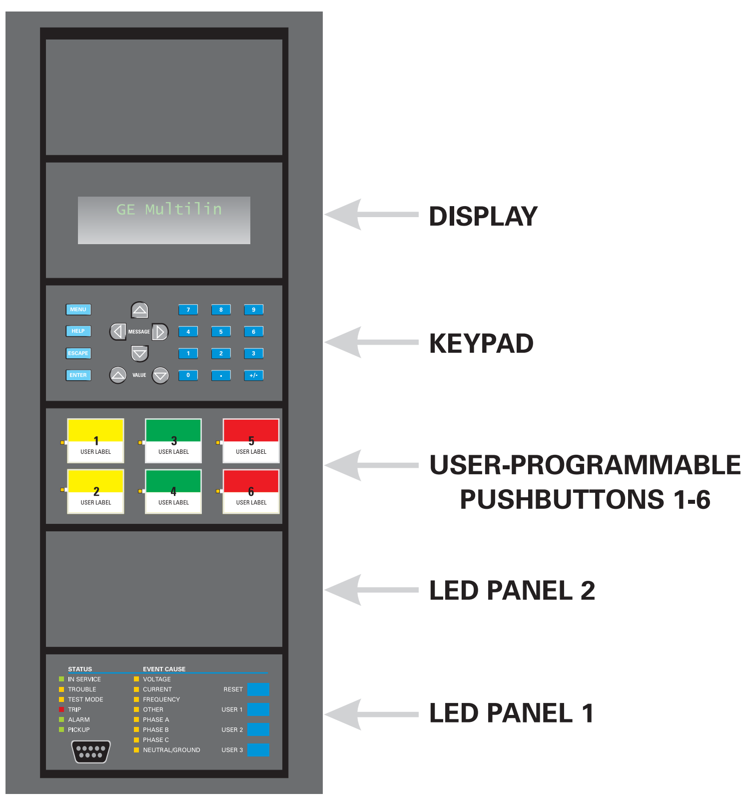


Figure 4–3: UR-SERIES VERTICAL FACEPLATE PANELS

4.2.2 LED INDICATORS

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.

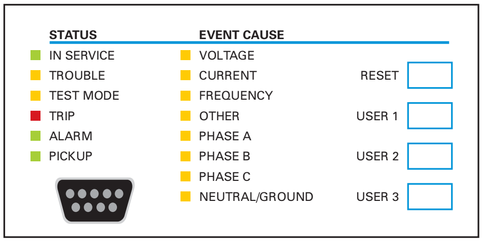


Figure 4–4: LED PANEL 1

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.

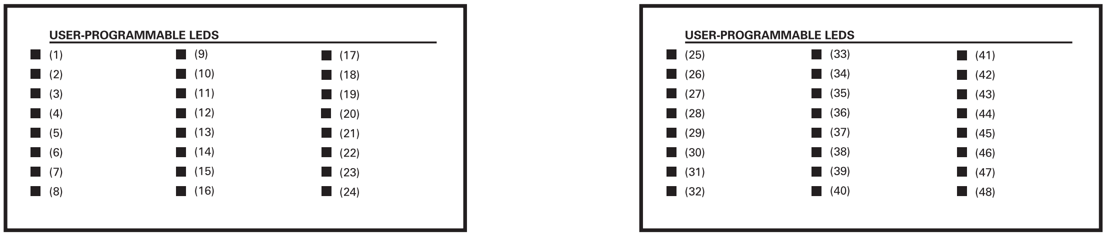


Figure 4–5: LED PANELS 2 AND 3 (INDEX TEMPLATE)

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.

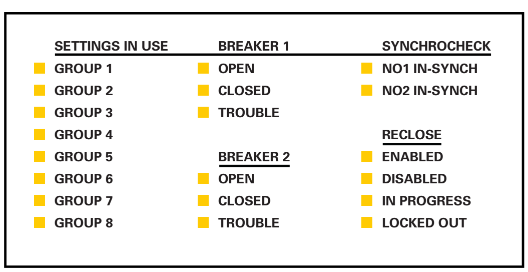


Figure 4–6: LED PANEL 2 (DEFAULT LABELS)

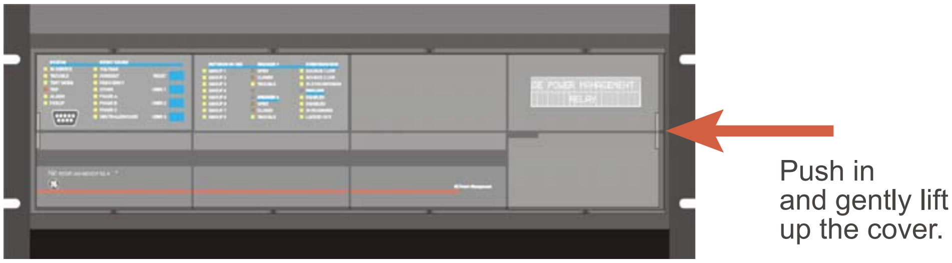
d) INSTALLING THE CUSTOMIZED DISPLAY MODULE

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

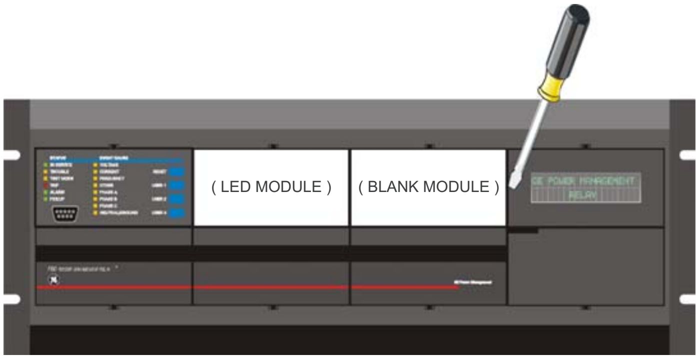
http://www.GEindustrial.com/multilin/support/ur/

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).



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 DISPLAY MODULE

The following items are required to customize the F60 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.

4

4.2.3 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.

4.2.4 KEYPAD

Display messages are organized into 'pages' under the following headings: Actual Values, Settings, Commands, and Targets. The MENU key navigates through these pages. Each heading page is broken down further into logical subgroups.

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

The · key initiates and advance to the next character in text edit mode or enters a decimal point. The HELP key may be pressed at any time for context sensitive help messages. The ENTER key stores altered setting values.

4

4.2.5 BREAKER CONTROL

a) DESCRIPTION

The F60 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 PUSHBUTTON (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
PASSWORD
```

This message appears when the USER 1, USER 2, or USER 3 key is pressed and a **COMMAND PASSWORD** is required; i.e. if **COMMAND PASSWORD** is enabled and no commands have been issued within the last 30 minutes.

```
   Press USER 1
 To Select Breaker
```

This message appears if the correct password is entered or if none is required. This message will be maintained for 30 seconds or until the USER 1 key is pressed again.

```
BKR1-(Name) SELECTED
USER 2=CLS/USER 3=OP
```

This message is displayed after the USER 1 key is pressed for the second time. Three possible actions can be performed from this state within 30 seconds as per items **(1)**, **(2)** and **(3)** below:

(1)

```
  USER 2 OFF/ON
To Close BKR1-(Name)
```

If the USER 2 key is pressed, this message appears for 20 seconds. If the USER 2 key is pressed again within that time, a signal is created that can be programmed to operate an output relay to close breaker No. 1.

(2)

```
  USER 3 OFF/ON
 To Open BKR1-(Name)
```

If the USER 3 key is pressed, this message appears for 20 seconds. If the USER 3 key is pressed again within that time, a signal is created that can be programmed to operate an output relay to open breaker No. 1.

(3)

```
BKR2-(Name) SELECTED
USER 2=CLS/USER 3=OP
```

If the USER 1 key is pressed at this step, this message appears showing that a different breaker is selected. Three possible actions can be performed from this state as per **(1)**, **(2)** and **(3)**. Repeatedly pressing the USER 1 key alternates between available breakers. Pressing keys other than USER 1, 2 or 3 at any time aborts the breaker control function.

e) CONTROL OF ONE BREAKER

For this application the relay is connected and programmed for breaker 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     ■■ SETTINGS        ■■ COMMANDS         No Active
■■ STATUS            ■■ PRODUCT SETUP   ■■ VIRTUAL INPUTS    Targets

⇨    MENU
  USER DISPLAYS
  (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 ■■ PRODUCT SETUP	◀▶	■ PASSWORD ■ SECURITY	◀▶	ACCESS LEVEL: 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.

4

4.2.7 CHANGING SETTINGS

a) ENTERING NUMERICAL DATA

Each numerical setting has its own minimum, maximum, and increment value associated with it. These parameters define what values are acceptable for a setting.

```
FLASH MESSAGE
TIME:  1.0 s
```
⇩

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

```
MINIMUM:   0.5
MAXIMUM:  10.0
```

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

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

- **0 to 9** and ▪ (decimal point): The relay numeric keypad works the same as that of any electronic calculator. A number is entered one digit at a time. The leftmost digit is entered first and the rightmost digit is entered last. Pressing the MESSAGE ◀ 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
```
⇩

As an example, set the flash message time setting to 2.5 seconds. Press the appropriate numeric keys in the sequence "2 . 5". The display message will change as the digits are being entered.

```
NEW SETTING
HAS BEEN STORED
```

Until ENTER is pressed, editing changes are not registered by the relay. Therefore, press ENTER to store the new value in memory. This flash message will momentarily appear as confirmation of the storing process. Numerical values which contain decimal places will be rounded-off if more decimal place digits are entered than specified by the step value.

b) ENTERING ENUMERATION DATA

Enumeration settings have data values which are part of a set, whose members are explicitly defined by a name. A set is comprised of two or more members.

```
ACCESS LEVEL:
Restricted
```

For example, the selections available for **ACCESS LEVEL** are "Restricted", "Command", "Setting", and "Factory Service".

Enumeration type values are changed using the VALUE keys. The VALUE ▲ key displays the next selection while the VALUE ▼ key displays the previous selection.

```
ACCESS LEVEL:
Setting
```
⇩

If the **ACCESS LEVEL** needs to be "Setting", press the VALUE keys until the proper selection is displayed. Press HELP at any time for the context sensitive help messages.

```
NEW SETTING
HAS BEEN STORED
```

Changes are not registered by the relay until the ENTER key is pressed. Pressing ENTER stores the new value in memory. This flash message momentarily appears as confirmation of the storing process.

c) ENTERING ALPHANUMERIC TEXT

Text settings have data values which are fixed in length, but user-defined in character. They may be comprised of upper case letters, lower case letters, numerals, and a selection of special characters.

There are several places where text messages may be programmed to allow the relay to be customized for specific applications. One example is the Message Scratchpad. Use the following procedure to enter alphanumeric text messages.

For example: to enter the text, "Breaker #1"

1. Press 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

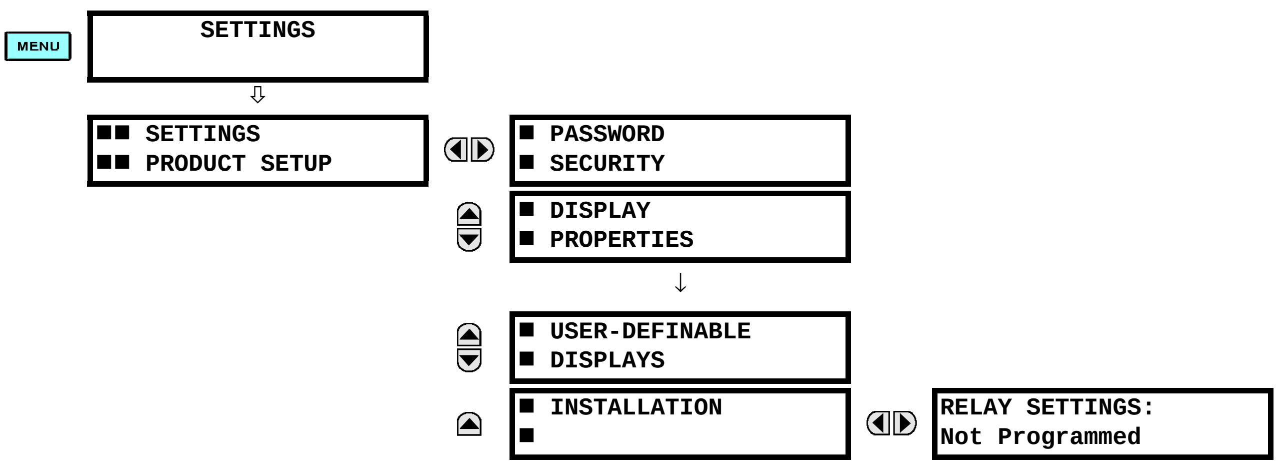
```
RELAY SETTINGS:
Not Programmed
```

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.

4

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.



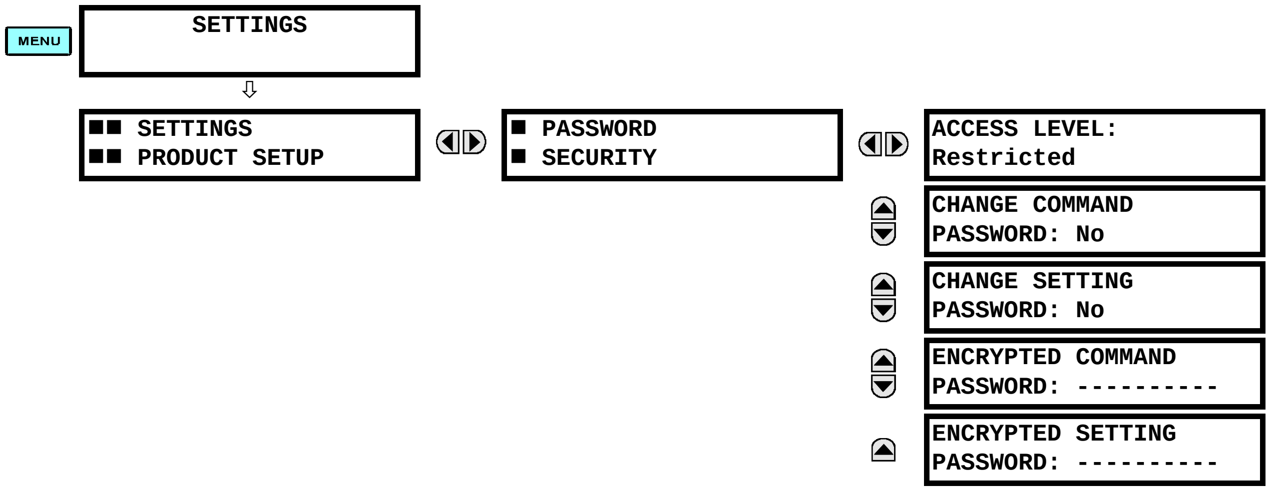
5. After the **RELAY SETTINGS: Not Programmed** message appears on the display, press the VALUE keys change the selection to "Programmed".
6. Press the [ENTER] key.

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.

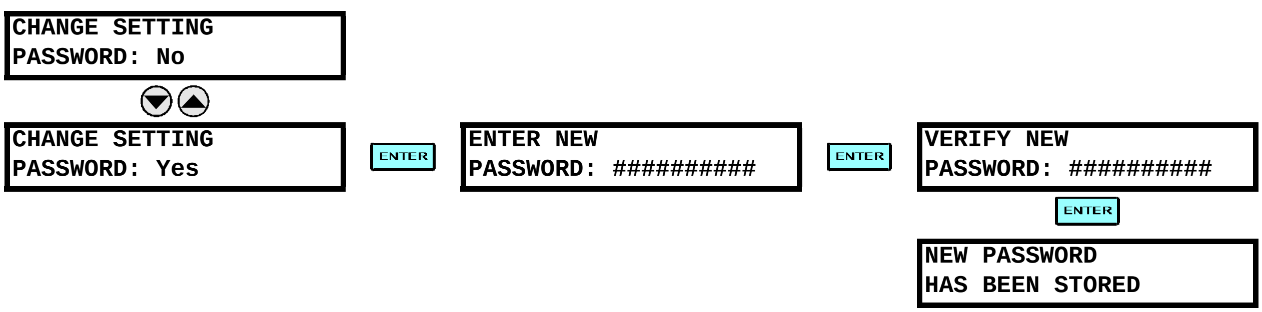
e) ENTERING INITIAL PASSWORDS

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.



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.



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.

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g) INVALID PASSWORD ENTRY

In the event that an incorrect Command or Setting password has been entered via the faceplate interface three times within a three-minute time span, the LOCAL ACCESS DENIED FlexLogic™ operand will be set to “On” and the F60 will not allow Settings or Command access via the faceplate interface for the next ten minutes. The **TOO MANY ATTEMPTS – BLOCKED FOR 10 MIN!** flash message will appear upon activation of the ten minute timeout or any other time a user attempts any change to the defined tier during the ten minute timeout. The LOCAL ACCESS DENIED FlexLogic™ operand will be set to “Off” after the expiration of the ten-minute timeout.

In the event that an incorrect Command or Setting password has been entered via the any external communications interface three times within a three-minute time span, the REMOTE ACCESS DENIED FlexLogic™ operand will be set to “On” and the F60 will not allow Settings or Command access via the any external communications interface for the next ten minutes. The REMOTE ACCESS DENIED FlexLogic™ operand will be set to “Off” after the expiration of the ten-minute timeout.

5.1.1 SETTINGS MAIN MENU

■■ SETTINGS ■■ PRODUCT SETUP	■ PASSWORD ■ SECURITY	See page 5-8.
	■ DISPLAY ■ PROPERTIES	See page 5-9.
	■ CLEAR RELAY ■ RECORDS	See page 5-11.
	■ COMMUNICATIONS ■	See page 5-12.
	■ MODBUS USER MAP ■	See page 5-23.
	■ REAL TIME ■ CLOCK	See page 5-24.
	■ FAULT REPORTS ■	See page 5-24.
	■ OSCILLOGRAPHY ■	See page 5-25.
	■ DATA LOGGER ■	See page 5-27.
	■ DEMAND ■	See page 5-29.
	■ USER-PROGRAMMABLE ■ LEDS	See page 5-30.
	■ USER-PROGRAMMABLE ■ SELF TESTS	See page 5-33.
	■ CONTROL ■ PUSHBUTTONS	See page 5-34.
	■ USER-PROGRAMMABLE ■ PUSHBUTTONS	See page 5-35.
	■ FLEX STATE ■ PARAMETERS	See page 5-36.
	■ USER-DEFINABLE ■ DISPLAYS	See page 5-37.
	■ DIRECT I/O ■	See page 5-39.
	■ TELEPROTECTION ■	See page 5-44.
	■ INSTALLATION ■	See page 5-45.
■■ SETTINGS ■■ SYSTEM SETUP	■ AC INPUTS ■	See page 5-46.
	■ POWER SYSTEM ■	See page 5-47.

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	■ SIGNAL SOURCES ■	See page 5-48.
	■ BREAKERS ■	See page 5-50.
	■ FLEXCURVES ■	See page 5-53.
■■ SETTINGS ■■ FLEXLOGIC	■ FLEXLOGIC ■ EQUATION EDITOR	See page 5-73.
	■ FLEXLOGIC ■ TIMERS	See page 5-73.
	■ FLEXELEMENTS ■	See page 5-74.
	■ NON-VOLATILE ■ LATCHES	See page 5-78.
■■ SETTINGS ■■ GROUPED ELEMENTS	■ SETTING GROUP 1 ■	See page 5-79.
	■ SETTING GROUP 2 ■	
	↓	
	■ SETTING GROUP 6 ■	
■■ SETTINGS ■■ CONTROL ELEMENTS	■ SETTING GROUPS ■	See page 5-127.
	■ SELECTOR SWITCH ■	See page 5-128.
	■ UNDERFREQUENCY ■	See page 5-134.
	■ OVERFREQUENCY ■	See page 5-135.
	■ FREQUENCY RATE ■ OF CHANGE	See page 5-136.
	■ SYNCHROCHECK ■	See page 5-138.
	■ AUTORECLOSE ■	See page 5-142.
	■ DIGITAL ELEMENTS ■	See page 5-148.
	■ DIGITAL COUNTERS ■	See page 5-151.
	■ MONITORING ■ ELEMENTS	See page 5-153.

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	■ COLD LOAD PICKUP ■	See page 5-165.
■■ SETTINGS ■■ INPUTS / OUTPUTS	■ CONTACT INPUTS ■	See page 5-167.
	■ VIRTUAL INPUTS ■	See page 5-169.
	■ CONTACT OUTPUTS ■	See page 5-170.
	■ VIRTUAL OUTPUTS ■	See page 5-172.
	■ REMOTE DEVICES ■	See page 5-173.
	■ REMOTE INPUTS ■	See page 5-174.
	■ REMOTE OUTPUTS ■ DNA BIT PAIRS	See page 5-175.
	■ REMOTE OUTPUTS ■ UserSt BIT PAIRS	See page 5-175.
	■ RESETTING ■	See page 5-176.
	■ DIRECT INPUTS ■	See page 5-176.
	■ DIRECT OUTPUTS ■	See page 5-176.
	■ TELEPROTECTION ■	See page 5-180.
■■ SETTINGS ■■ TRANSDUCER I/O	■ DCMA INPUTS ■	See page 5-182.
	■ RTD INPUTS ■	See page 5-183.
	■ DCMA OUTPUTS ■	See page 5-183.
■■ SETTINGS ■■ TESTING	TEST MODE FUNCTION: Disabled	See page 5-187.
	TEST MODE INITIATE: On	See page 5-187.
	■ FORCE CONTACT ■ INPUTS	See page 5-188.
	■ FORCE CONTACT ■ OUTPUTS	See page 5-188.

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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.

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

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

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

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

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

- **FUNCTION setting:** This setting programs the element to be operational when selected as "Enabled". The factory default is "Disabled". Once programmed to "Enabled", any element associated with the Function becomes active and all options become available.
- **NAME setting:** This setting is used to uniquely identify the element.
- **SOURCE setting:** This setting is used to select the parameter or set of parameters to be monitored.
- **PICKUP setting:** For simple elements, this setting is used to program the level of the measured parameter above or below which the pickup state is established. In more complex elements, a set of settings may be provided to define the range of the measured parameters which will cause the element to pickup.
- **PICKUP DELAY setting:** This setting sets a time-delay-on-pickup, or on-delay, for the duration between the Pickup and Operate output states.
- **RESET DELAY setting:** This setting is used to set a time-delay-on-dropout, or off-delay, for the duration between the Operate output state and the return to logic 0 after the input transits outside the defined pickup range.
- **BLOCK setting:** The default output operand state of all comparators is a logic 0 or "flag not set". The comparator remains in this default state until a logic 1 is asserted at the RUN input, allowing the test to be performed. If the RUN input changes to logic 0 at any time, the comparator returns to the default state. The RUN input is used to supervise the comparator. The BLOCK input is used as one of the inputs to RUN control.

- **TARGET setting:** This setting is used to define the operation of an element target message. When set to Disabled, no target message or illumination of a faceplate LED indicator is issued upon operation of the element. When set to Self-Reset, the target message and LED indication follow the Operate state of the element, and self-resets once the operate element condition clears. When set to Latched, the target message and LED indication will remain visible after the element output returns to logic 0 - until a RESET command is received by the relay.
- **EVENTS setting:** This setting is used to control whether the Pickup, Dropout or Operate states are recorded by the event recorder. When set to Disabled, element pickup, dropout or operate are not recorded as events. When set to Enabled, events are created for:

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

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

5.1.3 INTRODUCTION TO AC SOURCES

a) BACKGROUND

The F60 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.

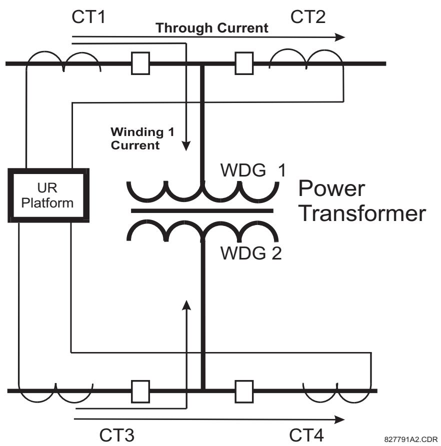

Figure 5–1: BREAKER-AND-A-HALF SCHEME

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)	4
VT Bank (3 phase channels, 1 auxiliary channel)	2

c) CT/VT INPUT CHANNEL CONFIGURATION

Upon relay startup, configuration settings for every bank of current or voltage input channels in the relay are automatically generated from the order code. Within each bank, a channel identification label is automatically assigned to each bank of channels in a given product. The ‘bank’ naming convention is based on the physical location of the channels, required by the user to know how to connect the relay to external circuits. Bank identification consists of the letter designation of the slot in which the CT/VT module is mounted as the first character, followed by numbers indicating the channel, either 1 or 5.

For three-phase channel sets, the number of the lowest numbered channel identifies the set. For example, F1 represents the three-phase channel set of F1/F2/F3, where F is the slot letter and 1 is the first channel of the set of three channels.

Upon startup, the CPU configures the settings required to characterize the current and voltage inputs, and will display them in the appropriate section in the sequence of the banks (as described above) as follows for a maximum configuration: F1, F5, M1, M5, U1, and U5.

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

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

5.2.1 PASSWORD SECURITY

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨ PASSWORD SECURITY

■ PASSWORD ■ SECURITY		ACCESS LEVEL: Restricted	Range: Restricted, Command, Setting, Factory Service (for factory use only)
	MESSAGE	CHANGE COMMAND PASSWORD: No	Range: No, Yes
	MESSAGE	CHANGE SETTING PASSWORD: No	Range: No, Yes
	MESSAGE	ENCRYPTED COMMAND PASSWORD: ----------	Range: 0 to 9999999999 Note: ---------- indicates no password
	MESSAGE	ENCRYPTED SETTING PASSWORD: ----------	Range: 0 to 9999999999 Note: ---------- indicates no password

Two levels of password security are provided: **Command** and **Setting**. The following command operations are under password supervision:

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

The following setting operations are under password supervision:

> 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 one to ten 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**.

In the event that an incorrect Command or Setting password has been entered via the faceplate interface three times within a three-minute time span, the LOCAL ACCESS DENIED FlexLogic™ operand will be set to “On” and the F60 will not allow Settings or Command access via the faceplate interface for the next ten minutes. The **TOO MANY ATTEMPTS – BLOCKED FOR 10 MIN!** flash message will appear upon activation of the ten minute timeout or any other time a user attempts any change to the defined tier during the ten minute timeout. The LOCAL ACCESS DENIED FlexLogic™ operand will be set to “Off” after the expiration of the ten-minute timeout.

In the event that an incorrect Command or Setting password has been entered via the any external communications interface three times within a three-minute time span, the REMOTE ACCESS DENIED FlexLogic™ operand will be set to “On” and the F60 will not allow Settings or Command access via the any external communications interface for the next ten minutes. The REMOTE ACCESS DENIED FlexLogic™ operand will be set to “Off” after the expiration of the ten-minute timeout.

The F60 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.

5.2.2 DISPLAY PROPERTIES

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ DISPLAY PROPERTIES

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

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

- **LANGUAGE**: This setting selects the language used to display settings, actual values, and targets. The range is dependent on the order code of the relay.
- **FLASH MESSAGE TIME**: Flash messages are status, warning, error, or information messages displayed for several seconds in response to certain key presses during setting programming. These messages override any normal messages. The duration of a flash message on the display can be changed to accommodate different reading rates.
- **DEFAULT MESSAGE TIMEOUT**: If the keypad is inactive for a period of time, the relay automatically reverts to a default message. The inactivity time is modified via this setting to ensure messages remain on the screen long enough during programming or reading of actual values.
- **DEFAULT MESSAGE INTENSITY**: To extend phosphor life in the vacuum fluorescent display, the brightness can be attenuated during default message display. During keypad interrogation, the display always operates at full brightness.
- **SCREEN SAVER FEATURE** and **SCREEN SAVER WAIT TIME**: These settings are only visible if the F60 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 F60 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 substi-

tuted 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 F60 applies a cut-off value to the magnitudes and angles of the measured voltages. If the magnitude is below the cut-off level, it is substituted with zero. This operation applies to phase and auxiliary voltages, and symmetrical components. The cut-off operation applies to quantities used for metering, protection, and control, as well as those used by communications protocols. Raw samples of the voltages available via oscillography are not subject cut-off.

The **CURRENT CUT-OFF LEVEL** and the **VOLTAGE CUT-OFF LEVEL** are used to determine the metered power cut-off levels. The power cut-off level is calculated as shown below. For Delta connections:

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

For Wye connections:

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

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

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

For example, given the following settings:

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

We have:

CT primary = “100 A”, and
VT primary = **PHASE VT SECONDARY** x **PHASE VT RATIO** = 66.4 V x 208 = 13811.2 V

The power cut-off is therefore:

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

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

NOTE

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

5.2.3 CLEAR RELAY RECORDS

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ CLEAR RELAY RECORDS

■ CLEAR RELAY ■ RECORDS	◁▷	CLEAR FAULT REPORTS: Off	Range: FlexLogic™ operand
MESSAGE	△▽	CLEAR EVENT RECORDS: Off	Range: FlexLogic™ operand
MESSAGE	△▽	CLEAR OSCILLOGRAPHY? No	Range: FlexLogic™ operand
MESSAGE	△▽	CLEAR DATA LOGGER: Off	Range: FlexLogic™ operand
MESSAGE	△▽	CLEAR ARC AMPS 1: Off	Range: FlexLogic™ operand
MESSAGE	△▽	CLEAR ARC AMPS 2: Off	Range: FlexLogic™ operand
MESSAGE	△▽	CLEAR DEMAND: Off	Range: FlexLogic™ operand
MESSAGE	△▽	CLEAR ENERGY: Off	Range: FlexLogic™ operand
MESSAG	△▽	CLEAR HIZ RECORDS: Off	Range: FlexLogic™ operand
MESSAGE	△▽	RESET UNAUTH ACCESS: Off	Range: FlexLogic™ operand
MESSAGE	△	CLEAR DIR I/O STATS: Off	Range: FlexLogic™ operand. Valid only for units with Direct I/O module.

Selected records can be cleared from user-programmable conditions with FlexLogic™ operands. Assigning user-programmable pushbuttons to clear specific records are typical applications for these commands. Since the F60 responds to rising edges of the configured FlexLogic™ operands, they must be asserted for at least 50 ms to take effect.

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

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

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

   CLEAR DEMAND: "PUSHBUTTON 1 ON"

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

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

5.2.4 COMMUNICATIONS

a) MAIN MENU

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS

■ COMMUNICATIONS ■		■ SERIAL PORTS ■	See below.
	MESSAGE	■ NETWORK ■	See page 5–13.
	MESSAGE	■ MODBUS PROTOCOL ■	See page 5–13.
	MESSAGE	■ DNP PROTOCOL ■	See page 5–14.
	MESSAGE	■ DNP / IEC104 ■ POINT LISTS	See page 5–17.
	MESSAGE	■ IEC 61850 PROTOCOL ■	See page 5–18.
	MESSAGE	■ WEB SERVER ■ HTTP PROTOCOL	See page 5–20.
	MESSAGE	■ TFTP PROTOCOL ■	See page 5–20.
	MESSAGE	■ IEC 60870-5-104 ■ PROTOCOL	See page 5–21.
	MESSAGE	■ SNTP PROTOCOL ■	See page 5–21.
	MESSAGE	■ EGD PROTOCOL ■	See page 5–22.

b) SERIAL PORTS

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

■ SERIAL PORTS ■		RS485 COM1 BAUD RATE: 19200	*Range: 300, 1200, 2400, 4800, 9600, 14400, 19200, 28800, 33600, 38400, 57600, 115200. Only active if CPU Type E is ordered.*
	MESSAGE	RS485 COM1 PARITY: None	*Range: None, Odd, Even Only active if CPU Type E is ordered*
	MESSAGE	RS485 COM1 RESPONSE MIN TIME: 0 ms	*Range: 0 to 1000 ms in steps of 10 Only active if CPU Type E is ordered*
	MESSAGE	RS485 COM2 BAUD RATE: 19200	*Range: 300, 1200, 2400, 4800, 9600, 14400, 19200, 28800, 33600, 38400, 57600, 115200*
	MESSAGE	RS485 COM2 PARITY: None	*Range: None, Odd, Even*
	MESSAGE	RS485 COM2 RESPONSE MIN TIME: 0 ms	*Range: 0 to 1000 ms in steps of 10*

The F60 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 ■		IP ADDRESS: 0.0.0.0	*Range: Standard IP address format* *Not shown if CPU Type E is ordered.*
	MESSAGE	SUBNET IP MASK: 0.0.0.0	*Range: Standard IP address format* *Not shown if CPU Type E is ordered.*
	MESSAGE	GATEWAY IP ADDRESS: 0.0.0.0	*Range: Standard IP address format* *Not shown if CPU Type E is ordered.*
	MESSAGE	■ OSI NETWORK ■ ADDRESS (NSAP)	*Range: Select to enter the* **OSI NETWORK ADDRESS**. *Not shown if CPU Type E is ordered.*
	MESSAGE	ETHERNET OPERATION MODE: Full-Duplex	*Range: Half-Duplex, Full-Duplex* *Not shown if CPU Type E or N is ordered.*

These messages appear only if the F60 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.

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d) MODBUS PROTOCOL

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

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

The serial communication ports utilize the Modbus protocol, unless configured for DNP or IEC 60870-5-104 operation (see descriptions below). This allows the EnerVista UR Setup software to be used. The UR operates as a Modbus slave device only. When using Modbus protocol on the RS232 port, the F60 will respond regardless of the **MODBUS SLAVE ADDRESS** programmed. For the RS485 ports each F60 must have a unique address from 1 to 254. Address 0 is the broadcast address which all Modbus slave devices listen to. Addresses do not have to be sequential, but no two devices can have the same address or conflicts resulting in errors will occur. Generally, each device added to the link should use the next higher address starting at 1. Refer to Appendix B for more information on the Modbus protocol.

NOTE

Changes to the MODBUS TCP PORT NUMBER setting will not take effect until the F60 is restarted.

e) DNP PROTOCOL

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

■ DNP PROTOCOL ■		■ DNP CHANNELS ■	Range: see sub-menu below
	MESSAGE	DNP ADDRESS: 65519	Range: 0 to 65519 in steps of 1
	MESSAGE	■ DNP NETWORK ■ CLIENT ADDRESSES	Range: see sub-menu below
	MESSAGE	DNP TCP/UDP PORT NUMBER: 20000	Range: 1 to 65535 in steps of 1
	MESSAGE	DNP UNSOL RESPONSE FUNCTION: Disabled	Range: Enabled, Disabled
	MESSAGE	DNP UNSOL RESPONSE TIMEOUT: 5 s	Range: 0 to 60 s in steps of 1
	MESSAGE	DNP UNSOL RESPONSE MAX RETRIES: 10	Range: 1 to 255 in steps of 1
	MESSAGE	DNP UNSOL RESPONSE DEST ADDRESS: 1	Range: 0 to 65519 in steps of 1
	MESSAGE	DNP CURRENT SCALE FACTOR: 1	Range: 0.001, 0.01. 0.1, 1, 10, 100, 1000, 10000, 100000
	MESSAGE	DNP VOLTAGE SCALE FACTOR: 1	Range: 0.001, 0.01. 0.1, 1, 10, 100, 1000, 10000, 100000
	MESSAGE	DNP POWER SCALE FACTOR: 1	Range: 0.001, 0.01. 0.1, 1, 10, 100, 1000, 10000, 100000
	MESSAGE	DNP ENERGY SCALE FACTOR: 1	Range: 0.001, 0.01. 0.1, 1, 10, 100, 1000, 10000, 100000
	MESSAGE	DNP 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
	MESSAGE	DNP MESSAGE FRAGMENT SIZE: 240	Range: 30 to 2048 in steps of 1
	MESSAGE	DNP OBJECT 1 DEFAULT VARIATION: 2	Range: 1, 2

MESSAGE		DNP OBJECT 2 DEFAULT VARIATION: 2	Range: 1, 2
MESSAGE		DNP OBJECT 20 DEFAULT VARIATION: 1	Range: 1, 2, 5, 6
MESSAGE		DNP OBJECT 21 DEFAULT VARIATION: 1	Range: 1, 2, 9, 10
MESSAGE		DNP OBJECT 22 DEFAULT VARIATION: 1	Range: 1, 2, 5, 6
MESSAGE		DNP OBJECT 23 DEFAULT VARIATION: 2	Range: 1, 2, 5, 6
MESSAGE		DNP OBJECT 30 DEFAULT VARIATION: 1	Range: 1, 2, 3, 4, 5
MESSAGE		DNP OBJECT 32 DEFAULT VARIATION: 1	Range: 1, 2, 3, 4, 5, 7
MESSAGE		DNP NUMBER OF PAIRED CONTROL POINTS: 0	Range: 0 to 32 in steps of 1

The F60 supports the Distributed Network Protocol (DNP) version 3.0. The F60 can be used as a DNP slave device connected to multiple DNP masters (usually an RTU or a SCADA master station). Since the F60 maintains two sets of DNP data change buffers and connection information, two DNP masters can actively communicate with the F60 at one time.

The DNP Channels sub-menu is shown below.

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

■ DNP CHANNELS ■		DNP CHANNEL 1 PORT: NETWORK	Range: NONE, COM1 - RS485, COM2 - RS485, FRONT PANEL - RS232, NETWORK - TCP, NETWORK - UDP
	MESSAGE	DNP CHANNEL 2 PORT: COM2 - RS485	Range: NONE, COM1 - RS485, COM2 - RS485, FRONT PANEL - RS232, NETWORK - TCP, NETWORK - UDP

The **DNP CHANNEL 1(2) PORT** settings select the communications port assigned to the DNP protocol for each channel. Once DNP is assigned to a serial port, the Modbus protocol is disabled on that port. Note that COM1 can be used only in non-Ethernet UR relays. When this setting is set to “Network - TCP”, the DNP protocol can be used over TCP/IP on channels 1 or 2. When this value is set to “Network - UDP”, the DNP protocol can be used over UDP/IP on channel 1 only. Refer to *Appendix E* for additional information on the DNP protocol.

NOTE

Changes to the DNP CHANNEL 1(2) PORT settings will take effect only after power has been cycled to the relay.

The **DNP NETWORK CLIENT ADDRESS** settings can force the F60 to respond to a maximum of five specific DNP masters. The settings in this sub-menu are shown below.

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

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

The **DNP UNSOL RESPONSE FUNCTION** should be “Disabled” for RS485 applications since there is no collision avoidance mechanism. The **DNP UNSOL RESPONSE TIMEOUT** sets the time the F60 waits for a DNP master to confirm an unsolicited response. The **DNP UNSOL RESPONSE MAX RETRIES** setting determines the number of times the F60 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 F60 from the current TCP connection or the most recent UDP message.

The **DNP SCALE FACTOR** settings are numbers used to scale Analog Input point values. These settings group the F60 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 F60 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 F60 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 F60 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 F60, 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 F60. Changing this time allows the DNP master to send time synchronization commands more or less often, as required.

The **DNP MESSAGE FRAGMENT SIZE** setting determines the size, in bytes, at which message fragmentation occurs. Large fragment sizes allow for more efficient throughput; smaller fragment sizes cause more application layer confirmations to be necessary which can provide for more robust data transfer over noisy communication channels.

NOTE

When the DNP data points (analog inputs and/or binary inputs) are configured for Ethernet-enabled relays, check the “DNP Points Lists” F60 web page to view the points lists. This page can be viewed with a web browser by entering the F60 IP address to access the F60 “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.

The DNP binary outputs typically map one-to-one to IED data points. That is, each DNP binary output controls a single physical or virtual control point in an IED. In the F60 relay, DNP binary outputs are mapped to virtual inputs. However, some legacy DNP implementations use a mapping of one DNP binary output to two physical or virtual control points to support the concept of trip/close (for circuit breakers) or raise/lower (for tap changers) using a single control point. That is, the DNP master can operate a single point for both trip and close, or raise and lower, operations. The F60 can be configured to support paired control points, with each paired control point operating two virtual inputs. The **DNP NUMBER OF PAIRED CONTROL POINTS** setting allows configuration of from 0 to 32 binary output paired controls. Points not configured as paired operate on a one-to-one basis.

The **DNP ADDRESS** setting is the DNP slave address. This number identifies the F60 on a DNP communications link. Each DNP slave should be assigned a unique address.

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

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

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

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

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

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

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

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

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

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

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

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

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

NOTE: **Changes to the DNP / IEC 60870-5-104 point lists will not take effect until the F60 is restarted.**

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g) IEC 61850 PROTOCOL

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

■ GSSE / GOOSE ■ CONFIGURATION	REMOTE I/O TRANSFER METHOD: GSSE	Range: None, GSSE, GOOSE
MESSAGE	DEFAULT GSSE/GOOSE: UPDATE TIME: 60 s	Range: 1 to 60 s in steps of 1
MESSAGE	GOOSE TRANSMIT VLAN PRIORITY: 4	Range: 0 to 7 in steps of 1
MESSAGE	GOOSE TRANSMIT VLAN ID: 0	Range: 0 to 4095 in steps of 1
MESSAGE	GOOSE TRANSMIT ETYPE APPID: 0	Range: 0 to 16383 in steps of 1
■ SERVER ■ CONFIGURATION	LD NAME: IECDevice	Range: up to 32 alphanumeric characters
MESSAGE	IEC/MMS TCP PORT NUMBER: 102	Range: 1 to 65535 in steps of 1
MESSAGE	INCLUDE NON-IEC DATA: Enabled	Range: Disabled, Enabled
MESSAGE	NUMBER OF STATUS POINTS IN GGIO1: 8	Range: 8 to 128 in steps of 8
MESSAGE	SERVER SCANNING: Disabled	Range: Disabled, Enabled
MESSAGE	CLEAR XCBR1 OpCnt: No	Range: No, Yes
MESSAGE	CLEAR XCBR2 OpCnt: No	Range: No, Yes
■ IEC 61850 LOGICAL ■ NODE NAME PREFIXES	■ PIOC LOGICAL NODE ■ NAME PREFIXES	
MESSAGE	■ PTOC LOGICAL NODE ■ NAME PREFIXES	
	↓	
MESSAGE	■ PTRC LOGICAL NODE ■ NAME PREFIXES	
■ MMXU DEADBANDS ■	■ MMXU1 DEADBANDS ■	
MESSAGE	■ MMXU2 DEADBANDS ■	
MESSAGE	■ MMXU3 DEADBANDS ■	
MESSAGE	■ MMXU4 DEADBANDS ■	

```
■ GGIO2 CONTROL          ◄►   ■ GGIO2 CF SPCSO 1
■ CONFIGURATION               ■

                 MESSAGE ▲▼   ■ GGIO2 CF SPCSO 2
                              ■
                                      ↓
                 MESSAGE ▲    ■ GGIO2 CF SPCSO64
                              ■
```

SOFTWARE OPTION

The F60 Feeder Management Relay is provided with optional IEC 61850 communications capability. This feature is specified as a software option at the time of ordering. Refer to the *Ordering* section of chapter 2 for additional details. The IEC 61850 protocol feature are not available if CPU Type E is ordered.

The F60 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 F60 operates as an IEC 61850 server. The *Remote Inputs/Outputs* section in this chapter describe the peer-to-peer GSSE/GOOSE message scheme.

The **REMOTE I/O TRANSFER METHOD** selects the method used to transfer remote input/output data. This can be either IEC 61850 GSSE, IEC 61850 GOOSE, or none (remote inputs/outputs disabled). GOOSE messages are more efficient and can make use of Ethernet priority tagging and virtual LAN functionality. All relays exchanging remote input/output data must be set to the same transfer method.

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

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

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

The **NUMBER OF STATUS POINTS IN GGIO1** setting determines the number of "Ind" (single point status indications) that are instantiated in the GGIO1 logical node. The indication points in GGIO1 are mapped to FlexStates in the F60. These FlexStates allow user-customized access to the FlexLogic™ operand states in the relay.

The **SERVER SCANNING** feature should be set to "Disabled" when IEC 61850 client/server functionality is not required. IEC 61850 has two modes of functionality: GOOSE/GSSE inter-device communication and client/server communication. If the GOOSE/GSSE functionality is required without the IEC 61850 client server feature, then server scanning can be disabled to increase CPU resources. When server scanning is disabled, there will be not updated to the IEC 61850 logical node status values in the F60. Clients will still be able to connect to the server (F60 relay), but most data values will not be updated. This setting does not affect GOOSE/GSSE operation.

NOTE

Changes to the **LD NAME**, **NUMBER OF STATUS POINTS IN GGIO1**, and **SERVER SCANNING** settings will not take effect until the F60 is restarted.

The **CLEAR XCBR1(2) OpCnt** settings represent the breaker operating counters. As breakers operate by opening and closing, the XCBR operating counter status attribute (OpCnt) increments with every operation. Frequent breaker operation may result in very large OpCnt values over time. This setting allows the OpCnt to be reset to "0" for XCBR1 and XCBR2.

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

The MMXU deadband settings represent the deadband values used to determine when the update the MMXU "mag" and "cVal" values from the associated "instmag" and "instcVal" values. The "mag" and "cVal" values are used for the IEC 61850 buffered and unbuffered reports. These settings correspond to the associated "db" data items in the CF functional constraint of the MMXU logical node, as per the IEC 61850 standard. According to IEC 61850-7-3, the db value "shall represent the percentage of difference between the maximum and minimum in units of 0.00%". Thus, it is important to know the maximum value for each MMXU measured quantity, since this represents the 100.00% value for the deadband.

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

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

The GGIO2 control configuration settings are used to set the control model for each input. The available choices are "0" (status only), "1" (direct control), and "2" (SBO with normal security). The GGIO2 control points are used to control the F60 virtual inputs.

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

h) WEB SERVER HTTP PROTOCOL

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

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

The F60 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 F60 has the ethernet option installed. The web pages are organized as a series of menus that can be accessed starting at the F60 "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 F60 into the "Address" box on the web browser.

i) TFTP PROTOCOL

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

■ TFTP PROTOCOL ■	◀▶	TFTP MAIN UDP PORT NUMBER: 69	*Range: 1 to 65535 in steps of 1*
MESSAGE	▲▼	TFTP DATA UDP PORT 1 NUMBER: 0	*Range: 0 to 65535 in steps of 1*
MESSAGE	▲	TFTP DATA UDP PORT 2 NUMBER: 0	*Range: 0 to 65535 in steps of 1*

The Trivial File Transfer Protocol (TFTP) can be used to transfer files from the F60 over a network. The F60 operates as a TFTP server. TFTP client software is available from various sources, including Microsoft Windows NT. The `dir.txt` file obtained from the F60 contains a list and description of all available files (event records, oscillography, etc.).

j) IEC 60870-5-104 PROTOCOL

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

■ IEC 60870-5-104 ■ PROTOCOL	◁▷	IEC 60870-5-104 FUNCTION: Disabled	*Range: Enabled, Disabled*
MESSAGE	△▽	IEC TCP PORT NUMBER: 2404	*Range: 1 to 65535 in steps of 1*
MESSAGE	△▽	■ IEC NETWORK ■ CLIENT ADDRESSES	
MESSAGE	△▽	IEC COMMON ADDRESS OF ASDU: 0	*Range: 0 to 65535 in steps of 1*
MESSAGE	△▽	IEC CYCLIC DATA PERIOD: 60 s	*Range: 1 to 65535 s in steps of 1*
MESSAGE	△▽	IEC CURRENT DEFAULT THRESHOLD: 30000	*Range: 0 to 65535 in steps of 1*
MESSAGE	△▽	IEC VOLTAGE DEFAULT THRESHOLD: 30000	*Range: 0 to 65535 in steps of 1*
MESSAGE	△▽	IEC POWER DEFAULT THRESHOLD: 30000	*Range: 0 to 65535 in steps of 1*
MESSAGE	△▽	IEC ENERGY DEFAULT THRESHOLD: 30000	*Range: 0 to 65535 in steps of 1*
MESSAGE	△	IEC OTHER DEFAULT THRESHOLD: 30000	*Range: 0 to 65535 in steps of 1*

The F60 supports the IEC 60870-5-104 protocol. The F60 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 F60 maintains two sets of IEC 60870-5-104 data change buffers, no more than two masters should actively communicate with the F60 at one time.

The **IEC ------- DEFAULT THRESHOLD** settings are used to determine when to trigger spontaneous responses containing M_ME_NC_1 analog data. These settings group the F60 analog data into types: current, voltage, power, energy, and other. Each setting represents the default threshold value for all M_ME_NC_1 analog points of that type. For example, to trigger spontaneous responses from the F60 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 F60, 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 FUNCTION setting is set to "Enabled", the DNP protocol will not be operational. When this setting is changed it will not become active until power to the relay has been cycled (Off/On).

k) 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 F60 supports the Simple Network Time Protocol specified in RFC-2030. With SNTP, the F60 can obtain clock time over an Ethernet network. The F60 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 F60 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 F60 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 F60 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 F60 clock is closely synchronized with the SNTP/NTP server. It may take up to two minutes for the F60 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 F60 then listens to SNTP messages sent to the "all ones" broadcast address for the subnet. The F60 waits up to eighteen minutes (>1024 seconds) without receiving an SNTP broadcast message before signaling an SNTP self-test error.

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

l) EGD PROTOCOL

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

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

5

The F60 Feeder Management Relay is provided with optional Ethernet Global Data (EGD) communications capability. This feature is specified as a software option at the time of ordering. Refer to the *Ordering* section of chapter 2 for additional details. The Ethernet Global Data (EGD) protocol feature is not available if CPU Type E is ordered.

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

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

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

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

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

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

Fast exchanges (50 to 1000 ms) are generally used in control schemes. The F60 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
■ CONFIGURATION
```

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

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

- **EXCH 1 DESTINATION**: This setting specifies the destination IP address of the produced EGD exchange. This is usually unicast or broadcast.
- **EXCH 1 DATA RATE**: This setting specifies the rate at which this EGD exchange is transmitted. If the setting is 50 ms, the exchange data will be updated and sent once every 50 ms. If the setting is 1000 ms, the exchange data will be updated and sent once per second. EGD exchange 1 has a setting range of 50 to 1000 ms. Exchanges 2 and 3 have a setting range of 500 to 1000 ms.
- **EXCH 1 DATA ITEM 1 to 20/50**: These settings specify the data items that are part of this EGD exchange. Almost any data from the F60 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.

5.2.5 MODBUS USER MAP

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ MODBUS USER MAP

```
■ MODBUS USER MAP
■
```

	ADDRESS 1: 0 VALUE: 0	Range: 0 to 65535 in steps of 1
	↓	
MESSAGE	ADDRESS 256: 0 VALUE: 0	Range: 0 to 65535 in steps of 1

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

5.2.6 REAL TIME CLOCK

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ REAL TIME CLOCK

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

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

5.2.7 FAULT REPORTS

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

■ FAULT REPORT 1 ■	◀▶	FAULT REPORT 1 SOURCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE	▲▼	FAULT REPORT 1 TRIG: Off	Range: FlexLogic™ operand
MESSAGE	▲▼	FAULT REPORT 1 Z1 MAG: 3.00 Ω	Range: 0.01 to 250.00 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 F60 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)

NOTE The fault locator does not report fault type or location if the source VTs are connected in the Delta configuration.

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.

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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.

WARNING

When changes are made to the oscillography settings, all existing oscillography records will be CLEARED.

b) DIGITAL CHANNELS

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

```
■ DIGITAL CHANNELS
■
```

```
DIGITAL CHANNEL  1:
Off
```
Range: FlexLogic™ operand

↓

MESSAGE
```
DIGITAL CHANNEL 63:
Off
```
Range: FlexLogic™ operand

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

↓

MESSAGE
```
ANALOG CHANNEL 16:
Off
```
Range: Off, any FlexAnalog parameter
See Appendix A for complete list.

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.

NOTE

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

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

5.2.9 DATA LOGGER

PATH: SETTINGS ⇨⇩ PRODUCT SETUP ⇨⇩ DATA LOGGER

■ DATA LOGGER ■	◁▷	DATA LOGGER MODE: Continuous	Range: *Continuous, Trigger*
MESSAGE	△▽	DATA LOGGER TRIGGER: Off	Range: *FlexLogic™ operand*
MESSAGE	△▽	DATA LOGGER RATE: 60000 ms	Range: *15 to 3600000 ms in steps of 1*
MESSAGE	△▽	DATA LOGGER CHNL 1: Off	Range: *Off, any FlexAnalog parameter. See Appendix A: FlexAnalog Parameters for complete list.*
MESSAGE	△▽	DATA LOGGER CHNL 2: Off	Range: *Off, any FlexAnalog parameter. See Appendix A: FlexAnalog Parameters for complete list.*
		↓	
MESSAGE	△▽	DATA LOGGER CHNL 16: Off	Range: *Off, any FlexAnalog parameter. See Appendix A: FlexAnalog Parameters for complete list.*
MESSAGE	△	DATA LOGGER CONFIG: 0 CHNL x 0.0 DAYS	Range: *Not applicable - shows computed data only*

The data logger samples and records up to 16 analog parameters at a user-defined sampling rate. This recorded data may be downloaded to EnerVista UR Setup and displayed with *parameters* on the vertical axis and *time* on the horizontal axis. All data is stored in non-volatile memory, meaning that the information is retained when power to the relay is lost.

For a fixed sampling rate, the data logger can be configured with a few channels over a long period or a larger number of channels for a shorter period. The relay automatically partitions the available memory between the channels in use. Example storage capacities for a system frequency of 60 Hz are shown in the following table.

Table 5–2: DATA LOGGER STORAGE CAPACITY EXAMPLE

SAMPLING RATE	CHANNELS	DAYS	STORAGE CAPACITY
15 ms	1	0.1	954 s
	8	0.1	120 s
	9	0.1	107 s
	16	0.1	60 s
1000 ms	1	0.7	65457 s
	8	0.1	8182 s
	9	0.1	7273 s
	16	0.1	4091 s
60000 ms	1	45.4	3927420 s
	8	5.6	490920 s
	9	5	436380 s
	16	2.8	254460 s
3600000 ms	1	2727.5	235645200 s
	8	340.9	29455200 s
	9	303	26182800 s

NOTE

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

5

- **DATA LOGGER MODE**: This setting configures the mode in which the data logger will operate. When set to "Continuous", the data logger will actively record any configured channels at the rate as defined by the **DATA LOGGER RATE**. The data logger will be idle in this mode if no channels are configured. When set to "Trigger", the data logger will begin to record any configured channels at the instance of the rising edge of the **DATA LOGGER TRIGGER** source FlexLogic™ operand. The **Data Logger will ignore** all subsequent triggers and will continue to record data until the active record is full. Once the data logger is full a **CLEAR DATA LOGGER** command is required to clear the data logger record before a new record can be started. Performing the **CLEAR DATA LOGGER** command will also stop the current record and reset the data logger to be ready for the next trigger.
- **DATA LOGGER TRIGGER**: This setting selects the signal used to trigger the start of a new data logger record. Any FlexLogic™ operand can be used as the trigger source. The **DATA LOGGER TRIGGER** setting only applies when the mode is set to "Trigger".
- **DATA LOGGER RATE:** This setting selects the time interval at which the actual value data will be recorded.
- **DATA LOGGER CHNL 1(16):** This setting selects the metering actual value that is to be recorded in Channel 1(16) of the data log. The parameters available in a given relay are dependent on: the type of relay, the type and number of CT/VT hardware modules installed, and the type and number of Analog Input hardware modules installed. Upon startup, the relay will automatically prepare the parameter list. A list of all possible analog metering actual value parameters is shown in Appendix A: *FlexAnalog Parameters*. The parameter index number shown in any of the tables is used to expedite the selection of the parameter on the relay display. It can be quite time-consuming to scan through the list of parameters via the relay keypad/display – entering this number via the relay keypad will cause the corresponding parameter to be displayed.
- **DATA LOGGER CONFIG:** This display presents the total amount of time the Data Logger can record the channels not selected to "Off" without over-writing old data.

5.2.10 DEMAND

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ DEMAND

■ DEMAND ■		CRNT DEMAND METHOD: Thermal Exponential	*Range: Thermal Exponential, Block Interval, Rolling Demand*
MESSAGE		POWER DEMAND METHOD: Thermal Exponential	*Range: Thermal Exponential, Block Interval, Rolling Demand*
MESSAGE		DEMAND INTERVAL: 15 MIN	*Range: 5, 10, 15, 20, 30, 60 minutes*
MESSAGE		DEMAND TRIGGER: Off	*Range: FlexLogic™ operand 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:

$$d(t) = D(1 - e^{-kt}) \quad \textbf{(EQ 5.6)}$$

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.

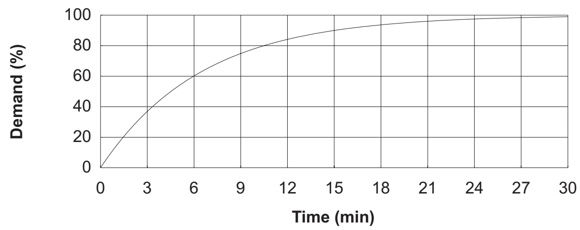

Figure 5–2: THERMAL DEMAND CHARACTERISTIC

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 calculating 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 ■ LEDS	◀▶	■ LED TEST ■	See below
MESSAGE	▲▼	■ TRIP & ALARM ■ LEDS	See page 5–32.
MESSAGE	▲▼	■ USER-PROGRAMMABLE ■ LED1	See page 5–32.
MESSAGE	▲▼	■ USER-PROGRAMMABLE ■ LED2	
		↓	
MESSAGE	▲	■ USER-PROGRAMMABLE ■ LED48	

5

b) LED TEST

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

■ LED TEST ■	◀▶	LED TEST FUNCTION: Disabled	*Range: Disabled, Enabled.*
MESSAGE	▲	LED TEST CONTROL: Off	*Range: FlexLogic™ operand*

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

The test consists of three stages.

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

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

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

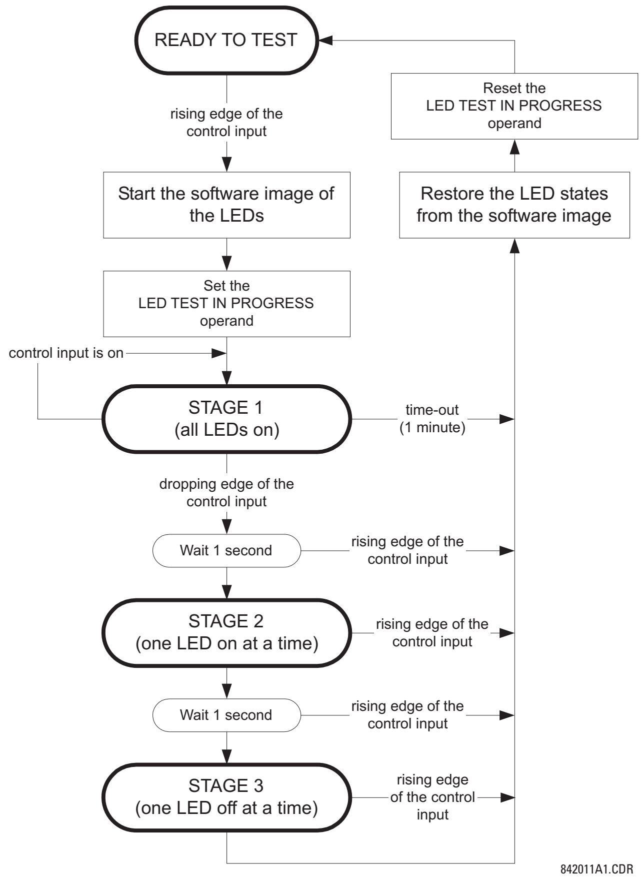

Figure 5–3: LED TEST SEQUENCE

APPLICATION EXAMPLE 1:

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

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

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

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

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

APPLICATION EXAMPLE 2:

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

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

c) TRIP AND ALARM LEDS

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

```
■ TRIP & ALARM LEDS
■
```

	TRIP LED INPUT: Off	Range: *FlexLogic™ operand*
MESSAGE	ALARM LED INPUT: Off	Range: *FlexLogic™ operand*

The Trip and Alarm LEDs are 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
```

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

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

- 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 5–3: 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

Menu		Setting	Range
■ USER-PROGRAMMABLE ■ SELF TESTS	◁▷	DIRECT RING BREAK FUNCTION: Enabled	Range: *Disabled, Enabled. Valid for units equipped with Direct Input/Output module.*
MESSAGE	△▽	DIRECT DEVICE OFF FUNCTION: Enabled	Range: *Disabled, Enabled. Valid for units equipped with Direct Input/Output module.*
MESSAGE	△▽	REMOTE DEVICE OFF FUNCTION: Enabled	Range: *Disabled, Enabled. Valid for units that contain a CPU with Ethernet capability.*
MESSAGE	△▽	PRI. ETHERNET FAIL FUNCTION: Disabled	Range: *Disabled, Enabled. Valid for units that contain a CPU with a primary fiber port.*
MESSAGE	△▽	SEC. ETHERNET FAIL FUNCTION: Disabled	Range: *Disabled, Enabled. Valid for units that contain a CPU with a redundant fiber port.*
MESSAGE	△▽	BATTERY FAIL FUNCTION: Enabled	Range: *Disabled, Enabled.*
MESSAGE	△▽	SNTP FAIL FUNCTION: Enabled	Range: *Disabled, Enabled. Valid for units that contain a CPU with Ethernet capability.*
MESSAGE	△	IRIG-B FAIL FUNCTION: Enabled	Range: *Disabled, Enabled.*

5

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              CONTROL PUSHBUTTON 1      Range: Disabled, Enabled
■ PUSHBUTTON 1         FUNCTION: Disabled

            MESSAGE    CONTROL PUSHBUTTON 1      Range: Disabled, Enabled
                       EVENTS: Disabled
```

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 F60 is ordered with twelve user programmable pushbuttons.

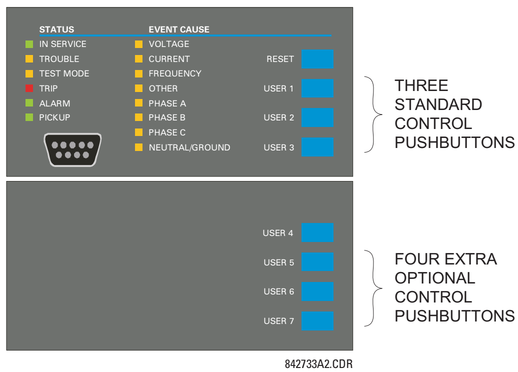

Figure 5–4: CONTROL PUSHBUTTONS

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

Each control pushbutton asserts its own FlexLogic™ operand, 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 3 pushbuttons as shown below. If configured for manual control, Breaker Control typically uses the larger, optional user-programmable pushbuttons, making the control pushbuttons available for other user applications.

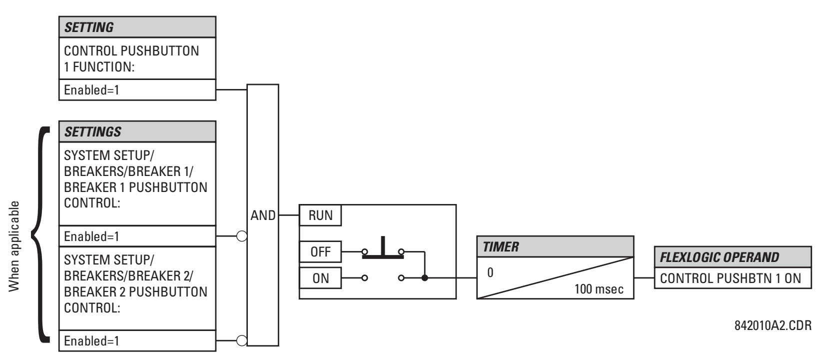

Figure 5–5: CONTROL PUSHBUTTON LOGIC

5.2.14 USER-PROGRAMMABLE PUSHBUTTONS

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 F60 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.GEmultilin.com.

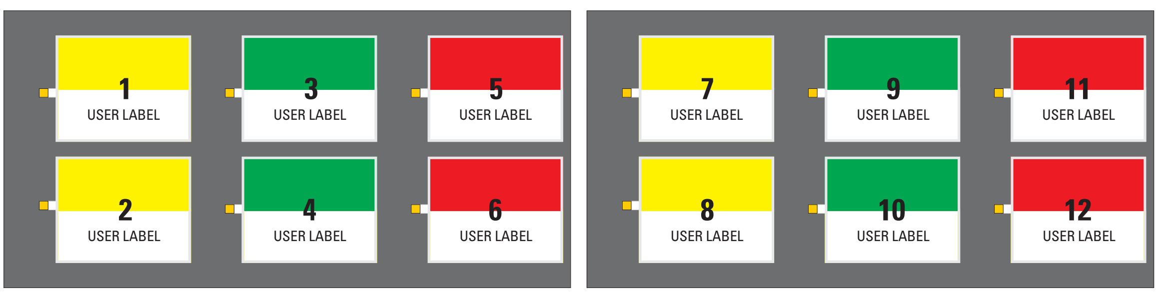

Figure 5–6: USER-PROGRAMMABLE PUSHBUTTONS

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

5.2.15 FLEX STATE PARAMETERS

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ FLEX STATE PARAMETERS

■ FLEX STATE ■ PARAMETERS		PARAMETER 1: Off	Range: FlexLogic™ operand
MESSAGE		PARAMETER 2: Off	Range: FlexLogic™ operand
		↓	
MESSAGE		PARAMETER 256: Off	Range: FlexLogic™ operand

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

The state bits may be read out in the “Flex States” register array beginning at Modbus address 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.

5.2.16 USER-DEFINABLE DISPLAYS

a) MAIN MENU

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

■ USER-DEFINABLE ■ DISPLAYS		INVOKE AND SCROLL: Off	*Range: FlexLogic™ operand*
	MESSAGE	■ USER DISPLAY 1 ■	*Range: up to 20 alphanumeric characters*
		↓	
	MESSAGE	■ USER DISPLAY 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 ■		DISP 1 TOP LINE:	*Range: up to 20 alphanumeric characters*
	MESSAGE	DISP 1 BOTTOM LINE:	*Range: up to 20 alphanumeric characters*
	MESSAGE	DISP 1 ITEM 1 0	*Range: 0 to 65535 in steps of 1*
	MESSAGE	DISP 1 ITEM 2 0	*Range: 0 to 65535 in steps of 1*
	MESSAGE	DISP 1 ITEM 3 0	*Range: 0 to 65535 in steps of 1*
	MESSAGE	DISP 1 ITEM 4 0	*Range: 0 to 65535 in steps of 1*
	MESSAGE	DISP 1 ITEM 5: 0	*Range: 0 to 65535 in steps of 1*

Any existing system display can be automatically copied into an available user display by selecting the existing display and pressing the ENTER key. The display will then prompt **ADD TO USER DISPLAY LIST?**. After selecting “Yes”, a message indicates that the selected display has been added to the user display list. When this type of entry occurs, the sub-menus are automatically configured with the proper content – this content may subsequently be edited.

This menu is used **to enter** user-defined text and/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:

■ USER DISPLAY 1 ■	◄►	DISP 1 TOP LINE: Current X ~ A	Shows user-defined text with first Tilde marker.
MESSAGE	▲▼	DISP 1 BOTTOM LINE: Current Y ~ A	Shows user-defined text with second Tilde marker.
MESSAGE	▲▼	DISP 1 ITEM 1: 6016	Shows decimal form of user-selected Modbus Register Address, corresponding to first Tilde marker.
MESSAGE	▲▼	DISP 1 ITEM 2: 6357	Shows decimal form of user-selected Modbus Register Address, corresponding to 2nd Tilde marker.
MESSAGE	▲▼	DISP 1 ITEM 3: 0	This item is not being used - there is no corresponding Tilde marker in Top or Bottom lines.
MESSAGE	▲▼	DISP 1 ITEM 4: 0	This item is not being used - there is no corresponding Tilde marker in Top or Bottom lines.
MESSAGE	▲	DISP 1 ITEM 5: 0	This item is not being used - there is no corresponding Tilde marker in Top or Bottom lines.

USER DISPLAYS	→	Current X 0.850 A Current Y 0.327 A	Shows the resultant display content.

5

5.2.17 DIRECT INPUTS/OUTPUTS

a) MAIN MENU

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

■ DIRECT I/O ■		DIRECT OUTPUT DEVICE ID: 1	Range: 1 to 16
	MESSAGE	DIRECT I/O CH1 RING CONFIGURATION: Yes	Range: Yes, No
	MESSAGE	DIRECT I/O CH2 RING CONFIGURATION: Yes	Range: Yes, No
	MESSAGE	DIRECT I/O DATA RATE: 64 kbps	Range: 64 kbps, 128 kbps
	MESSAGE	DIRECT I/O CHANNEL CROSSOVER: Disabled	Range: Disabled, Enabled
	MESSAGE	■ CRC ALARM CH1 ■	See page 5-43.
	MESSAGE	■ CRC ALARM CH2 ■	See page 5-43.
	MESSAGE	■ UNRETURNED ■ MESSAGES ALARM CH1	See page 5-43.
	MESSAGE	■ UNRETURNED ■ MESSAGES ALARM CH2	See page 5-43.

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 ⇨ PRODUCT SETUP ⇨⇩ DIRECT I/O ⇨⇩ DIRECT I/O DATA RATE setting is not applicable to these modules.

The **DIRECT I/O CHANNEL CROSSOVER** setting applies to F60s 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.

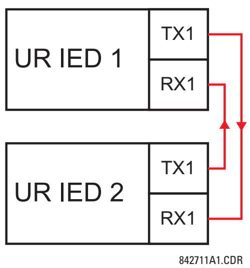

Figure 5–7: INPUT/OUTPUT EXTENSION VIA DIRECT INPUTS/OUTPUTS

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.

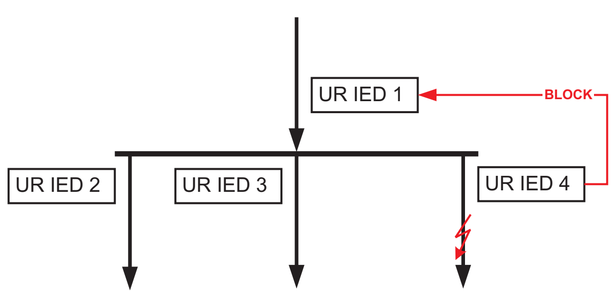

Figure 5–8: SAMPLE INTERLOCKING BUSBAR PROTECTION SCHEME

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

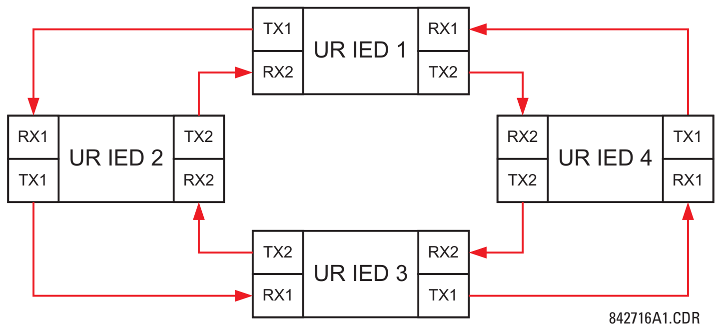

Figure 5–9: INTERLOCKING BUS PROTECTION SCHEME VIA DIRECT INPUTS/OUTPUTS

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:

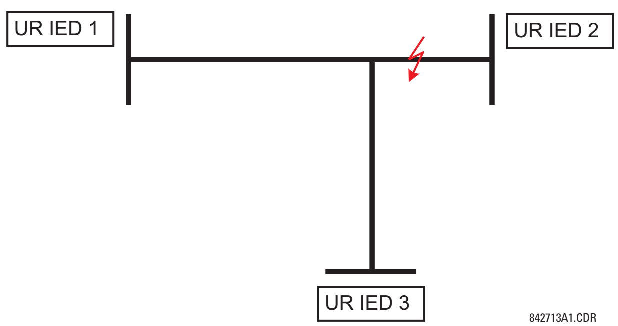

Figure 5–10: THREE-TERMINAL LINE APPLICATION

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):

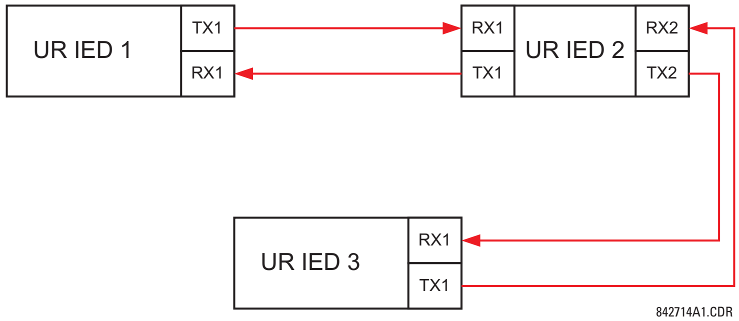

Figure 5–11: SINGLE-CHANNEL OPEN LOOP CONFIGURATION

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

UR IED 1: **DIRECT OUTPUT DEVICE ID:** "1"
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"

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

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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.

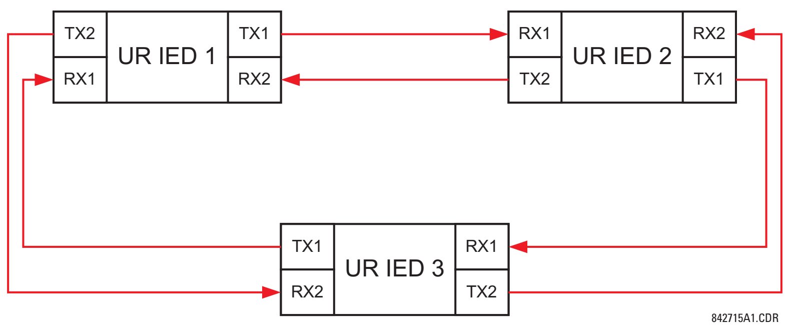

Figure 5–12: DUAL-CHANNEL CLOSED LOOP (DUAL-RING) CONFIGURATION

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

UR IED 1: **DIRECT OUTPUT DEVICE ID:** "1"
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"

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

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

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

b) CRC ALARM CH1(2)

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

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

The F60 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.

5

- **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}.

c) UNRETURNED MESSAGES ALARM CH1(2)

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

■ UNRETURNED ■ MESSAGES ALARM CH1	◁▷	UNRET MSGS ALARM CH1 FUNCTION: Disabled	*Range: Enabled, Disabled*
MESSAGE	△▽	UNRET MSGS ALARM CH1 MESSAGE COUNT: 600	*Range: 100 to 10000 in steps of 1*
MESSAGE	△▽	UNRET MSGS ALARM CH1 THRESHOLD: 10	*Range: 1 to 1000 in steps of 1*
MESSAGE	△	UNRET MSGS ALARM CH1 EVENTS: Disabled	*Range: Enabled, Disabled*

The F60 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 TELEPROTECTION

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ TELEPROTECTION

■ TELEPROTECTION ■	TELEPROTECTION FUNCTION: Disabled	*Range: Disabled, Enabled*
MESSAGE	NUMBER OF TERMINALS: 2	*Range: 2, 3*
MESSAGE	NUMBER OF COMM CHANNELS: 1	*Range: 1, 2*
MESSAGE	LOCAL RELAY ID NUMBER: 0	*Range: 0 to 255 in steps of 1*
MESSAGE	TERMINAL 1 RELAY ID NUMBER: 0	*Range: 0 to 255 in steps of 1*
MESSAGE	TERMINAL 2 RELAY ID NUMBER: 0	*Range: 0 to 255 in steps of 1*

Digital teleprotection functionality is designed to transfer protection commands between 2 or 3 relays in a secure, fast, dependable, and deterministic fashion. Possible applications are permissive or blocking pilot schemes and direct transfer trip (DTT). Teleprotection can be applied over any analog or digital channels and any communications media, such as direct fiber, copper wires, optical networks, or microwave radio links. A mixture of communication media is possible.

Once teleprotection is enabled and the teleprotection input/outputs are configured, data packets are transmitted continuously every 1/4 cycle (3/8 cycle if using C37.94 modules) from peer-to-peer. Security of communication channel data is achieved by using CRC-32 on the data packet.

NOTE: Teleprotection inputs/outputs and direct inputs/outputs are mutually exclusive – as such, they cannot be used simultaneously. Once teleprotection inputs/outputs are enabled, direct inputs/outputs are blocked, and *vice versa*.

- **NUMBER OF TERMINALS**: Specifies whether the teleprotection system operates between 2 peers or 3 peers.
- **NUMBER OF CHANNELS**: Specifies how many channels are used. If the **NUMBER OF TERMINALS** is “3” (three-terminal system), set the **NUMBER OF CHANNELS** to “2”. For a two-terminal system, the **NUMBER OF CHANNELS** can set to “1” or “2” (redundant channels).
- **LOCAL RELAY ID NUMBER**, **TERMINAL 1 RELAY ID NUMBER**, and **TERMINAL 2 RELAY ID NUMBER**: In installations that use multiplexers or modems, it is desirable to ensure that the data used by the relays protecting a given line is from the correct relays. The teleprotection function performs this check by reading the message ID sent by transmitting relays and comparing it to the programmed ID in the receiving relay. This check is also used to block inputs if inadvertently set to loopback mode or data is being received from a wrong relay by checking the ID on a received channel. If an incorrect ID is found on a channel during normal operation, the TELEPROT CH1(2) ID FAIL FlexLogic™ operand is set, driving the event with the same name and blocking the teleprotection inputs. For commissioning purposes, the result of channel identification is also shown in the **STATUS ⇨⇩ CHANNEL TESTS ⇨⇩ VALIDITY OF CHANNEL CONFIGURATION** actual value. The default value of “0” for the **LOCAL RELAY ID NUMBER** indicates that relay ID is not to be checked.

On two- terminals two-channel systems, the same **LOCAL RELAY ID NUMBER** is transmitted over both channels; as such, only the **TERMINAL 1 ID NUMBER** has to be programmed on the receiving end.

5.2.19 INSTALLATION

PATH: SETTINGS ⇨ PRODUCT SETUP ⇨⇩ INSTALLATION

■ INSTALLATION ■		RELAY SETTINGS: Not Programmed	*Range: Not Programmed, Programmed*
MESSAGE		RELAY NAME: Relay-1	*Range: up to 20 alphanumeric characters*

To safeguard against the installation of a relay without any entered settings, the unit will not allow signaling of any output relay until **RELAY SETTINGS** is set to "Programmed". This setting is defaulted to "Not Programmed" when at the factory. The **UNIT NOT PROGRAMMED** self-test error message is displayed until the relay is put into the "Programmed" state.

The **RELAY NAME** setting allows the user to uniquely identify a relay. This name will appear on generated reports. This name is also used to identify specific devices which are engaged in automatically sending/receiving data over the Ethernet communications channel using the IEC 61850 protocol.

5

5.3.1 AC INPUTS

a) CURRENT BANKS

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨ AC INPUTS ⇨ CURRENT BANK F1(F5)

■ CURRENT BANK F1 ■	◁▷	PHASE CT F1 PRIMARY: 1 A	*Range: 1 to 65000 A in steps of 1*
MESSAGE	△▽	PHASE CT F1 SECONDARY: 1 A	*Range: 1 A, 5 A*
MESSAGE	△▽	GROUND CT F1 PRIMARY: 1 A	*Range: 1 to 65000 A in steps of 1*
MESSAGE	△	GROUND CT F1 SECONDARY: 1 A	*Range: 1 A, 5 A*

NOTE

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

Two 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**} 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

The following rule applies:

$$\text{SRC 1} = \text{F1} + \text{F5} \quad \textbf{(EQ 5.7)}$$

1 pu is the highest primary current. In this case, 1000 is entered and the secondary current from the 500:1 and 800:1 ratio CTs 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

■ VOLTAGE BANK F5 ■		PHASE VT F5 CONNECTION: Wye	Range: Wye, Delta
	MESSAGE	PHASE VT F5 SECONDARY: 66.4 V	Range: 50.0 to 240.0 V in steps of 0.1
	MESSAGE	PHASE VT F5 RATIO: 1.00 :1	Range: 1.00 to 24000.00 in steps of 0.01
	MESSAGE	AUXILIARY VT F5 CONNECTION: Vag	Range: Vn, Vag, Vbg, Vcg, Vab, Vbc, Vca
	MESSAGE	AUXILIARY VT F5 SECONDARY: 66.4 V	Range: 50.0 to 240.0 V in steps of 0.1
	MESSAGE	AUXILIARY VT F5 RATIO: 1.00 :1	Range: 1.00 to 24000.00 in steps of 0.01

CAUTION

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

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

Xa, where ***X*** = {**F**} and ***a*** = {**5**}.

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

With VTs installed, the relay can perform voltage measurements as well as power calculations. Enter the **PHASE VT F5 CONNECTION** made to the system as “Wye” or “Delta”. An open-delta source VT connection would be entered as “Delta”. 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. $(13800 / 14400) \times 120$. For a Wye connection, the voltage value entered must be the phase to neutral voltage which would be $115 / \sqrt{3} = 66.4$.

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

NOTE

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

5.3.2 POWER SYSTEM

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ POWER SYSTEM

■ POWER SYSTEM ■		NOMINAL FREQUENCY: 60 Hz	Range: 25 to 60 Hz in steps of 1
	MESSAGE	PHASE ROTATION: ABC	Range: ABC, ACB
	MESSAGE	FREQUENCY AND PHASE REFERENCE: SRC 1	Range: SRC 1, SRC 2
	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 ($V_{ANGLE\ REF} = V_A$), while Clarke transformation of the phase signals is used for frequency metering and tracking ($V_{FREQUENCY} = (2V_A - V_B - V_C)/3$) 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.

5.3.3 SIGNAL SOURCES

PATH: SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ SIGNAL SOURCES ⇨ SOURCE 1(2)

■ SOURCE 1 ■	◀▶	SOURCE 1 NAME: SRC 1	*Range: up to 6 alphanumeric characters*
MESSAGE	▲▼	SOURCE 1 PHASE CT: None	*Range: None, F1, F5, F1+F5,... up to a combination of any 6 CTs. Only Phase CT inputs are displayed.*
MESSAGE	▲▼	SOURCE 1 GROUND CT: None	*Range: None, F1, F5, F1+F5,... up to a combination of any 6 CTs. Only Ground CT inputs are displayed.*
MESSAGE	▲▼	SOURCE 1 PHASE VT: None	*Range: None, F1, F5 Only phase voltage inputs will be displayed.*
MESSAGE	▲	SOURCE 1 AUX VT: None	*Range: None, F1, F5 Only auxiliary voltage inputs will be displayed.*

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

“F” represents the module slot position. The number directly following this letter represents either the first bank of four channels (1, 2, 3, 4) called “1” or the second bank of four channels (5, 6, 7, 8) called “5” in a particular CT/VT module. Refer to the *Introduction to AC Sources* section at the beginning of this chapter for additional details on this concept.

It is possible to select the sum of up to six (6) 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.

Disturbance Detectors (Internal):

The 50DD element is a sensitive current disturbance detector that detects any disturbance on the protected system. 50DD is intended for use in conjunction with measuring elements, blocking of current based elements (to prevent maloperation as a result of the wrong settings), and starting oscillography data capture. A disturbance detector is provided for each Source.

The 50DD function responds to the changes in magnitude of the sequence currents. The disturbance detector scheme logic is as follows:

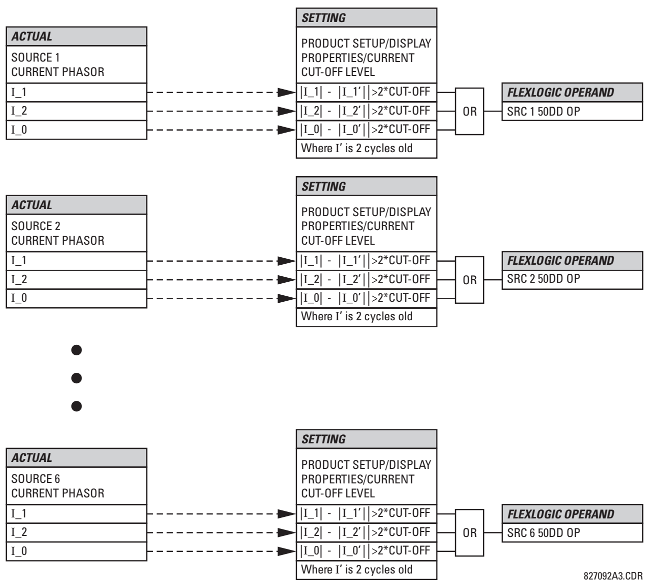

Figure 5–13: DISTURBANCE DETECTOR LOGIC DIAGRAM

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

5.3.4 BREAKERS

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

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

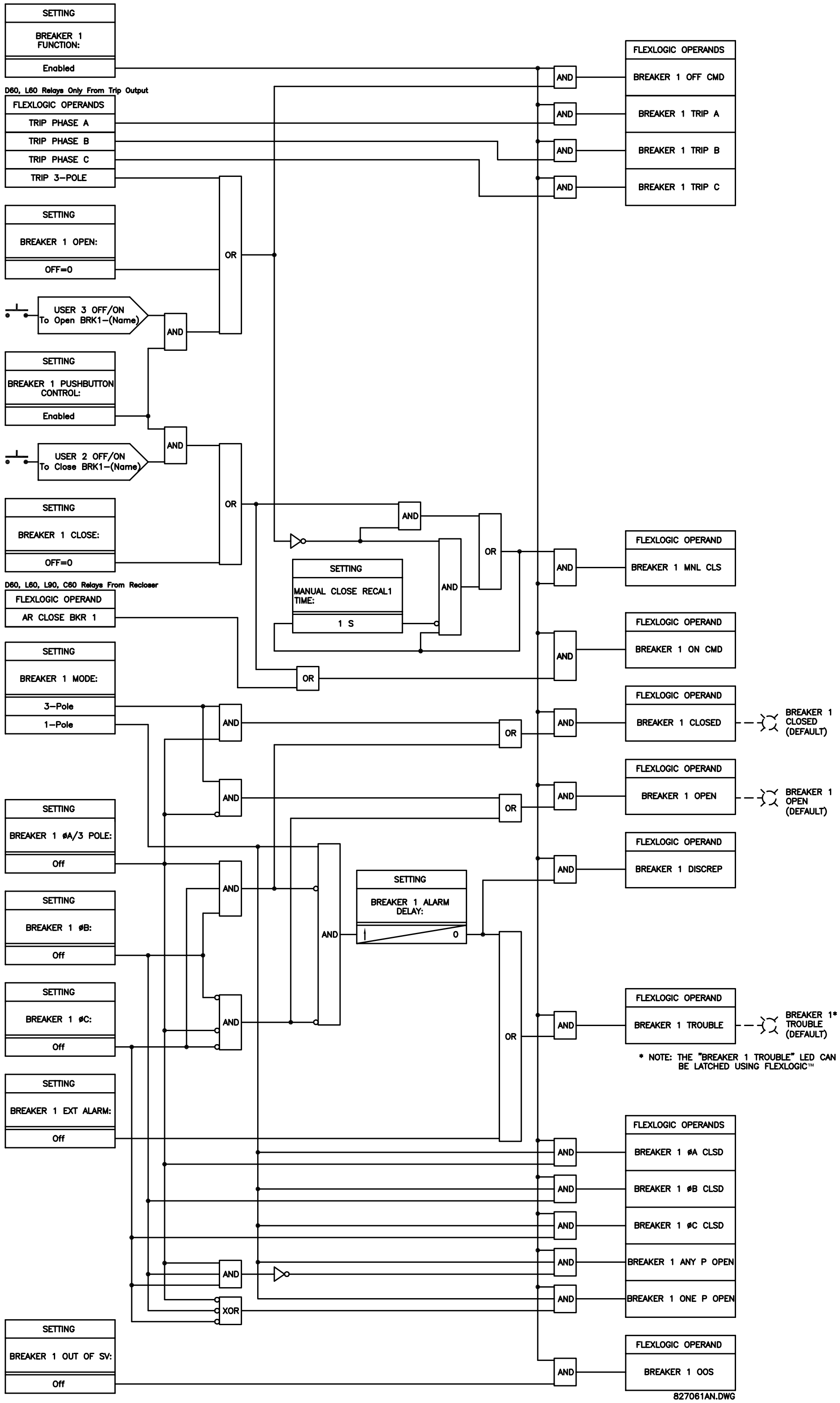

Figure 5–14: DUAL BREAKER CONTROL SCHEME LOGIC

5

5.3.5 FLEXCURVES™

a) SETTINGS

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

```
■ FLEXCURVE A          FLEXCURVE A TIME AT
■                      0.00 xPKP:      0 ms
```

Range: 0 to 65535 ms in steps of 1

FlexCurves™ A through D have settings for entering times to Reset/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 5–4: 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.

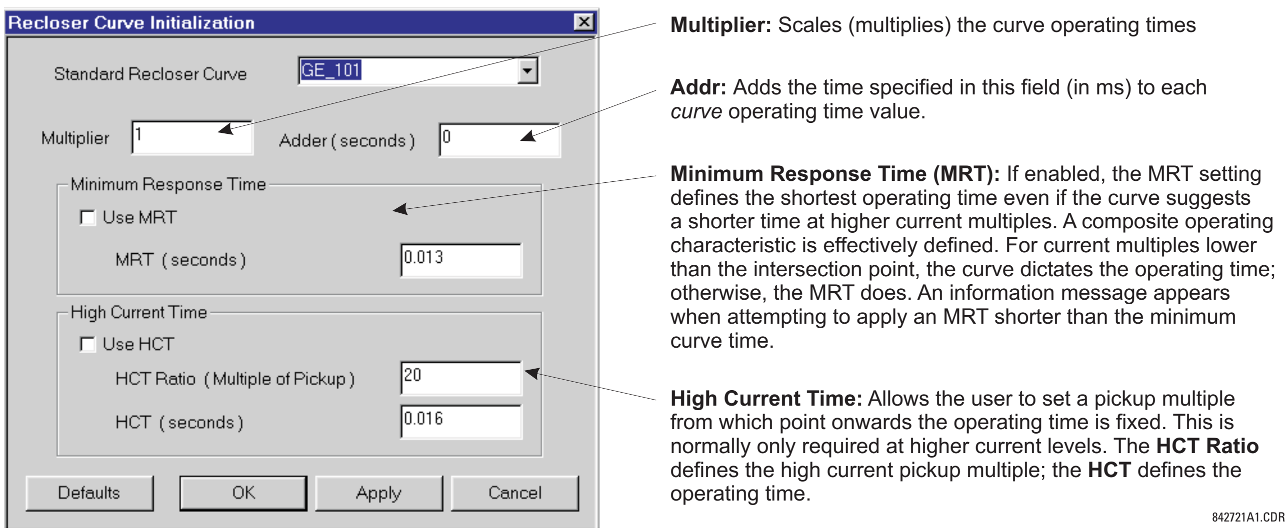

Figure 5–15: RECLOSER CURVE INITIALIZATION

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).

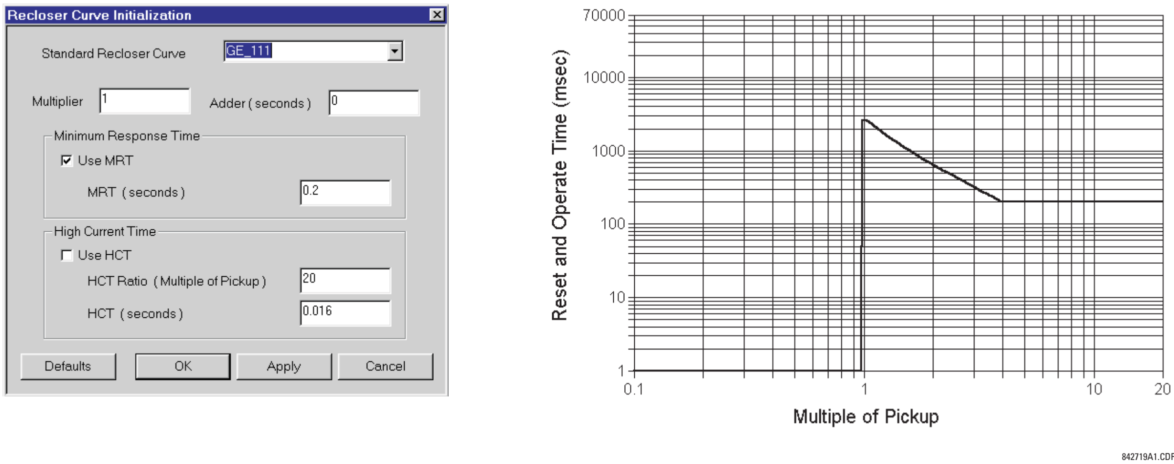

Figure 5–16: COMPOSITE RECLOSER CURVE WITH HCT DISABLED

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

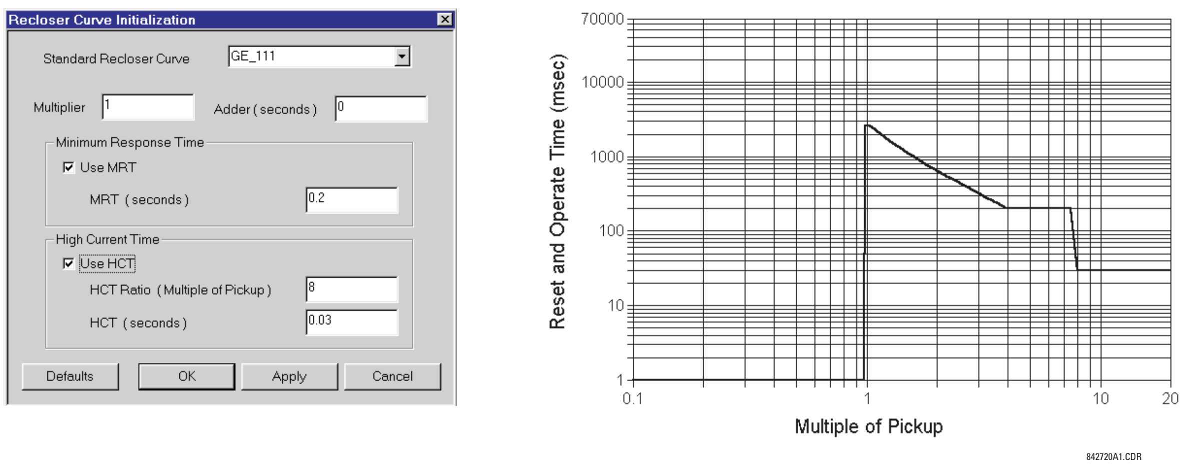

Figure 5–17: COMPOSITE RECLOSER CURVE WITH HCT ENABLED

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 F60 are displayed in the following graphs.

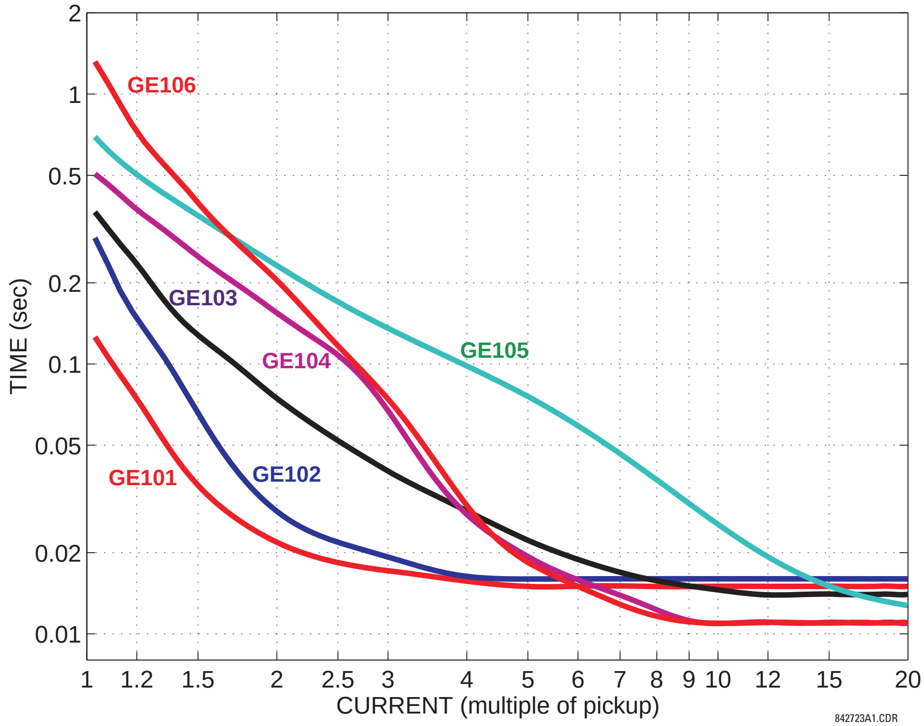

Figure 5–18: RECLOSER CURVES GE101 TO GE106

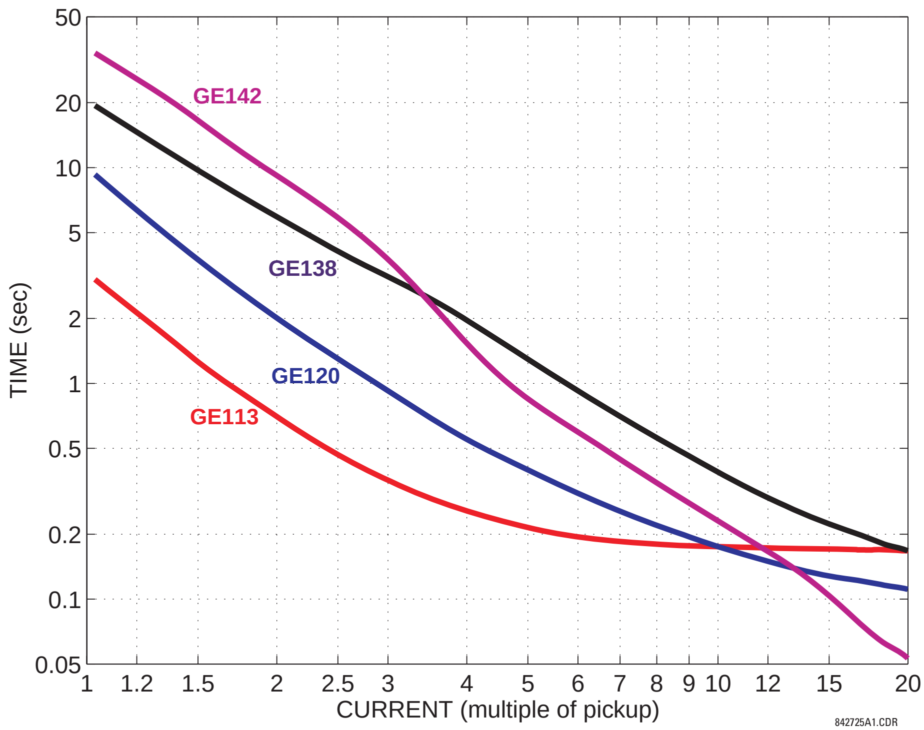

Figure 5–19: RECLOSER CURVES GE113, GE120, GE138 AND GE142

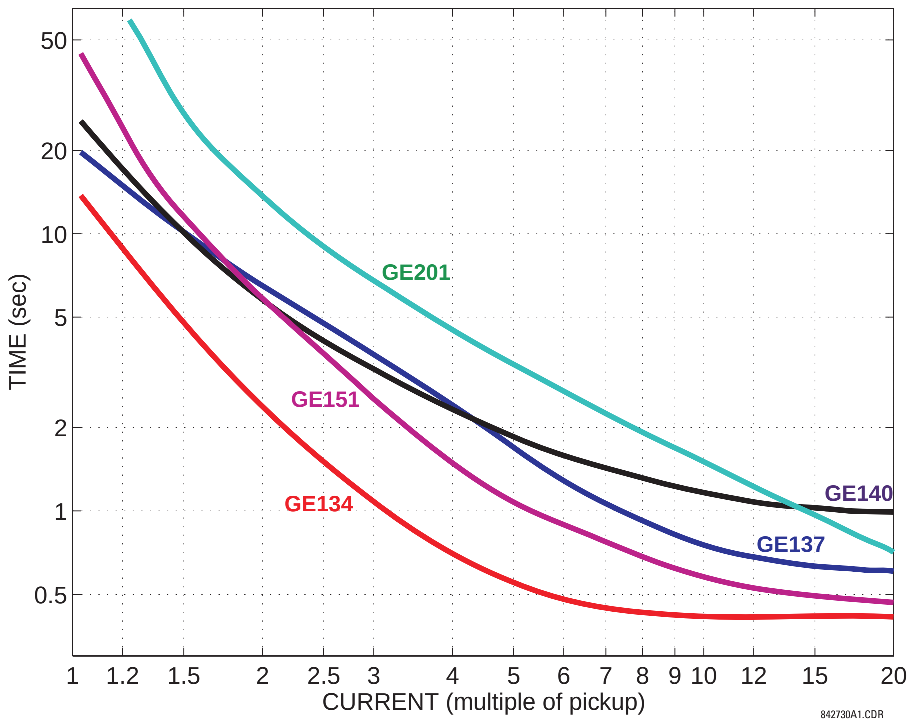

Figure 5–20: RECLOSER CURVES GE134, GE137, GE140, GE151 AND GE201

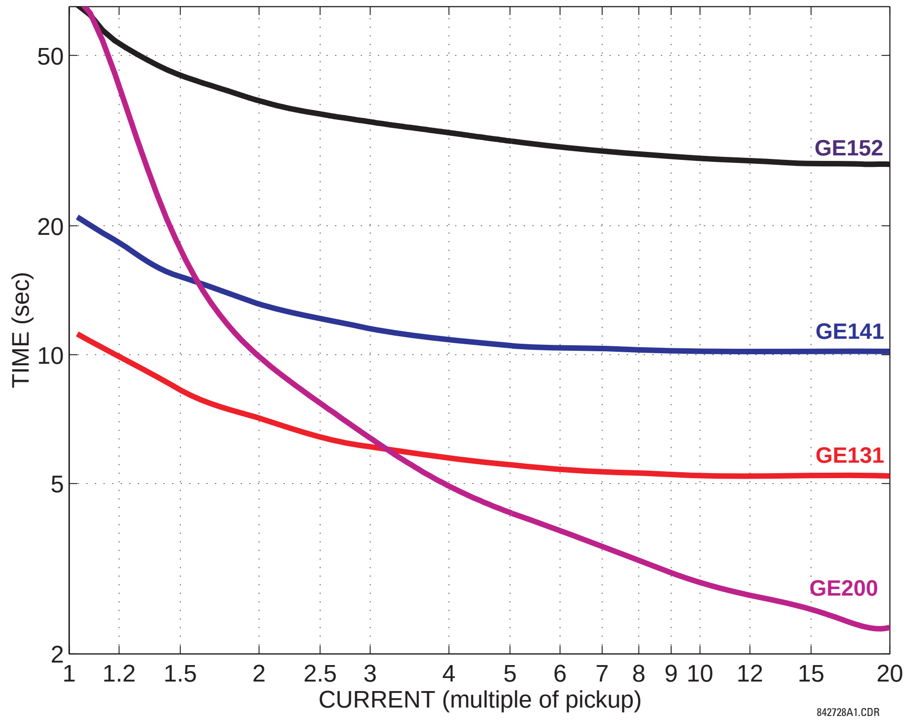

Figure 5–21: RECLOSER CURVES GE131, GE141, GE152, AND GE200

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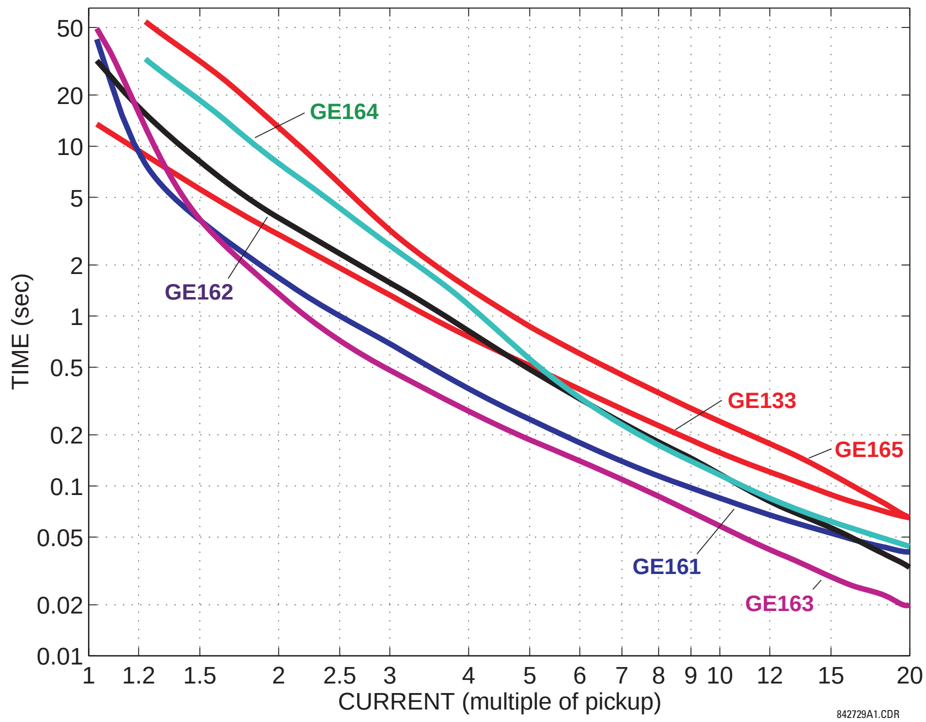

Figure 5–22: RECLOSER CURVES GE133, GE161, GE162, GE163, GE164 AND GE165

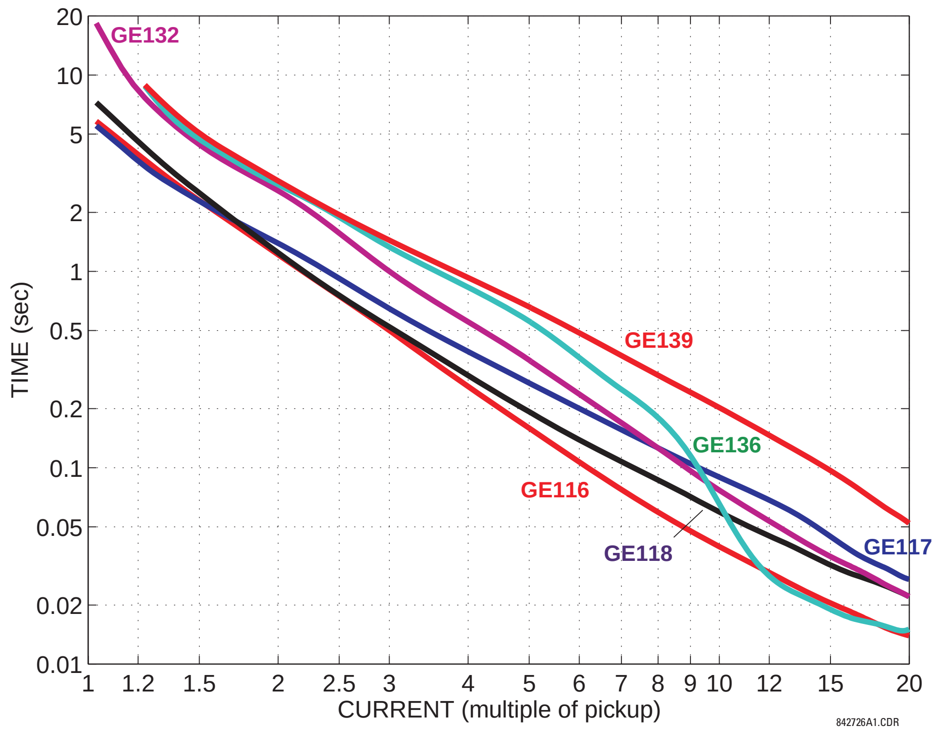

Figure 5–23: RECLOSER CURVES GE116, GE117, GE118, GE132, GE136, AND GE139

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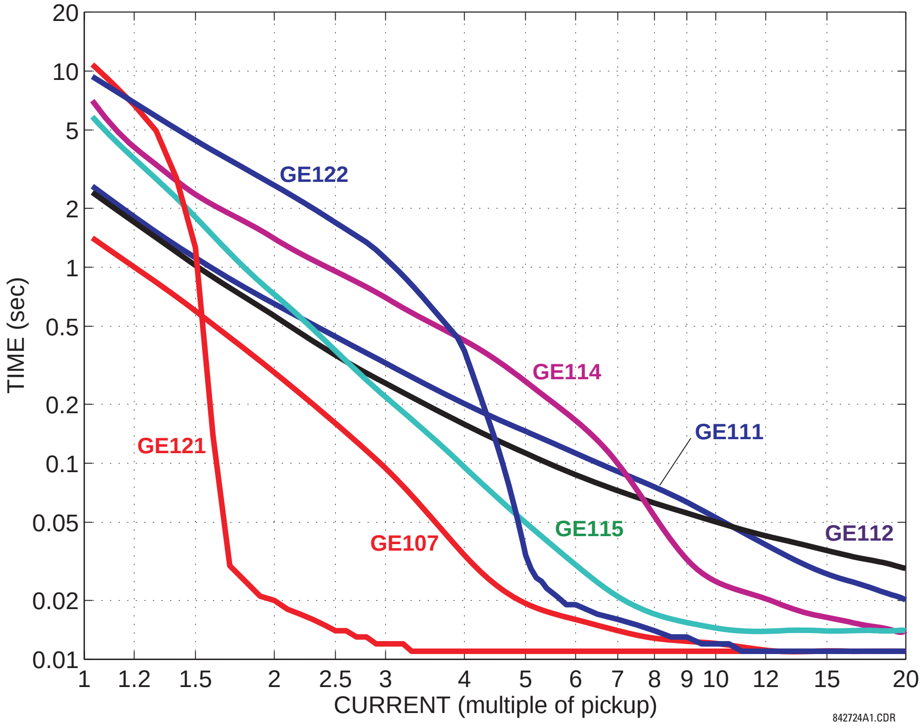

Figure 5–24: RECLOSER CURVES GE107, GE111, GE112, GE114, GE115, GE121, AND GE122

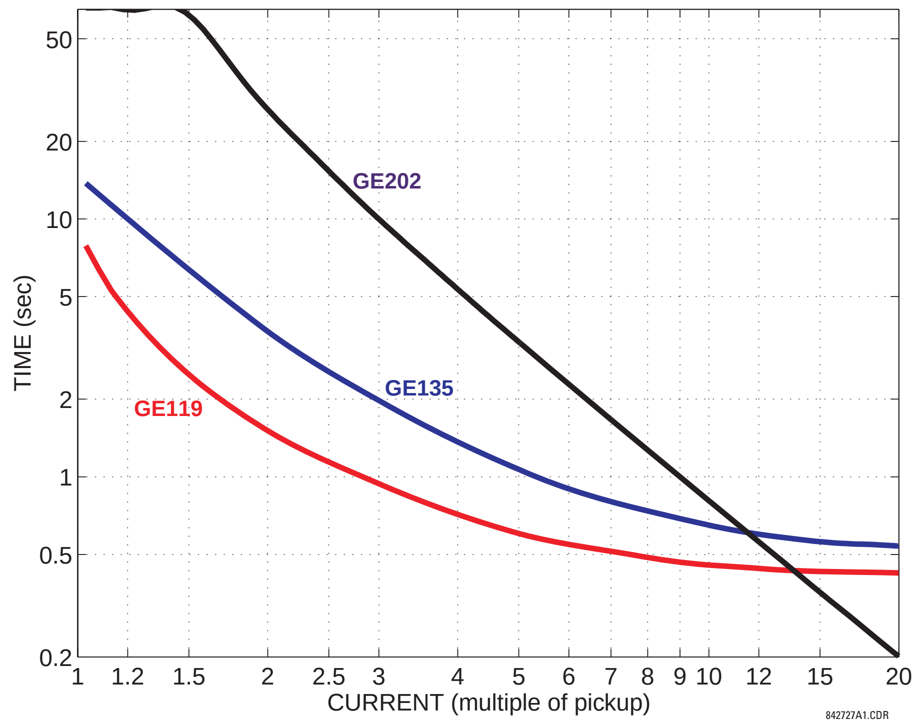

Figure 5–25: RECLOSER CURVES GE119, GE135, AND GE202

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5.4.1 INTRODUCTION TO FLEXLOGIC™

To provide maximum flexibility to the user, the arrangement of internal digital logic combines fixed and user-programmed parameters. Logic upon which individual features are designed is fixed, and all other logic, from digital input signals through elements or combinations of elements to digital outputs, is variable. The user has complete control of all variable logic through FlexLogic™. In general, the system receives analog and digital inputs which it uses to produce analog and digital outputs. The major sub-systems of a generic UR-series relay involved in this process are shown below.

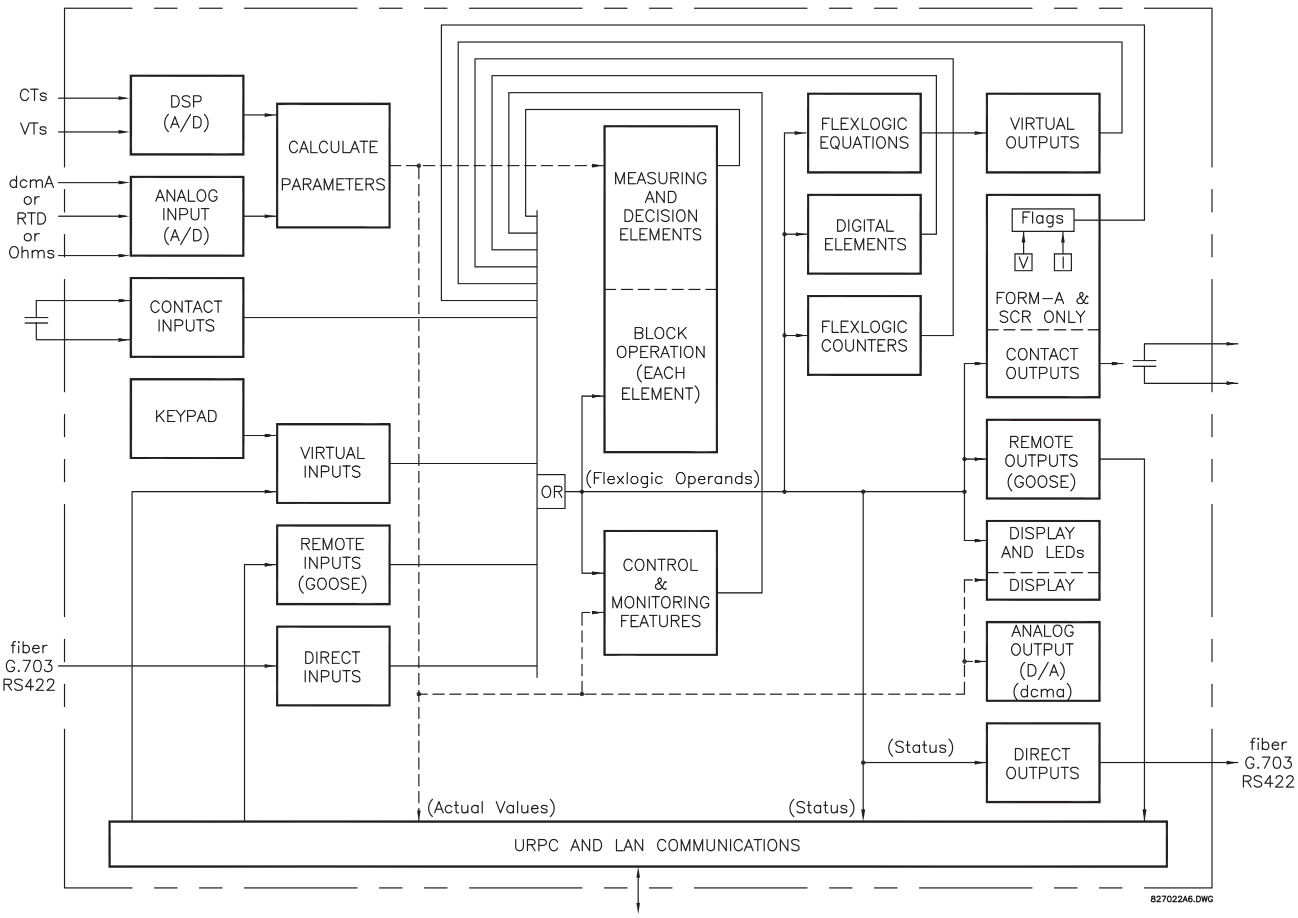

Figure 5–26: UR ARCHITECTURE OVERVIEW

The states of all digital signals used in the F60 are represented by flags (or FlexLogic™ operands, which are described later in this section). A digital "1" is represented by a 'set' flag. Any external contact change-of-state can be used to block an element from operating, as an input to a control feature in a FlexLogic™ equation, or to operate a contact output. The state of the contact input can be displayed locally or viewed remotely via the communications facilities provided. If a simple scheme where a contact input is used to block an element is desired, this selection is made when programming the element. This capability also applies to the other features that set flags: elements, virtual inputs, remote inputs, schemes, and human operators.

If more complex logic than presented above is required, it is implemented via FlexLogic™. For example, if it is desired to have the closed state of contact input H7a and the operated state of the phase undervoltage element block the operation of the phase time overcurrent element, the two control input states are programmed in a FlexLogic™ equation. This equation ANDs the two control inputs to produce a 'virtual output' which is then selected when programming the phase time overcurrent to be used as a blocking input. Virtual outputs can only be created by FlexLogic™ equations.

Traditionally, protective relay logic has been relatively limited. Any unusual applications involving interlocks, blocking, or supervisory functions had to be hard-wired using contact inputs and outputs. FlexLogic™ minimizes the requirement for auxiliary components and wiring while making more complex schemes possible.

The logic that determines the interaction of inputs, elements, schemes and outputs is field programmable through the use of logic equations that are sequentially processed. The use of virtual inputs and outputs in addition to hardware is available internally and on the communication ports for other relays to use (distributed FlexLogic™).

FlexLogic™ allows users to customize the relay through a series of equations that consist of operators and operands. The operands are the states of inputs, elements, schemes and outputs. The operators are logic gates, timers and latches (with set and reset inputs). A system of sequential operations allows any combination of specified operands to be assigned as inputs to specified operators to create an output. The final output of an equation is a numbered register called a virtual output. Virtual outputs can be used as an input operand in any equation, including the equation that generates the output, as a seal-in or other type of feedback.

A FlexLogic™ equation consists of parameters that are either operands or operators. Operands have a logic state of 1 or 0. Operators provide a defined function, such as an AND gate or a Timer. Each equation defines the combinations of parameters to be used to set a Virtual Output flag. Evaluation of an equation results in either a 1 (=ON, i.e. flag set) or 0 (=OFF, i.e. flag not set). Each equation is evaluated at least 4 times every power system cycle.

Some types of operands are present in the relay in multiple instances; e.g. contact and remote inputs. These types of operands are grouped together (for presentation purposes only) on the faceplate display. The characteristics of the different types of operands are listed in the table below.

Table 5–5: F60 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 5–6: F60 FLEXLOGIC™ OPERANDS (Sheet 1 of 6)

OPERAND TYPE	OPERAND SYNTAX	OPERAND DESCRIPTION
CONTROL PUSHBTONS	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 (per CT bank)	AR1 ENABLED AR1 RIP AR1 LO AR1 BLK FROM MAN CLS AR1 CLOSE AR1 SHOT CNT=0 ↓ AR1 SHOT CNT=4 AR1 DISABLED	Autoreclose 1 is enabled Autoreclose 1 is in progress Autoreclose 1 is locked out Autoreclose 1 is temporarily disabled Autoreclose 1 close command is issued Autoreclose 1 shot count is 0 Autoreclose 1 shot count is 4 Autoreclose 1 is disabled
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 5–6: F60 FLEXLOGIC™ OPERANDS (Sheet 2 of 6)

OPERAND TYPE	OPERAND SYNTAX	OPERAND DESCRIPTION
ELEMENT: Breaker Control	BREAKER 1 OFF CMD BREAKER 1 ON CMD BREAKER 1 φA CLSD BREAKER 1 φB CLSD BREAKER 1 φC CLSD BREAKER 1 CLOSED BREAKER 1 OPEN BREAKER 1 DISCREP BREAKER 1 TROUBLE BREAKER 1 MNL CLS BREAKER 1 TRIP A BREAKER 1 TRIP B BREAKER 1 TRIP C BREAKER 1 ANY P OPEN BREAKER 1 ONE P OPEN BREAKER 1 OOS	Breaker 1 OFF command Breaker 1 ON command Breaker 1 phase A is closed Breaker 1 phase B is closed Breaker 1 phase C is closed Breaker 1 is closed Breaker 1 is open Breaker 1 has discrepancy Breaker 1 trouble alarm Breaker 1 manual close Breaker 1 trip phase A command Breaker 1 trip phase B command Breaker 1 trip phase C command At least one pole of Breaker 1 is open Only one pole of Breaker 1 is open Breaker 1 is out of service
	BREAKER 2	Same set of operands as shown for BREAKER 1
ELEMENT Cold Load Pickup	COLD LOAD 1 OP COLD LOAD 2 OP	Cold Load Pickup element 1 has operated Cold Load Pickup element 2 has operated
ELEMENT: Digital Counters	Counter 1 HI Counter 1 EQL Counter 1 LO ↓ Counter 8 HI Counter 8 EQL Counter 8 LO	Digital Counter 1 output is 'more than' comparison value Digital Counter 1 output is 'equal to' comparison value Digital Counter 1 output is 'less than' comparison value ↓ Digital Counter 8 output is 'more than' comparison value Digital Counter 8 output is 'equal to' comparison value Digital Counter 8 output is 'less than' comparison value
ELEMENT: Digital Elements	Dig Element 1 PKP Dig Element 1 OP Dig Element 1 DPO ↓ Dig Element 48 PKP Dig Element 48 OP Dig Element 48 DPO	Digital Element 1 is picked up Digital Element 1 is operated Digital Element 1 is dropped out ↓ Digital Element 48 is picked up Digital Element 48 is operated Digital Element 48 is dropped out
ELEMENT: Sensitive Directional Power	DIR POWER 1 STG1 PKP DIR POWER 1 STG2 PKP DIR POWER 1 STG1 DPO DIR POWER 1 STG2 DPO DIR POWER 1 STG1 OP DIR POWER 1 STG2 OP DIR POWER 1 PKP DIR POWER 1 DPO DIR POWER 1 OP	Stage 1 of the Directional Power element 1 has picked up Stage 2 of the Directional Power element 1 has picked up Stage 1 of the Directional Power element 1 has dropped out Stage 2 of the Directional Power element 1 has dropped out Stage 1 of the Directional Power element 1 has operated Stage 2 of the Directional Power element 1 has operated The Directional Power element has picked up The Directional Power element has dropped out The Directional Power element has operated
	DIR POWER 2	Same set of operands as DIR POWER 1
ELEMENT Frequency Rate of Change	FREQ RATE n PKP FREQ RATE n DPO FREQ RATE n OP	The n-th Frequency Rate of Change element has picked up The n-th Frequency Rate of Change element has dropped out The n-th Frequency Rate of Change element has operated
ELEMENT: FlexElements™	FxE 1 PKP FxE 1 OP FxE 1 DPO ↓ FxE 8 PKP FxE 8 OP FxE 8 DPO	FlexElement™ 1 has picked up FlexElement™ 1 has operated FlexElement™ 1 has dropped out ↓ FlexElement™ 8 has picked up FlexElement™ 8 has operated FlexElement™ 8 has dropped out
ELEMENT: Ground Instantaneous Overcurrent	GROUND IOC1 PKP GROUND IOC1 OP GROUND IOC1 DPO	Ground Instantaneous Overcurrent 1 has picked up Ground Instantaneous Overcurrent 1 has operated Ground Instantaneous Overcurrent 1 has dropped out
	GROUND IOC2	Same set of operands as shown for GROUND IOC 1
ELEMENT: Ground Time Overcurrent	GROUND TOC1 PKP GROUND TOC1 OP GROUND TOC1 DPO	Ground Time Overcurrent 1 has picked up Ground Time Overcurrent 1 has operated Ground Time Overcurrent 1 has dropped out
	GROUND TOC2	Same set of operands as shown for GROUND TOC1

Table 5–6: F60 FLEXLOGIC™ OPERANDS (Sheet 3 of 6)

OPERAND TYPE	OPERAND SYNTAX	OPERAND DESCRIPTION
ELEMENT High Impedance Fault Detection (Hi-Z)	HI-Z ARC DETECTED HI-Z ARC DETECTED-A HI-Z ARC DETECTED-B HI-Z ARC DETECTED-C HI-Z ARC DETECTED-N HI-Z DOWNED COND HI-Z DOWNED COND-A HI-Z DOWNED COND-B HI-Z DOWNED COND-C HI-Z DOWNED COND-N HI-Z ARC SUSPECTED HI-Z ARC SUSPECTED-A HI-Z ARC SUSPECTED-B HI-Z ARC SUSPECTED-C HI-Z ARC SUSPECTED-N HI-Z IOC A HI-Z IOC B HI-Z IOC C HI-Z LOSS OF LOAD-A HI-Z LOSS OF LOAD-B HI-Z LOSS OF LOAD-C	The Hi-Z element has operated The Hi-Z Phase A element has operated The Hi-Z Phase B element has operated The Hi-Z Phase C element has operated The Hi-Z Neutral element has operated The Hi-Z Downed Conductor element has operated The Hi-Z Downed Conductor Phase A element has operated The Hi-Z Downed Conductor Phase B element has operated The Hi-Z Downed Conductor Phase C element has operated The Hi-Z Downed Conductor Neutral element has operated The Hi-Z Arcing Suspected element has operated The Hi-Z Arcing Suspected Phase A element has operated The Hi-Z Arcing Suspected Phase B element has operated The Hi-Z Arcing Suspected Phase C element has operated The Hi-Z Arcing Suspected Neutral element has operated The Hi-Z IOC A element has operated The Hi-Z IOC B element has operated The Hi-Z IOC C element has operated The Hi-Z Phase A Loss of Load element has operated The Hi-Z Phase B Loss of Load element has operated The Hi-Z Phase C Loss of Load element has operated
ELEMENT Non-Volatile Latches	LATCH 1 ON LATCH 1 OFF ↓ LATCH 16 ON LATCH 16 OFF	Non-Volatile Latch 1 is ON (Logic = 1) Non-Voltage Latch 1 is OFF (Logic = 0) ↓ Non-Volatile Latch 16 is ON (Logic = 1) Non-Voltage Latch 16 is OFF (Logic = 0)
ELEMENT: Load Encroachment	LOAD ENCHR PKP LOAD ENCHR OP LOAD ENCHR DPO	Load Encroachment has picked up Load Encroachment has operated Load Encroachment has dropped out
ELEMENT: Negative Sequence Directional Overcurrent	NEG SEQ DIR OC1 FWD NEG SEQ DIR OC1 REV NEG SEQ DIR OC2 FWD NEG SEQ DIR OC2 REV	Negative Sequence Directional OC1 Forward has operated Negative Sequence Directional OC1 Reverse has operated Negative Sequence Directional OC2 Forward has operated Negative Sequence Directional OC2 Reverse has operated
ELEMENT: Negative Sequence Instantaneous Overcurrent	NEG SEQ IOC1 PKP NEG SEQ IOC1 OP NEG SEQ IOC1 DPO	Negative Sequence Instantaneous Overcurrent 1 has picked up Negative Sequence Instantaneous Overcurrent 1 has operated Negative Sequence Instantaneous Overcurrent 1 has dropped out
	NEG SEQ IOC2	Same set of operands as shown for NEG SEQ IOC1
ELEMENT: Negative Sequence Overvoltage	NEG SEQ OV PKP NEG SEQ OV DPO NEG SEQ OV OP	Negative Sequence Overvoltage element has picked up Negative Sequence Overvoltage element has dropped out Negative Sequence Overvoltage element has operated
ELEMENT: Negative Sequence Time Overcurrent	NEG SEQ TOC1 PKP NEG SEQ TOC1 OP NEG SEQ TOC1 DPO	Negative Sequence Time Overcurrent 1 has picked up Negative Sequence Time Overcurrent 1 has operated Negative Sequence Time Overcurrent 1 has dropped out
	NEG SEQ TOC2	Same set of operands as shown for NEG SEQ TOC1
ELEMENT: Neutral Instantaneous Overcurrent	NEUTRAL IOC1 PKP NEUTRAL IOC1 OP NEUTRAL IOC1 DPO	Neutral Instantaneous Overcurrent 1 has picked up Neutral Instantaneous Overcurrent 1 has operated Neutral Instantaneous Overcurrent 1 has dropped out
	NEUTRAL IOC2	Same set of operands as shown for NEUTRAL IOC1
ELEMENT: Neutral Overvoltage	NEUTRAL OV1 PKP NEUTRAL OV1 DPO NEUTRAL OV1 OP	Neutral Overvoltage element has picked up Neutral Overvoltage element has dropped out Neutral Overvoltage element has operated
ELEMENT: Neutral Time Overcurrent	NEUTRAL TOC1 PKP NEUTRAL TOC1 OP NEUTRAL TOC1 DPO	Neutral Time Overcurrent 1 has picked up Neutral Time Overcurrent 1 has operated Neutral Time Overcurrent 1 has dropped out
	NEUTRAL TOC2	Same set of operands as shown for NEUTRAL TOC1
ELEMENT: Neutral Directional Overcurrent	NTRL DIR OC1 FWD NTRL DIR OC1 REV	Neutral Directional OC1 Forward has operated Neutral Directional OC1 Reverse has operated
	NTRL DIR OC2	Same set of operands as shown for NTRL DIR OC1
ELEMENT: Overfrequency	OVERFREQ 1 PKP OVERFREQ 1 OP OVERFREQ 1 DPO	Overfrequency 1 has picked up Overfrequency 1 has operated Overfrequency 1 has dropped out
	OVERFREQ 2 to 4	Same set of operands as shown for OVERFREQ 1

Table 5–6: F60 FLEXLOGIC™ OPERANDS (Sheet 4 of 6)

OPERAND TYPE	OPERAND SYNTAX	OPERAND DESCRIPTION
ELEMENT: Phase Directional Overcurrent	PH DIR1 BLK A PH DIR1 BLK B PH DIR1 BLK C PH DIR1 BLK	Phase A Directional 1 Block Phase B Directional 1 Block Phase C Directional 1 Block Phase Directional 1 Block
	PH DIR2	Same set of operands as shown for PH DIR1
ELEMENT: Phase Instantaneous Overcurrent	PHASE IOC1 PKP PHASE IOC1 OP PHASE IOC1 DPO PHASE IOC1 PKP A PHASE IOC1 PKP B PHASE IOC1 PKP C PHASE IOC1 OP A PHASE IOC1 OP B PHASE IOC1 OP C PHASE IOC1 DPO A PHASE IOC1 DPO B PHASE IOC1 DPO C	At least one phase of PHASE IOC1 has picked up At least one phase of PHASE IOC1 has operated At least one phase of PHASE IOC1 has dropped out Phase A of PHASE IOC1 has picked up Phase B of PHASE IOC1 has picked up Phase C of PHASE IOC1 has picked up Phase A of PHASE IOC1 has operated Phase B of PHASE IOC1 has operated Phase C of PHASE IOC1 has operated Phase A of PHASE IOC1 has dropped out Phase B of PHASE IOC1 has dropped out Phase C of PHASE IOC1 has dropped out
	PHASE IOC2	Same set of operands as shown for PHASE IOC1
ELEMENT: Phase Overvoltage	PHASE OV1 PKP PHASE OV1 OP PHASE OV1 DPO PHASE OV1 PKP A PHASE OV1 PKP B PHASE OV1 PKP C PHASE OV1 OP A PHASE OV1 OP B PHASE OV1 OP C PHASE OV1 DPO A PHASE OV1 DPO B PHASE OV1 DPO C	At least one phase of Overvoltage 1 has picked up At least one phase of Overvoltage 1 has operated At least one phase of Overvoltage 1 has dropped out Phase A of Overvoltage 1 has picked up Phase B of Overvoltage 1 has picked up Phase C of Overvoltage 1 has picked up Phase A of Overvoltage 1 has operated Phase B of Overvoltage 1 has operated Phase C of Overvoltage 1 has operated Phase A of Overvoltage 1 has dropped out Phase B of Overvoltage 1 has dropped out Phase C of Overvoltage 1 has dropped out
ELEMENT: Phase Time Overcurrent	PHASE TOC1 PKP PHASE TOC1 OP PHASE TOC1 DPO PHASE TOC1 PKP A PHASE TOC1 PKP B PHASE TOC1 PKP C PHASE TOC1 OP A PHASE TOC1 OP B PHASE TOC1 OP C PHASE TOC1 DPO A PHASE TOC1 DPO B PHASE TOC1 DPO C	At least one phase of PHASE TOC1 has picked up At least one phase of PHASE TOC1 has operated At least one phase of PHASE TOC1 has dropped out Phase A of PHASE TOC1 has picked up Phase B of PHASE TOC1 has picked up Phase C of PHASE TOC1 has picked up Phase A of PHASE TOC1 has operated Phase B of PHASE TOC1 has operated Phase C of PHASE TOC1 has operated Phase A of PHASE TOC1 has dropped out Phase B of PHASE TOC1 has dropped out Phase C of PHASE TOC1 has dropped out
	PHASE TOC2	Same set of operands as shown for PHASE TOC1
ELEMENT: Phase Undervoltage	PHASE UV1 PKP PHASE UV1 OP PHASE UV1 DPO PHASE UV1 PKP A PHASE UV1 PKP B PHASE UV1 PKP C PHASE UV1 OP A PHASE UV1 OP B PHASE UV1 OP C PHASE UV1 DPO A PHASE UV1 DPO B PHASE UV1 DPO C	At least one phase of UV1 has picked up At least one phase of UV1 has operated At least one phase of UV1 has dropped out Phase A of UV1 has picked up Phase B of UV1 has picked up Phase C of UV1 has picked up Phase A of UV1 has operated Phase B of UV1 has operated Phase C of UV1 has operated Phase A of UV1 has dropped out Phase B of UV1 has dropped out Phase C of UV1 has dropped out
	PHASE UV2	Same set of operands as shown for PHASE UV1
ELEMENT: Selector Switch	SELECTOR 1 POS Y SELECTOR 1 BIT 0 SELECTOR 1 BIT 1 SELECTOR 1 BIT 2 SELECTOR 1 STP ALARM SELECTOR 1 BIT ALARM SELECTOR 1 ALARM SELECTOR 1 PWR ALARM	Selector Switch 1 is in Position Y (mutually exclusive operands). First bit of the 3-bit word encoding position of Selector 1. Second bit of the 3-bit word encoding position of Selector 1. Third bit of the 3-bit word encoding position of Selector 1. Position of Selector 1 has been pre-selected with the stepping up control input but not acknowledged. Position of Selector 1 has been pre-selected with the 3-bit control input but not acknowledged. Position of Selector 1 has been pre-selected but not acknowledged. Position of Selector Switch 1 is undetermined or restored from memory when the relay powers up and synchronizes to the 3-bit input.
	SELECTOR 2	Same set of operands as shown above for SELECTOR 1

Table 5–6: F60 FLEXLOGIC™ OPERANDS (Sheet 5 of 6)

OPERAND TYPE	OPERAND SYNTAX	OPERAND DESCRIPTION
ELEMENT: Setting Group	SETTING GROUP ACT 1 ↓ SETTING GROUP ACT 6	Setting Group 1 is active ↓ Setting Group 6 is active
ELEMENT: Disturbance Detector	SRCx 50DD OP	Source x Disturbance Detector has operated
ELEMENT: VTFF (Voltage Transformer Fuse Failure)	SRCx VT FUSE FAIL OP SRCx VT FUSE FAIL DPO SRCx VT FUSE FAIL VOL LOSS	Source x VT Fuse Failure detector has operated Source x VT Fuse Failure detector has dropped out Source x has lost voltage signals (V2 below 15% AND V1 below 5% of nominal)
ELEMENT: Synchrocheck	SYNC 1 DEAD S OP SYNC 1 DEAD S DPO SYNC 1 SYNC OP SYNC 1 SYNC DPO SYNC 1 CLS OP SYNC 1 CLS DPO SYNC 1 V1 ABOVE MIN SYNC 1 V1 BELOW MAX SYNC 1 V2 ABOVE MIN SYNC 1 V2 BELOW MAX	Synchrocheck 1 dead source has operated Synchrocheck 1 dead source has dropped out Synchrocheck 1 in synchronization has operated Synchrocheck 1 in synchronization has dropped out Synchrocheck 1 close has operated Synchrocheck 1 close has dropped out Synchrocheck 1 V1 is above the minimum live voltage Synchrocheck 1 V1 is below the maximum dead voltage Synchrocheck 1 V2 is above the minimum live voltage Synchrocheck 1 V2 is below the maximum dead voltage
	SYNC 2	Same set of operands as shown for SYNC 1
ELEMENT: Teleprotection Inputs/Outputs	TELEPRO CH1 FAIL TELEPRO CH2 FAIL TELEPRO CH1 ID FAIL TELEPRO CH2 ID FAIL TELEPRO CH1 CRC FAIL TELEPRO CH2 CRC FAIL TELEPRO CH1 PKT LOST TELEPRO CH2 PKT LOST TELEPRO INPUT 1-1 On ↓ TELEPRO INPUT 1-16 On TELEPRO INPUT 2-1 On ↓ TELEPRO INPUT 2-16 On	Channel 1 failed Channel 2 failed The ID check for a peer relay on channel 1 has failed The ID check for a peer relay on channel 2 has failed CRC detected packet corruption on channel 1 CRC detected packet corruption on channel 2 CRC detected lost packet on channel 1 CRC detected lost packet on channel 2 Flag is set, Logic =1 ↓ Flag is set, Logic =1 Flag is set, Logic =1 ↓ Flag is set, Logic =1
ELEMENT: Underfrequency	UNDERFREQ 1 PKP UNDERFREQ 1 OP UNDERFREQ 1 DPO	Underfrequency 1 has picked up Underfrequency 1 has operated Underfrequency 1 has dropped out
	UNDERFREQ 2 to 6	Same set of operands as shown for UNDERFREQ 1 above
FIXED OPERANDS	Off	Logic = 0. Does nothing and may be used as a delimiter in an equation list; used as ‘Disable’ by other features.
	On	Logic = 1. Can be used as a test setting.
INPUTS/OUTPUTS: Contact Inputs	Cont Ip 1 On Cont Ip 2 On ↓ Cont Ip 1 Off Cont Ip 2 Off ↓	(will not appear unless ordered) (will not appear unless ordered) ↓ (will not appear unless ordered) (will not appear unless ordered) ↓
INPUTS/OUTPUTS: Contact Outputs, Current (from detector on Form-A output only)	Cont Op 1 IOn Cont Op 2 IOn ↓	(will not appear unless ordered) (will not appear unless ordered) ↓
	Cont Op 1 IOff Cont Op 2 IOff ↓	(will not appear unless ordered) (will not appear unless ordered) ↓
INPUTS/OUTPUTS: Contact Outputs, Voltage (from detector on Form-A output only)	Cont Op 1 VOn Cont Op 2 VOn ↓	(will not appear unless ordered) (will not appear unless ordered) ↓
	Cont Op 1 VOff Cont Op 2 VOff ↓	(will not appear unless ordered) (will not appear unless ordered) ↓
INPUTS/OUTPUTS Direct Inputs	DIRECT INPUT 1 On ↓ DIRECT INPUT 32 On	Flag is set, logic=1 ↓ Flag is set, logic=1
INPUTS/OUTPUTS: Remote Inputs	REMOTE INPUT 1 On ↓ REMOTE INPUT 32 On	Flag is set, logic=1 ↓ Flag is set, logic=1

Table 5–6: F60 FLEXLOGIC™ OPERANDS (Sheet 6 of 6)

OPERAND TYPE	OPERAND SYNTAX	OPERAND DESCRIPTION
INPUTS/OUTPUTS: Virtual Inputs	Virt Ip 1 On ↓ Virt Ip 64 On	Flag is set, logic=1 ↓ Flag is set, logic=1
INPUTS/OUTPUTS: Virtual Outputs	Virt Op 1 On ↓ Virt Op 96 On	Flag is set, logic=1 ↓ Flag is set, logic=1
LED TEST	LED TEST IN PROGRESS	An LED test has been initiated and has not finished.
REMOTE DEVICES	REMOTE DEVICE 1 On ↓ REMOTE DEVICE 16 On	Flag is set, logic=1 ↓ Flag is set, logic=1
	REMOTE DEVICE 1 Off ↓ REMOTE DEVICE 16 Off	Flag is set, logic=1 ↓ Flag is set, logic=1
RESETTING	RESET OP RESET OP (COMMS) RESET OP (OPERAND) RESET OP (PUSHBUTTON)	Reset command is operated (set by all 3 operands below) Communications source of the reset command Operand (assigned in the **INPUTS/OUTPUTS** ⇨⇩ **RESETTING** menu) source of the reset command Reset key (pushbutton) source of the reset command
SELF-DIAGNOSTICS	ANY MAJOR ERROR ANY MINOR ERROR ANY SELF-TEST BATTERY FAIL DIRECT DEVICE OFF DIRECT RING BREAK DSP ERROR EEPROM DATA ERROR EQUIPMENT MISMATCH FLEXLOGIC ERR TOKEN IRIG-B FAILURE LATCHING OUT ERROR LOW ON MEMORY NO DSP INTERRUPTS PRI ETHERNET FAIL PROGRAM MEMORY PROTOTYPE FIRMWARE REMOTE DEVICE OFF SEC ETHERNET FAIL SNTP FAILURE SYSTEM EXCEPTION UNIT NOT CALIBRATED UNIT NOT PROGRAMMED WATCHDOG ERROR	Any of the major self-test errors generated (major error) Any of the minor self-test errors generated (minor error) Any self-test errors generated (generic, any error) See description in Chapter 7: Commands and Targets.
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 PUSHBUTTON x OFF	Pushbutton Number x is in the 'On' position 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 5–7: 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 5–8: FLEXLOGIC™ OPERATORS

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

5.4.4 FLEXLOGIC™ EXAMPLE

This section provides an example of implementing logic for a typical application. The sequence of the steps is quite important as it should minimize the work necessary to develop the relay settings. Note that the example presented in the figure below is intended to demonstrate the procedure, not to solve a specific application situation.

In the example below, it is assumed that logic has already been programmed to produce Virtual Outputs 1 and 2, and is only a part of the full set of equations used. When using FlexLogic™, it is important to make a note of each Virtual Output used – a Virtual Output designation (1 to 96) can only be properly assigned once.

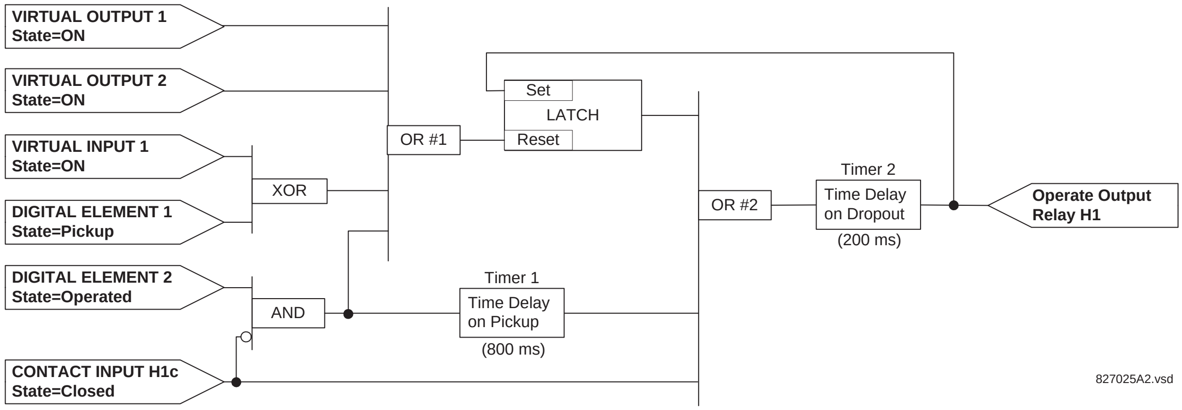

Figure 5–27: EXAMPLE LOGIC SCHEME

1. Inspect the example logic diagram to determine if the required logic can be implemented with the FlexLogic™ operators. If this is not possible, the logic must be altered until this condition is satisfied. Once this is done, count the inputs to each gate to verify that the number of inputs does not exceed the FlexLogic™ limits, which is unlikely but possible. If the number of inputs is too high, subdivide the inputs into multiple gates to produce an equivalent. For example, if 25 inputs to an AND gate are required, connect Inputs 1 through 16 to AND(16), 17 through 25 to AND(9), and the outputs from these two gates to AND(2).

   Inspect each operator between the initial operands and final virtual outputs to determine if the output from the operator is used as an input to more than one following operator. If so, the operator output must be assigned as a Virtual Output.

   For the example shown above, the output of the AND gate is used as an input to both OR#1 and Timer 1, and must therefore be made a Virtual Output and assigned the next available number (i.e. Virtual Output 3). The final output must also be assigned to a Virtual Output as Virtual Output 4, which will be programmed in the contact output section to operate relay H1 (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.

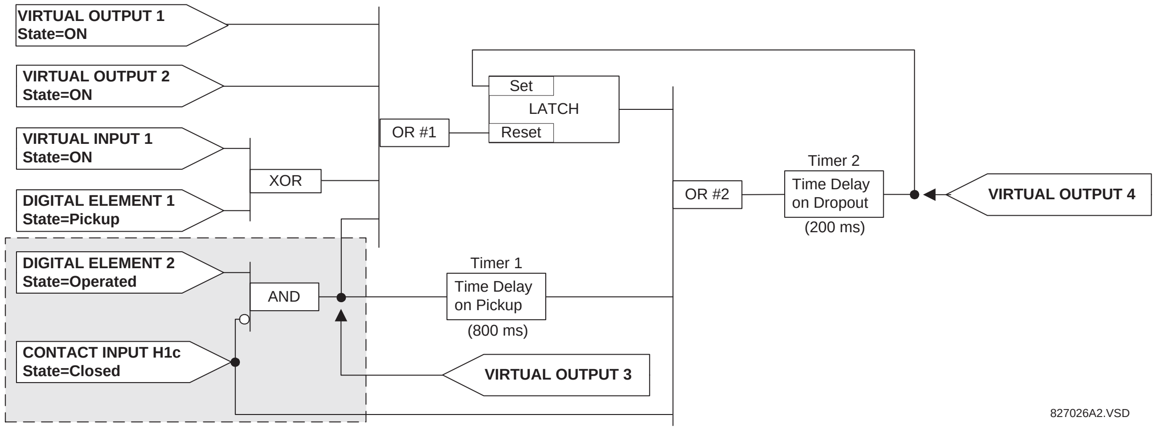

Figure 5–28: LOGIC EXAMPLE WITH VIRTUAL OUTPUTS

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.

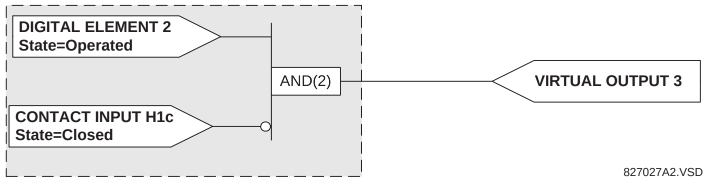

Figure 5–29: LOGIC FOR VIRTUAL OUTPUT 3

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.

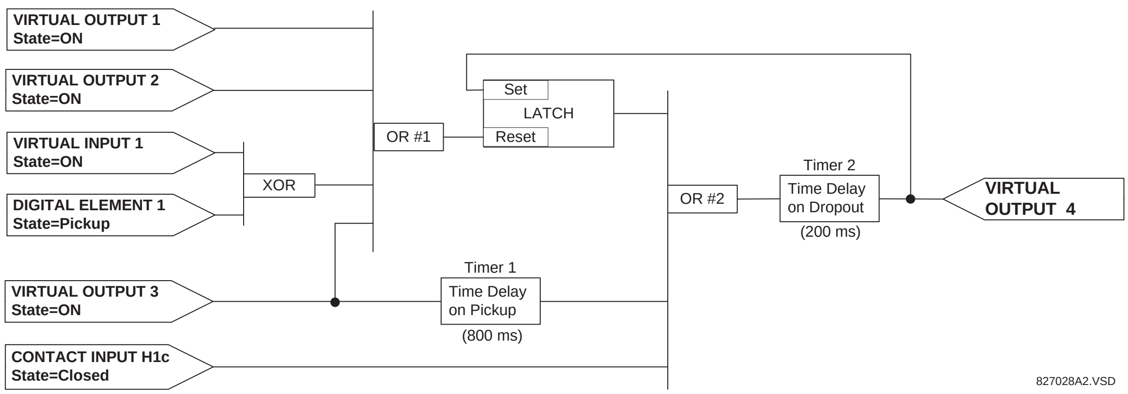

Figure 5–30: LOGIC FOR VIRTUAL OUTPUT 4

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.

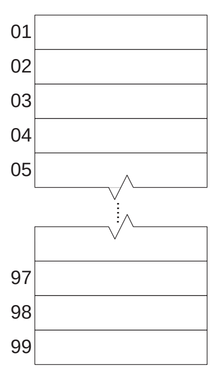

Figure 5–31: FLEXLOGIC™ WORKSHEET

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.

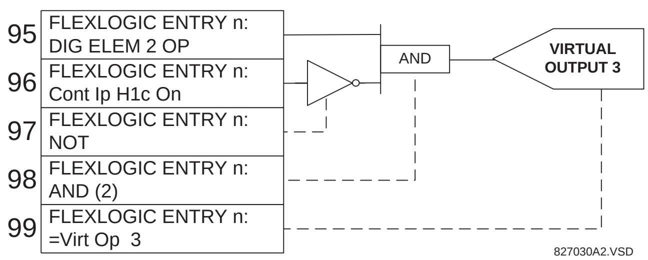

Figure 5–32: FLEXLOGIC™ EQUATION FOR VIRTUAL OUTPUT 3

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".

5

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.

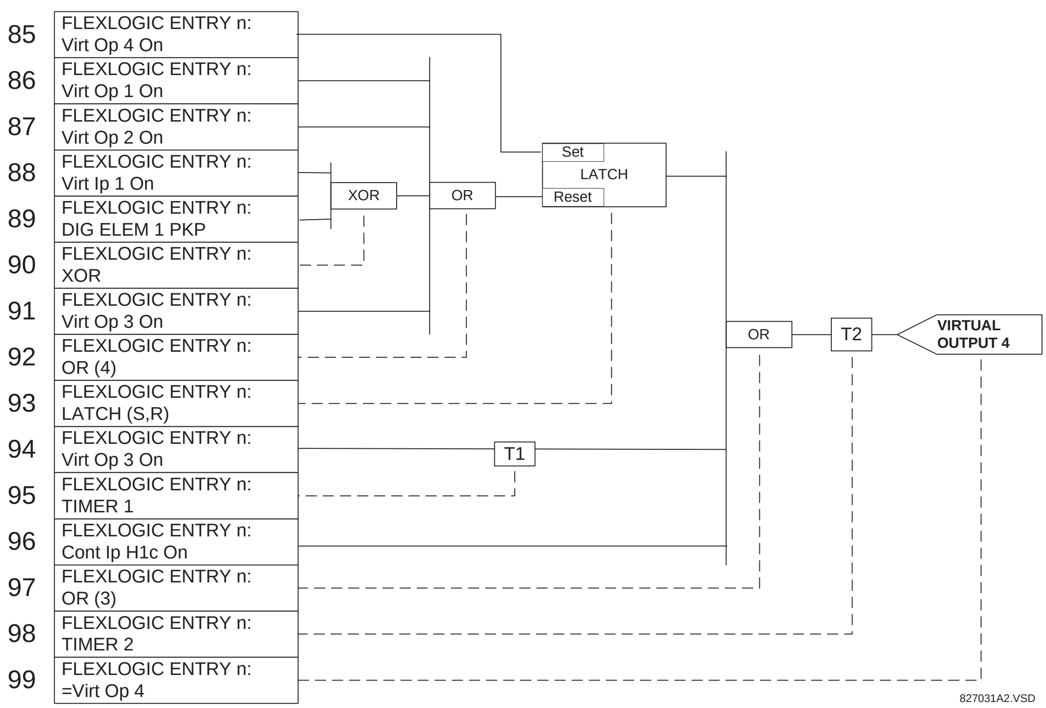

Figure 5–33: FLEXLOGIC™ EQUATION FOR VIRTUAL OUTPUT 4

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

5

PATH: SETTINGS ⇨⇩ FLEXLOGIC ⇨ FLEXLOGIC EQUATION EDITOR

■ FLEXLOGIC ■ EQUATION EDITOR		FLEXLOGIC ENTRY 1: END	Range: FlexLogic™ parameters
		↓	
	MESSAGE	FLEXLOGIC ENTRY 512: 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 ■ TIMER 1		TIMER 1 TYPE: millisecond	Range: millisecond, second, minute
	MESSAGE	TIMER 1 PICKUP DELAY: 0	Range: 0 to 60000 in steps of 1
	MESSAGE	TIMER 1 DROPOUT DELAY: 0	Range: 0 to 60000 in steps of 1

There are 32 identical FlexLogic™ timers available. These timers can be used as operators for FlexLogic™ equations.

- **TIMER 1 TYPE:** This setting is used to select the time measuring unit.
- **TIMER 1 PICKUP DELAY:** Sets the time delay to pickup. If a pickup delay is not required, set this function to "0".
- **TIMER 1 DROPOUT DELAY:** Sets the time delay to dropout. If a dropout delay is not required, set this function to "0".

5.4.7 FLEXELEMENTS™

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

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

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

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

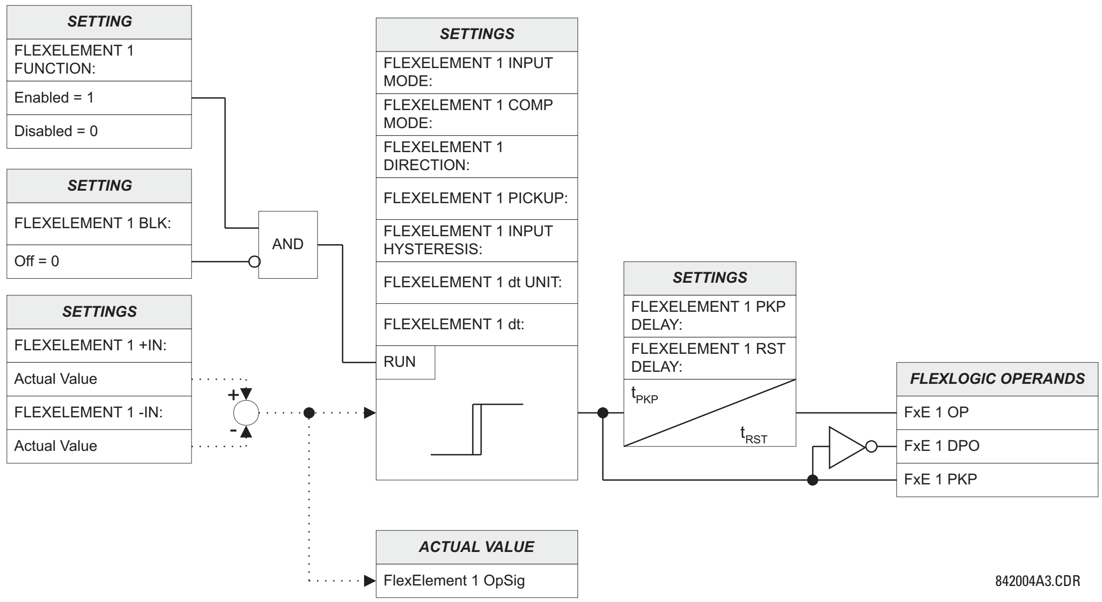

Figure 5–34: FLEXELEMENT™ SCHEME LOGIC

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 “Level”. The element responds to the rate of change of its operating signal if the **FLEXELEMENT 1 COMP MODE** setting is set to “Delta”. In this case the **FLEXELEMENT 1 dt UNIT** and **FLEXELEMENT 1 dt** settings specify how the rate of change is derived.

The **FLEXELEMENT 1 DIRECTION** setting enables the relay to respond to either high or low values of the operating signal. The following figure explains the application of the **FLEXELEMENT 1 DIRECTION**, **FLEXELEMENT 1 PICKUP** and **FLEXELEMENT 1 HYSTERESIS** settings.

5

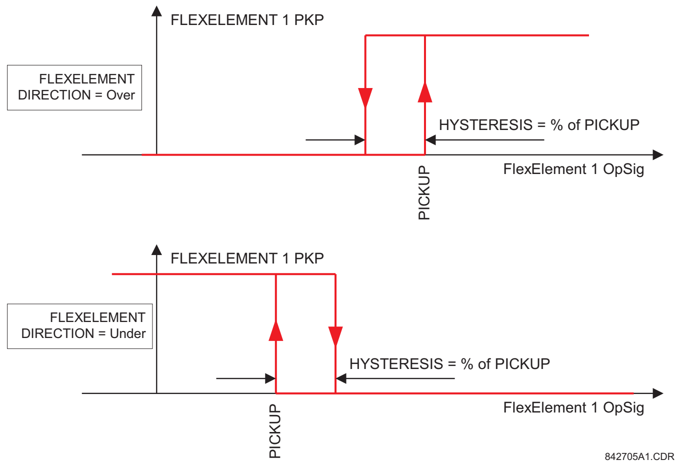

Figure 5–35: FLEXELEMENT™ DIRECTION, PICKUP, AND HYSTERESIS

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.

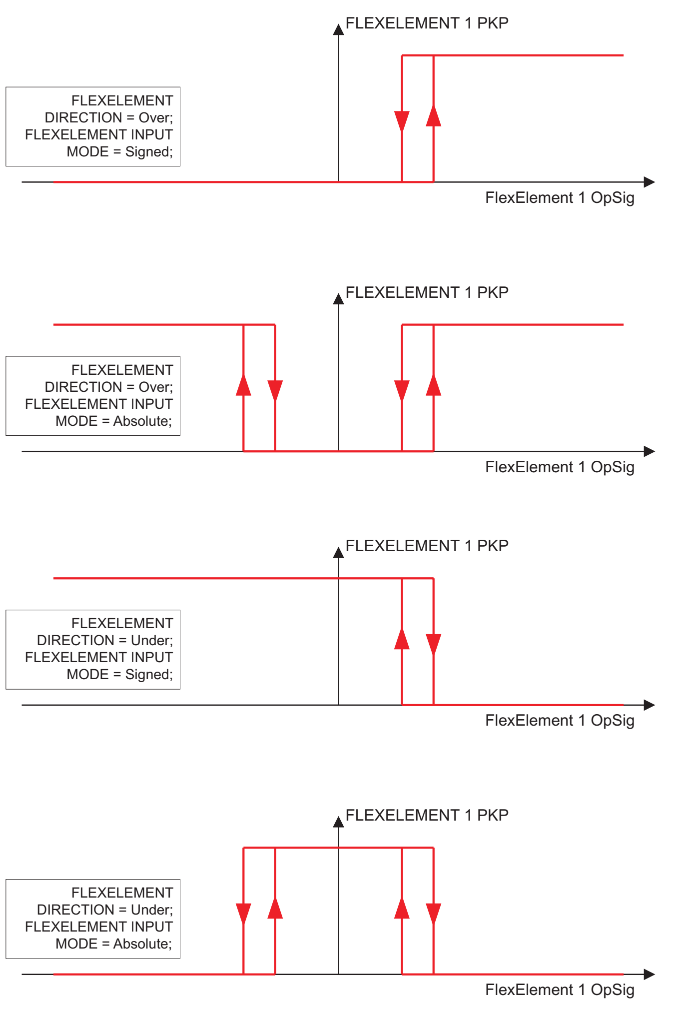

Figure 5–36: FLEXELEMENT™ INPUT MODE SETTING

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 5–9: FLEXELEMENT™ BASE UNITS

BREAKER ARCING AMPS (Brk X Arc Amp A, B, and C)	BASE = 2000 $kA^2 \times$ cycle
dcmA	BASE = maximum value of the **DCMA INPUT MAX** setting for the two transducers configured under the +IN and –IN inputs.
FREQUENCY	f_{BASE} = 1 Hz
FREQUENCY RATE OF CHANGE	df/dt_{BASE} = 1 Hz/s
PHASE ANGLE	φ_{BASE} = 360 degrees (see the UR angle referencing convention)
POWER FACTOR	PF_{BASE} = 1.00
RTDs	BASE = 100°C
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 (Positive and Negative Watthours, 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 THD & HARMONICS	BASE = 100% of fundamental frequency component
SOURCE VOLTAGE	V_{BASE} = maximum nominal primary RMS value of the +IN and –IN inputs
SYNCHROCHECK (Max Delta Volts)	V_{BASE} = maximum primary RMS value of all the sources related to the +IN and –IN inputs

The **FLEXELEMENT 1 HYSTERESIS** setting defines the pickup–dropout relation of the element by specifying the width of the hysteresis loop as a percentage of the pickup value as shown in the FlexElement™ Direction, Pickup, and Hysteresis diagram.

The **FLEXELEMENT 1 DT UNIT** setting specifies the time unit for the setting **FLEXELEMENT 1 dt**. This setting is applicable only if **FLEXELEMENT 1 COMP MODE** is set to “Delta”. The **FLEXELEMENT 1 DT** setting specifies duration of the time interval for the rate of change mode of operation. This setting is applicable only if **FLEXELEMENT 1 COMP MODE** is set to “Delta”.

This **FLEXELEMENT 1 PKP DELAY** setting specifies the pickup delay of the element. The **FLEXELEMENT 1 RST DELAY** setting specifies the reset delay of the element.

5.4.8 NON-VOLATILE LATCHES

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

■ LATCH 1 ■	◀▶	LATCH 1 FUNCTION: Disabled	*Range: Disabled, Enabled*
MESSAGE	▲▼	LATCH 1 TYPE: Reset Dominant	*Range: Reset Dominant, Set Dominant*
MESSAGE	▲▼	LATCH 1 SET: Off	*Range: FlexLogic™ operand*
MESSAGE	▲▼	LATCH 1 RESET: Off	*Range: FlexLogic™ operand*
MESSAGE	▲▼	LATCH 1 TARGET: Self-reset	*Range: Self-reset, Latched, Disabled*
MESSAGE	▲	LATCH 1 EVENTS: Disabled	*Range: Disabled, Enabled*

The non-volatile latches provide a permanent logical flag that is stored safely and will not reset upon reboot after the relay is powered down. Typical applications include sustaining operator commands or permanently block relay functions, such as Autorecloser, until a deliberate 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.

5

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

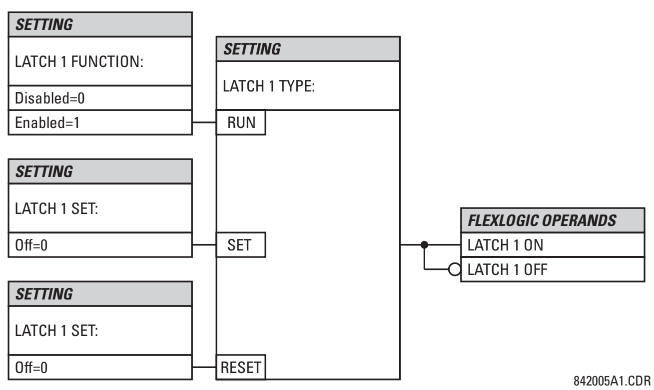

Figure 5–37: NON-VOLATILE LATCH OPERATION TABLE (N=1 to 16) AND LOGIC

5.5.1 OVERVIEW

Each protection element can be assigned up to six different sets of settings according to Setting Group designations 1 to 6. The performance of these elements is defined by the active Setting Group at a given time. Multiple setting groups allow the user to conveniently change protection settings for different operating situations (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 ■	◀▶	■ LOAD ENCROACHMENT ■	See page 5-80.
MESSAGE	▲▼	■ PHASE CURRENT ■	See page 5-82.
MESSAGE	▲▼	■ NEUTRAL CURRENT ■	See page 5-92.
MESSAGE	▲▼	■ GROUND CURRENT ■	See page 5-100.
MESSAGE	▲▼	■ NEGATIVE SEQUENCE ■ CURRENT	See page 5-103.
MESSAGE	▲▼	■ BREAKER FAILURE ■	See page 5-108.
MESSAGE	▲▼	■ VOLTAGE ELEMENTS ■	See page 5-117.
MESSAGE	▲	■ SENSITIVE ■ DIRECTIONAL POWER	See page 5-124.

Each of the six Setting Group menus is identical. **SETTING GROUP 1** (the default active group) automatically becomes active if no other group is active (see the *Control Elements* section for additional details).

5

5.5.3 LOAD ENCROACHMENT

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

■ LOAD ENCROACHMENT ■	◁▷	LOAD ENCROACHMENT FUNCTION: Disabled	*Range: Disabled, Enabled*
MESSAGE	△▽	LOAD ENCROACHMENT SOURCE: SRC 1	*Range: SRC 1, SRC 2*
MESSAGE	△▽	LOAD ENCROACHMENT MIN VOLT: 0.250 pu	*Range: 0.000 to 3.000 pu in steps of 0.001*
MESSAGE	△▽	LOAD ENCROACHMENT REACH: 1.00 Ω	*Range: 0.02 to 250.00 ohms in steps of 0.01*
MESSAGE	△▽	LOAD ENCROACHMENT ANGLE: 30°	*Range: 5 to 50° in steps of 1*
MESSAGE	△▽	LOAD ENCROACHMENT PKP DELAY: 0.000 s	*Range: 0.000 to 65.535 s in steps of 0.001*
MESSAGE	△▽	LOAD ENCROACHMENT RST DELAY: 0.000 s	*Range: 0.000 to 65.535 s in steps of 0.001*
MESSAGE	△▽	LOAD ENCRMNT BLK: Off	*Range: Flexlogic™ operand*
MESSAGE	△▽	LOAD ENCROACHMENT TARGET: Self-reset	*Range: Self-reset, Latched, Disabled*
MESSAGE	△	LOAD ENCROACHMENT EVENTS: Disabled	*Range: Disabled, Enabled*

The Load Encroachment element responds to the positive-sequence voltage and current and applies a characteristic shown in the figure below.

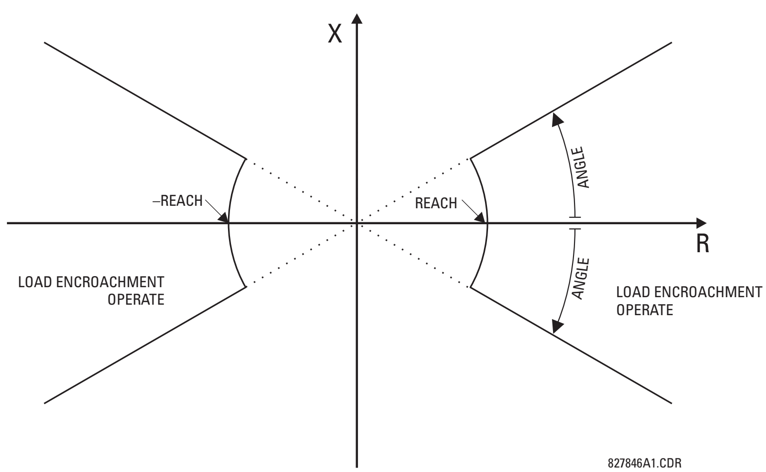

Figure 5–38: LOAD ENCROACHMENT CHARACTERISTIC

The element operates if the positive-sequence voltage is above a settable level and asserts its output signal that can be used to block selected protection elements such as distance or phase overcurrent. The following figure shows an effect of the Load Encroachment characteristics used to block the Quad distance element.

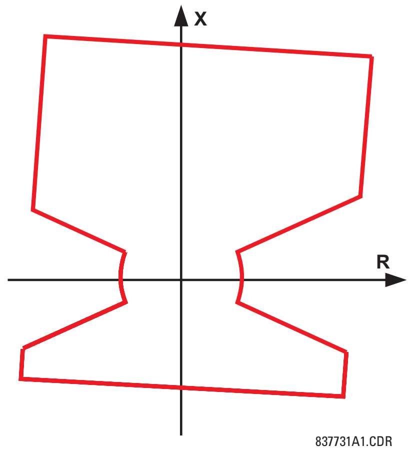

Figure 5–39: LOAD ENCROACHMENT APPLIED TO DISTANCE ELEMENT

- **LOAD ENCROACHMENT MIN VOLT:** This setting specifies the minimum positive-sequence voltage required for operation of the element. If the voltage is below this threshold a blocking signal will not be asserted by the element. When selecting this setting one must remember that the F60 measures the phase-to-ground sequence voltages regardless of the VT connection.

  The nominal VT secondary voltage as specified under PATH: SYSTEM SETUP ⇨⇩ AC INPUTS ⇨ VOLTAGE BANK X5 ⇨⇩ PHASE VT SECONDARY is the p.u. base for this setting.

- **LOAD ENCROACHMENT REACH:** This setting specifies the resistive reach of the element as shown in the Load Encroachment Characteristic diagram. This setting should be entered in secondary ohms and be calculated as the positive-sequence resistance seen by the relay under maximum load conditions and unity power factor.

- **LOAD ENCROACHMENT ANGLE:** This setting specifies the size of the blocking region as shown on the Load Encroachment Characteristic diagram and applies to the positive sequence impedance.

5

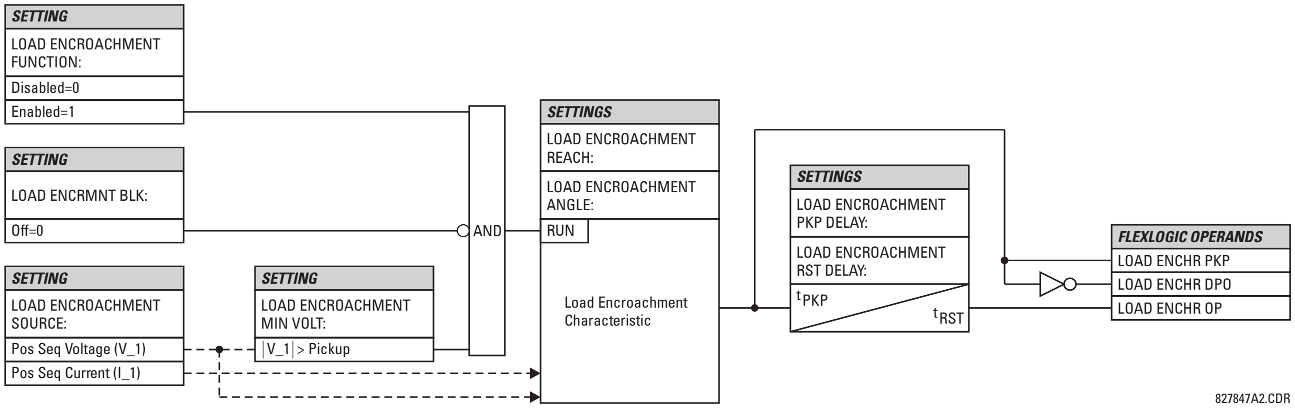

Figure 5–40: LOAD ENCROACHMENT SCHEME LOGIC

5.5.4 PHASE CURRENT

a) MAIN MENU

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

■ PHASE CURRENT ■		■ PHASE TOC1 ■	See page 5-87.
	MESSAGE	■ PHASE TOC2 ■	See page 5-87.
	MESSAGE	■ PHASE IOC1 ■	See page 5-89.
	MESSAGE	■ PHASE IOC2 ■	See page 5-89.
	MESSAGE	■ PHASE ■ DIRECTIONAL 1	See page 5-90.
	MESSAGE	■ PHASE ■ DIRECTIONAL 2	See page 5-90.

The F60 Feeder Management Relay has two (2) phase time overcurrent, two (2) phase instantaneous overcurrent, and two (2) phase directional overcurrent elements.

5

b) INVERSE TIME OVERCURRENT CHARACTERISTICS

The inverse time overcurrent curves used by the time overcurrent elements are the IEEE, IEC, GE Type IAC, and I^2t standard curve shapes. This allows for simplified coordination with downstream devices. If 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 5–10: OVERCURRENT CURVE TYPES

IEEE	IEC	GE TYPE IAC	OTHER
IEEE Extremely Inv.	IEC Curve A (BS142)	IAC Extremely Inv.	I^2t
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.

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:

$$T = TDM \times \left[\frac{A}{\left(\frac{I}{I_{pickup}}\right)^{p} - 1} + B \right], \quad T_{RESET} = TDM \times \left[\frac{t_r}{\left(\frac{I}{I_{pickup}}\right)^{2} - 1} \right] \qquad \textbf{(EQ 5.8)}$$

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 5–11: 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 5–12: IEEE CURVE TRIP TIMES (IN SECONDS)

MULTIPLIER (TDM)	CURRENT (I / I_{pickup})									
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
IEEE EXTREMELY INVERSE										
0.5	11.341	4.761	1.823	1.001	0.648	0.464	0.355	0.285	0.237	0.203
1.0	22.682	9.522	3.647	2.002	1.297	0.927	0.709	0.569	0.474	0.407
2.0	45.363	19.043	7.293	4.003	2.593	1.855	1.418	1.139	0.948	0.813
4.0	90.727	38.087	14.587	8.007	5.187	3.710	2.837	2.277	1.897	1.626
6.0	136.090	57.130	21.880	12.010	7.780	5.564	4.255	3.416	2.845	2.439
8.0	181.454	76.174	29.174	16.014	10.374	7.419	5.674	4.555	3.794	3.252
10.0	226.817	95.217	36.467	20.017	12.967	9.274	7.092	5.693	4.742	4.065
IEEE VERY INVERSE										
0.5	8.090	3.514	1.471	0.899	0.654	0.526	0.450	0.401	0.368	0.345
1.0	16.179	7.028	2.942	1.798	1.308	1.051	0.900	0.802	0.736	0.689
2.0	32.358	14.055	5.885	3.597	2.616	2.103	1.799	1.605	1.472	1.378
4.0	64.716	28.111	11.769	7.193	5.232	4.205	3.598	3.209	2.945	2.756
6.0	97.074	42.166	17.654	10.790	7.849	6.308	5.397	4.814	4.417	4.134
8.0	129.432	56.221	23.538	14.387	10.465	8.410	7.196	6.418	5.889	5.513
10.0	161.790	70.277	29.423	17.983	13.081	10.513	8.995	8.023	7.361	6.891
IEEE MODERATELY INVERSE										
0.5	3.220	1.902	1.216	0.973	0.844	0.763	0.706	0.663	0.630	0.603
1.0	6.439	3.803	2.432	1.946	1.688	1.526	1.412	1.327	1.260	1.207
2.0	12.878	7.606	4.864	3.892	3.377	3.051	2.823	2.653	2.521	2.414
4.0	25.756	15.213	9.729	7.783	6.753	6.102	5.647	5.307	5.041	4.827
6.0	38.634	22.819	14.593	11.675	10.130	9.153	8.470	7.960	7.562	7.241
8.0	51.512	30.426	19.458	15.567	13.507	12.204	11.294	10.614	10.083	9.654
10.0	64.390	38.032	24.322	19.458	16.883	15.255	14.117	13.267	12.604	12.068

IEC CURVES

For European applications, the relay offers three standard curves defined in IEC 255-4 and British standard BS142. These are defined as IEC Curve A, IEC Curve B, and IEC Curve C. The formulae for these curves are:

$$T = TDM \times \left[\frac{K}{(I/I_{pickup})^E - 1} \right], \; T_{RESET} = TDM \times \left[\frac{t_r}{(I/I_{pickup})^2 - 1} \right] \quad \textbf{(EQ 5.9)}$$

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

MULTIPLIER (TDM)	CURRENT (I / I_{pickup})									
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
IEC CURVE A										
0.05	0.860	0.501	0.315	0.249	0.214	0.192	0.176	0.165	0.156	0.149
0.10	1.719	1.003	0.630	0.498	0.428	0.384	0.353	0.330	0.312	0.297
0.20	3.439	2.006	1.260	0.996	0.856	0.767	0.706	0.659	0.623	0.594
0.40	6.878	4.012	2.521	1.992	1.712	1.535	1.411	1.319	1.247	1.188
0.60	10.317	6.017	3.781	2.988	2.568	2.302	2.117	1.978	1.870	1.782
0.80	13.755	8.023	5.042	3.984	3.424	3.070	2.822	2.637	2.493	2.376
1.00	17.194	10.029	6.302	4.980	4.280	3.837	3.528	3.297	3.116	2.971
IEC CURVE B										
0.05	1.350	0.675	0.338	0.225	0.169	0.135	0.113	0.096	0.084	0.075
0.10	2.700	1.350	0.675	0.450	0.338	0.270	0.225	0.193	0.169	0.150
0.20	5.400	2.700	1.350	0.900	0.675	0.540	0.450	0.386	0.338	0.300
0.40	10.800	5.400	2.700	1.800	1.350	1.080	0.900	0.771	0.675	0.600
0.60	16.200	8.100	4.050	2.700	2.025	1.620	1.350	1.157	1.013	0.900
0.80	21.600	10.800	5.400	3.600	2.700	2.160	1.800	1.543	1.350	1.200
1.00	27.000	13.500	6.750	4.500	3.375	2.700	2.250	1.929	1.688	1.500
IEC CURVE C										
0.05	3.200	1.333	0.500	0.267	0.167	0.114	0.083	0.063	0.050	0.040
0.10	6.400	2.667	1.000	0.533	0.333	0.229	0.167	0.127	0.100	0.081
0.20	12.800	5.333	2.000	1.067	0.667	0.457	0.333	0.254	0.200	0.162
0.40	25.600	10.667	4.000	2.133	1.333	0.914	0.667	0.508	0.400	0.323
0.60	38.400	16.000	6.000	3.200	2.000	1.371	1.000	0.762	0.600	0.485
0.80	51.200	21.333	8.000	4.267	2.667	1.829	1.333	1.016	0.800	0.646
1.00	64.000	26.667	10.000	5.333	3.333	2.286	1.667	1.270	1.000	0.808
IEC SHORT TIME										
0.05	0.153	0.089	0.056	0.044	0.038	0.034	0.031	0.029	0.027	0.026
0.10	0.306	0.178	0.111	0.088	0.075	0.067	0.062	0.058	0.054	0.052
0.20	0.612	0.356	0.223	0.175	0.150	0.135	0.124	0.115	0.109	0.104
0.40	1.223	0.711	0.445	0.351	0.301	0.269	0.247	0.231	0.218	0.207
0.60	1.835	1.067	0.668	0.526	0.451	0.404	0.371	0.346	0.327	0.311
0.80	2.446	1.423	0.890	0.702	0.602	0.538	0.494	0.461	0.435	0.415
1.00	3.058	1.778	1.113	0.877	0.752	0.673	0.618	0.576	0.544	0.518

IAC CURVES:

The curves for the General Electric type IAC relay family are derived from the formulae:

$$T = \text{TDM} \times \left(A + \frac{B}{(I/I_{pkp}) - C} + \frac{D}{((I/I_{pkp}) - C)^2} + \frac{E}{((I/I_{pkp}) - C)^3} \right),\ T_{RESET} = TDM \times \left[\frac{t_r}{(I/I_{pkp})^2 - 1} \right] \quad \textbf{(EQ 5.10)}$$

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 5–15: 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 5–16: IAC CURVE TRIP TIMES

MULTIPLIER (TDM)	CURRENT (I / I_{pickup})									
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
IAC EXTREMELY INVERSE										
0.5	1.699	0.749	0.303	0.178	0.123	0.093	0.074	0.062	0.053	0.046
1.0	3.398	1.498	0.606	0.356	0.246	0.186	0.149	0.124	0.106	0.093
2.0	6.796	2.997	1.212	0.711	0.491	0.372	0.298	0.248	0.212	0.185
4.0	13.591	5.993	2.423	1.422	0.983	0.744	0.595	0.495	0.424	0.370
6.0	20.387	8.990	3.635	2.133	1.474	1.115	0.893	0.743	0.636	0.556
8.0	27.183	11.987	4.846	2.844	1.966	1.487	1.191	0.991	0.848	0.741
10.0	33.979	14.983	6.058	3.555	2.457	1.859	1.488	1.239	1.060	0.926
IAC VERY INVERSE										
0.5	1.451	0.656	0.269	0.172	0.133	0.113	0.101	0.093	0.087	0.083
1.0	2.901	1.312	0.537	0.343	0.266	0.227	0.202	0.186	0.174	0.165
2.0	5.802	2.624	1.075	0.687	0.533	0.453	0.405	0.372	0.349	0.331
4.0	11.605	5.248	2.150	1.374	1.065	0.906	0.810	0.745	0.698	0.662
6.0	17.407	7.872	3.225	2.061	1.598	1.359	1.215	1.117	1.046	0.992
8.0	23.209	10.497	4.299	2.747	2.131	1.813	1.620	1.490	1.395	1.323
10.0	29.012	13.121	5.374	3.434	2.663	2.266	2.025	1.862	1.744	1.654
IAC INVERSE										
0.5	0.578	0.375	0.266	0.221	0.196	0.180	0.168	0.160	0.154	0.148
1.0	1.155	0.749	0.532	0.443	0.392	0.360	0.337	0.320	0.307	0.297
2.0	2.310	1.499	1.064	0.885	0.784	0.719	0.674	0.640	0.614	0.594
4.0	4.621	2.997	2.128	1.770	1.569	1.439	1.348	1.280	1.229	1.188
6.0	6.931	4.496	3.192	2.656	2.353	2.158	2.022	1.921	1.843	1.781
8.0	9.242	5.995	4.256	3.541	3.138	2.878	2.695	2.561	2.457	2.375
10.0	11.552	7.494	5.320	4.426	3.922	3.597	3.369	3.201	3.072	2.969
IAC SHORT INVERSE										
0.5	0.072	0.047	0.035	0.031	0.028	0.027	0.026	0.026	0.025	0.025
1.0	0.143	0.095	0.070	0.061	0.057	0.054	0.052	0.051	0.050	0.049
2.0	0.286	0.190	0.140	0.123	0.114	0.108	0.105	0.102	0.100	0.099
4.0	0.573	0.379	0.279	0.245	0.228	0.217	0.210	0.204	0.200	0.197
6.0	0.859	0.569	0.419	0.368	0.341	0.325	0.314	0.307	0.301	0.296
8.0	1.145	0.759	0.559	0.490	0.455	0.434	0.419	0.409	0.401	0.394
10.0	1.431	0.948	0.699	0.613	0.569	0.542	0.524	0.511	0.501	0.493

I2t CURVES:

The curves for the I^2t are derived from the formulae:

$$T = \text{TDM} \times \left[\frac{100}{\left(\frac{I}{I_{pickup}} \right)^2} \right], \; T_{RESET} = \text{TDM} \times \left[\frac{100}{\left(\frac{I}{I_{pickup}} \right)^{-2}} \right] \quad \textbf{(EQ 5.11)}$$

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 5–17: I^2T CURVE TRIP TIMES

MULTIPLIER (TDM)	CURRENT (I / I_{pickup})									
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
0.01	0.44	0.25	0.11	0.06	0.04	0.03	0.02	0.02	0.01	0.01
0.10	4.44	2.50	1.11	0.63	0.40	0.28	0.20	0.16	0.12	0.10
1.00	44.44	25.00	11.11	6.25	4.00	2.78	2.04	1.56	1.23	1.00
10.00	444.44	250.00	111.11	62.50	40.00	27.78	20.41	15.63	12.35	10.00
100.00	4444.4	2500.0	1111.1	625.00	400.00	277.78	204.08	156.25	123.46	100.00
600.00	26666.7	15000.0	6666.7	3750.0	2400.0	1666.7	1224.5	937.50	740.74	600.00

FLEXCURVES™:

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

$$T = \text{TDM} \times \left[\text{FlexCurve Time at} \left(\frac{I}{I_{pickup}} \right) \right] \quad \text{when} \left(\frac{I}{I_{pickup}} \right) \geq 1.00 \quad \textbf{(EQ 5.12)}$$

$$T_{RESET} = \text{TDM} \times \left[\text{FlexCurve Time at} \left(\frac{I}{I_{pickup}} \right) \right] \quad \text{when} \left(\frac{I}{I_{pickup}} \right) \leq 0.98 \quad \textbf{(EQ 5.13)}$$

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)

DEFINITE TIME CURVE:

The Definite Time curve shape operates as soon as the pickup level is exceeded for a specified period of time. The base definite time curve delay is in seconds. The curve multiplier of 0.00 to 600.00 makes this delay adjustable from instantaneous to 600.00 seconds in steps of 10 ms.

$$T = \text{TDM} \;\text{ in seconds, when } I > I_{pickup} \quad \textbf{(EQ 5.14)}$$

$$T_{RESET} = -\text{TDM} \;\text{ in seconds} \quad \textbf{(EQ 5.15)}$$

where: T = Operate Time (sec.), TDM = Multiplier setting
I = Input Current, I_{pickup} = Pickup Current setting
T_{RESET} = Reset Time in seconds (assuming energy capacity is 100% and RESET: Timed)

RECLOSER CURVES:

The F60 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(2)

■ PHASE TOC1 ■	PHASE TOC1 FUNCTION: Disabled	*Range: Disabled, Enabled*
MESSAGE	PHASE TOC1 SIGNAL SOURCE: SRC 1	*Range: SRC 1, SRC 2*
MESSAGE	PHASE TOC1 INPUT: Phasor	*Range: Phasor, RMS*
MESSAGE	PHASE TOC1 PICKUP: 1.000 pu	*Range: 0.000 to 30.000 pu in steps of 0.001*
MESSAGE	PHASE TOC1 CURVE: IEEE Mod Inv	*Range: See Overcurrent Curve Types table*
MESSAGE	PHASE TOC1 TD MULTIPLIER: 1.00	*Range: 0.00 to 600.00 in steps of 0.01*
MESSAGE	PHASE TOC1 RESET: Instantaneous	*Range: Instantaneous, Timed*
MESSAGE	PHASE TOC1 VOLTAGE RESTRAINT: Disabled	*Range: Disabled, Enabled*
MESSAGE	PHASE TOC1 BLOCK A: Off	*Range: FlexLogic™ operand*
MESSAGE	PHASE TOC1 BLOCK B: Off	*Range: FlexLogic™ operand*
MESSAGE	PHASE TOC1 BLOCK C: Off	*Range: FlexLogic™ operand*
MESSAGE	PHASE TOC1 TARGET: Self-reset	*Range: Self-reset, Latched, Disabled*
MESSAGE	PHASE TOC1 EVENTS: Disabled	*Range: Disabled, Enabled*

The phase time overcurrent element can provide a desired time-delay operating characteristic versus the applied current or be used as a simple Definite Time element. The phase current input quantities may be programmed as fundamental phasor magnitude or total waveform RMS magnitude as required by the application.

Two methods of resetting operation are available: “Timed” and “Instantaneous” (refer to the Inverse *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.

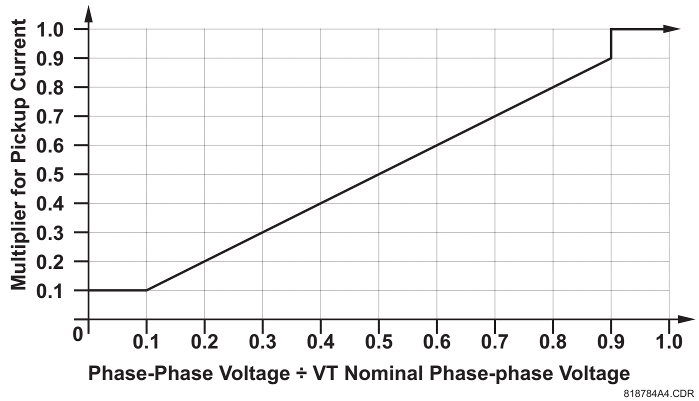

Figure 5–41: PHASE TOC VOLTAGE RESTRAINT CHARACTERISTIC

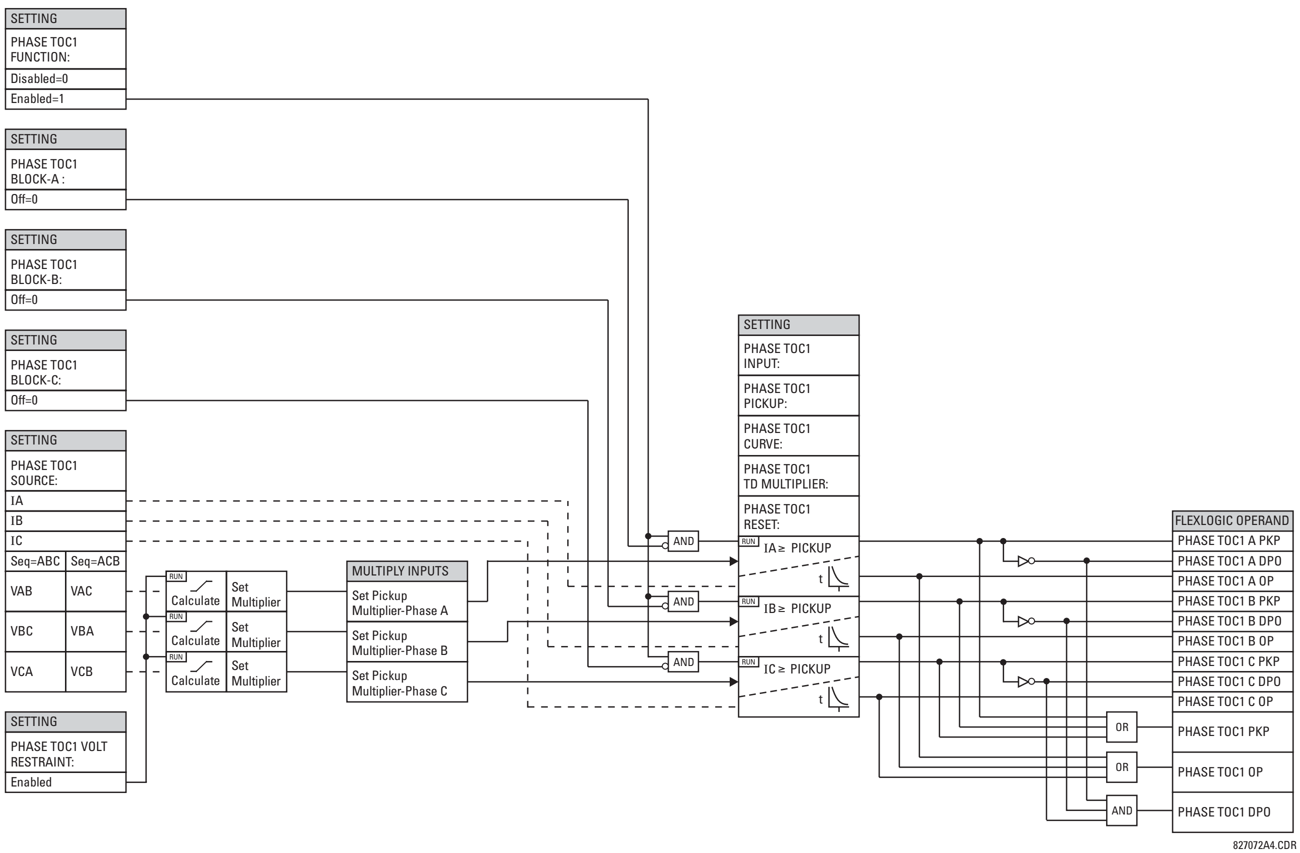

Figure 5–42: PHASE TOC1 SCHEME LOGIC

d) PHASE INSTANTANEOUS OVERCURRENT (ANSI 50P)

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

■ PHASE IOC1 ■	◁▷	PHASE IOC1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	△▽	PHASE IOC1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE	△▽	PHASE IOC1 PICKUP: 1.000 pu	Range: 0.000 to 30.000 pu in steps of 0.001
MESSAGE	△▽	PHASE IOC1 PICKUP DELAY: 0.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	△▽	PHASE IOC1 RESET DELAY: 0.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	△▽	PHASE IOC1 BLOCK A: Off	Range: FlexLogic™ operand
MESSAGE	△▽	PHASE IOC1 BLOCK B: Off	Range: FlexLogic™ operand
MESSAGE	△▽	PHASE IOC1 BLOCK C: Off	Range: FlexLogic™ operand
MESSAGE	△▽	PHASE IOC1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	△	PHASE IOC1 EVENTS: Disabled	Range: Disabled, Enabled

5

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.

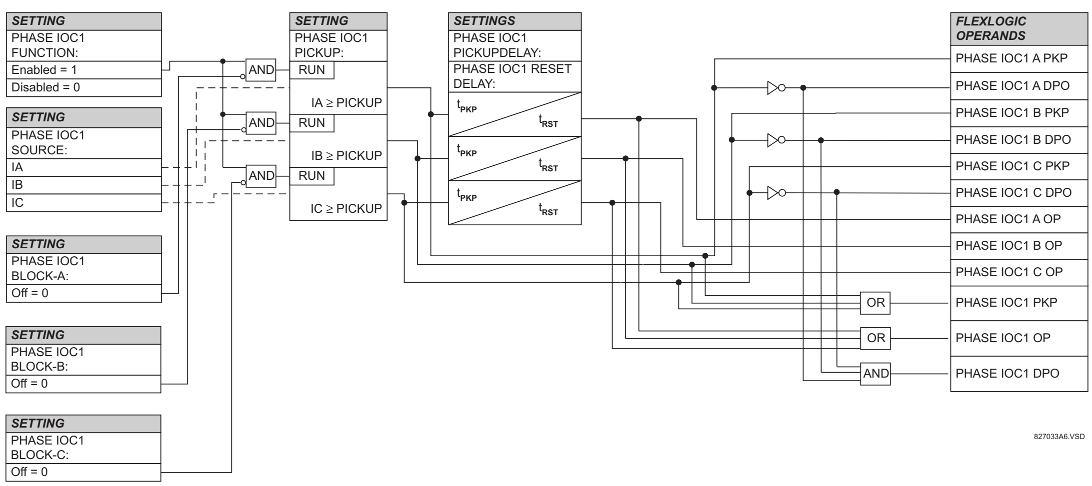

Figure 5–43: PHASE IOC1 SCHEME LOGIC

e) PHASE DIRECTIONAL OVERCURRENT (ANSI 67P)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨ PHASE CURRENT ⇨ PHASE DIRECTIONAL 1(2)

■ PHASE ■ DIRECTIONAL 1	PHASE DIR 1 FUNCTION: Disabled	*Range: Disabled, Enabled*
MESSAGE	PHASE DIR 1 SIGNAL SOURCE: SRC 1	*Range: SRC 1, SRC 2*
MESSAGE	PHASE DIR 1 BLOCK: Off	*Range: FlexLogic™ operand*
MESSAGE	PHASE DIR 1 ECA: 30	*Range: 0 to 359° in steps of 1*
MESSAGE	PHASE DIR POL V1 THRESHOLD: 0.700 pu	*Range: 0.000 to 3.000 pu in steps of 0.001*
MESSAGE	PHASE DIR 1 BLOCK WHEN V MEM EXP: No	*Range: No, Yes*
MESSAGE	PHASE DIR 1 TARGET: Self-reset	*Range: Self-reset, Latched, Disabled*
MESSAGE	PHASE DIR 1 EVENTS: Disabled	*Range: Disabled, Enabled*

5

The phase directional elements (one for each of phases A, B, and C) determine the phase current flow direction for steady state and fault conditions and can be used to control the operation of the phase overcurrent elements via the **BLOCK** inputs of these elements.

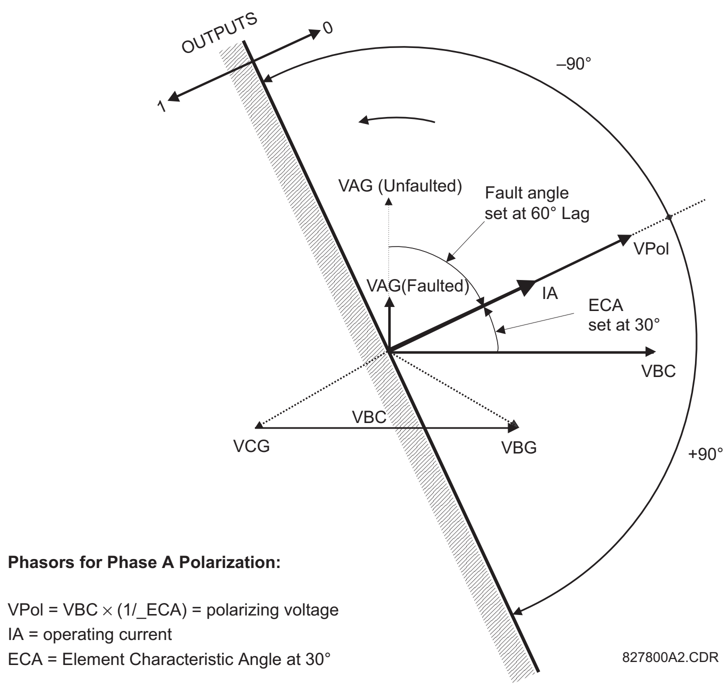

Figure 5–44: PHASE A DIRECTIONAL POLARIZATION

This element is intended to apply a block signal to an overcurrent element to prevent an operation when current is flowing in a particular direction. The direction of current flow is determined by measuring the phase angle between the current from the phase CTs and the line-line voltage from the VTs, based on the 90° or 'quadrature' connection. If there is a requirement to supervise overcurrent elements for flows in opposite directions, such as can happen through a bus-tie breaker, two phase directional elements should be programmed with opposite ECA settings.

To increase security for three phase faults very close to the VTs used to measure the polarizing voltage, a 'voltage memory' feature is incorporated. This feature stores the polarizing voltage the moment before the voltage collapses, and uses it to determine direction. The voltage memory remains valid for one second after the voltage has collapsed.

The main component of the phase directional element is the phase angle comparator with two inputs: the operating signal (phase current) and the polarizing signal (the line voltage, shifted in the leading direction by the characteristic angle, ECA).

The following table shows the operating and polarizing signals used for phase directional control:

PHASE	OPERATING SIGNAL	POLARIZING SIGNAL V_{pol}	
		ABC PHASE SEQUENCE	ACB PHASE SEQUENCE
A	Angle of IA	Angle of VBC × (1∠ECA)	Angle of VCB × (1∠ECA)
B	Angle of IB	Angle of VCA × (1∠ECA)	Angle of VAC × 1∠ECA)
C	Angle of IC	Angle of VAB × (1∠ECA)	Angle of VBA × (1∠ECA)

MODE OF OPERATION:

- When the function is "Disabled", or the operating current is below 5% × CT nominal, the element output is "0".
- When the function is "Enabled", the operating current is above 5% × CT nominal, and the polarizing voltage is above the set threshold, the element output is dependent on the phase angle between the operating and polarizing signals:

  – The element output is logic "0" when the operating current is within polarizing voltage ±90°.
  – For all other angles, the element output is logic "1".
- Once the voltage memory has expired, the phase overcurrent elements under directional control can be set to block or trip on overcurrent as follows:

  – When **BLOCK WHEN V MEM EXP** is set to "Yes", the directional element will block the operation of any phase overcurrent element under directional control when voltage memory expires.
  – When **BLOCK WHEN V MEM EXP** is set to "No", the directional element allows tripping of phase overcurrent elements under directional control when voltage memory expires.

In all cases, directional blocking will be permitted to resume when the polarizing voltage becomes greater than the 'polarizing voltage threshold'.

SETTINGS:

- **PHASE DIR 1 SIGNAL SOURCE:** This setting is used to select the source for the operating and polarizing signals. The operating current for the phase directional element is the phase current for the selected current source. The polarizing voltage is the line voltage from the phase VTs, based on the 90° or 'quadrature' connection and shifted in the leading direction by the element characteristic angle (ECA).
- **PHASE DIR 1 ECA:** This setting is used to select the element characteristic angle, i.e. the angle by which the polarizing voltage is shifted in the leading direction to achieve dependable operation. In the design of the UR-series elements, a block is applied to an element by asserting logic 1 at the blocking input. This element should be programmed via the ECA setting so that the output is **logic 1 for current in the non-tripping direction**.
- **PHASE DIR 1 POL V THRESHOLD:** This setting is used to establish the minimum level of voltage for which the phase angle measurement is reliable. The setting is based on VT accuracy. The default value is "0.700 pu".
- **PHASE DIR 1 BLOCK WHEN V MEM EXP:** This setting is used to select the required operation upon expiration of voltage memory. When set to "Yes", the directional element blocks the operation of any phase overcurrent element under directional control, when voltage memory expires; when set to "No", the directional element allows tripping of phase overcurrent elements under directional control.

NOTE

The Phase Directional element responds to the forward load current. In the case of a following reverse fault, the element needs some time – in the order of 8 ms – to establish a blocking signal. Some protection elements such as instantaneous overcurrent may respond to reverse faults before the blocking signal is established. Therefore, a coordination time of at least 10 ms must be added to all the instantaneous protection elements under the supervision of the Phase Directional element. If current reversal is of a concern, a longer delay – in the order of 20 ms – may be needed.

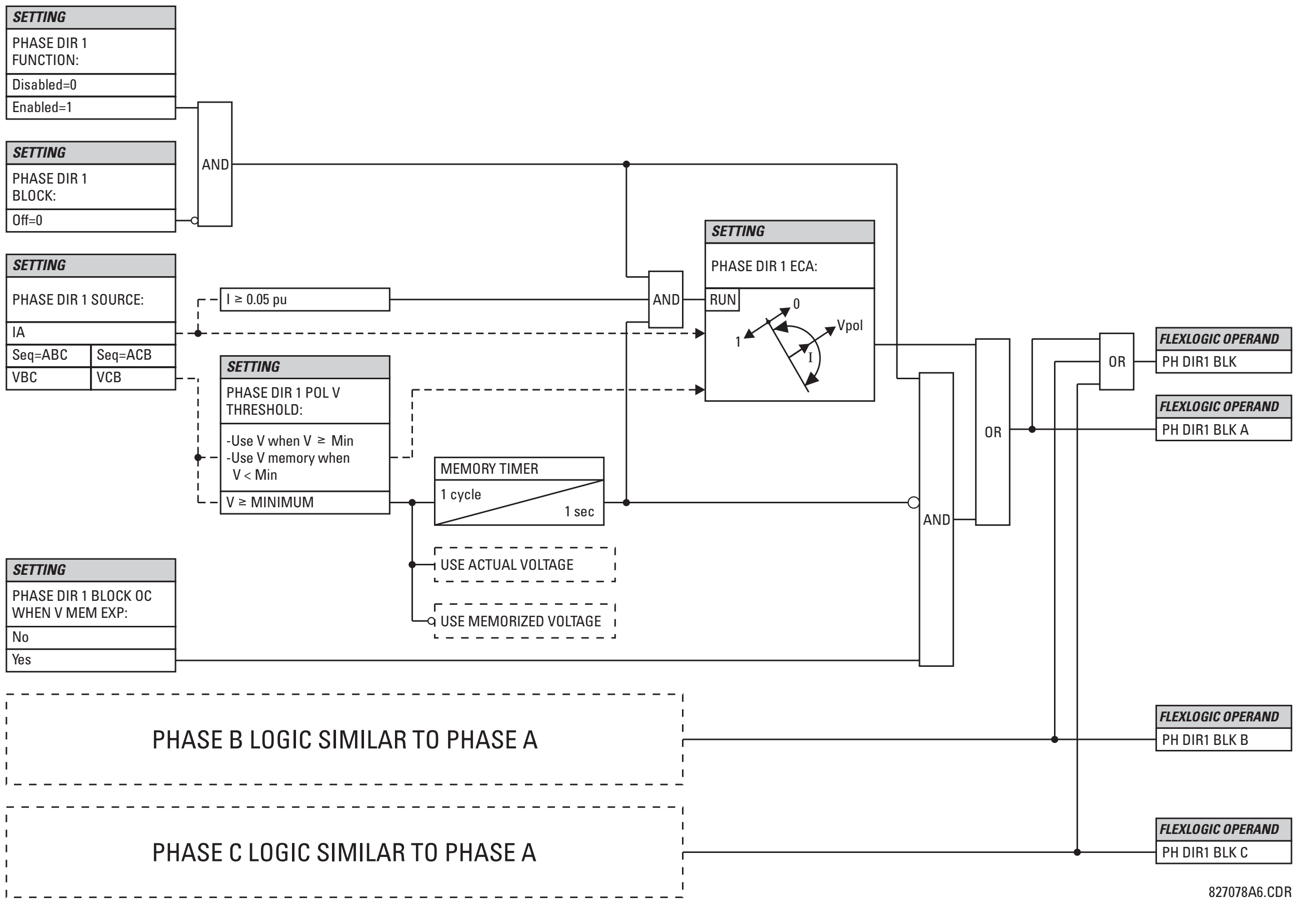

Figure 5–45: PHASE DIRECTIONAL SCHEME LOGIC

5.5.5 NEUTRAL CURRENT

a) MAIN MENU

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

■ NEUTRAL CURRENT ■	■ NEUTRAL TOC1 ■	See page 5–93.
MESSAGE	■ NEUTRAL TOC2 ■	See page 5–93.
MESSAGE	■ NEUTRAL IOC1 ■	See page 5–94.
MESSAGE	■ NEUTRAL IOC2 ■	See page 5–94.
MESSAGE	■ NEUTRAL ■ DIRECTIONAL OC1	See page 5–95.
MESSAGE	■ NEUTRAL ■ DIRECTIONAL OC2	See page 5–95.

The F60 Feeder Management Relay has two (2) Neutral Time Overcurrent, two (2) Neutral Instantaneous Overcurrent, and two (2) Neutral Directional Overcurrent elements.

b) NEUTRAL TIME OVERCURRENT (ANSI 51N)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ NEUTRAL CURRENT ⇨ NEUTRAL TOC1(2)

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

The Neutral Time Overcurrent element can provide a desired time-delay operating characteristic versus the applied current or be used as a simple Definite Time element. The neutral current input value is a quantity calculated as 3Io from the phase currents and may be programmed as fundamental phasor magnitude or total waveform RMS magnitude as required by the application.

Two methods of resetting operation are available: “Timed” and “Instantaneous” (refer to the *Inverse 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.

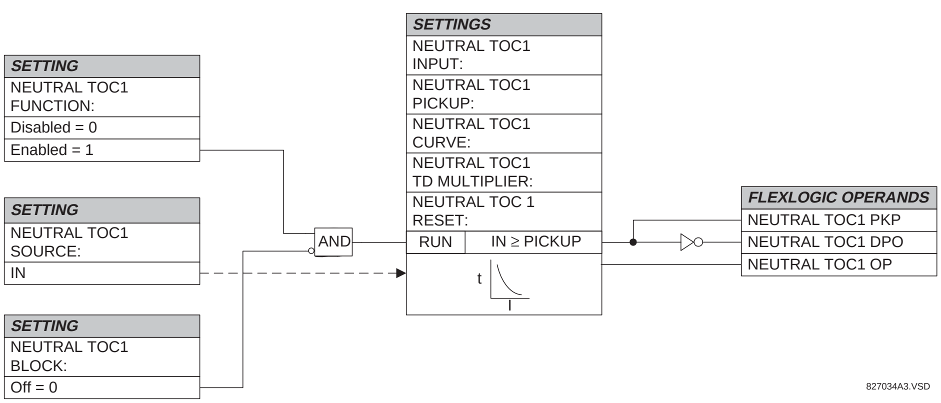

Figure 5–46: NEUTRAL TOC1 SCHEME LOGIC

5

c) NEUTRAL INSTANTANEOUS OVERCURRENT (ANSI 50N)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ NEUTRAL CURRENT ⇨⇩ NEUTRAL IOC1(2)

■ NEUTRAL IOC1 ■	NEUTRAL IOC1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	NEUTRAL IOC1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE	NEUTRAL IOC1 PICKUP: 1.000 pu	Range: 0.000 to 30.000 pu in steps of 0.001
MESSAGE	NEUTRAL IOC1 PICKUP DELAY: 0.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	NEUTRAL IOC1 RESET DELAY: 0.00 s	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE	NEUTRAL IOC1 BLOCK: Off	Range: FlexLogic™ operand
MESSAGE	NEUTRAL IOC1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	NEUTRAL IOC1 EVENTS: Disabled	Range: Disabled, Enabled

5

The Neutral Instantaneous Overcurrent element may be used as an instantaneous function with no intentional delay or as a Definite Time function. The element essentially responds to the magnitude of a neutral current fundamental frequency phasor calculated from the phase currents. A “positive-sequence restraint” is applied for better performance. A small portion (6.25%) of the positive-sequence current magnitude is subtracted from the zero-sequence current magnitude when forming the operating quantity of the element as follows:

$$I_{op} = 3 \times (|I\_0| - K \cdot |I\_1|) \quad \text{where } K = 1/16 \qquad \text{(EQ 5.16)}$$

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

- system unbalances under heavy load conditions
- transformation errors of current transformers (CTs) during double-line and three-phase faults
- switch-off transients during double-line and three-phase faults

The positive-sequence restraint must be considered when testing for pickup accuracy and response time (multiple of pickup). The operating quantity depends on how test currents are injected into the relay (single-phase injection: $I_{op} = 0.9375 \cdot I_{injected}$; three-phase pure zero-sequence injection: $I_{op} = 3 \times I_{injected}$).

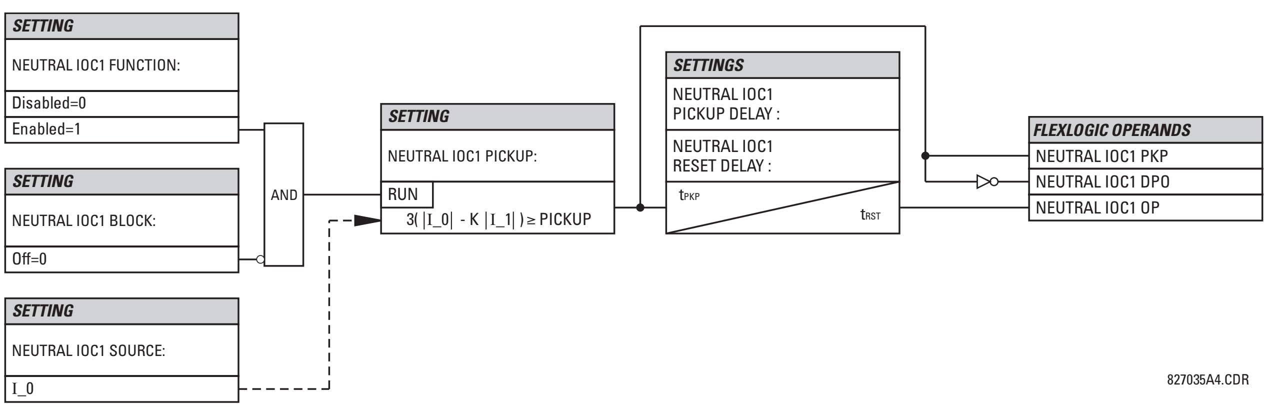

Figure 5–47: NEUTRAL IOC1 SCHEME LOGIC

d) NEUTRAL DIRECTIONAL OVERCURRENT (ANSI 67N)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨ NEUTRAL CURRENT ⇨⇩ NEUTRAL DIRECTIONAL OC1(2)

■ NEUTRAL ■ DIRECTIONAL OC1	◀▶	NEUTRAL DIR OC1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	▲▼	NEUTRAL DIR OC1 SOURCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE	▲▼	NEUTRAL DIR OC1 POLARIZING: Voltage	Range: Voltage, Current, Dual
MESSAGE	▲▼	NEUTRAL DIR OC1 POL VOLT: Calculated V0	Range: Calculated V0, Measured VX
MESSAGE	▲▼	NEUTRAL DIR OC1 OP CURR: Calculated 3I0	Range: Calculated 3I0, Measured IG
MESSAGE	▲▼	NEUTRAL DIR OC1 POS- SEQ RESTRAINT: 0.063	Range: 0.000 to 0.500 in steps of 0.001
MESSAGE	▲▼	NEUTRAL DIR OC1 OFFSET: 0.00 Ω	Range: 0.00 to 250.00 Ω in steps of 0.01
MESSAGE	▲▼	NEUTRAL DIR OC1 FWD ECA: 75° Lag	Range: –90 to 90° in steps of 1
MESSAGE	▲▼	NEUTRAL DIR OC1 FWD LIMIT ANGLE: 90°	Range: 40 to 90° in steps of 1
MESSAGE	▲▼	NEUTRAL DIR OC1 FWD PICKUP: 0.050 pu	Range: 0.002 to 30.000 pu in steps of 0.001
MESSAGE	▲▼	NEUTRAL DIR OC1 REV LIMIT ANGLE: 90°	Range: 40 to 90° in steps of 1
MESSAGE	▲▼	NEUTRAL DIR OC1 REV PICKUP: 0.050 pu	Range: 0.002 to 30.000 pu in steps of 0.001
MESSAGE	▲▼	NEUTRAL DIR OC1 BLK: Off	Range: FlexLogic™ operand
MESSAGE	▲▼	NEUTRAL DIR OC1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	▲	NEUTRAL DIR OC1 EVENTS: Disabled	Range: Disabled, Enabled

There are two Neutral Directional Overcurrent protection elements available. The element provides both forward and reverse fault direction indications the NEUTRAL DIR OC1 FWD and NEUTRAL DIR OC1 REV operands, respectively. The output operand is asserted if the magnitude of the operating current is above a pickup level (overcurrent unit) and the fault direction is seen as "forward or "reverse", respectively (directional unit).

The **overcurrent unit** responds to the magnitude of a fundamental frequency phasor of the either the neutral current calculated from the phase currents or the ground current. There are two separate pickup settings for the forward- and reverse-looking functions, respectively. If set to use the calculated 3I_0, the element applies a "positive-sequence restraint" for better performance: a small user-programmable portion of the positive–sequence current magnitude is subtracted from the zero-sequence current magnitude when forming the operating quantity.

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

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

- System unbalances under heavy load conditions.

- Transformation errors of current transformers (CTs) during double-line and three-phase faults.
- Switch-off transients during double-line and three-phase faults.

The positive-sequence restraint must be considered when testing for pickup accuracy and response time (multiple of pickup). The operating quantity depends on the way the test currents are injected into the relay (single-phase injection: $I_{op} = (1 - K) \times I_{injected}$; three-phase pure zero-sequence injection: $I_{op} = 3 \times I_{injected}$).

The positive-sequence restraint is removed for low currents. If the positive-sequence current is below 0.8 pu, the restraint is removed by changing the constant *K* to zero. This facilitates better response to high-resistance faults when the unbalance is very small and there is no danger of excessive CT errors as the current is low.

The **directional unit** uses the zero-sequence current (I_0) or ground current (IG) for fault direction discrimination and may be programmed to use either zero-sequence voltage (“Calculated V0” or “Measured VX”), ground current (IG), or both for polarizing. The following tables define the neutral directional overcurrent element.

Table 5–18: QUANTITIES FOR "CALCULATED 3I0" CONFIGURATION

DIRECTIONAL UNIT				OVERCURRENT UNIT
POLARIZING MODE	**DIRECTION**	**COMPARED PHASORS**		
Voltage	Forward	–V_0 + Z_offset × I_0	I_0 × 1∠ECA	$I_{op} = 3 \times (\lvert I\_0\rvert - K \times \lvert I\_1\rvert)$ if $\lvert I_1\rvert > 0.8$ pu $I_{op} = 3 \times (\lvert I\_0\rvert)$ if $\lvert I_1\rvert \le 0.8$ pu
	Reverse	–V_0 + Z_offset × I_0	–I_0 × 1∠ECA	
Current	Forward	IG	I_0	
	Reverse	IG	–I_0	
Dual	Forward	–V_0 + Z_offset × I_0	I_0 × 1∠ECA	
		or		
		IG	I_0	
	Reverse	–V_0 + Z_offset × I_0	–I_0 × 1∠ECA	
		or		
		IG	–I_0	

Table 5–19: QUANTITIES FOR "MEASURED IG" CONFIGURATION

DIRECTIONAL UNIT				OVERCURRENT UNIT
POLARIZING MODE	**DIRECTION**	**COMPARED PHASORS**		
Voltage	Forward	–V_0 + Z_offset × IG/3	IG × 1∠ECA	$I_{op} = \lvert IG\rvert$
	Reverse	–V_0 + Z_offset × IG/3	–IG × 1∠ECA	

where: $V\_0 = \frac{1}{3}(VAG + VBG + VCG) =$ zero sequence voltage ,

$I\_0 = \frac{1}{3}IN = \frac{1}{3}(IA + IB + IC) =$ zero sequence current ,

ECA = element characteristic angle and IG = ground current

When **NEUTRAL DIR OC1 POL VOLT** is set to “Measured VX”, one-third of this voltage is used in place of V_0. The following figure explains the usage of the voltage polarized directional unit of the element.

The figure below shows the voltage-polarized phase angle comparator characteristics for a phase A to ground fault, with:

ECA = 90° (element characteristic angle = centerline of operating characteristic)
FWD LA = 80° (forward limit angle = the ± angular limit with the ECA for operation)
REV LA = 80° (reverse limit angle = the ± angular limit with the ECA for operation)

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

The forward-looking function is designed to be more secure as compared to the reverse-looking function, and therefore, should be used for the tripping direction. The reverse-looking function is designed to be faster as compared to the forward-looking function and should be used for the blocking direction. This allows for better protection coordination.

The above bias should be taken into account when using the neutral directional overcurrent element to directionalize other protection elements.

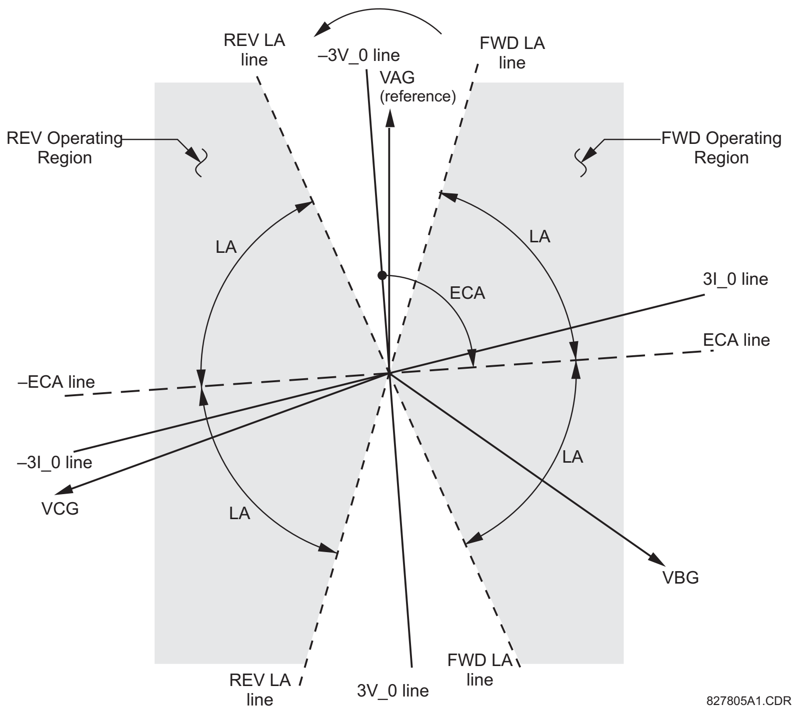

Figure 5–48: NEUTRAL DIRECTIONAL VOLTAGE-POLARIZED CHARACTERISTICS

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

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

    The zero-sequence (V_0) or auxiliary voltage (Vx), accordingly, must be higher than 0.02 pu nominal voltage to be validated as a polarizing signal. If the polarizing signal is invalid, neither forward nor reverse indication is given.
  - If “Current” polarizing is selected, the element uses the ground current angle connected externally and configured under **NEUTRAL OC1 SOURCE** for polarization. The Ground CT must be connected between the ground and neutral point of an adequate local source of ground current. The ground current must be higher than 0.05 pu to be validated as a polarizing signal. If the polarizing signal is not valid, neither forward nor reverse indication is given.

    For a choice of current polarizing, it is recommended that the polarizing signal be analyzed to ensure that a known direction is maintained irrespective of the fault location. For example, if using an autotransformer neutral current as a polarizing source, it should be ensured that a reversal of the ground current does not occur for a high-side fault. The low-side system impedance should be assumed minimal when checking for this condition. A similar situation arises for a Wye/Delta/Wye transformer, where current in one transformer winding neutral may reverse when faults on both sides of the transformer are considered.
  - If "Dual" polarizing is selected, the element performs both directional comparisons as described above. A given direction is confirmed if either voltage or current comparators indicate so. If a conflicting (simultaneous forward and reverse) indication occurs, the forward direction overrides the reverse direction.
- **NEUTRAL DIR OC1 POL VOLT:** Selects the polarizing voltage used by the directional unit when "Voltage" or "Dual" polarizing mode is set. The polarizing voltage can be programmed to be either the zero-sequence voltage calculated from the phase voltages ("Calculated V0") or supplied externally as an auxiliary voltage ("Measured VX").

- **NEUTRAL DIR OC1 OP CURR:** This setting indicates whether the 3I_0 current calculated from the phase currents, or the ground current shall be used by this protection. This setting acts as a switch between the neutral and ground modes of operation (67N and 67G). If set to “Calculated 3I0” the element uses the phase currents and applies the positive-sequence restraint; if set to “Measured IG” the element uses ground current supplied to the ground CT of the CT bank configured as **NEUTRAL DIR OC1 SOURCE**. If this setting is “Measured IG”, then the **NEUTRAL DIR OC1 POLARIZING** setting must be “Voltage”, as it is not possible to use the ground current as an operating and polarizing signal simultaneously.
- **NEUTRAL DIR OC1 POS-SEQ RESTRAINT**: This setting controls the amount of the positive-sequence restraint. Set to 0.063 for backward compatibility with firmware revision 3.40 and older. Set to zero to remove the restraint. Set higher if large system unbalances or poor CT performance are expected.
- **NEUTRAL DIR OC1 OFFSET:** This setting specifies the offset impedance used by this protection. The primary application for the offset impedance is to guarantee correct identification of fault direction on series compensated lines. In regular applications, the offset impedance ensures proper operation even if the zero-sequence voltage at the relaying point is very small. If this is the intent, the offset impedance shall not be larger than the zero-sequence impedance of the protected circuit. Practically, it shall be several times smaller. The offset impedance shall be entered in secondary ohms.
- **NEUTRAL DIR OC1 FWD ECA:** This setting defines the characteristic angle (ECA) for the forward direction in the "Voltage" polarizing mode. The "Current" polarizing mode uses a fixed ECA of 0°. The ECA in the reverse direction is the angle set for the forward direction shifted by 180°.
- **NEUTRAL DIR OC1 FWD LIMIT ANGLE:** This setting defines a symmetrical (in both directions from the ECA) limit angle for the forward direction.
- **NEUTRAL DIR OC1 FWD PICKUP:** This setting defines the pickup level for the overcurrent unit of the element in the forward direction. When selecting this setting it must be kept in mind that the design uses a ‘positive-sequence restraint’ technique for the “Calculated 3I0” mode of operation.
- **NEUTRAL DIR OC1 REV LIMIT ANGLE:** This setting defines a symmetrical (in both directions from the ECA) limit angle for the reverse direction.
- **NEUTRAL DIR OC1 REV PICKUP:** This setting defines the pickup level for the overcurrent unit of the element in the reverse direction. When selecting this setting it must be kept in mind that the design uses a ‘positive-sequence restraint’ technique for the “Calculated 3I0” mode of operation.

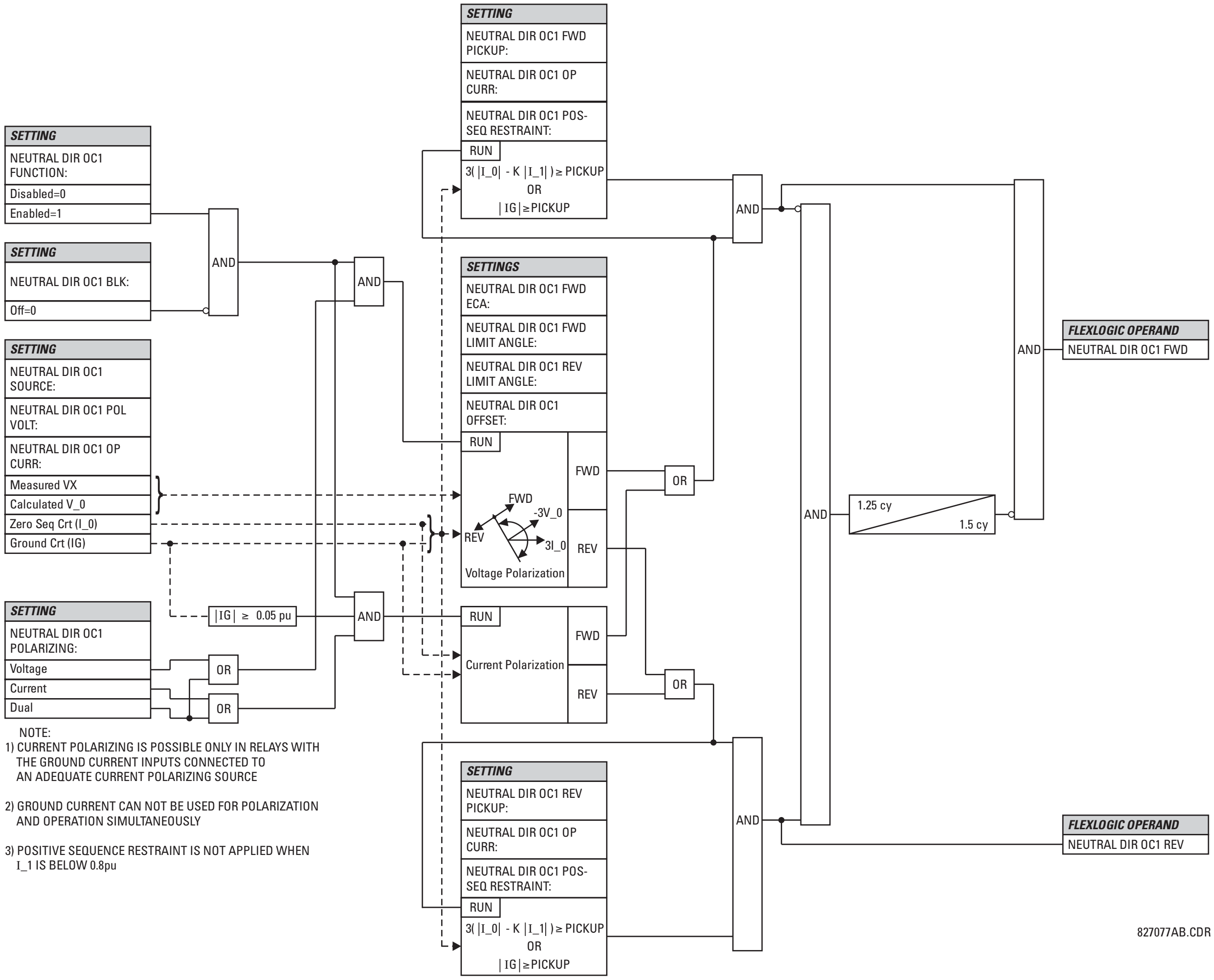

Figure 5–49: NEUTRAL DIRECTIONAL OVERCURRENT LOGIC

5

5.5.6 GROUND CURRENT

a) GROUND TIME OVERCURRENT (ANSI 51G)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ GROUND CURRENT ⇨ GROUND TOC1(2)

■ GROUND TOC1 ■	GROUND TOC1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	GROUND TOC1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE	GROUND TOC1 INPUT: Phasor	Range: Phasor, RMS
MESSAGE	GROUND TOC1 PICKUP: 1.000 pu	Range: 0.000 to 30.000 pu in steps of 0.001
MESSAGE	GROUND TOC1 CURVE: IEEE Mod Inv	Range: see the Overcurrent Curve Types table
MESSAGE	GROUND TOC1 TD MULTIPLIER: 1.00	Range: 0.00 to 600.00 in steps of 0.01
MESSAGE	GROUND TOC1 RESET: Instantaneous	Range: Instantaneous, Timed
MESSAGE	GROUND TOC1 BLOCK: Off	Range: FlexLogic™ operand
MESSAGE	GROUND TOC1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	GROUND TOC1 EVENTS: Disabled	Range: Disabled, Enabled

This element can provide a desired time-delay operating characteristic versus the applied current or be used as a simple Definite Time element. The ground current input value is the quantity measured by the ground input CT and is the fundamental phasor or RMS magnitude. Two methods of resetting operation are available; “Timed” and “Instantaneous” (refer to the *Inverse Time Overcurrent Curve Characteristics* section for details). When the element is blocked, the time accumulator will reset according to the reset characteristic. For example, if the element reset characteristic is set to “Instantaneous” and the element is blocked, the time accumulator will be cleared immediately.

NOTE: These elements measure the current that is connected to the ground channel of a CT/VT module. 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.

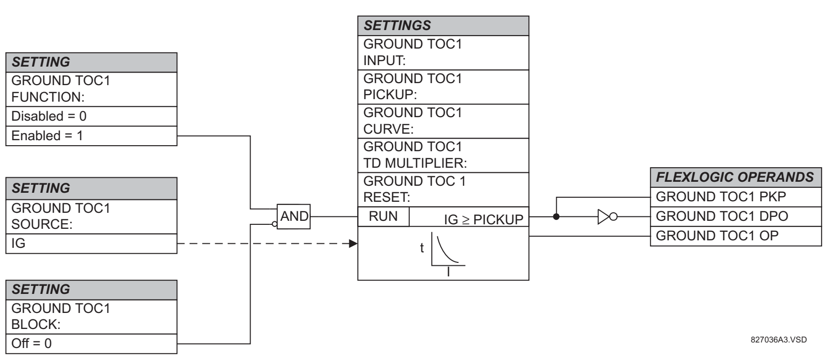

Figure 5–50: GROUND TOC1 SCHEME LOGIC

b) GROUND INSTANTANEOUS OVERCURRENT (ANSI 50G)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ GROUND CURRENT ⇨⇩ GROUND IOC1(2)

■ GROUND IOC1	GROUND IOC1 FUNCTION: Disabled	Range: *Disabled, Enabled*
MESSAGE	GROUND IOC1 SIGNAL SOURCE: SRC 1	Range: *SRC 1, SRC 2*
MESSAGE	GROUND IOC1 PICKUP: 1.000 pu	Range: *0.000 to 30.000 pu in steps of 0.001*
MESSAGE	GROUND IOC1 PICKUP DELAY: 0.00 s	Range: *0.00 to 600.00 s in steps of 0.01*
MESSAGE	GROUND IOC1 RESET DELAY: 0.00 s	Range: *0.00 to 600.00 s in steps of 0.01*
MESSAGE	GROUND IOC1 BLOCK: Off	Range: *FlexLogic™ operand*
MESSAGE	GROUND IOC1 TARGET: Self-reset	Range: *Self-reset, Latched, Disabled*
MESSAGE	GROUND IOC1 EVENTS: Disabled	Range: *Disabled, Enabled*

The Ground Instantaneous Overcurrent element may be used as an instantaneous element with no intentional delay or as a Definite Time element. The ground current input is the quantity measured by the ground input CT and is the fundamental phasor magnitude.

5

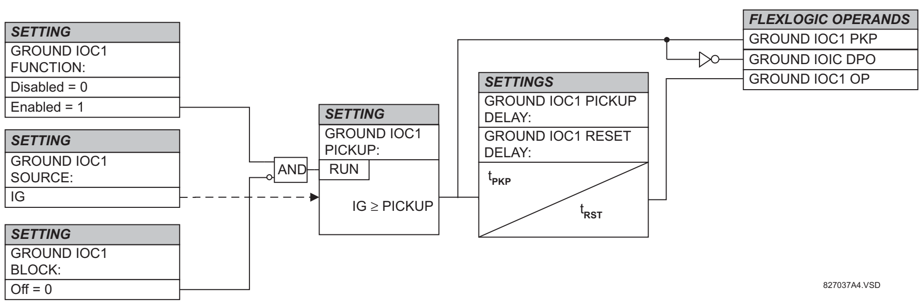

Figure 5–51: GROUND IOC1 SCHEME LOGIC

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.

5.5.7 NEGATIVE SEQUENCE CURRENT

a) MAIN MENU

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

■ NEGATIVE SEQUENCE ■ CURRENT		■ NEG SEQ TOC1 ■	See page 5–103.
	MESSAGE	■ NEG SEQ TOC2 ■	See page 5–103.
	MESSAGE	■ NEG SEQ IOC1 ■	See page 5–104.
	MESSAGE	■ NEG SEQ IOC2 ■	See page 5–104.
	MESSAGE	■ NEG SEQ DIR OC2 ■	See page 5–105.
	MESSAGE	■ NEG SEQ DIR OC2 ■	See page 5–105.

The F60 Feeder Management Relay has two (2) Negative Sequence Time Overcurrent, two (2) Negative Sequence Instantaneous Overcurrent, and two (2) Negative Sequence Directional Overcurrent elements.

b) NEGATIVE SEQUENCE TIME OVERCURRENT (ANSI 51_2)

PATH: SETTINGS ⇩ GROUPED ELEMENTS ⇨⇩ SETTING GROUP 1(6) ⇨⇩ NEGATIVE SEQUENCE CURRENT ⇨ NEG SEQ TOC1(2)

■ NEG SEQ TOC1 ■	NEG SEQ TOC1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	NEG SEQ TOC1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE	NEG SEQ TOC1 PICKUP: 1.000 pu	Range: 0.000 to 30.000 pu in steps of 0.001
MESSAGE	NEG SEQ TOC1 CURVE: IEEE Mod Inv	Range: see OVERCURRENT CURVE TYPES table
MESSAGE	NEG SEQ TOC1 TD MULTIPLIER: 1.00	Range: 0.00 to 600.00 in steps of 0.01
MESSAGE	NEG SEQ TOC1 RESET: Instantaneous	Range: Instantaneous, Timed
MESSAGE	NEG SEQ TOC1 BLOCK: Off	Range: FlexLogic™ operand
MESSAGE	NEG SEQ TOC1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	NEG SEQ TOC1 EVENTS: Disabled	Range: Disabled, Enabled

The negative sequence time overcurrent element may be used to determine and clear unbalance in the system. The input for calculating negative sequence current is the fundamental phasor value.

Two methods of resetting operation are available; “Timed” and “Instantaneous” (refer to the *Inverse Time Overcurrent Characteristics* sub-section for details on curve setup, trip times and reset operation). When the element is blocked, the time accumulator 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.

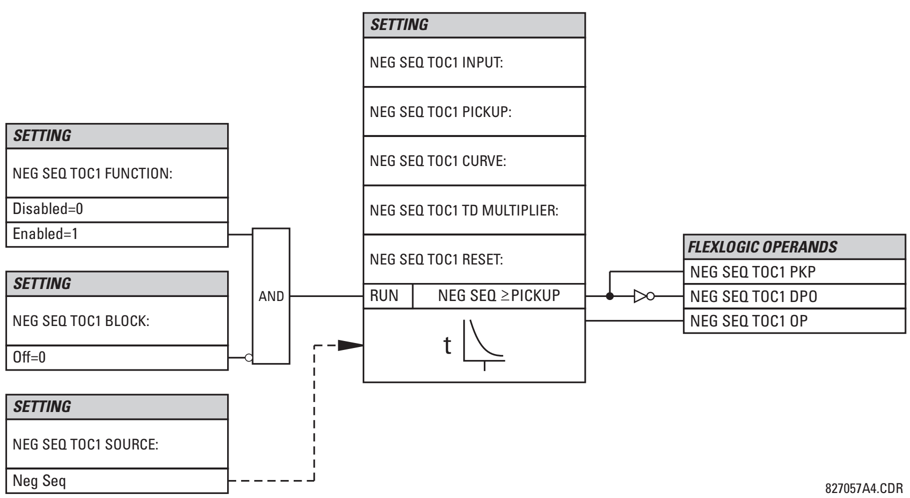

Figure 5–52: NEGATIVE SEQUENCE TOC1 SCHEME LOGIC

c) NEGATIVE SEQUENCE INSTANTANEOUS OVERCURRENT (ANSI 50_2)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ NEGATIVE SEQUENCE CURRENT ⇨⇩ NEG SEQ OC1(2)

■ NEG SEQ IOC1 ■		NEG SEQ IOC1 FUNCTION: Disabled	Range: Disabled, Enabled
	MESSAGE	NEG SEQ IOC1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
	MESSAGE	NEG SEQ IOC1 PICKUP: 1.000 pu	Range: 0.000 to 30.000 pu in steps of 0.001
	MESSAGE	NEG SEQ IOC1 PICKUP DELAY: 0.00 s	Range: 0.00 to 600.00 s in steps of 0.01
	MESSAGE	NEG SEQ IOC1 RESET DELAY: 0.00 s	Range: 0.00 to 600.00 s in steps of 0.01
	MESSAGE	NEG SEQ IOC1 BLOCK: Off	Range: FlexLogic™ operand
	MESSAGE	NEG SEQ IOC1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
	MESSAGE	NEG SEQ IOC1 EVENTS: Disabled	Range: Disabled, Enabled

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The Negative Sequence Instantaneous Overcurrent element may be used as an instantaneous function with no intentional delay or as a Definite Time function. The element responds to the negative-sequence current fundamental frequency phasor magnitude (calculated from the phase currents) and applies a “positive-sequence” restraint for better performance: a small portion (12.5%) of the positive-sequence current magnitude is subtracted from the negative-sequence current magnitude when forming the operating quantity:

$$I_{op} = |I\_2| - K \cdot |I\_1| \quad \text{where } K = 1/8 \qquad \textbf{(EQ 5.18)}$$

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

- system unbalances under heavy load conditions
- transformation errors of current transformers (CTs) during three-phase faults
- fault inception and switch-off transients during three-phase faults

The positive-sequence restraint must be considered when testing for pickup accuracy and response time (multiple of pickup). The operating quantity depends on the way the test currents are injected into the relay (single phase injection: $I_{op} = 0.2917 \cdot I_{injected}$; three phase injection, opposite rotation: $I_{op} = I_{injected}$).

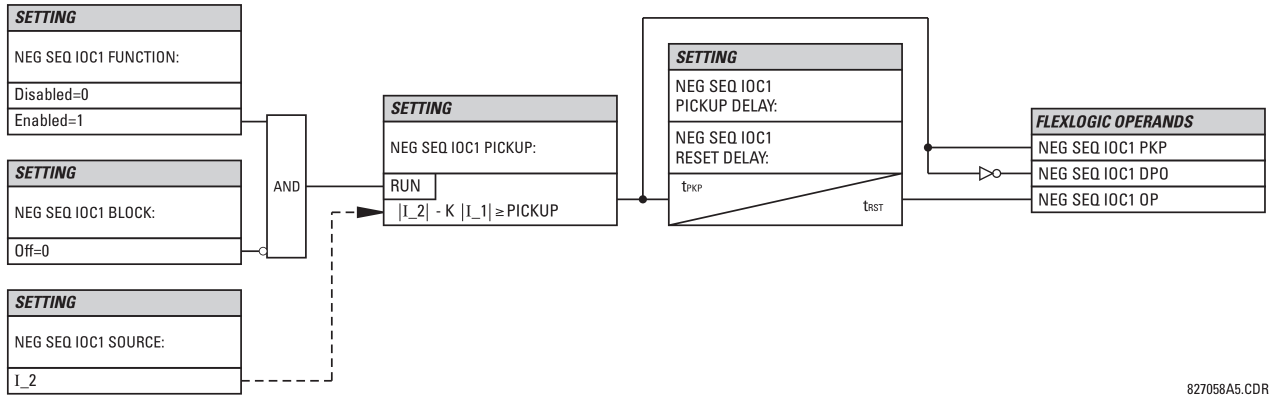

Figure 5–53: NEGATIVE SEQUENCE IOC1 SCHEME LOGIC

d) NEGATIVE SEQUENCE DIRECTIONAL OVERCURRENT (ANSI 67_2)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ NEGATIVE SEQUENCE CURRENT ⇨⇩ NEG SEQ DIR OC1(2)

■ NEG SEQ DIR OC1 ■	NEG SEQ DIR OC1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	NEG SEQ DIR OC1 SOURCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE	NEG SEQ DIR OC1 OFFSET: 0.00 Ω	Range: 0.00 to 250.00 Ω in steps of 0.01
MESSAGE	NEG SEQ DIR OC1 TYPE: Neg Sequence	Range: Neg Sequence, Zero Sequence
MESSAGE	NEG SEQ DIR OC1 POS- SEQ RESTRAINT: 0.063	Range: 0.000 to 0.500 in steps of 0.001
MESSAGE	NEG SEQ DIR OC1 FWD ECA: 75° Lag	Range: 0 to 90° Lag in steps of 1
MESSAGE	NEG SEQ DIR OC1 FWD LIMIT ANGLE: 90°	Range: 40 to 90° in steps of 1
MESSAGE	NEG SEQ DIR OC1 FWD PICKUP: 0.05 pu	Range: 0.05 to 30.00 pu in steps of 0.01
MESSAGE	NEG SEQ DIR OC1 REV LIMIT ANGLE: 90°	Range: 40 to 90° in steps of 1
MESSAGE	NEG SEQ DIR OC1 REV PICKUP: 0.05 pu	Range: 0.05 to 30.00 pu in steps of 0.01
MESSAGE	NEG SEQ DIR OC1 BLK: Off	Range: FlexLogic™ operand
MESSAGE	NEG SEQ DIR OC1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	NEG SEQ DIR OC1 EVENTS: Disabled	Range: Disabled, Enabled

There are two Negative Sequence Directional Overcurrent protection elements available. The element provides both forward and reverse fault direction indications through its output operands NEG SEQ DIR OC1 FWD and NEG SEQ DIR OC1 REV, respectively. The output operand is asserted if the magnitude of the operating current is above a pickup level (overcurrent unit) and the fault direction is seen as 'forward' or 'reverse', respectively (directional unit).

The **overcurrent unit** of the element essentially responds to the magnitude of a fundamental frequency phasor of either the negative-sequence or zero-sequence current as per user selection. The zero-sequence current should not be mistaken with the neutral current (factor 3 difference).

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

$$I_{op} = |I\_2| - K \times |I\_1| \quad \text{or} \quad I_{op} = |I\_0| - K \times |I\_1| \qquad \textbf{(EQ 5.19)}$$

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

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

The positive-sequence restraint must be considered when testing for pick-up accuracy and response time (multiple of pickup). The operating quantity depends on the way the test currents are injected into the relay:

- single-phase injection: $I_{op} = 1/3 \times (1 - K) \times I_{injected}$
- three-phase pure zero- or negative-sequence injection, respectively: $I_{op} = I_{injected}$.
- the directional unit uses the negative-sequence current and voltage for fault direction discrimination

The following table defines the Negative Sequence Directional Overcurrent element.

OVERCURRENT UNIT		DIRECTIONAL UNIT		
MODE	**OPERATING CURRENT**	**DIRECTION**	**COMPARED PHASORS**	
Negative-Sequence	I_{op} = |I_2| – K × |I_1|	Forward	–V_2 + Z_offset × I_2	I_2 × 1∠ECA
		Reverse	–V_2 + Z_offset × I_2	–(I_2 × 1∠ECA)
Zero-Sequence	I_{op} = |I_0| – K × |I_1|	Forward	–V_2 + Z_offset × I_2	I_2 × 1∠ECA
		Reverse	–V_2 + Z_offset × I_2	–(I_2 × 1∠ECA)

The negative-sequence voltage must be higher than the **PRODUCT SETUP ⇨⇩ DISPLAY PROPERTIES ⇨⇩ VOLTAGE CUT-OFF LEVEL** value to be validated for use as a polarizing signal. If the polarizing signal is not validated neither forward nor reverse indication is given. The following figure explains the usage of the voltage polarized directional unit of the element.

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

ECA = 75° (Element Characteristic Angle = centerline of operating characteristic)
FWD LA = 80° (Forward Limit Angle = ± the angular limit with the ECA for operation)
REV LA = 80° (Reverse Limit Angle = ± the angular limit with the ECA for operation)

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

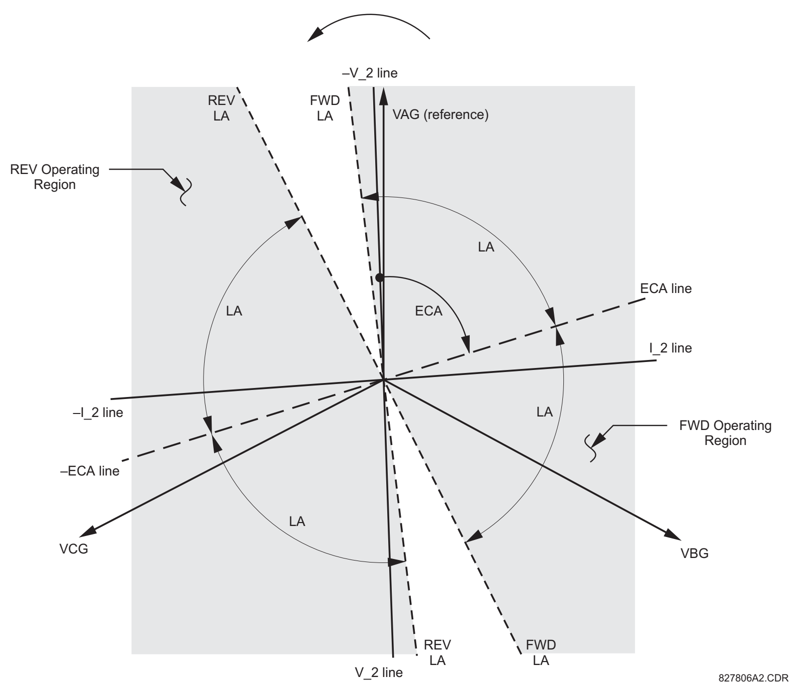

Figure 5–54: NEG SEQ DIRECTIONAL CHARACTERISTICS

The forward-looking function is designed to be more secure as compared to the reverse-looking function, and therefore, should be used for the tripping direction. The reverse-looking function is designed to be faster as compared to the forward-looking function and should be used for the blocking direction. This allows for better protection coordination. The above bias should be taken into account when using the Negative Sequence Directional Overcurrent element to 'directionalize' other protection elements.

- **NEG SEQ DIR OC1 OFFSET:** This setting specifies the offset impedance used by this protection. The primary application for the offset impedance is to guarantee correct identification of fault direction on series compensated lines (see the Application of Settings chapter for information on how to calculate this setting). In regular applications, the offset impedance ensures proper operation even if the negative-sequence voltage at the relaying point is very small. If this is the intent, the offset impedance shall not be larger than the negative-sequence impedance of the protected circuit. Practically, it shall be several times smaller. The offset impedance shall be entered in secondary ohms. See the Theory of Operation chapter for additional details.
- **NEG SEQ DIR OC1 TYPE:** This setting selects the operating mode for the overcurrent unit of the element. The choices are "Neg Sequence" and "Zero Sequence". In some applications it is advantageous to use a directional negative-sequence overcurrent function instead of a directional zero-sequence overcurrent function as inter-circuit mutual effects are minimized.
- **NEG SEQ DIR OC1 POS-SEQ RESTRAINT**: This setting controls the amount of the positive-sequence restraint. Set to 0.063 (in "Zero Sequence" mode) or 0.125 (in "Neg Sequence" mode) for backward compatibility with firmware revision 3.40 and older. Set to zero to remove the restraint. Set higher if large system unbalances or poor CT performance are expected.
- **NEG SEQ DIR OC1 FWD ECA:** This setting select the element characteristic angle (ECA) for the forward direction. The element characteristic angle in the reverse direction is the angle set for the forward direction shifted by 180°.
- **NEG SEQ DIR OC1 FWD LIMIT ANGLE:** This setting defines a symmetrical (in both directions from the ECA) limit angle for the forward direction.
- **NEG SEQ DIR OC1 FWD PICKUP:** This setting defines the pickup level for the overcurrent unit in the forward direction. Upon **NEG SEQ DIR OC1 TYPE** selection, this pickup threshold applies to zero- or negative-sequence current. When selecting this setting it must be kept in mind that the design uses a 'positive-sequence restraint' technique.
- **NEG SEQ DIR OC1 REV LIMIT ANGLE:** This setting defines a symmetrical (in both directions from the ECA) limit angle for the reverse direction.
- **NEG SEQ DIR OC1 REV PICKUP:** This setting defines the pickup level for the overcurrent unit in the reverse direction. Upon **NEG SEQ DIR OC1 TYPE** selection, this pickup threshold applies to zero- or negative-sequence current. When selecting this setting it must be kept in mind that the design uses a 'positive-sequence restraint' technique.

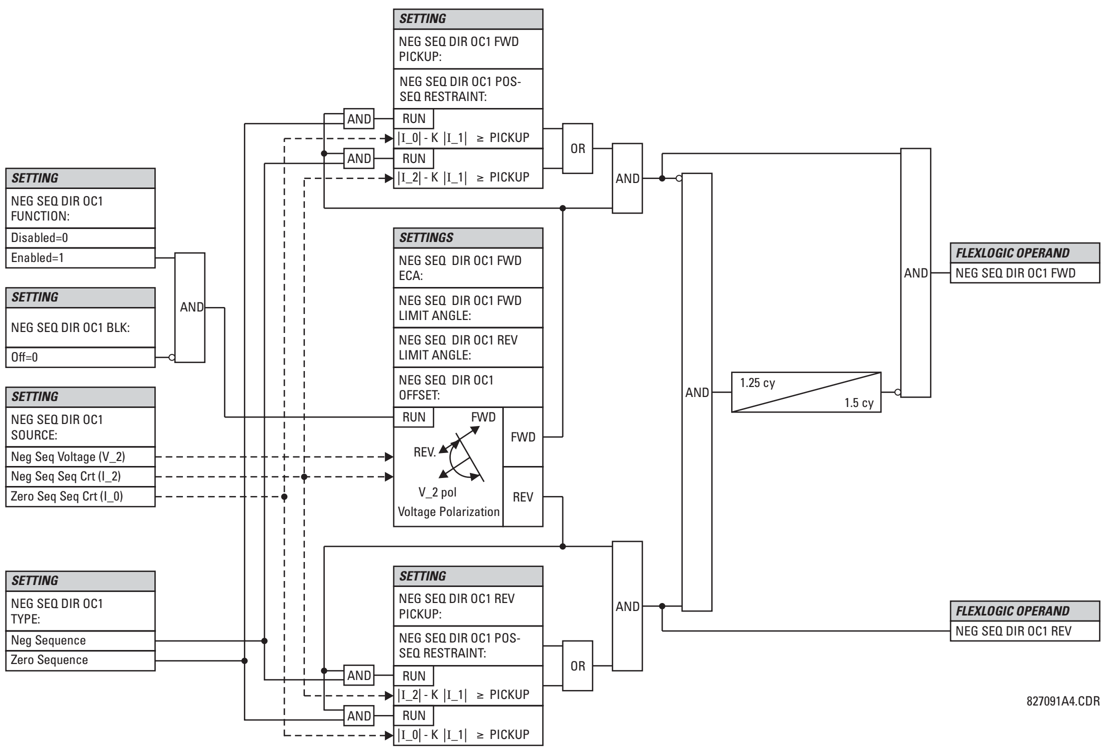

Figure 5–55: NEGATIVE SEQUENCE DIRECTIONAL OC1 SCHEME LOGIC

5.5.8 BREAKER FAILURE

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
MESSAGE	BF1 USE AMP SUPV: Yes	Range: Yes, No
MESSAGE	BF1 USE SEAL-IN: Yes	Range: Yes, No
MESSAGE	BF1 3-POLE INITIATE: Off	Range: FlexLogic™ operand
MESSAGE	BF1 BLOCK: Off	Range: FlexLogic™ operand
MESSAGE	BF1 PH AMP SUPV PICKUP: 1.050 pu	Range: 0.001 to 30.000 pu in steps of 0.001
MESSAGE	BF1 N AMP SUPV PICKUP: 1.050 pu	Range: 0.001 to 30.000 pu in steps of 0.001
MESSAGE	BF1 USE TIMER 1: Yes	Range: Yes, No
MESSAGE	BF1 TIMER 1 PICKUP DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
MESSAGE	BF1 USE TIMER 2: Yes	Range: Yes, No
MESSAGE	BF1 TIMER 2 PICKUP DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
MESSAGE	BF1 USE TIMER 3: Yes	Range: Yes, No
MESSAGE	BF1 TIMER 3 PICKUP DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
MESSAGE	BF1 BKR POS1 ϕA/3P: Off	Range: FlexLogic™ operand
MESSAGE	BF1 BKR POS2 ϕA/3P: Off	Range: FlexLogic™ operand
MESSAGE	BF1 BREAKER TEST ON: Off	Range: FlexLogic™ operand
MESSAGE	BF1 PH AMP HISET PICKUP: 1.050 pu	Range: 0.001 to 30.000 pu in steps of 0.001
MESSAGE	BF1 N AMP HISET PICKUP: 1.050 pu	Range: 0.001 to 30.000 pu in steps of 0.001
MESSAGE	BF1 PH AMP LOSET PICKUP: 1.050 pu	Range: 0.001 to 30.000 pu in steps of 0.001

MESSAGE	BF1 N AMP LOSET PICKUP: 1.050 pu	Range: 0.001 to 30.000 pu in steps of 0.001
MESSAGE	BF1 LOSET TIME DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
MESSAGE	BF1 TRIP DROPOUT DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
MESSAGE	BF1 TARGET Self-Reset	Range: Self-reset, Latched, Disabled
MESSAGE	BF1 EVENTS Disabled	Range: Disabled, Enabled
MESSAGE	BF1 PH A INITIATE: Off	Range: FlexLogic™ operand Valid only for 1-Pole breaker failure schemes.
MESSAGE	BF1 PH B INITIATE: Off	Range: FlexLogic™ operand Valid only for 1-Pole breaker failure schemes.
MESSAGE	BF1 PH C INITIATE: Off	Range: FlexLogic™ operand Valid only for 1-Pole breaker failure schemes.
MESSAGE	BF1 BKR POS1 φB Off	Range: FlexLogic™ operand Valid only for 1-Pole breaker failure schemes.
MESSAGE	BF1 BKR POS1 φC Off	Range: FlexLogic™ operand Valid only for 1-Pole breaker failure schemes.
MESSAGE	BF1 BKR POS2 φB Off	Range: FlexLogic™ operand Valid only for 1-Pole breaker failure schemes.
MESSAGE	BF1 BKR POS2 φC Off	Range: FlexLogic™ operand Valid only for 1-Pole breaker failure schemes.

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.

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Timer 3 logic (Slow Path) is supervised by a breaker auxiliary contact and a control switch contact used to indicate that the breaker is in/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:

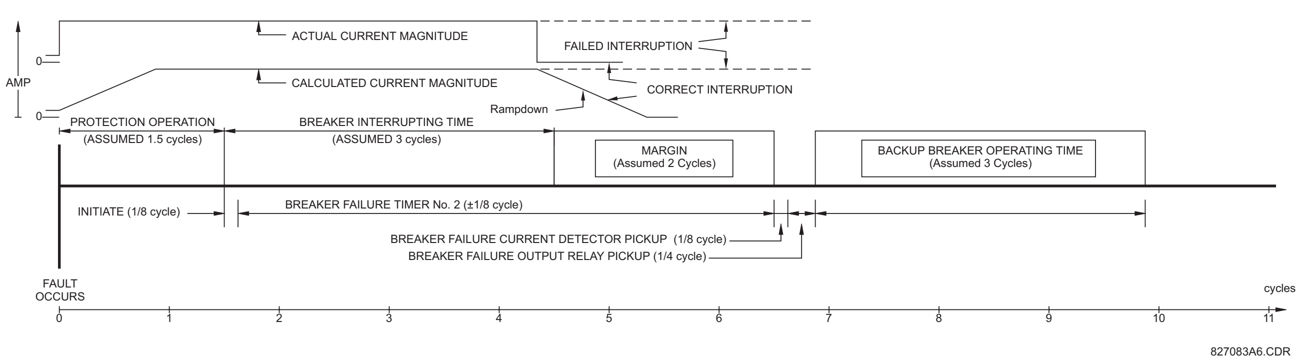

Figure 5–56: BREAKER FAILURE MAIN PATH SEQUENCE

The current supervision elements reset in less than 0.7 of a power cycle up to the multiple of pickup of 100 (threshold set at 0.01 of the actual fault current) as shown below.

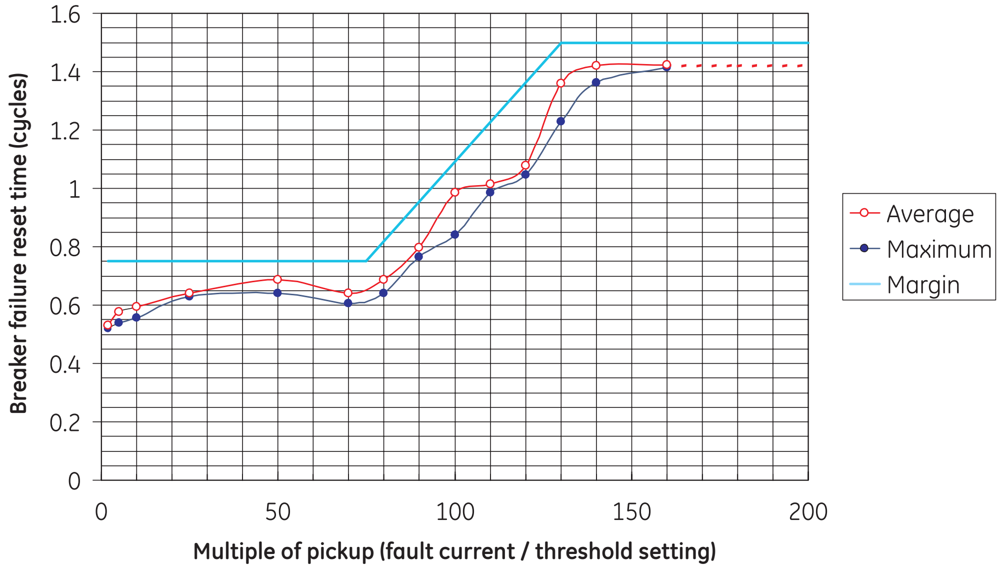

Figure 5–57: BREAKER FAILURE OVERCURRENT SUPERVISION RESET TIME

SETTINGS:

- **BF1 MODE:** This setting is used to select the breaker failure operating mode: single or three pole.
- **BF1 USE AMP SUPV:** If set to "Yes", the element will only be initiated if current flowing through the breaker is above the supervision pickup level.
- **BF1 USE SEAL-IN:** If set to "Yes", the element will only be sealed-in if current flowing through the breaker is above the supervision pickup level.
- **BF1 3-POLE INITIATE:** This setting selects the FlexLogic™ operand that will initiate 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 F60 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 ϕB / BF1 BKR POS 1 ϕC:** These settings select the FlexLogic™ operand to represents the protected breaker early-type auxiliary switch contact on poles B or C, accordingly. This contact is normally a non-multiplied Form-A contact. The contact may even be adjusted to have the shortest possible operating time. *This setting is valid only for 1-pole breaker failure schemes*.
- **BF1 BKR POS2 ϕB:** Selects the FlexLogic™ operand that represents the protected breaker normal-type auxiliary switch contact on pole B (52/a). This may be a multiplied contact. *This setting is valid only for 1-pole breaker failure schemes*.
- **BF1 BKR POS2 ϕC:** This setting selects the FlexLogic™ operand that represents the protected breaker normal-type auxiliary switch contact on pole C (52/a). This may be a multiplied contact. For single-pole operation, the scheme has the same overall general concept except that it provides re-tripping of each single pole of the protected breaker. The approach shown in the following single pole tripping diagram uses the initiating information to determine which pole is supposed to trip. The logic is segregated on a per-pole basis. The overcurrent detectors have ganged settings. *This setting is valid only for 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.

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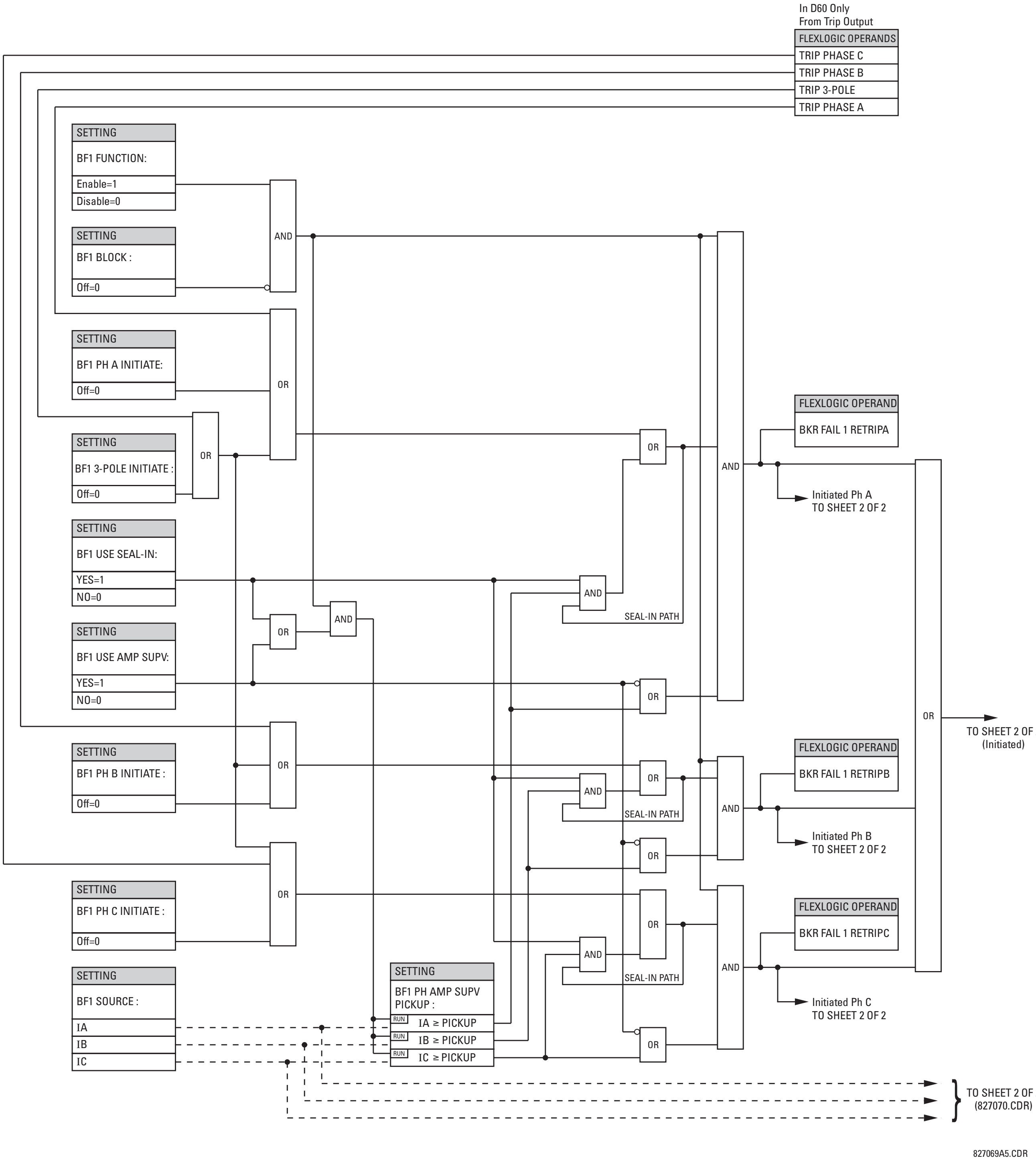

Figure 5–58: BREAKER FAILURE 1-POLE [INITIATE] (Sheet 1 of 2)

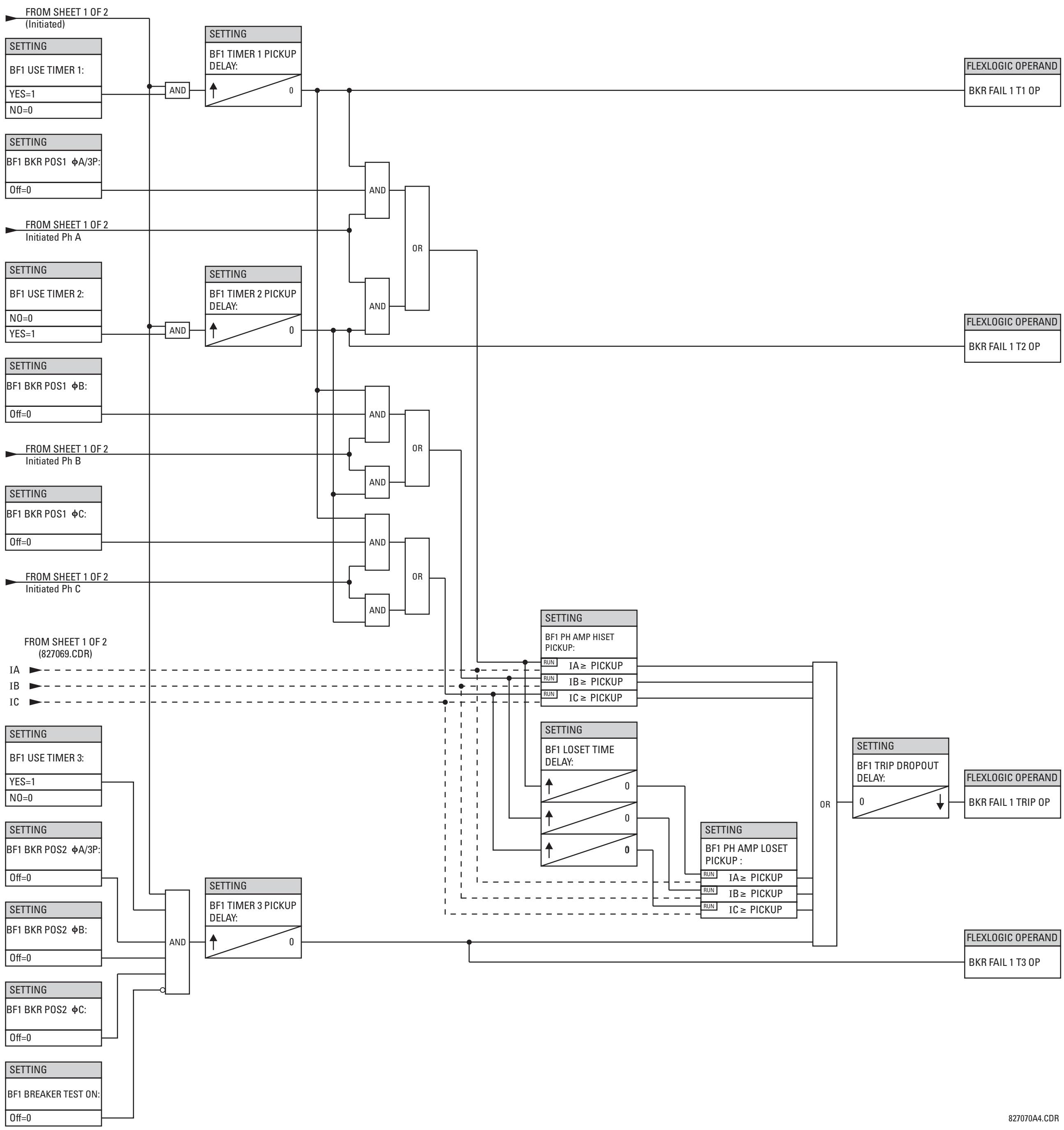

Figure 5–59: BREAKER FAILURE 1-POLE [TIMERS] (Sheet 2 of 2)

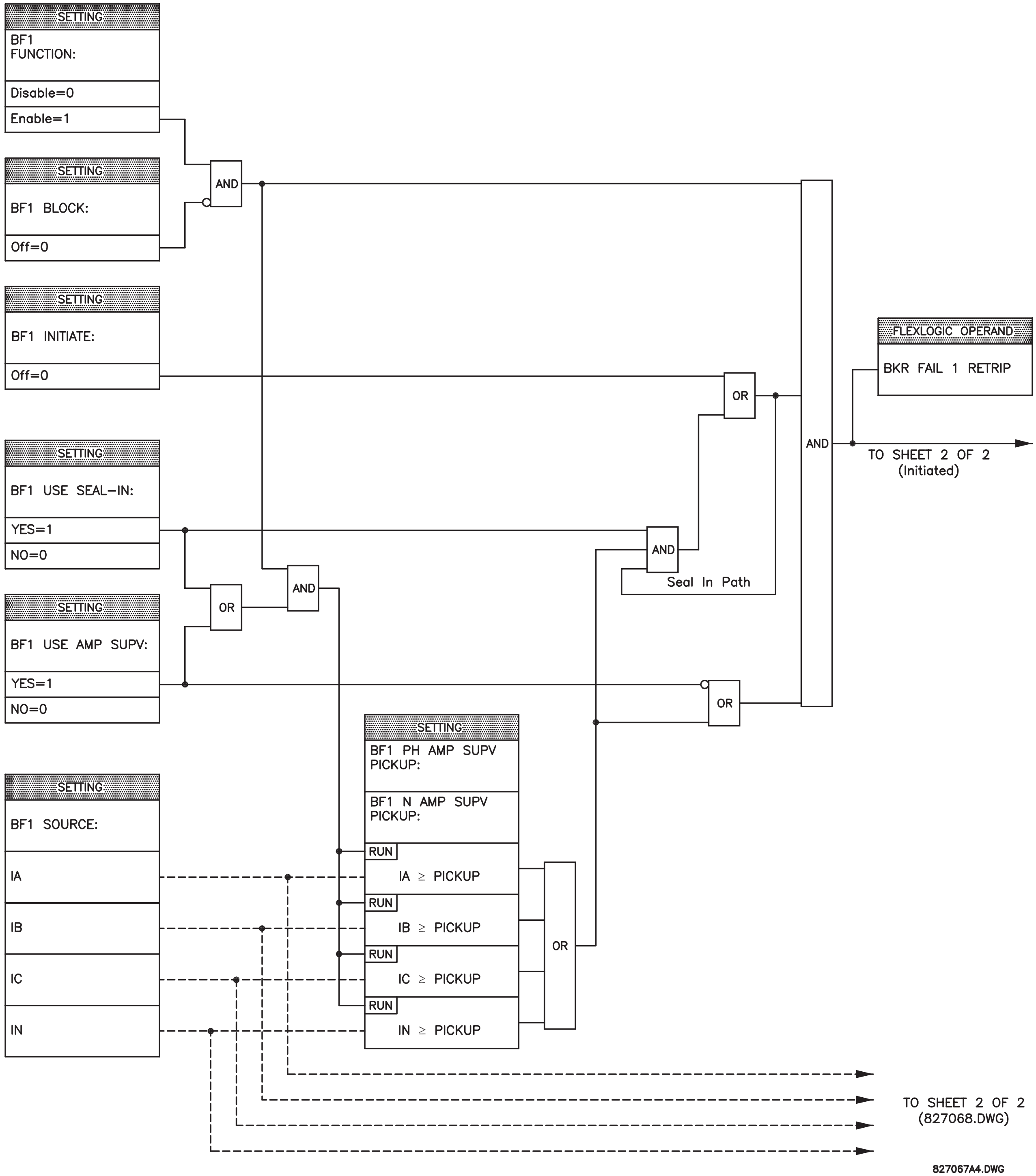

Figure 5–60: BREAKER FAILURE 3-POLE [INITIATE] (Sheet 1 of 2)

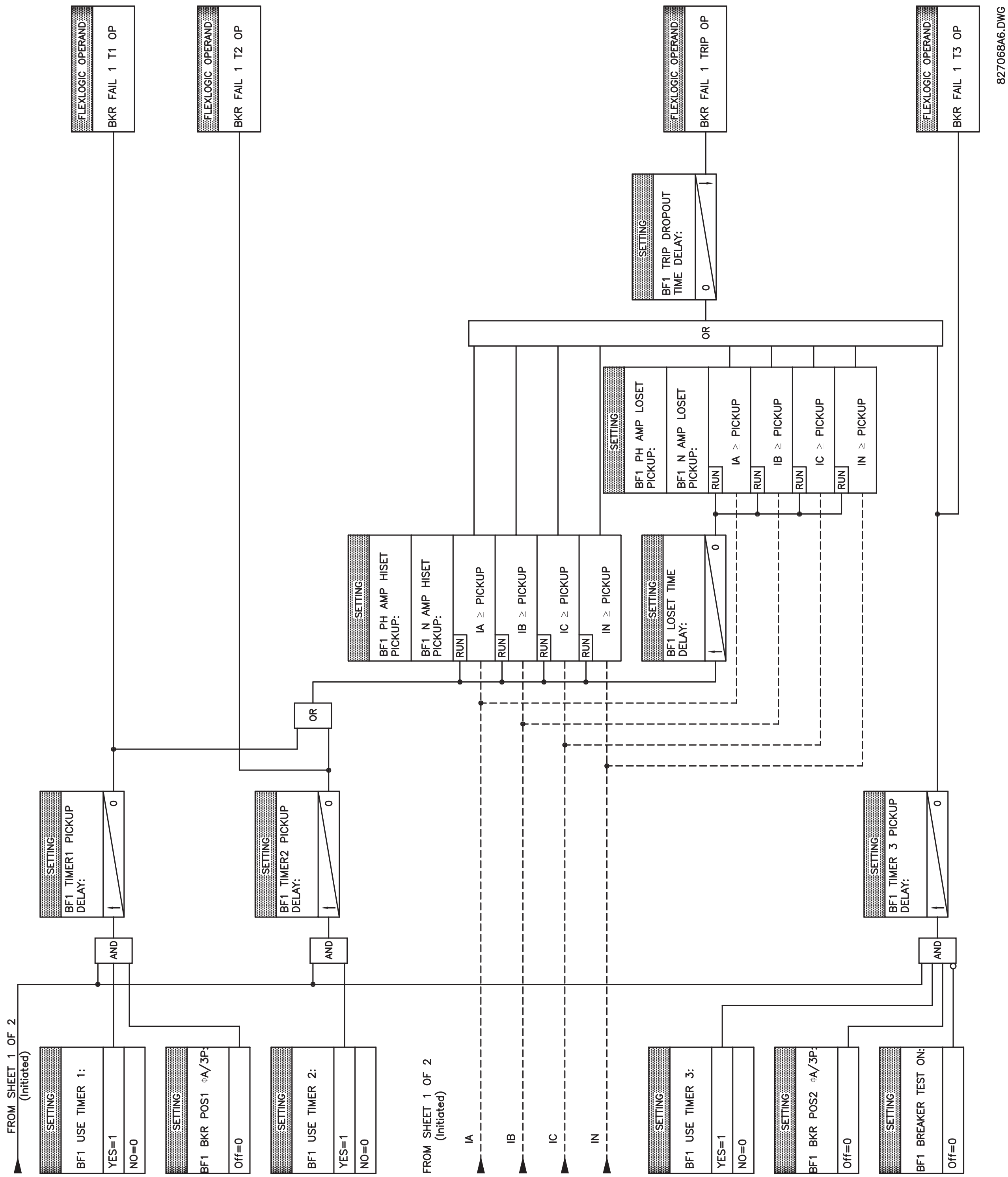

Figure 5–61: BREAKER FAILURE 3-POLE [TIMERS] (Sheet 2 of 2)

5.5.9 VOLTAGE ELEMENTS

a) MAIN MENU

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

■ VOLTAGE ELEMENTS ■		■ PHASE ■ UNDERVOLTAGE1	See page 5–118.
	MESSAGE	■ PHASE ■ UNDERVOLTAGE2	See page 5–118.
	MESSAGE	■ PHASE ■ OVERVOLTAGE1	See page 5–119.
	MESSAGE	■ NEUTRAL OV1 ■	See page 5–120.
	MESSAGE	■ NEUTRAL OV2 ■	See page 5–120.
	MESSAGE	■ NEUTRAL OV3 ■	See page 5–120.
	MESSAGE	■ NEG SEQ OV ■	See page 5–121.
	MESSAGE	■ AUXILIARY UV1 ■	See page 5–122.
	MESSAGE	■ AUXILIARY OV1 ■	See page 5–123.

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.

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

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.

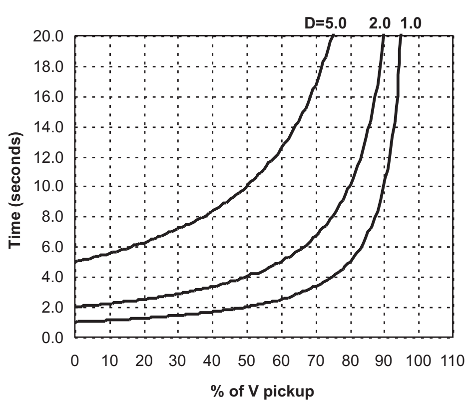

Figure 5–62: INVERSE TIME UNDERVOLTAGE CURVES

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b) PHASE UNDERVOLTAGE (ANSI 27P)

PATH: SETTINGS ⇨⇩ GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) ⇨⇩ VOLTAGE ELEMENTS ⇨ PHASE UNDERVOLTAGE1(2)

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

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This element may be used to give a desired time-delay operating characteristic versus the applied fundamental voltage (phase-to-ground or phase-to-phase for Wye VT connection, or phase-to-phase for Delta VT connection) or as a Definite Time element. The element resets instantaneously if the applied voltage exceeds the dropout voltage. The delay setting selects the minimum operating time of the phase undervoltage. The minimum voltage setting selects the operating voltage below which the element is blocked (a setting of "0" will allow a dead source to be considered a fault condition).

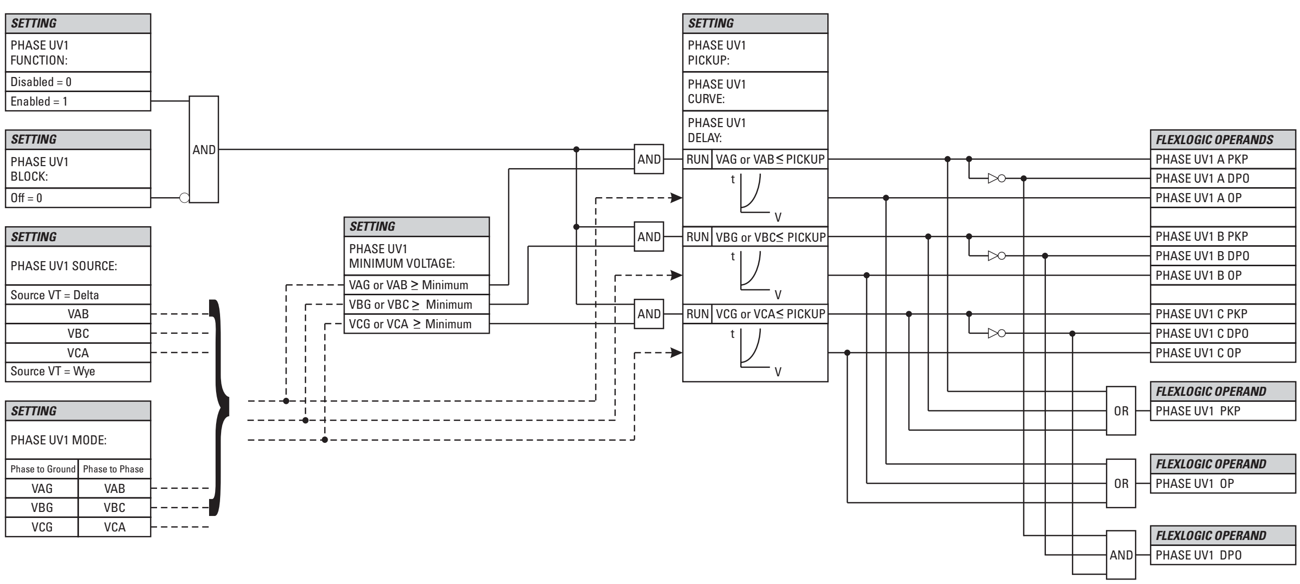

Figure 5–63: PHASE UNDERVOLTAGE1 SCHEME LOGIC

c) PHASE OVERVOLTAGE (ANSI 59P)

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

■ PHASE ■ OVERVOLTAGE1		PHASE OV1 FUNCTION: Disabled	Range: Disabled, Enabled
	MESSAGE	PHASE OV1 SIGNAL SOURCE: SRC 1	Range: SRC 1, SRC 2
	MESSAGE	PHASE OV1 PICKUP: 1.000 pu	Range: 0.000 to 3.000 pu in steps of 0.001
	MESSAGE	PHASE OV1 PICKUP DELAY: 1.00 s	Range: 0.00 to 600.00 s in steps of 0.01
	MESSAGE	PHASE OV1 RESET DELAY: 1.00 s	Range: 0.00 to 600.00 s in steps of 0.01
	MESSAGE	PHASE OV1 BLOCK: Off	Range: FlexLogic™ Operand
	MESSAGE	PHASE OV1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
	MESSAGE	PHASE OV1 EVENTS: Disabled	Range: Disabled, Enabled

The phase overvoltage element may be used as an instantaneous element with no intentional time delay or as a Definite Time element. The input voltage is the phase-to-phase voltage, either measured directly from Delta-connected VTs or as calculated from phase-to-ground (Wye) connected VTs. The specific voltages to be used for each phase are shown below.

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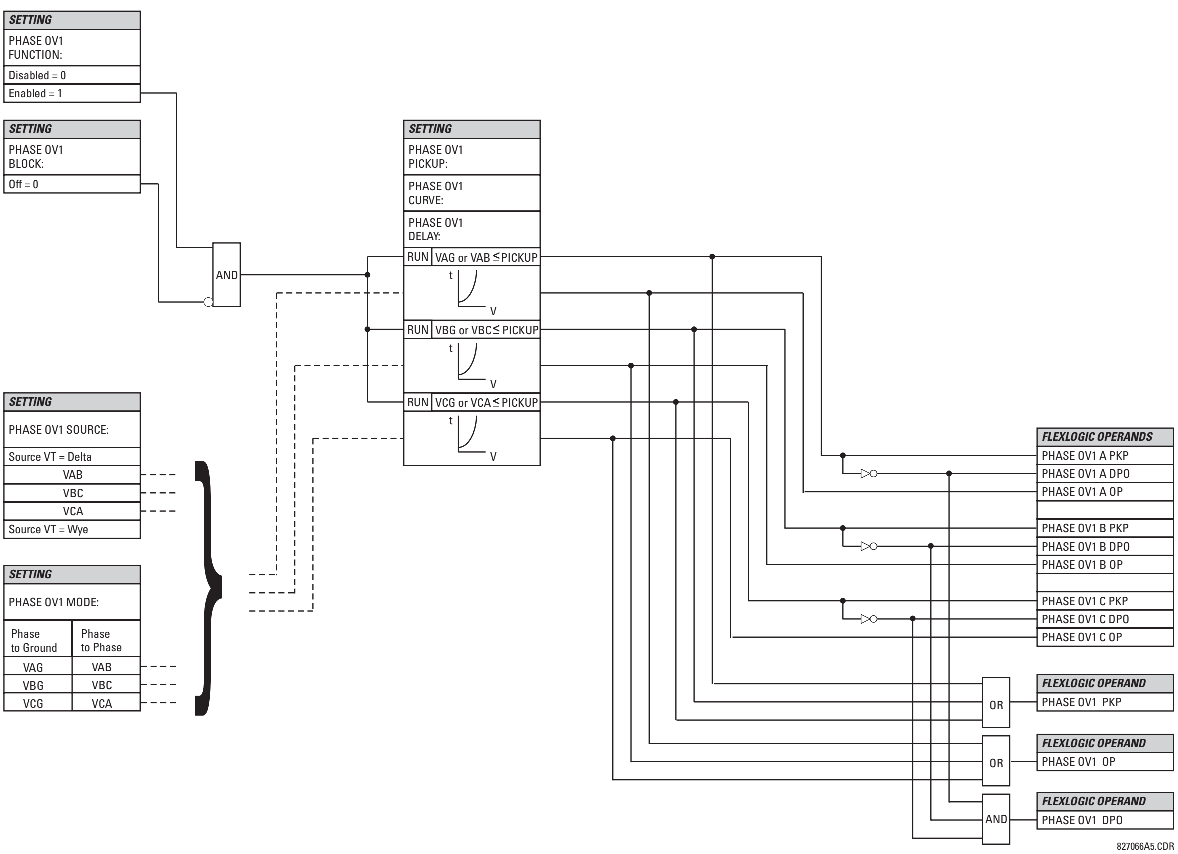

Figure 5–64: PHASE OVERVOLTAGE SCHEME LOGIC

d) NEUTRAL OVERVOLTAGE (ANSI 59N)

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

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

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

The Neutral Overvoltage element can provide a time-delayed operating characteristic versus the applied voltage (initialized from FlexCurves A, B, or C) or be used as a definite time element. The **NEUTRAL OV1(3) PICKUP DELAY** setting applies only if the **NEUTRAL OV1(3) CURVE** setting is "Definite time". The source assigned to this element must be configured for a phase VT.

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

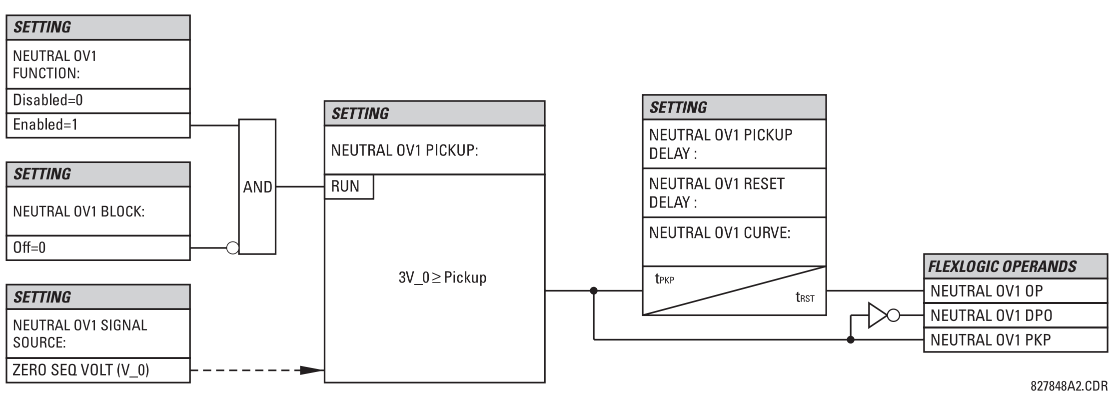

Figure 5–65: NEUTRAL OVERVOLTAGE1 SCHEME LOGIC

e) NEGATIVE SEQUENCE OVERVOLTAGE (ANSI 59_2)

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

■ NEG SEQ OV ■		NEG SEQ OV FUNCTION: Disabled	*Range: Disabled, Enabled*
	MESSAGE	NEG SEQ OV SIGNAL SOURCE: SRC 1	*Range: SRC 1, SRC 2*
	MESSAGE	NEG SEQ OV PICKUP: 0.300 pu	*Range: 0.000 to 1.250 pu in steps of 0.001*
	MESSAGE	NEG SEQ OV PICKUP DELAY: 0.50 s	*Range: 0.00 to 600.00 s in steps of 0.01*
	MESSAGE	NEG SEQ OV RESET DELAY: 0.50 s	*Range: 0.00 to 600.00 s in steps of 0.01*
	MESSAGE	NEG SEQ OV BLOCK: Off	*Range: FlexLogic™ operand*
	MESSAGE	NEG SEQ OV TARGET: Self-reset	*Range: Self-reset, Latched, Disabled*
	MESSAGE	NEG SEQ OV EVENTS: Disabled	*Range: Disabled, Enabled*

The negative sequence overvoltage element may be used to detect loss of one or two phases of the source, a reversed phase sequence of voltage, or a non-symmetrical system voltage condition.

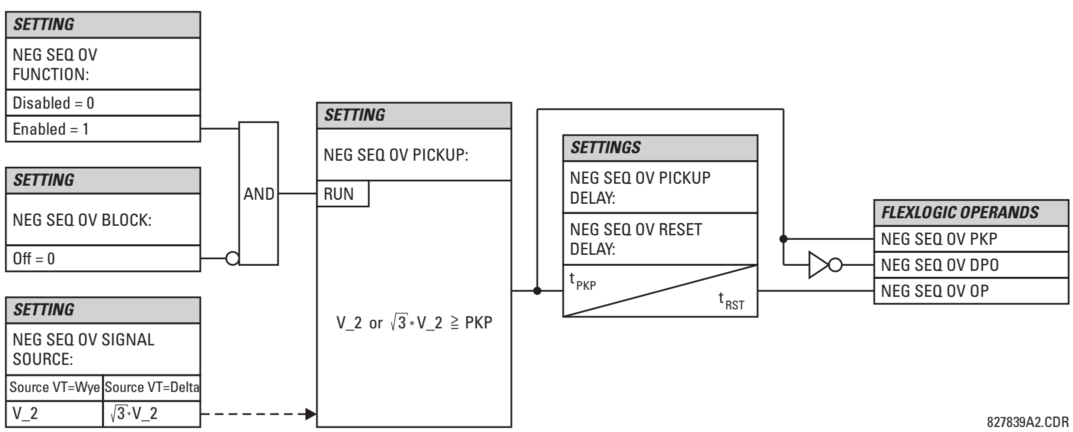

Figure 5–66: NEG SEQ OV SCHEME LOGIC

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f) 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
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

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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.

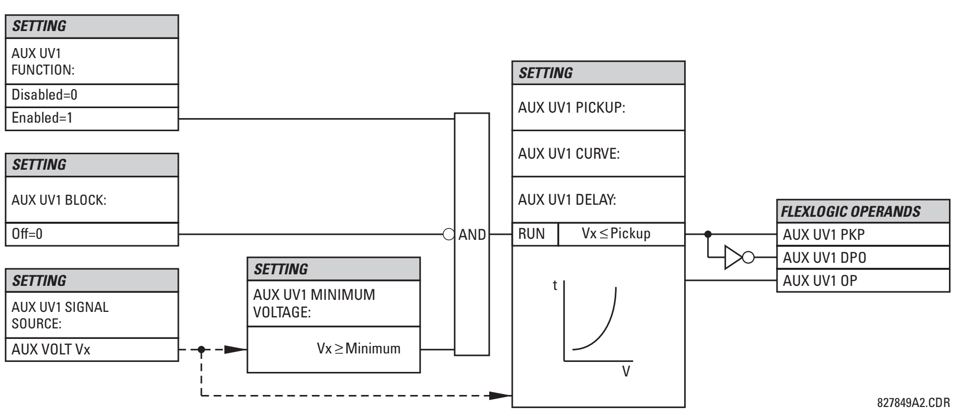

Figure 5–67: AUXILIARY UNDERVOLTAGE SCHEME LOGIC

g) AUXILIARY OVERVOLTAGE (ANSI 59X)

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

■ AUXILIARY OV1 ■	AUX OV1 FUNCTION: Disabled	*Range: Disabled, Enabled*
MESSAGE	AUX OV1 SIGNAL SOURCE: SRC 1	*Range: SRC 1, SRC 2*
MESSAGE	AUX OV1 PICKUP: 0.300 pu	*Range: 0.000 to 3.000 pu in steps of 0.001*
MESSAGE	AUX OV1 PICKUP DELAY: 1.00 s	*Range: 0.00 to 600.00 s in steps of 0.01*
MESSAGE	AUX OV1 RESET DELAY: 1.00 s	*Range: 0.00 to 600.00 s in steps of 0.01*
MESSAGE	AUX OV1 BLOCK: Off	*Range: FlexLogic™ operand*
MESSAGE	AUX OV1 TARGET: Self-reset	*Range: Self-reset, Latched, Disabled*
MESSAGE	AUX OV1 EVENTS: Disabled	*Range: Disabled, Enabled*

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.

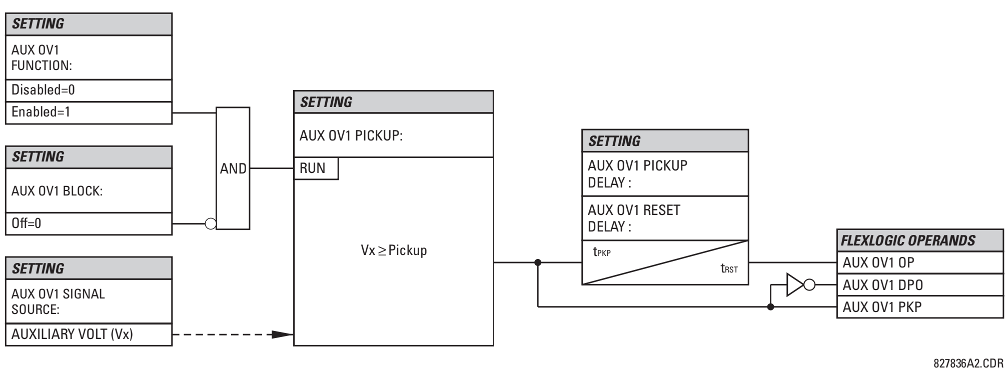

Figure 5–68: AUXILIARY OVERVOLTAGE SCHEME LOGIC

5.5.10 SENSITIVE DIRECTIONAL POWER

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
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:

$$P\cos\theta + Q\sin\theta > SMIN \quad \text{(EQ 5.20)}$$

where: *P* and *Q* are active and reactive powers as measured per the UR convention,
θ 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.

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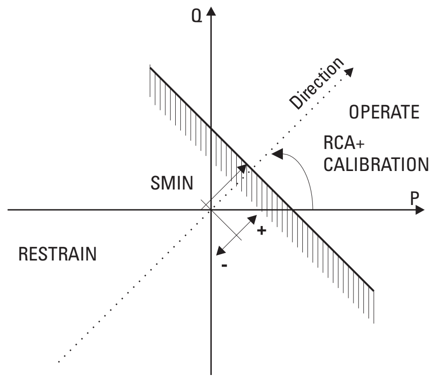

Figure 5–69: DIRECTIONAL POWER CHARACTERISTIC

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.

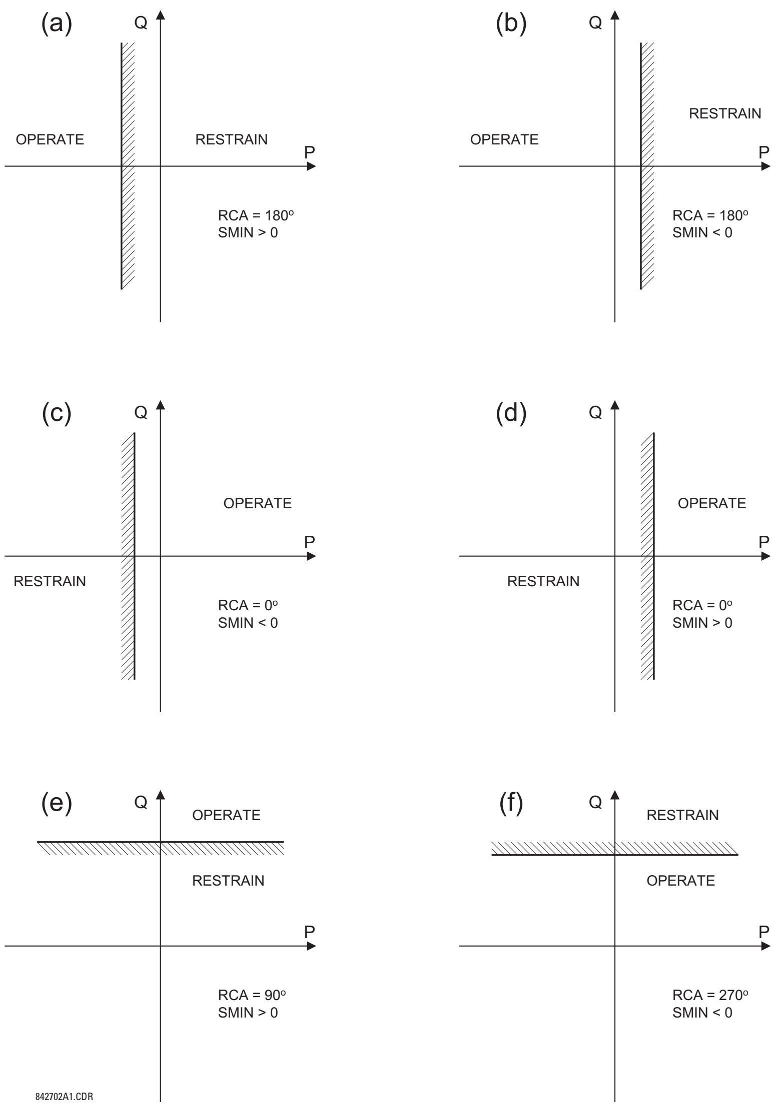

Figure 5–70: DIRECTIONAL POWER ELEMENT SAMPLE APPLICATIONS

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- **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 × VT pu base × CT pu base.

  For example, a setting of 2% for a 200 MW machine, is 0.02 × 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.

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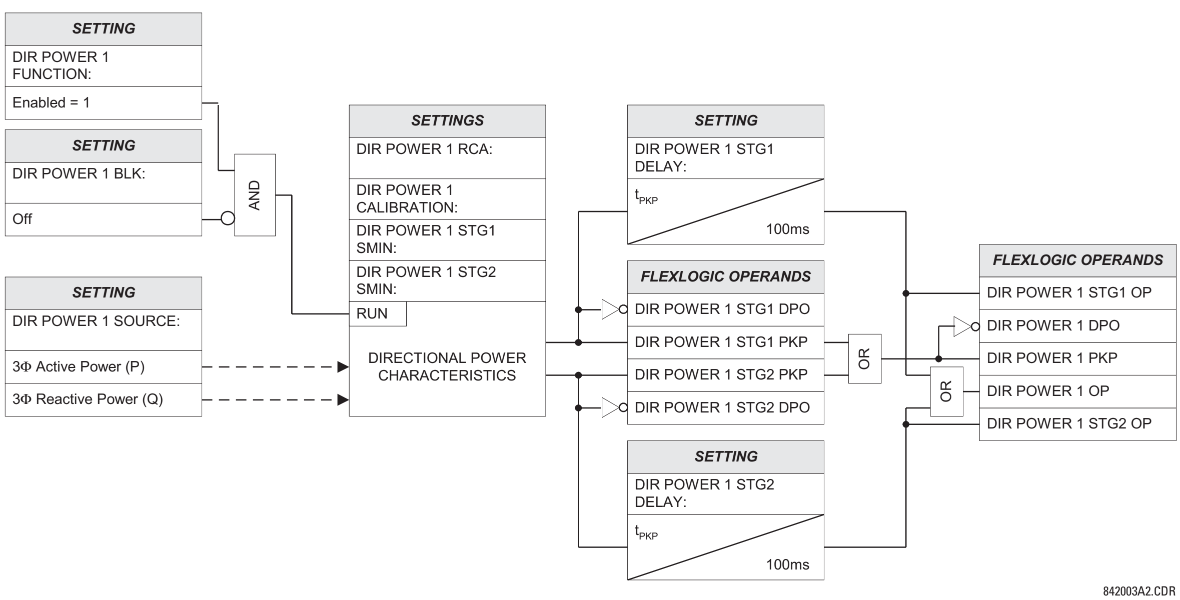

Figure 5–71: DIRECTIONAL POWER SCHEME LOGIC

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 ⇨ SETTING GROUPS

■ SETTING GROUPS ■	SETTING GROUPS FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	SETTING GROUPS BLK: Off	Range: FlexLogic™ operand
MESSAGE	GROUP 2 ACTIVATE ON: Off	Range: FlexLogic™ operand
MESSAGE	GROUP 3 ACTIVATE ON: Off	Range: FlexLogic™ operand
	↓	
MESSAGE	GROUP 6 ACTIVATE ON: Off	Range: FlexLogic™ operand
MESSAGE	GROUP 1 NAME:	Range: up to 16 alphanumeric characters
MESSAGE	GROUP 2 NAME:	Range: up to 16 alphanumeric characters
	↓	
MESSAGE	GROUP 6 NAME:	Range: up to 16 alphanumeric characters
MESSAGE	SETTING GROUP EVENTS: Disabled	Range: Disabled, Enabled

The Setting Groups menu controls the activation/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 **SETTING GROUP 1(6) NAME** settings allows to user to assign a name to each of the six settings groups. Once programmed, this name will appear on the second line of the GROUPED ELEMENTS ⇨ SETTING GROUP 1(6) menu display.

The relay can be set up via a FlexLogic™ equation to receive requests to activate or de-activate a particular non-default settings group. The following FlexLogic™ equation (see the figure below) illustrates requests via remote communications (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.

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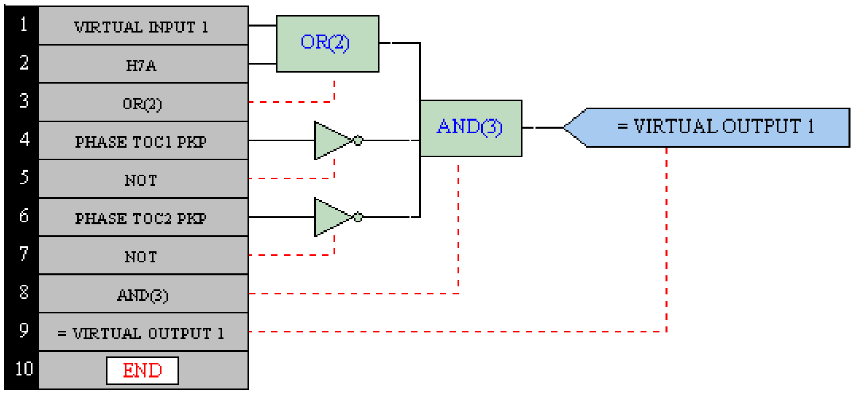

Figure 5–72: EXAMPLE FLEXLOGIC™ CONTROL OF A SETTINGS GROUP

5.6.3 SELECTOR SWITCH

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

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

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

The element provides for two control inputs. The step-up control allows stepping through selector position one step at a time with each pulse of the control input, such as a user-programmable pushbutton. The 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**) lockout 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 the element behavior on power up of the relay.

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

  When set to “Synchronize” selector switch acts as follows. For two power cycles, the selector applies position 0 to the switch and activates SELECTOR 1 PWR ALARM. After two power cycles expire, the selector synchronizes to the position dictated by the 3-bit control input. This operation does not wait for time-out or the acknowledging input. When the synchronization attempt is unsuccessful (i.e., the 3-bit input is not available (0,0,0) or out of range) then the selector switch output is set to position 0 (no output operand selected) and an alarm is established (SELECTOR 1 PWR ALARM).

  The operation of “Synch/Restore” mode is similar to the “Synchronize” mode. The only difference is that after an unsuccessful synchronization attempt, the switch will attempt to restore the position stored in the relay memory. The “Synch/Restore” mode is useful for applications where the selector switch is employed to change the setting group in redundant (two relay) protection schemes.
- **SELECTOR 1 EVENTS**: If enabled, the following events are logged:

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

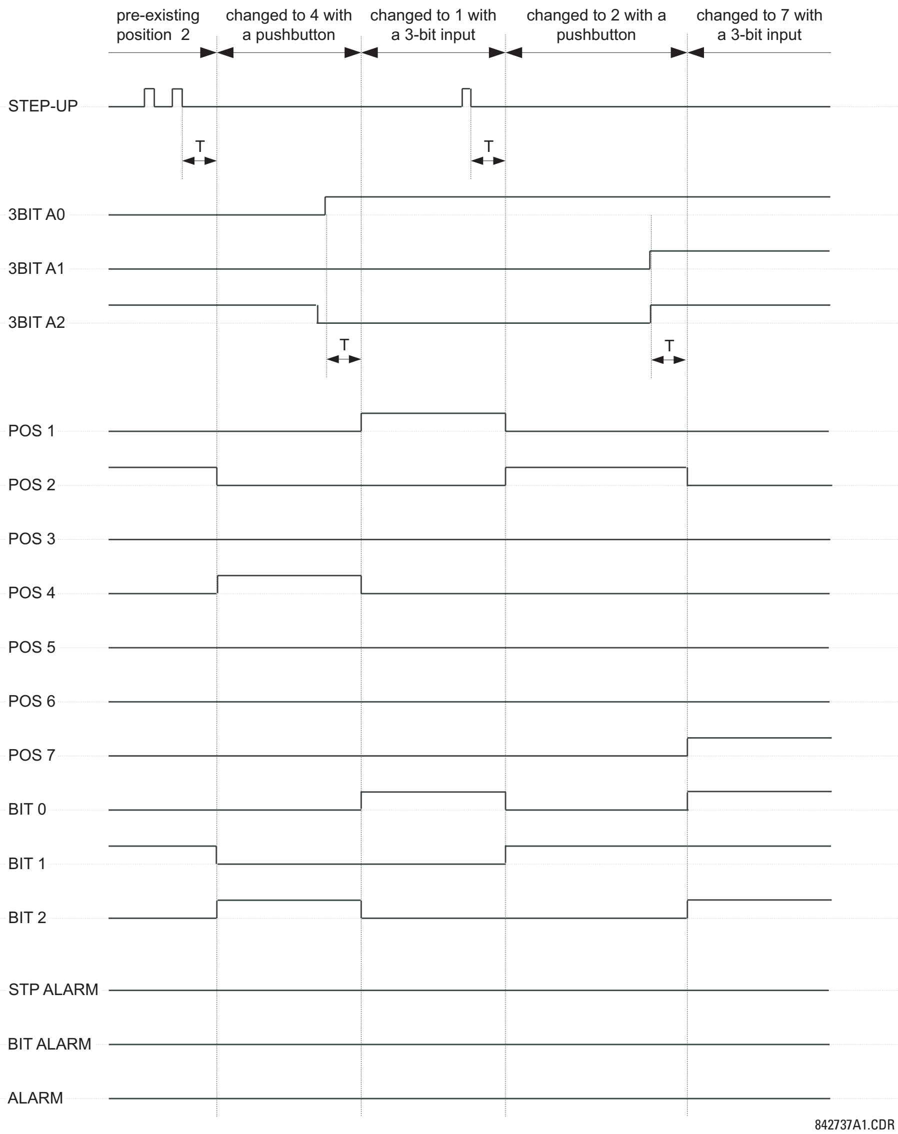

Figure 5–73: TIME-OUT MODE

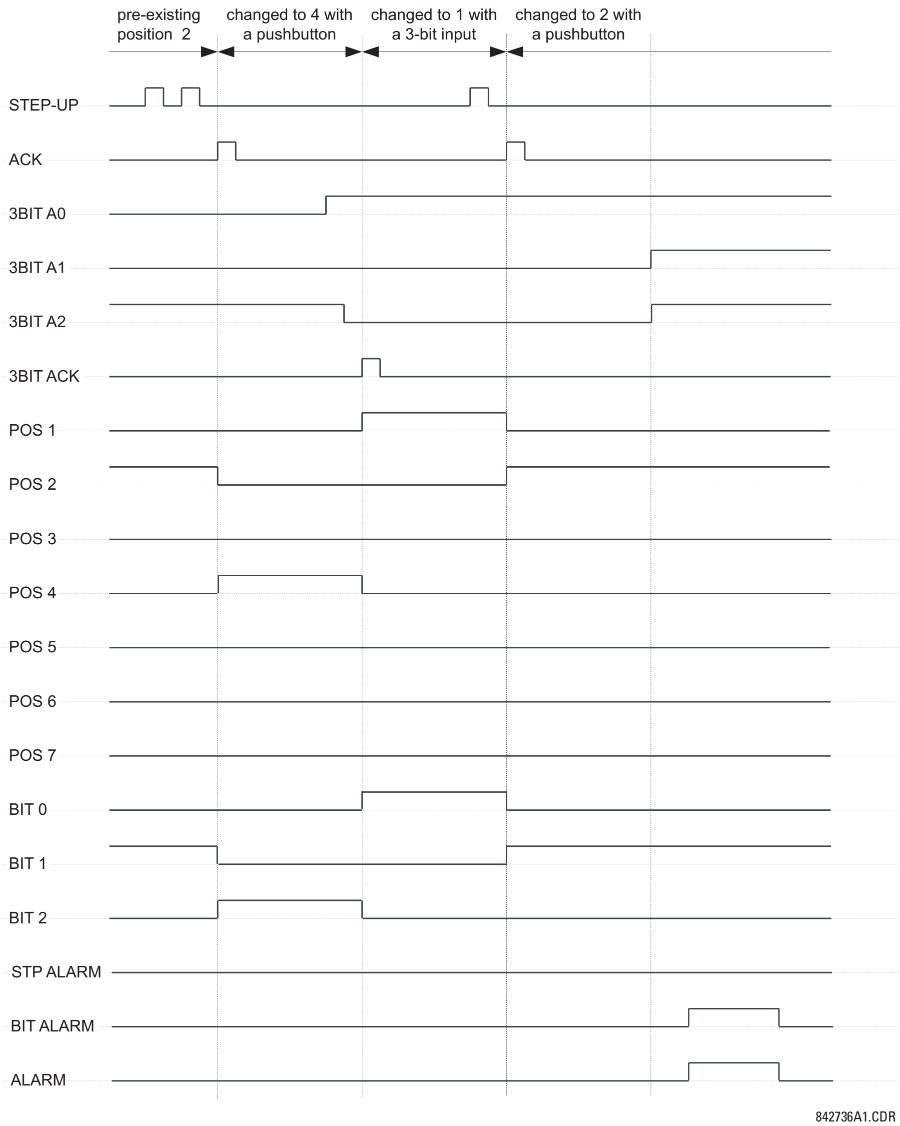

Figure 5–74: ACKNOWLEDGE MODE

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”
SETTING GROUPS BLK: “Off”
GROUP 2 ACTIVATE ON: “SELECTOR 1 POS 2"
GROUP 3 ACTIVATE ON: “SELECTOR 1 POS 3"
GROUP 4 ACTIVATE ON: “SELECTOR 1 POS 4"
GROUP 5 ACTIVATE ON: “Off”
GROUP 6 ACTIVATE ON: “Off”

Make the following changes to Selector Switch element in the **SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ SELECTOR SWITCH ⇨ SELECTOR SWITCH 1** menu to assign control to User Programmable Pushbutton 1 and Contact Inputs 1 through 3:

SELECTOR 1 FUNCTION: “Enabled”
SELECTOR 1 FULL-RANGE: “4”
SELECTOR 1 STEP-UP MODE: “Time-out”
SELECTOR 1 TIME-OUT: “5.0 s”
SELECTOR 1 STEP-UP: “PUSHBUTTON 1 ON”
SELECTOR 1 ACK: “Off”
SELECTOR 1 3BIT A0: “CONT IP 1 ON”
SELECTOR 1 3BIT A1: “CONT IP 2 ON”
SELECTOR 1 3BIT A2: “CONT IP 3 ON”
SELECTOR 1 3BIT MODE: “Time-out”
SELECTOR 1 3BIT ACK: “Off”
SELECTOR 1 POWER-UP MODE: “Synchronize”

Now, assign the contact output operation (assume the H6E module) to the Selector Switch element by making the following changes in the **SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ CONTACT OUTPUTS** menu:

OUTPUT H1 OPERATE: “SELECTOR 1 BIT 0"
OUTPUT H2 OPERATE: “SELECTOR 1 BIT 1"
OUTPUT H3 OPERATE: “SELECTOR 1 BIT 2"

Finally, assign configure User-Programmable Pushbutton 1 by making the following changes in the **SETTINGS ⇨ PRODUCT SETUP ⇨⇩ USER-PROGRAMMABLE PUSHBUTTONS ⇨ USER PUSHBUTTON 1** menu:

PUSHBUTTON 1 FUNCTION: “Self-reset”
PUSHBUTTON 1 DROP-OUT TIME: “0.10 s”

The logic for the selector switch is shown below:

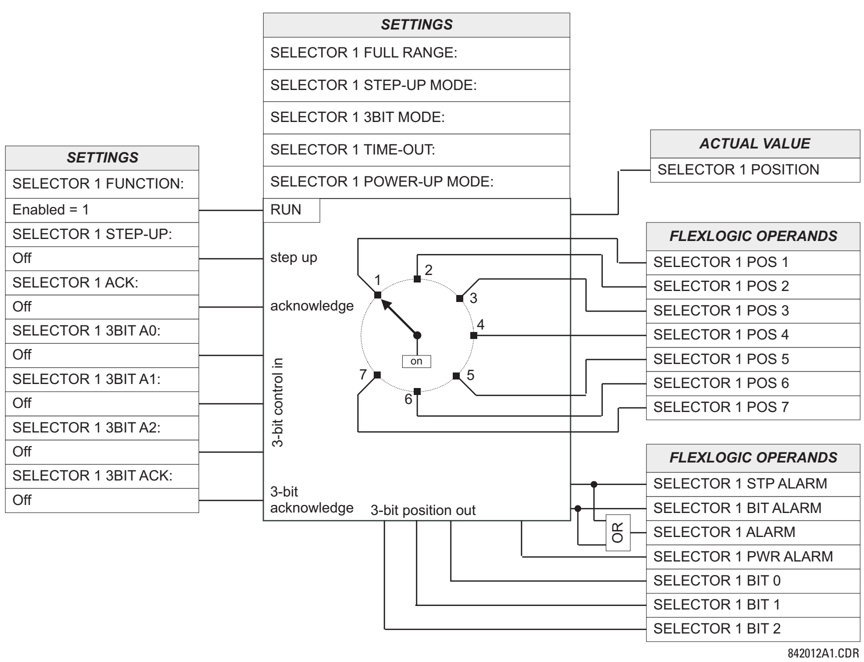

Figure 5–75: SELECTOR SWITCH LOGIC

5.6.4 UNDERFREQUENCY

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ UNDERFREQUENCY ⇨ UNDERFREQUENCY 1(6)

■ UNDERFREQUENCY 1 ■		UNDFREQ 1 FUNCTION: Disabled	Range: Disabled, Enabled
	MESSAGE	UNDERFREQ 1 BLOCK: Off	Range: FlexLogic™ operand
	MESSAGE	UNDERFREQ 1 SOURCE: SRC 1	Range: SRC 1, SRC 2
	MESSAGE	UNDERFREQ 1 MIN VOLT/AMP: 0.10 pu	Range: 0.10 to 1.25 pu in steps of 0.01
	MESSAGE	UNDERFREQ 1 PICKUP: 59.50 Hz	Range: 20.00 to 65.00 Hz in steps of 0.01
	MESSAGE	UNDERFREQ 1 PICKUP DELAY: 2.000 s	Range: 0.000 to 65.535 s in steps of 0.001
	MESSAGE	UNDERFREQ 1 RESET DELAY : 2.000 s	Range: 0.000 to 65.535 s in steps of 0.001
	MESSAGE	UNDERFREQ 1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
	MESSAGE	UNDERFREQ 1 EVENTS: Disabled	Range: Disabled, Enabled

5

There are six identical underfrequency elements, numbered from 1 through 6 inclusive.

The steady-state frequency of a power system is a certain indicator of the existing balance between the generated power and the load. Whenever this balance is disrupted through the loss of an important generating unit or the isolation of part of the system from the rest of the system, the effect will be a reduction in frequency. If the control systems of the system generators do not respond fast enough, the system may collapse. A reliable method to quickly restore the balance between load and generation is to automatically disconnect selected loads, based on the actual system frequency. This technique, called "load-shedding", maintains system integrity and minimize widespread outages. After the frequency returns to normal, the load may be automatically or manually restored.

The **UNDERFREQ 1 SOURCE** setting is used to select the source for the signal to be measured. The element first checks for a live phase voltage available from the selected Source. If voltage is not available, the element attempts to use a phase current. If neither voltage nor current is available, the element will not operate, as it will not measure a parameter above the minimum voltage/current setting.

The **UNDERFREQ 1 MIN VOLT/AMP** setting selects the minimum per unit voltage or current level required to allow the underfrequency element to operate. This threshold is used to prevent an incorrect operation because there is no signal to measure.

This **UNDERFREQ 1 PICKUP** setting is used to select the level at which the underfrequency element is to pickup. For example, if the system frequency is 60 Hz and the load shedding is required at 59.5 Hz, the setting will be 59.50 Hz.

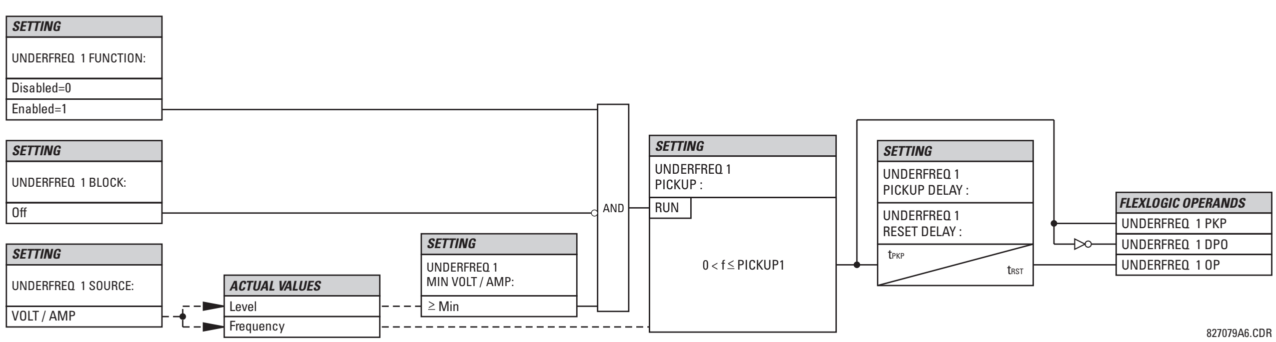

Figure 5–76: UNDERFREQUENCY SCHEME LOGIC

5.6.5 OVERFREQUENCY

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ OVERFREQUENCY ⇨ OVERFREQUENCY 1(4)

■ OVERFREQUENCY 1 ■	◁▷	OVERFREQ 1 FUNCTION: Disabled	*Range: Disabled, Enabled*
MESSAGE	△▽	OVERFREQ 1 BLOCK: Off	*Range: FlexLogic™ operand*
MESSAGE	△▽	OVERFREQ 1 SOURCE: SRC 1	*Range: SRC 1, SRC 2*
MESSAGE	△▽	OVERFREQ 1 PICKUP: 60.50 Hz	*Range: 20.00 to 65.00 Hz in steps of 0.01*
MESSAGE	△▽	OVERFREQ 1 PICKUP DELAY: 0.500 s	*Range: 0.000 to 65.535 s in steps of 0.001*
MESSAGE	△▽	OVERFREQ 1 RESET DELAY : 0.500 s	*Range: 0.000 to 65.535 s in steps of 0.001*
MESSAGE	△▽	OVERFREQ 1 TARGET: Self-reset	*Range: Self-reset, Latched, Disabled*
MESSAGE	△	OVERFREQ 1 EVENTS: Disabled	*Range: Disabled, Enabled*

There are four overfrequency elements, numbered 1 through 4.

A frequency calculation for a given source is made on the input of a voltage or current channel, depending on which is available. The channels are searched for the signal input in the following order: voltage channel A, auxiliary voltage channel, current channel A, ground current channel. The first available signal is used for frequency calculation.

The steady-state frequency of a power system is an indicator of the existing balance between the generated power and the load. Whenever this balance is disrupted through the disconnection of significant load or the isolation of a part of the system that has a surplus of generation, the effect will be an increase in frequency. If the control systems of the generators do not respond fast enough, to quickly ramp the turbine speed back to normal, the overspeed can lead to the turbine trip. The overfrequency element can be used to control the turbine frequency ramp down at a generating location. This element can also be used for feeder reclosing as part of the "after load shedding restoration".

The **OVERFREQ 1 SOURCE** setting selects the source for the signal to be measured. The **OVERFREQ 1 PICKUP** setting selects the level at which the overfrequency element is to pickup.

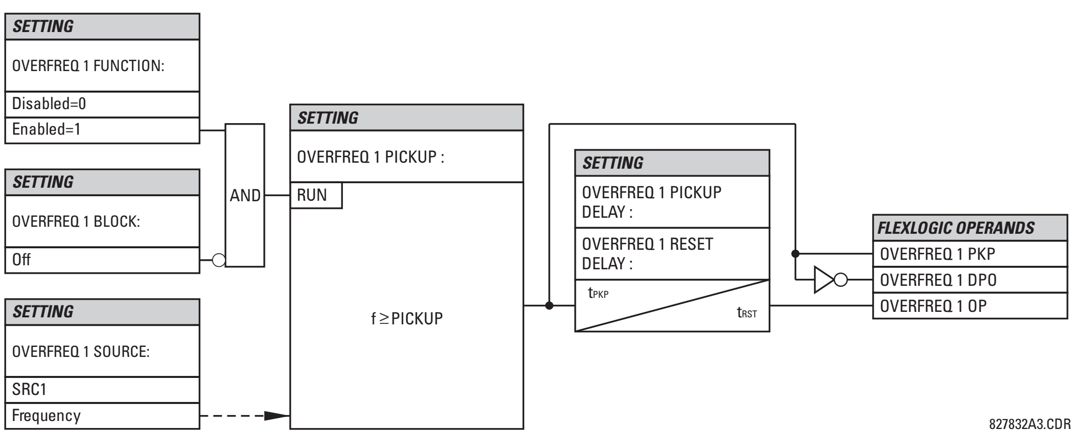

Figure 5–77: OVERFREQUENCY SCHEME LOGIC

5.6.6 FREQUENCY RATE OF CHANGE

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ FREQUENCY RATE OF CHANGE ⇨ FREQUENCY RATE OF CHANGE 1(4)

■ FREQUENCY RATE ■ OF CHANGE 1	◀▶	FREQ RATE 1 FUNCTION: Disabled	Range: *Disabled, Enabled*
MESSAGE	▲▼	FREQ RATE 1 SOURCE: SRC 1	Range: *SRC 1, SRC 2*
MESSAGE	▲▼	FREQ RATE 1 TREND: Decreasing	Range: *Increasing, Decreasing, Bi-directional*
MESSAGE	▲▼	FREQ RATE 1 PICKUP: 0.50 Hz/sec	Range: *0.10 to 15.00 Hz/sec in steps of 0.01*
MESSAGE	▲▼	FREQ RATE 1 OV SUPV PICKUP: 0.700 pu	Range: *0.100 to 3.000 pu in steps of 0.001*
MESSAGE	▲▼	FREQ RATE 1 OC SUPV PICKUP: 0.200 pu	Range: *0.000 to 30.000 pu in steps of 0.001*
MESSAGE	▲▼	FREQ RATE 1 MIN FREQUENCY: 45.00 Hz	Range: *20.00 to 80.00 Hz in steps of 0.01*
MESSAGE	▲▼	FREQ RATE 1 MAX FREQUENCY: 65.00 Hz	Range: *20.00 to 80.00 Hz in steps of 0.01*
MESSAGE	▲▼	FREQ RATE 1 PICKUP DELAY: 0.000 s	Range: *0 to 65.535 s in steps of 0.001*
MESSAGE	▲▼	FREQ RATE 1 RESET DELAY: 0.000 s	Range: *0 to 65.535 s in steps of 0.001*
MESSAGE	▲▼	FREQ RATE 1 BLOCK: Off	Range: *FlexLogic™ operand*
MESSAGE	▲▼	FREQ RATE 1 TARGET: Self-Reset	Range: *Self-Reset, Latched, Disabled*
MESSAGE	▲	FREQ RATE 1 EVENTS: Disabled	Range: *Disabled, Enabled*

Four (4) independent Rate of Change of Frequency elements are available. The element responds to rate of change of frequency with voltage, current and frequency supervision.

- **FREQ RATE 1 TREND:** This setting allows configuring the element to respond to increasing or decreasing frequency, or to frequency change in either direction.
- **FREQ RATE 1 PICKUP:** This setting specifies an intended df/dt pickup threshold. For applications monitoring a decreasing trend, set **FREQ RATE 1 TREND** to "Decreasing" and specify the pickup threshold accordingly. The operating condition is: $-df/dt > \text{Pickup}$.

  For applications monitoring an increasing trend, set **FREQ RATE 1 TREND** to "Increasing" and specify the pickup threshold accordingly. The operating condition is: $df/dt > \text{Pickup}$.

  For applications monitoring rate of change of frequency in any direction set **FREQ RATE 1 TREND** to "Bi-Directional" and specify the pickup threshold accordingly. The operating condition is: $\text{abs}(df/dt) > \text{Pickup}$
- **FREQ RATE 1 OV SUPV PICKUP:** This setting defines minimum voltage level required for operation of the element. The supervising function responds to the positive-sequence voltage. Overvoltage supervision should be used to prevent operation under specific system conditions such as faults.
- **FREQ RATE 1 OC SUPV PICKUP:** This setting defines minimum current level required for operation of the element. The supervising function responds to the positive-sequence current. Typical application includes load shedding. Set the pickup threshold to zero if no overcurrent supervision is required.

- **FREQ RATE 1 MIN FREQUENCY:** This setting defines minimum frequency level required for operation of the element. The setting may be used to effectively block the feature based on frequency. For example, if the intent is to monitor an increasing trend but only if the frequency is already above certain level, this setting should be set to the required frequency level.
- **FREQ RATE 1 MAX FREQUENCY:** This setting defines maximum frequency level required for operation of the element. The setting may be used to effectively block the feature based on frequency. For example, if the intent is to monitor a decreasing trend but only if the frequency is already below certain level (such as for load shedding), this setting should be set to the required frequency level.

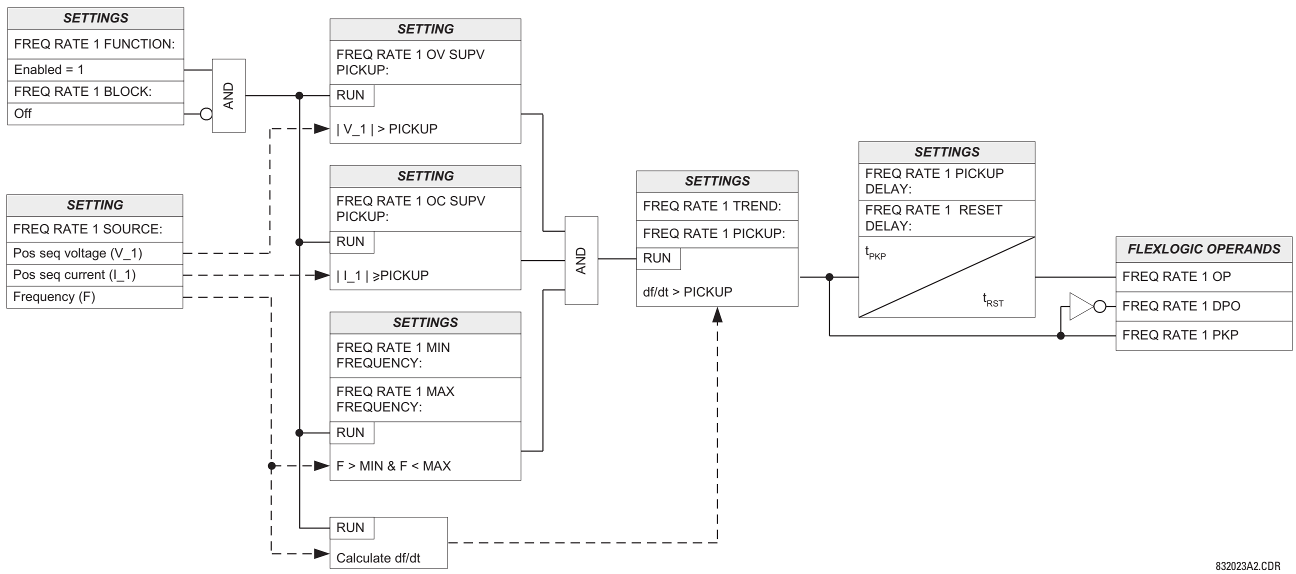

Figure 5–78: FREQUENCY RATE OF CHANGE SCHEME LOGIC

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5.6.7 SYNCHROCHECK

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
MESSAGE	SYNCHK1 V2 SOURCE: SRC 2	Range: SRC 1, SRC 2
MESSAGE	SYNCHK1 MAX VOLT DIFF: 10000 V	Range: 0 to 400000 V in steps of 1
MESSAGE	SYNCHK1 MAX ANGLE DIFF: 30°	Range: 0 to 100° in steps of 1
MESSAGE	SYNCHK1 MAX FREQ DIFF: 1.00 Hz	Range: 0.00 to 2.00 Hz in steps of 0.01
MESSAGE	SYNCHK1 MAX FREQ HYSTERESIS: 0.06 Hz	Range: 0.00 to 0.10 Hz in steps of 0.01
MESSAGE	SYNCHK1 DEAD SOURCE SELECT: LV1 and DV2	Range: None, LV1 and DV2, DV1 and LV2, DV1 or DV2, DV1 Xor DV2, DV1 and DV2
MESSAGE	SYNCHK1 DEAD V1 MAX VOLT: 0.30 pu	Range: 0.00 to 1.25 pu in steps of 0.01
MESSAGE	SYNCHK1 DEAD V2 MAX VOLT: 0.30 pu	Range: 0.00 to 1.25 pu in steps of 0.01
MESSAGE	SYNCHK1 LIVE V1 MIN VOLT: 0.70 pu	Range: 0.00 to 1.25 pu in steps of 0.01
MESSAGE	SYNCHK1 LIVE V2 MIN VOLT: 0.70 pu	Range: 0.00 to 1.25 pu in steps of 0.01
MESSAGE	SYNCHK1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	SYNCHK1 EVENTS: Disabled	Range: Disabled, Enabled

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 ΔΦ and the frequency difference ΔF (slip frequency). It can be defined as the time it would take the voltage phasor V1 or V2 to traverse an angle equal to $2 \times \Delta\Phi$ at a frequency equal to the frequency difference ΔF. This time can be calculated by:

$$T = \frac{1}{\frac{360^\circ}{2 \times \Delta\Phi} \times \Delta F} \qquad \text{(EQ 5.21)}$$

where: ΔΦ = phase angle difference in degrees; ΔF = frequency difference in Hz.

As an example; for the default values ($\Delta\Phi$ = 30°, ΔF = 0.1 Hz), the time while the angle between the two voltages will be less than the set value is:

$$T = \frac{1}{\frac{360^\circ}{2 \times \Delta\Phi} \times \Delta F} = \frac{1}{\frac{360^\circ}{2 \times 30^\circ} \times 0.1\text{ Hz}} = 1.66\text{ sec.} \quad \textbf{(EQ 5.22)}$$

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 only the auxiliary voltage is programmed in one of the sources to be used for synchrocheck.

NOTE

Exception: Synchronism cannot be checked between Delta connected phase VTs and a Wye connected auxiliary voltage.

2. The relay measures frequency and Volts/Hz from an input on a given source with priorities as established by the configuration of input channels to the source. The relay will use the phase channel of a three-phase set of voltages if programmed as part of that source. The relay will use the auxiliary voltage channel only if that channel is programmed as part of the Source and a three-phase set is not.

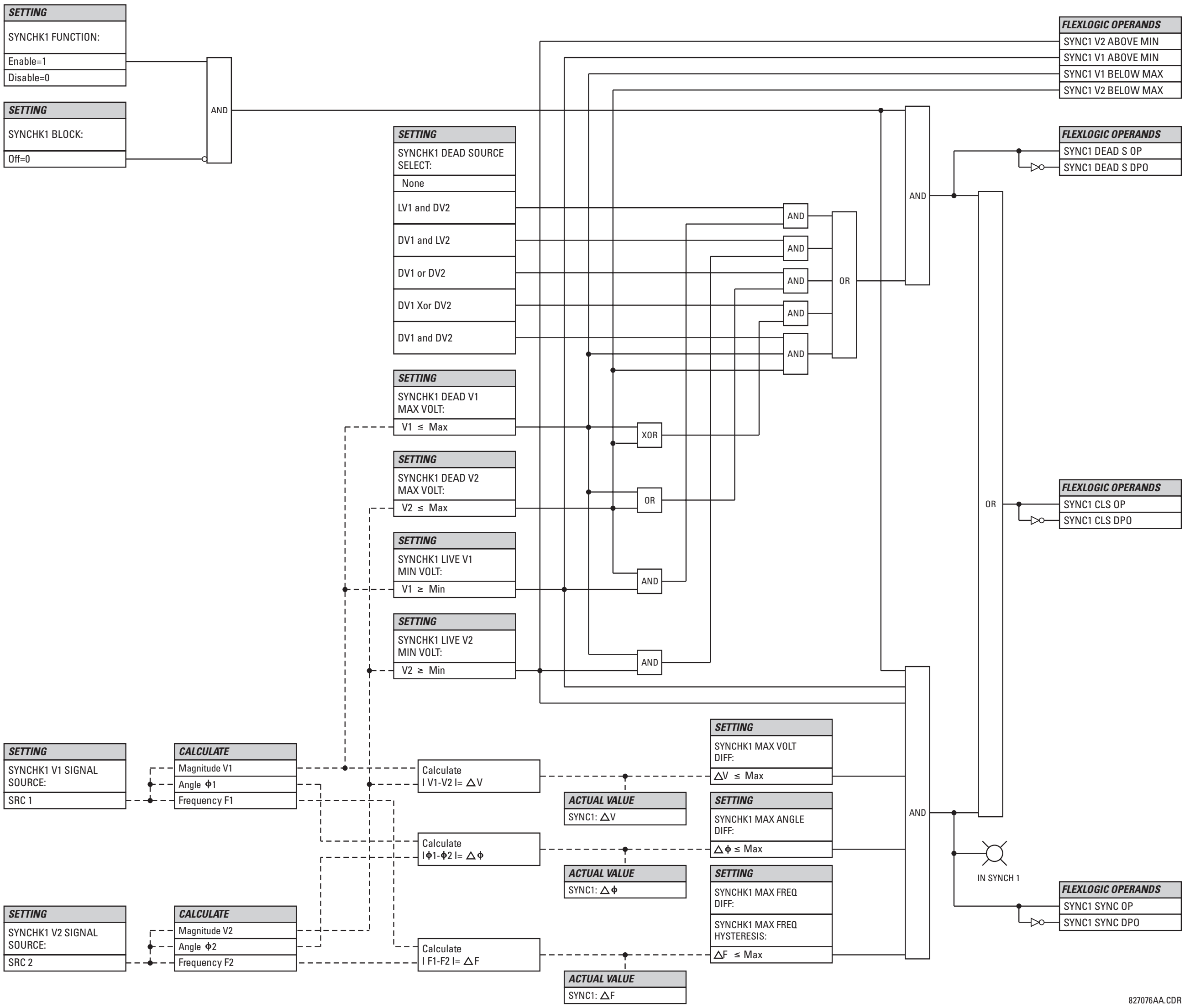


Figure 5–79: SYNCHROCHECK SCHEME LOGIC

5

5.6.8 AUTORECLOSE

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ AUTORECLOSE ⇨ AUTORECLOSE 1(2)

■ AUTORECLOSE 1 ■		AR1 FUNCTION: Disabled	Range: Disabled, Enabled
	MESSAGE	AR1 INITIATE: Off	Range: FlexLogic™ operand
	MESSAGE	AR1 BLOCK: Off	Range: FlexLogic™ operand
	MESSAGE	AR1 MAX NUMBER OF SHOTS: 1	Range: 1, 2, 3, 4
	MESSAGE	AR1 REDUCE MAX TO 1: Off	Range: FlexLogic™ operand
	MESSAGE	AR1 REDUCE MAX TO 2: Off	Range: FlexLogic™ operand
	MESSAGE	AR1 REDUCE MAX TO 3: Off	Range: FlexLogic™ operand
	MESSAGE	AR1 MANUAL CLOSE: Off	Range: FlexLogic™ operand
	MESSAGE	AR1 MNL RST FRM LO: Off	Range: FlexLogic™ operand
	MESSAGE	AR1 RESET LOCKOUT IF BREAKER CLOSED: Off	Range: Off, On
	MESSAGE	AR1 RESET LOCKOUT ON MANUAL CLOSE: Off	Range: Off, On
	MESSAGE	AR1 BKR CLOSED: Off	Range: FlexLogic™ operand
	MESSAGE	AR1 BKR OPEN: Off	Range: FlexLogic™ operand
	MESSAGE	AR1 BLK TIME UPON MNL CLS: 10.000 s	Range: 0.00 to 655.35 s in steps of 0.01
	MESSAGE	AR1 DEAD TIME 1: 1.000 s	Range: 0.00 to 655.35 s in steps of 0.01
	MESSAGE	AR1 DEAD TIME 2: 2.000 s	Range: 0.00 to 655.35 s in steps of 0.01
	MESSAGE	AR1 DEAD TIME 3: 3.000 s	Range: 0.00 to 655.35 s in steps of 0.01
	MESSAGE	AR1 DEAD TIME 4: 4.000 s	Range: 0.00 to 655.35 s in steps of 0.01
	MESSAGE	AR1 ADD DELAY 1: Off	Range: FlexLogic™ operand
	MESSAGE	AR1 DELAY 1: 0.000 s	Range: 0.00 to 655.35 s in steps of 0.01
	MESSAGE	AR1 ADD DELAY 2: Off	Range: FlexLogic™ operand

MESSAGE	▲▼	AR1 DELAY 2: 0.000 s	Range: 0.00 to 655.35 s in steps of 0.01
MESSAGE	▲▼	AR1 RESET LOCKOUT DELAY: 60.000	Range: 0.00 to 655.35 s in steps of 0.01
MESSAGE	▲▼	AR1 RESET TIME: 60.000 s	Range: 0.00 to 655.35 s in steps of 0.01
MESSAGE	▲▼	AR1 INCOMPLETE SEQ TIME: 5.000 s	Range: 0.00 to 655.35 s in steps of 0.01
MESSAGE	▲	AR1 EVENTS: Disabled	Range: Disabled, Enabled

The maximum number of autoreclosure elements available is equal to the number of installed CT banks.

The autoreclosure feature is intended for use with transmission and distribution lines, in three-pole tripping schemes for single breaker applications. Up to four selectable reclosures 'shots' are possible prior to locking out. Each shot has an independently settable dead time. The protection settings can be changed between shots if so desired, using FlexLogic™. Logic inputs are available for disabling or blocking the scheme.

Faceplate panel LEDs indicate the state of the autoreclose scheme as follows:

- Reclose Enabled: The scheme is enabled and may reclose if initiated.
- Reclose Disabled: The scheme is disabled.
- Reclose In Progress: An autoreclosure has been initiated but the breaker has not yet been signaled to close.
- Reclose Locked Out: The scheme has generated the maximum number of breaker closures allowed and, as the fault persists, will not close the breaker again; known as 'Lockout'. The scheme may also be sent in 'Lockout' when the incomplete sequence timer times out or when a block signal occurs while in 'reclose in progress'. The scheme must be reset from Lockout in order to perform reclose for further faults.

The reclosure scheme is considered *enabled* when all of the following conditions are true:

- The **AR1(2) FUNCTION** is set to "Enabled".
- The scheme is not in the 'Lockout' state.
- The 'Block' input is not asserted.
- The **AR1(2) BLK TIME UPON MNL CLS** timer is not active.

The autoreclose scheme is initiated by a trip signal from any selected protection feature operand. The scheme is initiated provided the circuit breaker is in the closed state before protection operation.

The reclose-in-progress (RIP) is set when a reclosing cycle begins following a reclose initiate signal. Once the cycle is successfully initiated, the RIP signal will seal-in and the scheme will continue through its sequence until one of the following conditions is satisfied:

- The close signal is issued when the dead timer times out, or
- The scheme goes to lockout.

While RIP is active, the scheme checks that the breaker is open and the shot number is below the limit, and then begins measuring the dead time.

Each of the four possible shots has an independently settable dead time. Two additional timers can be used to increase the initial set dead times 1 to 4 by a delay equal to **AR1(2) DELAY 1** or **AR1(2) DELAY 2** or the sum of these two delays depending on the selected settings. This offers enhanced setting flexibility using FlexLogic™ operands to turn the two additional timers "on" and "off". These operands may possibly include AR1 SHOT CNT =n, SETTING GROUP ACT 1, etc. The autoreclose provides up to maximum 4 selectable shots. Maximum number of shots can be dynamically modified through the settings **AR1(2) REDUCE MAX TO 1 (2, 3)**, using the appropriate FlexLogic™ operand.

Scheme lockout blocks all phases of the reclosing cycle, preventing automatic reclosure, if any of the following occurs:

- The maximum shot number was reached.
- A 'Block' input is in effect (for instance; Breaker Failure, bus differential protection operated, etc.).

- The ‘Incomplete Sequence’ timer times out.

The recloser will be latched in the Lockout state until a ‘reset from lockout’ signal is asserted, either from a manual close of the breaker or from a manual reset command (local or remote). The reset from lockout can be accomplished by operator command, by manually closing the breaker, or whenever the breaker has been closed and stays closed for a preset time.

After the dead time elapses, the scheme issues the close signal. The close signal is latched until the breaker closes or the scheme goes to Lockout.

A reset timer output resets the recloser following a successful reclosure sequence. The reset time is based on the breaker ‘reclaim time’ which is the minimum time required between successive reclose sequences.

SETTINGS:

- **AR1(2) INITIATE:** Selects the FlexLogic™ operand that initiates the scheme, typically the trip signal from protection.
- **AR1(2) BLOCK:** Selects the FlexLogic™ operand that blocks the autoreclosure initiate (it could be from the breaker failure, bus differential protection, etc.).
- **AR1(2) MAX NUMBER OF SHOTS:** Specifies the number of reclosures that can be attempted before reclosure goes to “Lockout” because the fault is permanent.
- **AR1(2) REDUCE MAX TO 1(3):** Selects the FlexLogic™ operand that changes the maximum number of shots from the initial setting to 1, 2, or 3, respectively.
- **AR1(2) MANUAL CLOSE:** Selects the logic input set when the breaker is manually closed.
- **AR1(2) MNL RST FRM LO:** Selects the FlexLogic™ operand that resets the autoreclosure from Lockout condition. Typically this is a manual reset from lockout, local or remote.
- **AR1(2) RESET LOCKOUT IF BREAKER CLOSED:** This setting allows the autoreclose scheme to reset from Lockout if the breaker has been manually closed and stays closed for a preset time. In order for this setting to be effective, the next setting (**AR1(2) RESET LOCKOUT ON MANUAL CLOSE**) should be disabled.
- **AR1(2) RESET LOCKOUT ON MANUAL CLOSE:** This setting allows the autoreclose scheme to reset from Lockout when the breaker is manually closed regardless if the breaker remains closed or not. This setting overrides the previous setting (**AR1 RESET LOCKOUT IF BREAKER CLOSED**).
- **AR1(2) BLK TIME UPON MNL CLS:** The autoreclose scheme can be disabled for a programmable time delay after the associated circuit breaker is manually closed. This prevents reclosing onto a fault after a manual close. This delay must be longer than the slowest expected trip from any protection not blocked after manual closing. If no overcurrent trips occur after a manual close and this time expires, the autoreclose scheme is enabled.
- **AR1(2) DEAD TIME 1 to AR1(2) DEAD TIME 4:** These are the intentional delays before first, second, third, and fourth breaker automatic reclosures (1st, 2nd, and 3rd shots), respectively, and should be set longer than the estimated deionizing time following a three pole trip.
- **AR1(2) ADD DELAY 1:** This setting selects the FlexLogic™ operand that introduces an additional delay (Delay 1) to the initial set Dead Time (1 to 4). When this setting is “Off”, Delay 1 is by-passed.
- **AR1(2) DELAY 1:** This setting establishes the extent of the additional dead time Delay 1.
- **AR1(2) ADD DELAY 2:** This setting selects the FlexLogic™ operand that introduces an additional delay (Delay 2) to the initial set Dead Time (1 to 4). When this setting is “Off”, Delay 2 is by-passed.
- **AR1(2) DELAY 2:** This setting establishes the extent of the additional dead time Delay 2.
- **AR1(2) RESET LOCKOUT DELAY:** This setting establishes how long the breaker should stay closed after a manual close command, in order for the autorecloser to reset from Lockout.
- **AR1(2) RESET TIME**: A reset timer output resets the recloser following a successful reclosure sequence. The setting is based on the breaker ‘reclaim time’ which is the minimum time required between successive reclose sequences.
- **AR1(2) INCOMPLETE SEQ TIME**: This timer defines the maximum time interval allowed for a single reclose shot. It is started whenever a reclosure is initiated and is active when the scheme is in the ‘reclose-in-progress’ state. If all conditions allowing a breaker closure are not satisfied when this time expires, the scheme goes to “Lockout”.

NOTE

This timer must be set to a delay less than the reset timer.

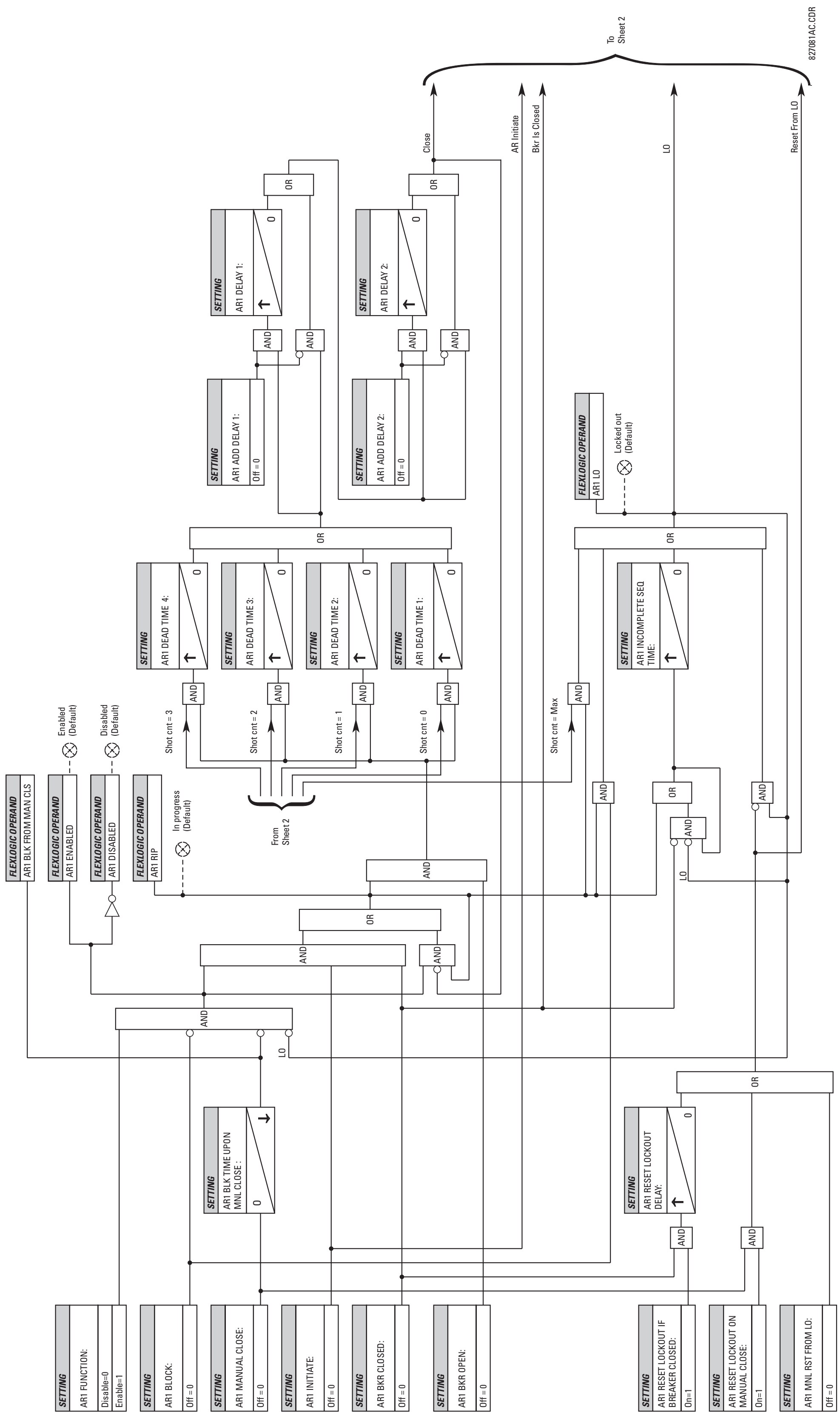


Figure 5–80: AUTORECLOSURE SCHEME LOGIC (Sheet 1 of 2)

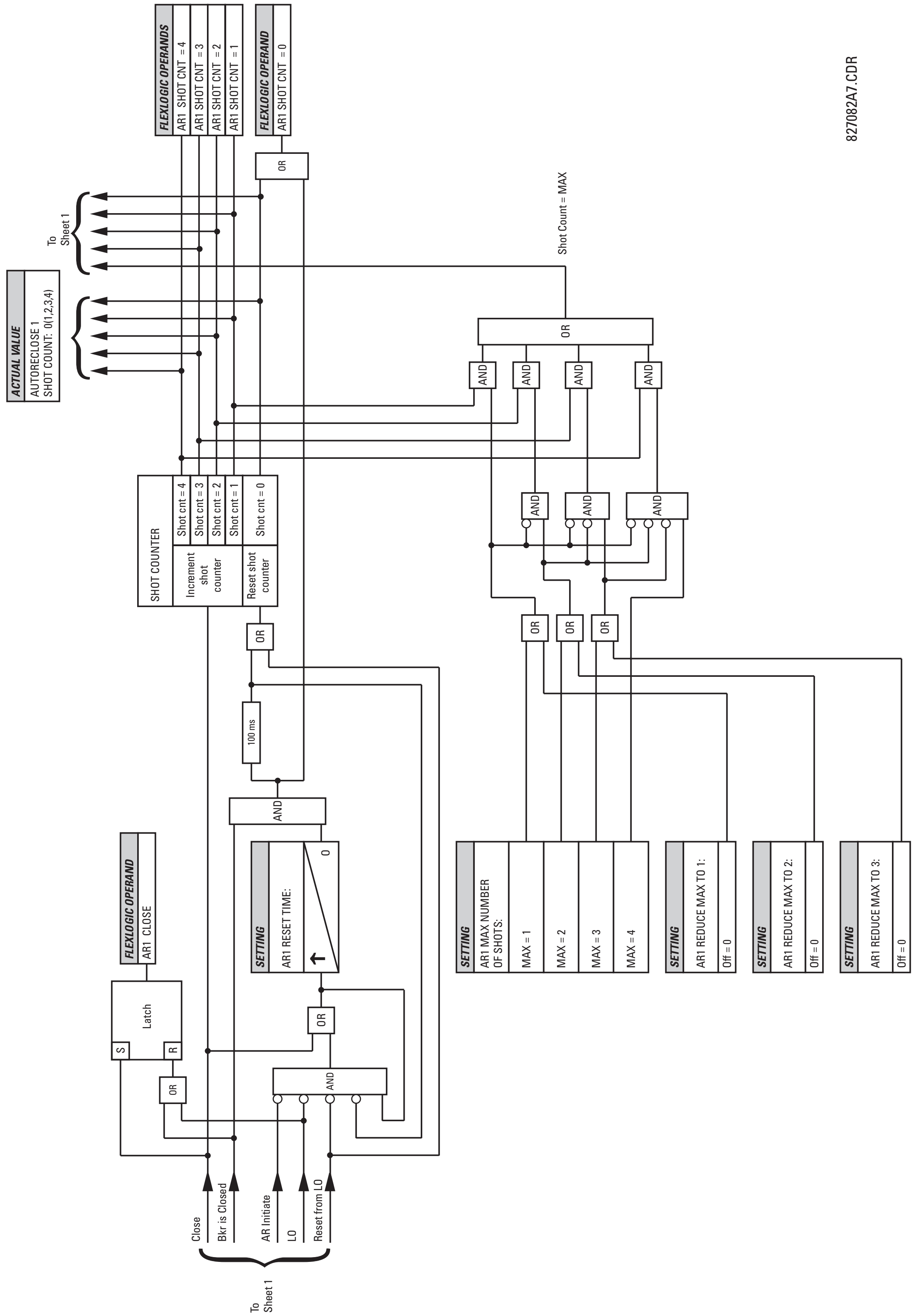


Figure 5–81: AUTORECLOSURE SCHEME LOGIC (Sheet 2 of 2)

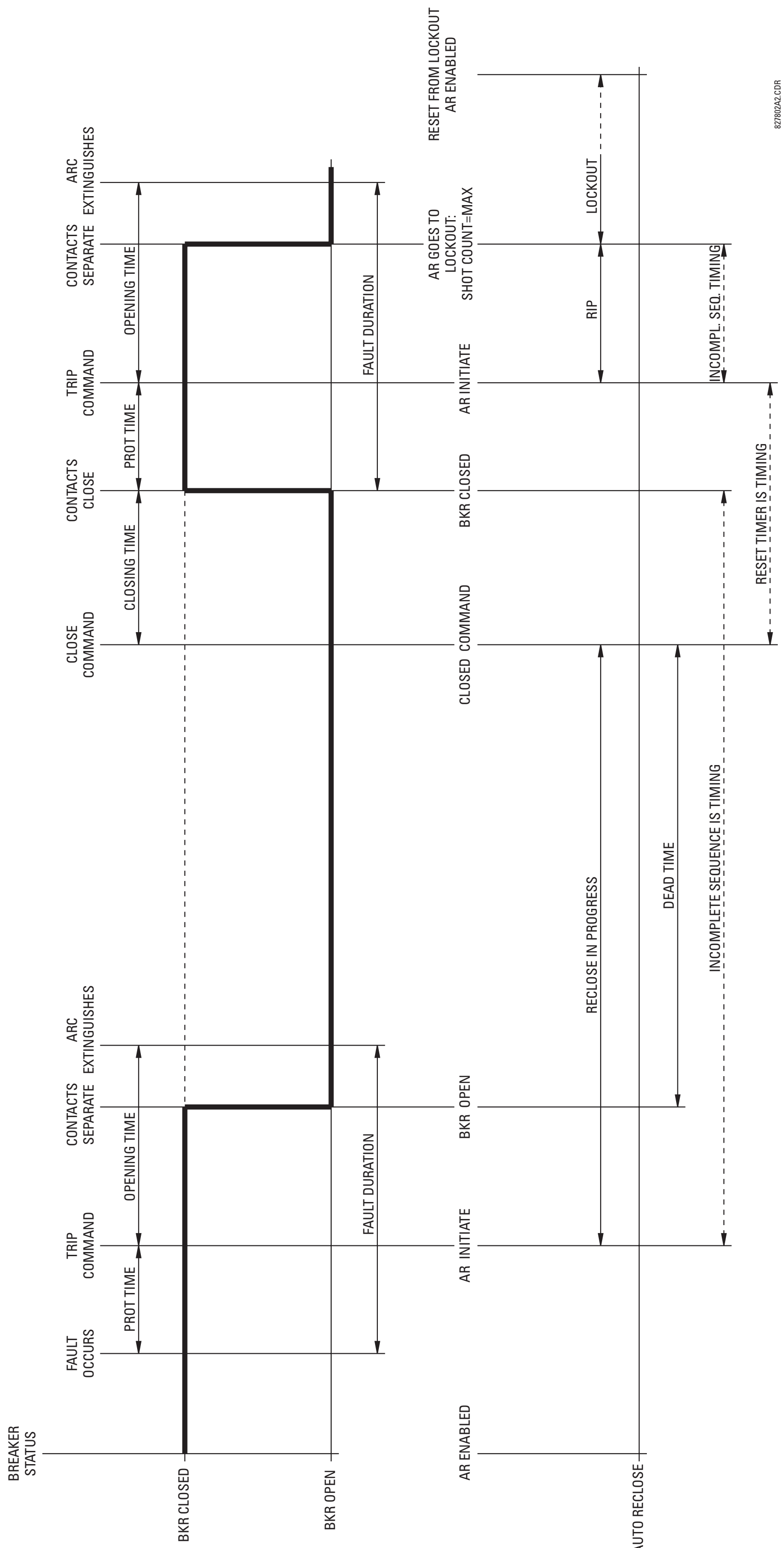


Figure 5–82: SINGLE SHOT AUTORECLOSING SEQUENCE - PERMANENT FAULT

5.6.9 DIGITAL ELEMENTS

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ DIGITAL ELEMENTS ⇨ DIGITAL ELEMENT 1(48)

■ DIGITAL ELEMENT 1 ■	DIGITAL ELEMENT 1 FUNCTION: Disabled	*Range: Disabled, Enabled*
MESSAGE	DIG ELEM 1 NAME: Dig Element 1	*Range: 16 alphanumeric characters*
MESSAGE	DIG ELEM 1 INPUT: Off	*Range: FlexLogic™ operand*
MESSAGE	DIG ELEM 1 PICKUP DELAY: 0.000 s	*Range: 0.000 to 999999.999 s in steps of 0.001*
MESSAGE	DIG ELEM 1 RESET DELAY: 0.000 s	*Range: 0.000 to 999999.999 s in steps of 0.001*
MESSAGE	DIG ELEMENT 1 PICKUP LED: Enabled	*Range: Disabled, Enabled*
MESSAGE	DIG ELEM 1 BLOCK: Off	*Range: FlexLogic™ operand*
MESSAGE	DIGITAL ELEMENT 1 TARGET: Self-reset	*Range: Self-reset, Latched, Disabled*
MESSAGE	DIGITAL ELEMENT 1 EVENTS: Disabled	*Range: Disabled, Enabled*

There are 48 identical digital elements available, numbered 1 to 48. A digital element can monitor any FlexLogic™ operand and present a target message and/or enable events recording depending on the output operand state. The digital element settings include a name which will be referenced in any target message, a blocking input from any selected FlexLogic™ operand, and a timer for pickup and reset delays for the output operand.

- **DIGITAL ELEMENT 1 INPUT:** Selects a FlexLogic™ operand to be monitored by the digital element.
- **DIGITAL ELEMENT 1 PICKUP DELAY:** Sets the time delay to pickup. If a pickup delay is not required, set to "0".
- **DIGITAL ELEMENT 1 RESET DELAY:** Sets the time delay to reset. If a reset delay is not required, set to "0".
- **DIGITAL ELEMENT 1 PICKUP LED**: This setting enables or disabled the digital element pickup LED. When set to "Disabled", the operation of the pickup LED is blocked.

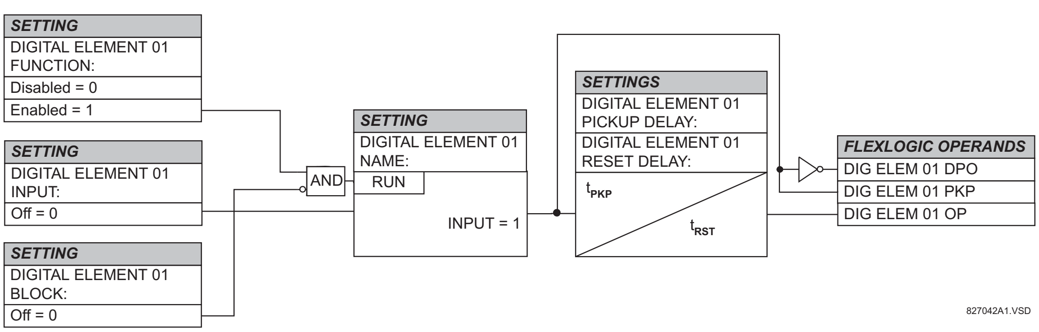


Figure 5–83: DIGITAL ELEMENT SCHEME LOGIC

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.

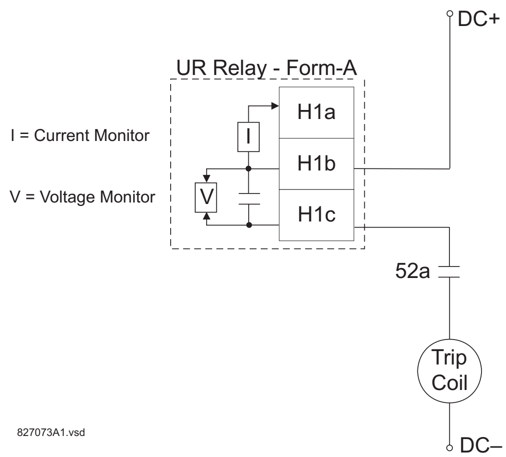


Figure 5–84: TRIP CIRCUIT EXAMPLE 1

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:

■ 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: Cont Ip 1 Off
MESSAGE		DIGITAL ELEMENT 1 TARGET: Self-reset
MESSAGE		DIGITAL ELEMENT 1 EVENTS: Enabled

NOTE

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

EXAMPLE 2: BREAKER TRIP CIRCUIT INTEGRITY MONITORING

If it is required to monitor the trip circuit continuously, independent of the breaker position (open or closed), a method to maintain the monitoring current flow through the trip circuit when the breaker is open must be provided (as shown in the figure below). This can be achieved by connecting a suitable resistor (see figure below) across the auxiliary contact in the trip circuit. In this case, it is not required to supervise the monitoring circuit with the breaker position – the **BLOCK** setting is selected to “Off”. In this case, the settings 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
```

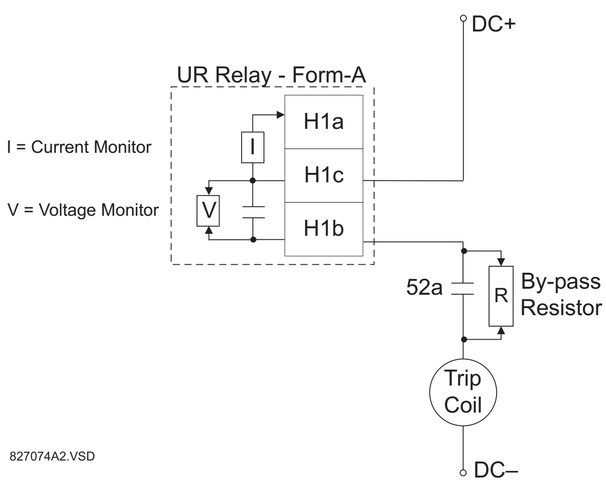


Figure 5–85: TRIP CIRCUIT EXAMPLE 2

Table 5–20: 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

5.6.10 DIGITAL COUNTERS

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.

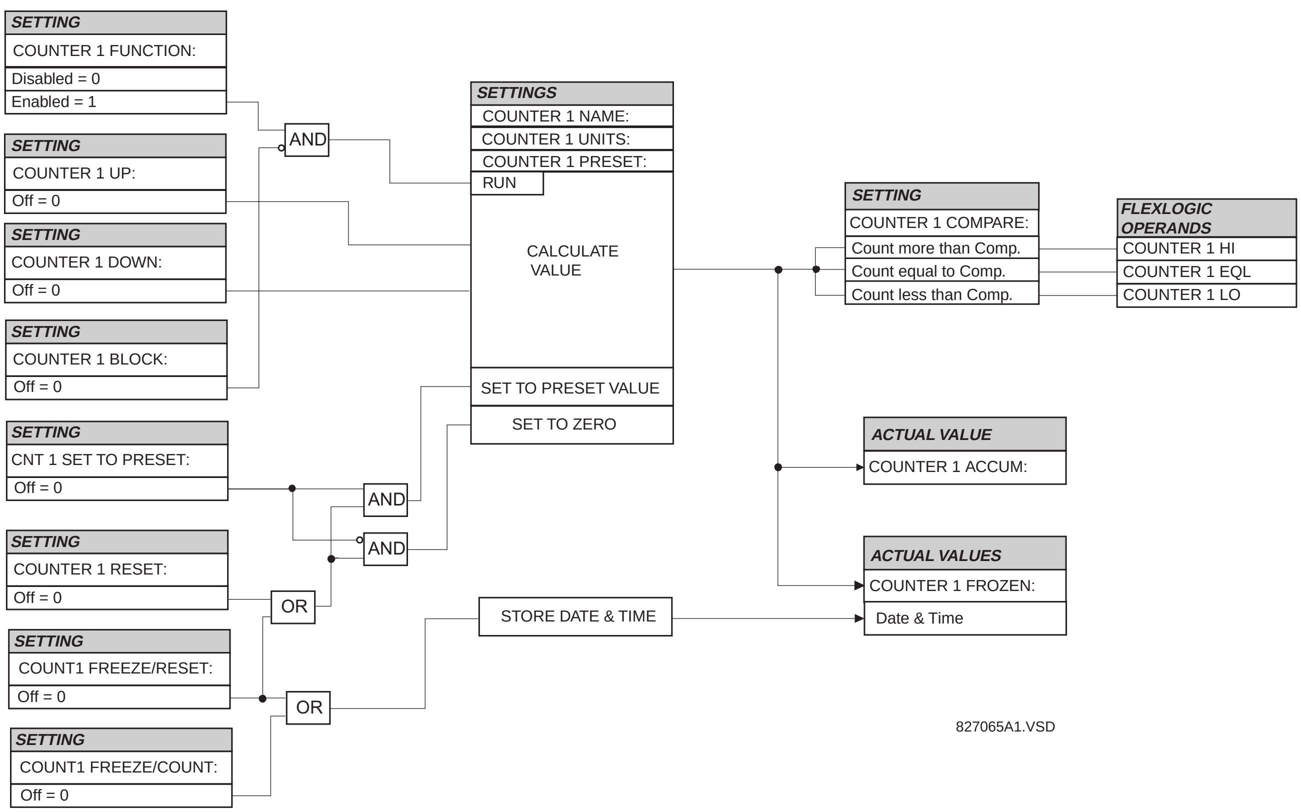


Figure 5–86: DIGITAL COUNTER SCHEME LOGIC

5.6.11 MONITORING ELEMENTS

a) MAIN MENU

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ MONITORING ELEMENTS

■ MONITORING ■ ELEMENTS	◁▷	■ HI-Z ■	See page 5-153.
MESSAGE	△▽	■ BREAKER 1 ■ ARCING CURRENT	See page 5-159.
MESSAGE	△▽	■ BREAKER 2 ■ ARCING CURRENT	See page 5-159.
MESSAGE	△▽	■ BREAKER ■ FLASHOVER 1	See page 5-161.
MESSAGE	△▽	■ BREAKER ■ FLASHOVER 2	See page 5-161.
MESSAGE	△▽	■ VT FUSE FAILURE 1 ■	See page 5-164.
MESSAGE	△	■ VT FUSE FAILURE 2 ■	See page 5-164.

b) HI-Z

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ MONITORING ELEMENTS ⇨ HI-Z

■ HI-Z ■	◁▷	HI-Z FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	△▽	HI-Z SOURCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE	△▽	HI-Z ARCING SENSITIVITY: 5	Range: 1 to 10 in steps of 1
MESSAGE	△▽	HI-Z PHASE EVENT COUNT: 30	Range: 10 to 250 in steps of 1
MESSAGE	△▽	HI-Z GROUND EVENT COUNT: 30	Range: 10 to 500 in steps of 1
MESSAGE	△▽	HI-Z EVENT COUNT TIME: 15 min	Range: 5 to 180 min. in steps of 1
MESSAGE	△▽	HI-Z OC PROTECTION COORD TIMEOUT: 15 s	Range: 10 to 200 s in steps of 1
MESSAGE	△▽	HI-Z PHASE OC MIN PICKUP: 1.50 pu	Range: 0.01 to 10.00 pu in steps of 0.01
MESSAGE	△▽	HI-Z NEUTRAL OC MIN PICKUP: 1.00 pu	Range: 0.01 to 10.00 pu in steps of 0.01
MESSAGE	△▽	HI-Z PHASE RATE OF CHANGE: 150 A/2cycle	Range: 1 to 999 A/2cycle in steps of 1
MESSAGE	△▽	HI-Z NEUTRAL RATE OF CHANGE: 150 A/2cycle	Range: 1 to 999 A/2cycle in steps of 1
MESSAGE	△▽	HI-Z LOSS OF LOAD THRESHOLD: 15%	Range: 5 to 100% in steps of 1

MESSAGE	HI-Z 3-PHASE EVENT THRESHOLD: 25 A	Range: 1 to 1000 A in steps of 1
MESSAGE	HI-Z VOLTAGE SUPV THRESHOLD: 5%	Range: 0 (off) to 100% in steps of 1
MESSAGE	HI-Z VOLTAGE SUPV DELAY: 60 cycles	Range: 0 to 300 cycles in steps of 2
MESSAGE	HI-Z EVEN HARMONIC RESTRAINT: 20%	Range: 0 to 100% in steps of 1
MESSAGE	HI-Z TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	HI-Z EVENTS: Disabled	Range: Disabled, Enabled

Some faults in overhead distribution feeders are characterized by low fault current due to high ground resistance. If the fault current is in the order of expected unbalance load or less, it cannot be reliably detected by overcurrent protection. These faults are classified as high-impedance (Hi-Z) faults. Since a Hi-Z fault is not accompanied by excessive current, it is generally not dangerous to the electrical installation except for some damage to the overhead conductor at the fault location. However, an undetected Hi-Z fault is a risk to people and property as well as having a potential to evolve into a full-blown fault.

The following event types are associated with Hi-Z faults. It is assumed that for all cases that ground is involved.

- High impedance fault: a fault with fault impedance sufficiently high such that it is not detected by overcurrent protection
- High impedance, downed conductor fault: a high impedance fault for which the primary conductor is no longer intact on pole top insulators, but instead is in contact with earth or a grounded object
- Arcing fault: any high impedance fault which exhibits arcing

Combinations of these events are possible: for example, an arcing high impedance, downed conductor fault. The Hi-Z element is intended to detect high impedance faults that arc and to differentiate those that are downed conductors from those that are not. It should be noted that no known technology can detect all Hi-Z faults.

The Hi-Z element was primarily designed for solidly grounded systems. The similar Hi-Z element in the DFM200 relay has been tested with some success on impedance grounded systems as well. However, there are no guarantees of certain operation of the high impedance fault detection element on non-solidly grounded systems.

The Hi-Z data collection consists of RMS Data Capture and Hi-Z Data capture:

- **RMS Data Capture:** The RMS data captures are triggered by two-cycle Hi-Z overcurrent conditions, loss of load conditions, and high arc confidence conditions. Captures triggered by loss of load and high arc confidence conditions are saved to a temporary capture table, and deleted if the event does not result in an Arcing or Downed Conductor condition. The relay maintains a history of four captures and utilizes a combination of age, priority and access for determining which capture to save.

  The RMS data capture contains the two-cycle RMS values for the voltage and current for each of the phases and current for the neutral channel. The capture frequency is half the system frequency. Each capture contains 1800 points.
- **High-Z Data Capture**: Hi-Z Data Captures are triggered and maintained in an identical manner as RMS Data Captures. The relay maintains four captures of 300 records each. The capture frequency is 1 Hz and the data collected is defined in the following two tables.

Table 5–21: HI-Z SPECIFIC DATA

#	NAME	DESCRIPTION
0	EadCounts	Total number of EAD counts for the phase
1	ArcConfidence	ArcConfidence for the phase
2	AccumArcConf	Accumulated ArcConfidence for the phase
3	RmsCurrent	The 2-cycle RMS current for the phase
4	HighROC	Flag indicating a high rate of change was detected
5	IOC	Flag indicating an instantaneous 2-cycle overcurrent was detected
6	LossOfLoad	Flag indicating a loss of load was detected
7	EadZeroed	Flag indicating that this phase's EAD table was cleared
8	HighZArmed	Flag indicating that this phase is armed for a high-Z detection
9	VoltageDip	Flag indicating that a voltage dip was detected on this phase
10	HighEad	Flag indicating that a high arc confidence occurred on this phase
11	ArcBurst	Flag indicating that an arc burst was identified on this phase
12	VDisturbanceCc	Cycle-to-cycle voltage disturbance
13	VDisturbanceAbs	Absolute voltage disturbance
14	HarmonicRestraint	Harmonic Restraint

Table 5–22: HI-Z CAPTURE DATA

#	NAME	DESCRIPTION
1	StatusMask	Bit-mask of the algorithm state (16 bits) BIT_ARCING BIT_DOWNED_COND BIT_ARC_TREND BIT_PHASE_A BIT_PHASE_B BIT_PHASE_C BIT_PHASE_N BIT_IOC_A BIT_IOC_B BIT_IOC_C BIT_IOC_N BIT_LOL_A BIT_LOL_B BIT_LOL_C BIT_I_DISTURBANCE BIT_V_DISTURBANCE
2	AlgorithmState	Present value of the High-Z output state machine: Normal = 0, Coordination Timeout = 1, Armed = 2, Arcing = 5, Downed Conductor = 9
3	EadZeroedFlag	Flag indicating the EAD table was cleared
4	SpectralFlag	Flag indicating the Spectral algorithm has found a match
5	ThreePhaseFlag	Flag indicating a three phase event was detected
6	PhaseInfo[4]	Phase specific information for the three phase currents and the neutral (see table below)

The algorithm is in "Normal" state when it detects no abnormal activity on the power system. While in the "Normal" state, any one of several power system events (a high output of the Expert Arc Detector, a significant loss of load, or a Hi-Z overcurrent) cause the algorithm to move to the "Coordination Timeout" state, where it remains for the time specified by the **OC PROTECTION COORD TIMEOUT** setting. Following this interval, the algorithm moves into its "Armed" state. The criteria for detecting arcing or a downed conductor are:

1. the Expert Arc Detector Algorithm's output reaches a high level enough times, and
2. its high level was last reached when the algorithm's state was "Armed".

The "Arcing Sensitivity" setting determines what level constitutes a "high" output from the Expert Arc Detector Algorithm, and the number that constitutes what "enough times" means. If these criteria are met, the algorithm temporarily moves to either the "Arcing" state or the "Downed Conductor" state, the difference being determined by whether or not there was a significant, precipitous loss of load (as determined by the **LOSS OF LOAD THRESHOLD** user setting) or a Hi-Z overcurrent (as determined by the **PHASE OC MIN PICKUP** and **NEUTRAL OC MIN PICKUP** user settings). If either of these caused the algorithm to move from its “Normal” state to its “Coordination Timeout” state, then the algorithm moves to the “Downed Conductor” state temporarily. Otherwise, it temporarily moves to the “Arcing” state. After pulsing either of these outputs, the algorithm's state returns to “Normal”. Also, if two minutes pass without high levels from the Expert Arc Detector Algorithm while the algorithm is in its Armed state, then it moves from the “Armed” state directly back to the “Normal” state.

The Hi-Z settings are described below:

- **HI-Z SOURCE**: Selects the source for the RMS currents and voltages used in Hi-Z algorithms. The source should include currents from the 8F/8G CT module and appropriate voltages. If the source does not include voltages, Voltage Supervision is disabled.
- **HI-Z ARCING SENSITIVITY**: This setting establishes the belief-in-arcing confidence level at which the Hi-Z element will recognize arcing and the number of times the algorithm must conform its belief in arcing before it produces an output. The range is 1 to 10, where 10 is the most sensitive and 1 is the least sensitive setting.

  A higher setting would be suitable for a very quiet, well-behaved power system. An initial setting of 5 is suggested if the user has no previous experience with the Hi-Z element.
- **HI-Z PHASE EVENT COUNT**: Specifies how many individual belief-in-arcing indications for a phase current must be counted in a specified time period before it is determined that an arcing-suspected event exists. These belief-in-arcing indications are detected by arc detection algorithms (energy and randomness) for a specific set of non-fundamental frequency component energies. This setting affects only the Hi-Z Arcing Suspected outputs.
- **HI-Z GROUND EVENT COUNT**: Specifies how many individual belief-in-arcing indications for a ground/neutral current must be counted in a specified time period before it is determined that an arcing-suspected event exists. These belief-in-arcing indications are detected by arc detection algorithms (energy and randomness) for a specific set of non-fundamental frequency component energies. This setting affects only the Hi-Z Arcing Suspected outputs.

5

- **HI-Z EVENT COUNT TIME**: Specifies the time (in minutes) over which the relay monitors long-term, sporadic, arcing events for determination of an arcing-suspected event. This setting affects only the Hi-Z Arcing Suspected outputs.
- **HI-Z OC PROTECTION COORD TIMEOUT**: This setting coordinates between the Hi-Z element and conventional feeder overcurrent protection. A downed conductor or an arcing, intact conductor will not be indicated before the expiration of this timeout, which begins when the Hi-Z element detects a trigger condition (i.e. loss of load, high rate of change, overcurrent, breaker open, or high belief-in-arcing confidence). Note that this is a minimum operating time; the actual operating time will depend on the fault characteristics and will likely be significantly longer than this setting.

  This value should be such that the conventional feeder overcurrent protection is given an opportunity to operate before the timeout expires. It is recommended that this timeout value not exceed 30 seconds, because arcing fault current often diminishes as the fault progresses, making the fault more difficult to detect with increasing time. After the timeout has expired, at least one additional arc burst must occur in order for the Hi-Z element to proceed with its analysis.
- **HI-Z PHASE OC MIN PICKUP**: Phase overcurrent minimum pickup indicates the level at which the Hi-Z element considers a phase current to be an overcurrent condition. The Hi-Z detection algorithms will ignore all data as long as an overcurrent condition exists on the system, because it is assumed that conventional feeder overcurrent protection will clear an overcurrent fault. It is recommended that this setting is above the maximum load current.
- **HI-Z NEUTRAL OC MIN PICKUP**: Neutral overcurrent minimum pickup indicates the level at which the Hi-Z element considers a neutral current to be an overcurrent condition. The Hi-Z detection algorithms will ignore all data as long as an overcurrent condition exists on the system, because it is assumed that conventional feeder overcurrent protection will clear an overcurrent fault. It is recommended that this setting is above the maximum 3Io (residual) current due to unbalanced loading.
- **HI-Z PHASE RATE OF CHANGE**: Establishes a threshold for determining when a high rate-of-change event occurs on a phase RMS current. An extremely high rate of change is not characteristic of most high impedance faults; it is more indicative of a low impedance fault or of the inrush of breaker closing. The inrush current produces substantial variations in the harmonics used by the high impedance algorithms. Therefore these algorithms ignore all data for several seconds following a high rate-of-change event that exceeds this setting.

  The RMS currents in the Hi-Z algorithms are calculated over a two-cycle time window. The rate-of-change is calculated as the difference between two consecutive two-cycle RMS readings. The recommended setting is 150 A per two-cycle interval. ***The setting is given in primary amperes***.

- **HI-Z NEUTRAL RATE OF CHANGE**: Establishes a threshold for determining when a high rate-of-change event occurs on a neutral RMS current. An extremely high rate of change is not characteristic of most high impedance faults; it is more indicative of a breaker closing, causing associated inrush. The inrush current produces substantial variations in the harmonics used by the high impedance algorithms. Therefore, these algorithms ignore all data for several seconds following a high rate-of-change event exceeding this setting.

  The RMS currents in the Hi-Z algorithms are calculated over a two-cycle time window. The rate-of-change is calculated as the difference between two consecutive two-cycle RMS readings. The recommended setting is 150 A per two-cycle interval. ***The setting is given in primary amperes***.

- **HI-Z LOSS OF LOAD THRESHOLD**: Establishes the loss of load level used as an indication of a downed conductor. A Loss of Load flag is set if the Hi-Z algorithms detect a percentage drop in phase current between two successive two-cycle RMS values that equals or exceeds the Loss of Load Threshold. The amount the phase current must decrease between successive two-cycle RMS values is based on this setting times the recent average phase current level. The range is 5 to 100%; 5% being the most sensitive.

- **HI-Z 3-PHASE EVENT THRESHOLD**: Establishes the level at which the Hi-Z element characterizes a sudden three-phase current increase as a three-phase event. The Hi-Z detection algorithms ignore the data generated by a large three-phase event. The recommended setting is 25 A (*primary*).

- **HI-Z VOLTAGE SUPV THRESHOLD**: In the event that a fault simultaneously occurs on two adjacent feeders (line voltage from the same bus), the drop in line voltage will cause a subsequent drop in load current. This function will block the Loss of Load flag from being set while the voltage is depressed. Thus, if the voltage level drops by a percentage greater than this threshold in successive two-cycle RMS samples, the Loss of Load flag will be blocked. If the setting is "0", the voltage supervision function will be disabled.

- **HI-Z VOLTAGE SUPV DELAY**: This setting adds time delay to the voltage supervision function. Specifically, the Loss of Load flag will continue to be blocked for the number of cycles specified by this setting.

- **HI-Z EVEN HARMONIC RESTRAINT**: This setting determines the level of the even harmonic at which the setting of the overcurrent flags is inhibited. The even harmonic content is evaluated on each phase current as a percentage of that phase's RMS current. The intent is to inhibit the setting of the overcurrent flags if the overcurrent is simply a surge caused by cold-load pickup or other inrush event.

NOTE

IMPORTANT NOTE REGARDING INSTALLATION: The F60 Hi-Z algorithm is adaptive in nature. The algorithm's internal thresholds gradually adapt to background "noise" on circuits with a moderate to high level of transient activity. For the first three to five days after installation (or after being out-of-service for a significant period), the F60 may identify some of this noise as arcing. This should be taken into account when responding to alarms during these type of operating periods.

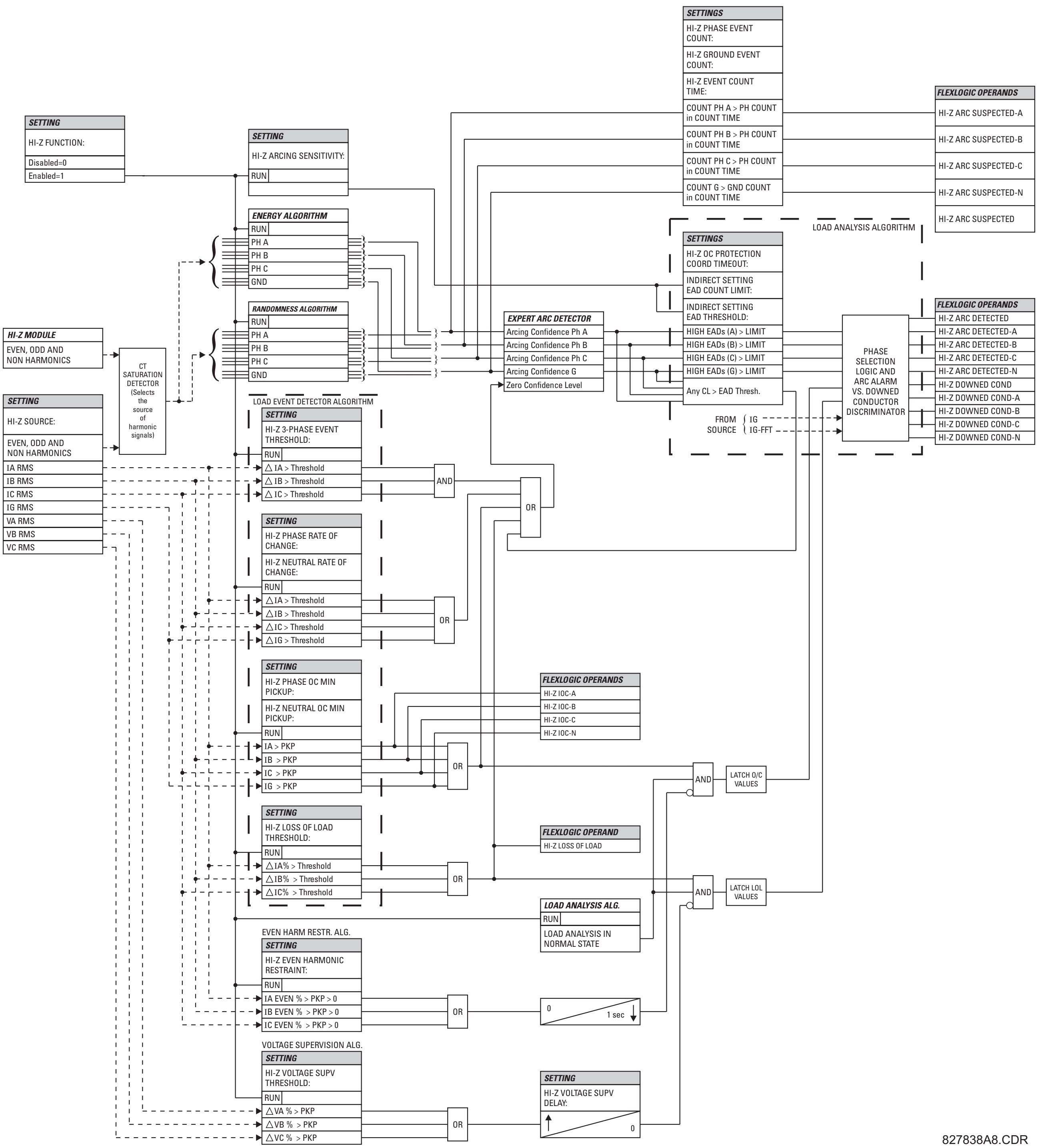


Figure 5–87: HI-Z SCHEME LOGIC

c) BREAKER ARCING CURRENT

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ MONITORING ELEMENTS ⇨ BREAKER 1(2) ARCING CURRENT

■ BREAKER 1 ■ ARCING CURRENT	◀▶	BKR 1 ARC AMP FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	▲▼	BKR 1 ARC AMP SOURCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE	▲▼	BKR 1 ARC AMP INT-A: Off	Range: FlexLogic™ operand
MESSAGE	▲▼	BKR 1 ARC AMP INT-B: Off	Range: FlexLogic™ operand
MESSAGE	▲▼	BKR 1 ARC AMP INT-C: Off	Range: FlexLogic™ operand
MESSAGE	▲▼	BKR 1 ARC AMP DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
MESSAGE	▲▼	BKR 1 ARC AMP LIMIT: 1000 kA2-cyc	Range: 0 to 50000 kA^2-cycle in steps of 1
MESSAGE	▲▼	BKR 1 ARC AMP BLOCK: Off	Range: FlexLogic™ operand
MESSAGE	▲▼	BKR 1 ARC AMP TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	▲	BKR 1 ARC AMP EVENTS: Disabled	Range: Disabled, Enabled

There is one Breaker Arcing Current element available per CT bank, with a minimum of 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(2) menus.

- **BKR 1(2) ARC AMP INT-A(C):** Select the same output operands that are configured to operate the output relays used to trip the breaker. In three-pole tripping applications, the same operand should be configured to initiate arcing current calculations for poles A, B and C of the breaker. In single-pole tripping applications, per-pole tripping operands should be configured to initiate the calculations for the poles that are actually tripped.
- **BKR 1(2) 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(2) ARC AMP LIMIT:** Selects the threshold value above which the output operand is set.

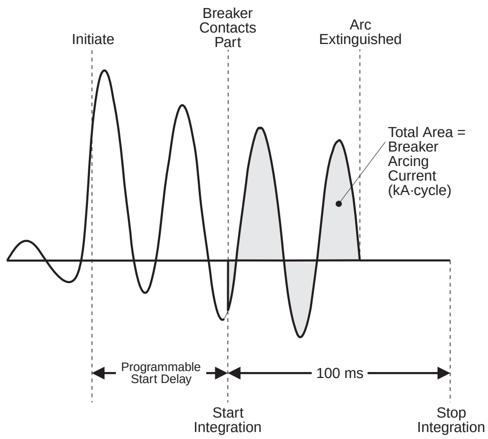


Figure 5–88: ARCING CURRENT MEASUREMENT

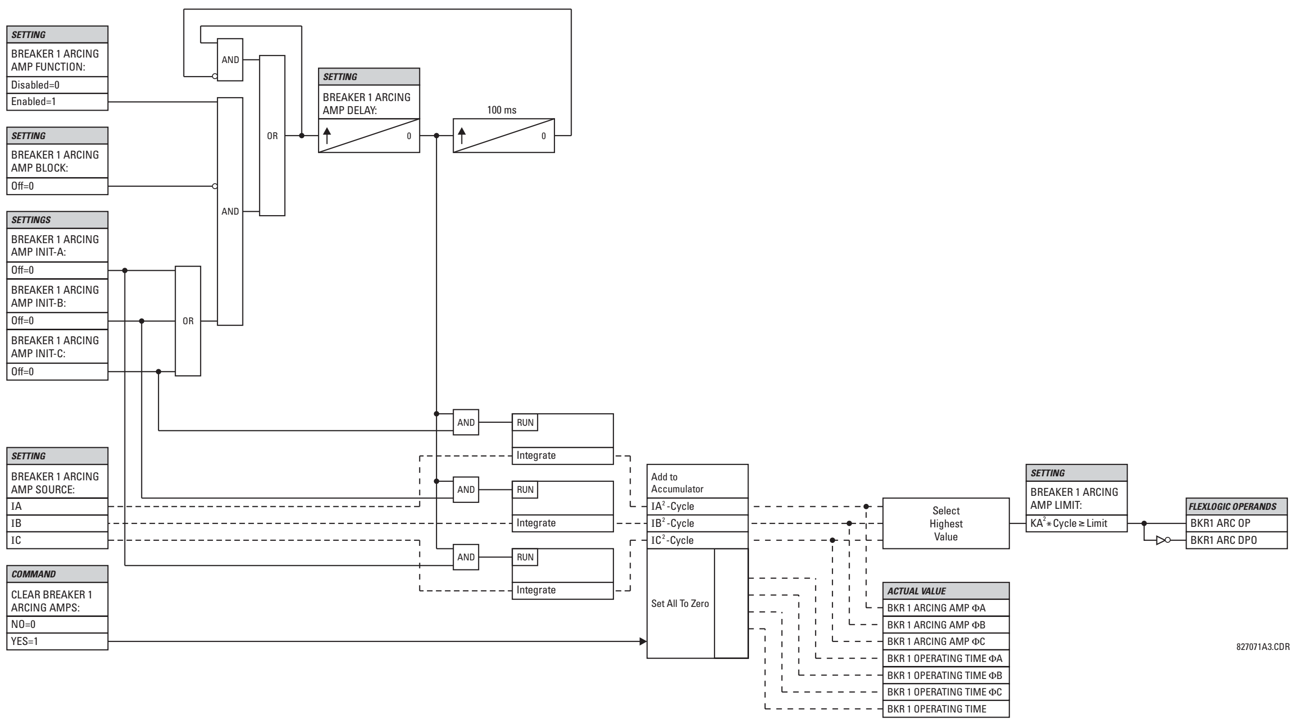


Figure 5–89: BREAKER ARCING CURRENT SCHEME LOGIC

d) 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
MESSAGE	▲▼	BKR 1 FLSHOVR SIDE 2 SRC: None	Range: None, SRC 1, SRC 2
MESSAGE	▲▼	BKR 1 STATUS CLSD A: Off	Range: FlexLogic™ operand
MESSAGE	▲▼	BKR 1 STATUS CLSD B: Off	Range: FlexLogic™ operand
MESSAGE	▲▼	BKR 1 STATUS CLSD C: Off	Range: FlexLogic™ operand
MESSAGE	▲▼	BKR 1 FLSHOVR V PKP: 0.850 pu	Range: 0.000 to 1.500 pu in steps of 0.001
MESSAGE	▲▼	BKR 1 FLSHOVR DIFF V PKP: 1000 V	Range: 0 to 100000 V in steps of 1
MESSAGE	▲▼	BKR 1 FLSHOVR AMP PKP: 0.600 pu	Range: 0.000 to 1.500 pu in steps of 0.001
MESSAGE	▲▼	BKR 1 FLSHOVR PKP DELAY: 0.100 s	Range: 0.000 to 65.535 s in steps of 0.001
MESSAGE	▲▼	BKR 1 FLSHOVR SPV A: Off	Range: FlexLogic™ operand
MESSAGE	▲▼	BKR 1 FLSHOVR SPV B: Off	Range: FlexLogic™ operand
MESSAGE	▲▼	BKR 1 FLSHOVR SPV C: Off	Range: FlexLogic™ operand
MESSAGE	▲▼	BKR 1 FLSHOVR BLOCK: Off	Range: FlexLogic™ operand
MESSAGE	▲▼	BKR 1 FLSHOVR TAR-GET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	▲	BKR 1 FLSHOVR EVENTS: Disabled	Range: Disabled, Enabled

The detection of the breaker flashover is based on the following condition:

1. Breaker open,
2. Voltage drop measured from either side of the breaker during the flashover period,
3. Voltage difference drop, and
4. Measured flashover current through the breaker.

Furthermore, the scheme is applicable for cases where either one or two sets of three-phase voltages are available across the breaker.

5

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.

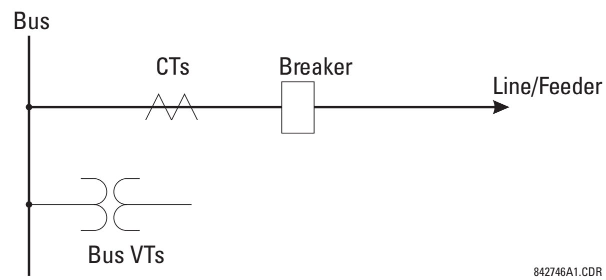
NOTE

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. ∆VA is greater than pickup (not applicable in this scheme)

The conditions at flashover detection are:

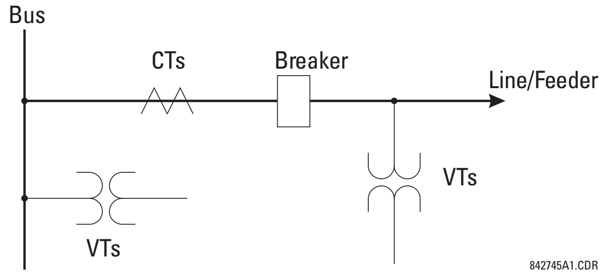
1. 52a status = 0
2. VAg, VBg, or VCg is lower than the pickup setting
3. IA, IB, or IC is greater than the pickup current flowing through the breaker
4. ∆VA is greater than pickup (not applicable in this scheme)

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 line 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.

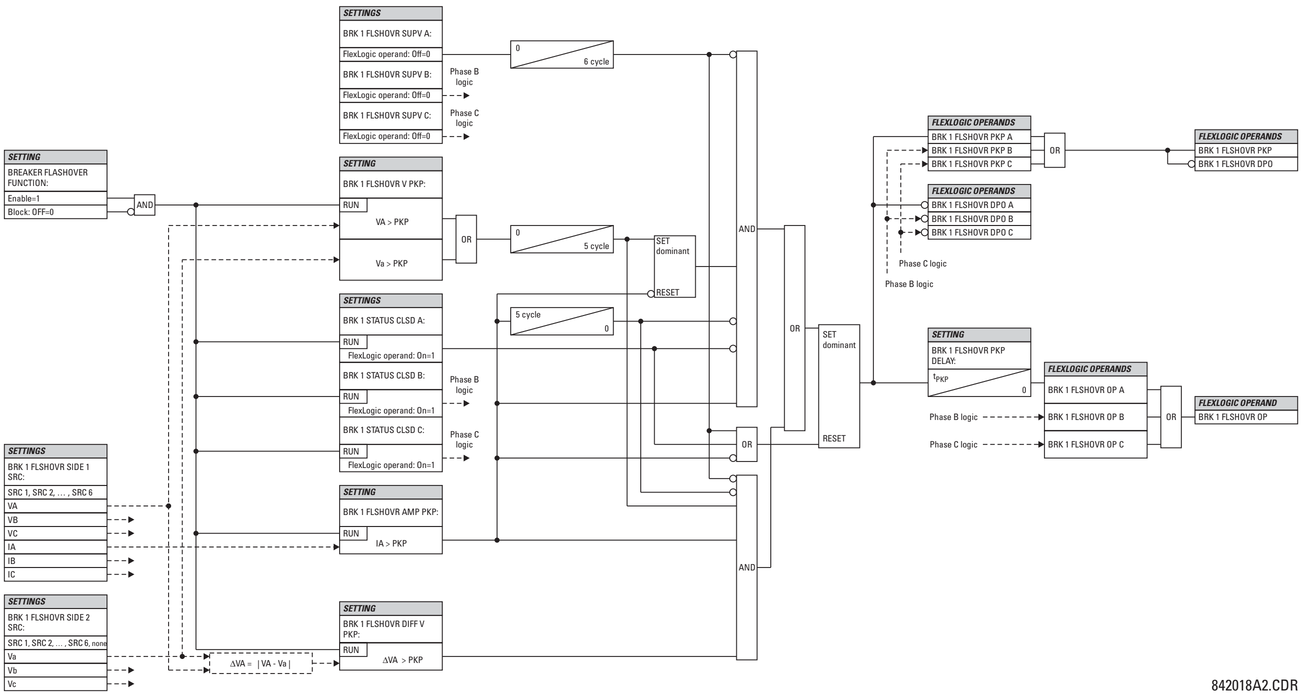


Figure 5–90: BREAKER FLASHOVER SCHEME LOGIC

5

e) VT FUSE FAILURE

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ MONITORING ELEMENTS ⇨⇩ VT FUSE FAILURE 1(2)

■ VT FUSE FAILURE 1 ■	VT FUSE FAILURE 1 FUNCTION: Disabled	*Range: Disabled, Enabled*

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(2) FUNCTION** setting enables/disables the fuse failure feature for each source.

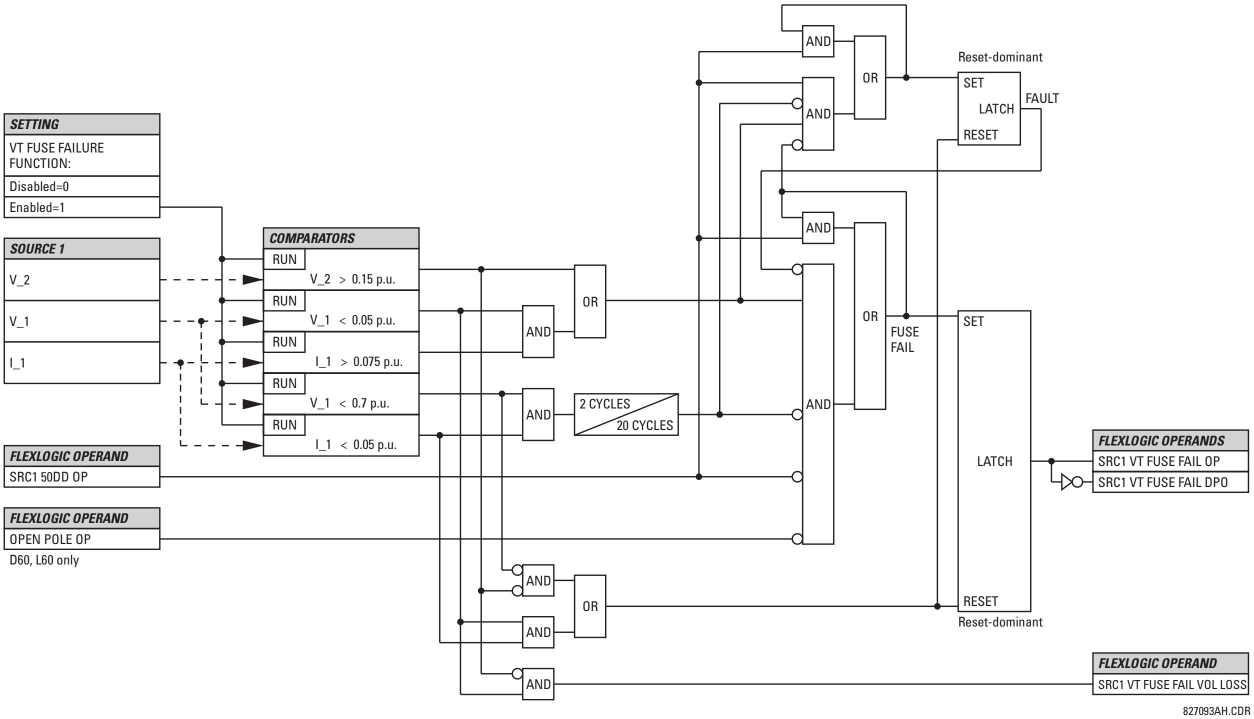


Figure 5–91: VT FUSE FAIL SCHEME LOGIC

5.6.12 COLD LOAD PICKUP

PATH: SETTINGS ⇨⇩ CONTROL ELEMENTS ⇨⇩ COLD LOAD PICKUP ⇨ COLD LOAD PICKUP 1(2)

■ COLD LOAD PICKUP 1 ■		COLD LOAD 1 FUNCTION: Disabled	*Range: Disabled, Enabled*
MESSAGE		COLD LOAD 1 PICKUP SOURCE: SRC 1	*Range: SRC 1, SRC 2*
MESSAGE		COLD LOAD 1 INIT: Off	*Range: FlexLogic™ operand*
MESSAGE		COLD LOAD 1 BLK: Off	*Range: FlexLogic™ operand*
MESSAGE		OUTAGE TIME BEFORE COLD LOAD1: 1000 s	*Range: 0 to 1000 s in steps of 1*
MESSAGE		ON-LOAD TIME BEFORE RESET1: 100.000	*Range: 0.000 to 1000 000.000 s in steps of 0.001*

There are two (2) identical Cold Load Pickup features available, numbered 1 and 2.

This feature can be used to change protection element settings when (by changing to another settings group) a cold load condition is expected to occur. A cold load condition can be caused by a prolonged outage of the load, by opening of the circuit breaker, or by a loss of supply even if the breaker remains closed. Upon the return of the source, the circuit will experience inrush current into connected transformers, accelerating currents into motors, and simultaneous demand from many other loads because the normal load diversity has been lost. During the cold load condition, the current level can be above the pickup setting of some protection elements, so this feature can be used to prevent the tripping that would otherwise be caused by the normal settings.

Without historical data on a particular feeder, some utilities assume an initial cold load current of about 500% of normal load, decaying to 300% after 1 second, 200% after 2 seconds, and 150% after 3 seconds.

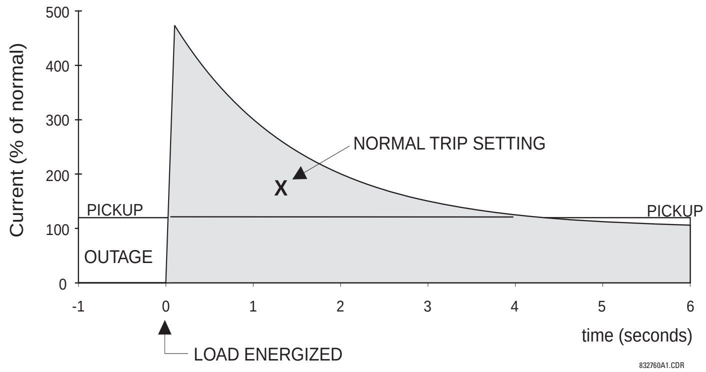


Figure 5–92: TYPICAL COLD LOAD PICKUP CHARACTERISTIC

There are two methods of initiating the operation of this feature.

The first initiation method is intended to automatically respond to a loss of the source to the feeder, by detecting that all phase currents have declined to zero for some time. When zero current on all phases has been detected, a timer is started. This timer is set to an interval after which it is expected the normal load diversity will have been lost, so setting groups are not changed for short duration outages. After the delay interval, the output operand is set.

The second initiation method is intended to automatically respond to an event that will set an operand, such as an operator-initiated virtual input. This second method of initiation sets the output operand immediately.

5

Both initiating inputs can be inhibited by a blocking input. Once cold load pickup is in operation, the output operand will remain set until at least one phase of the load has returned to a level above 2% of CT nominal for the interval programmed by the **ON-LOAD TIME BEFORE RESET** setting has expired. The reset delay interval is intended to be set to a period until the feeder load has decayed to normal levels, after which other features may be used to switch setting groups.

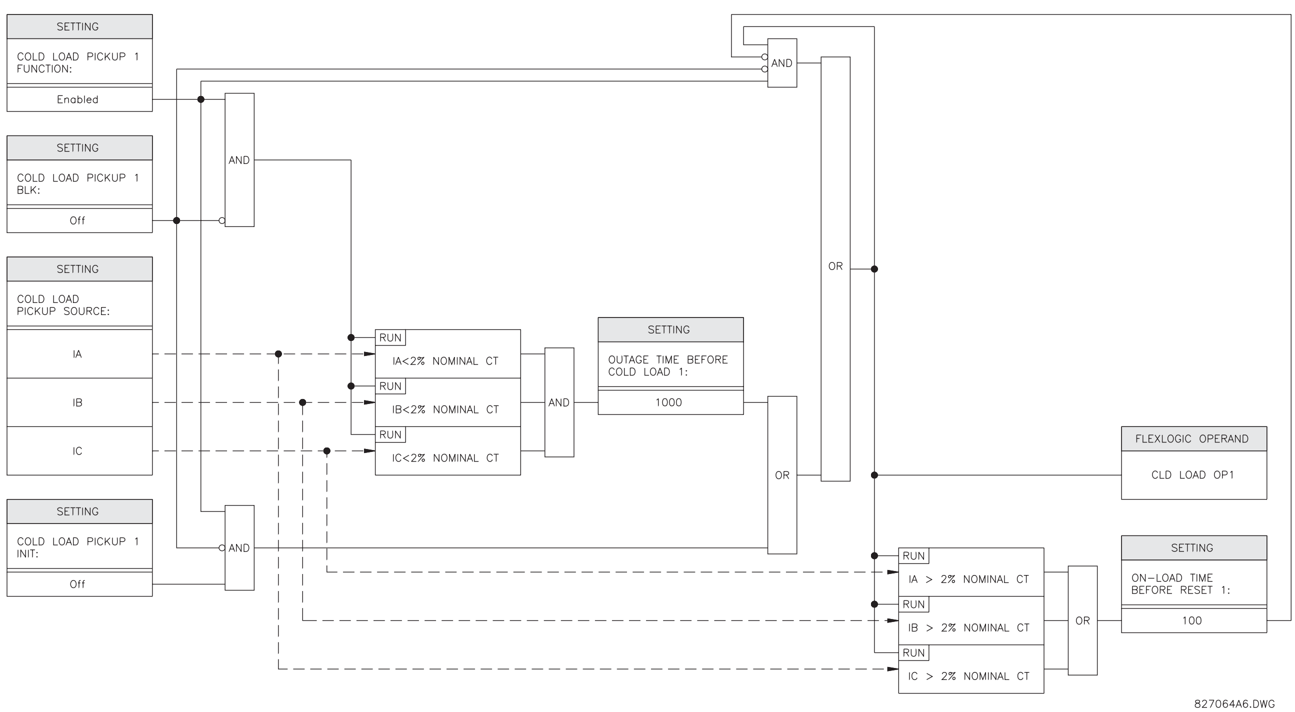


Figure 5–93: COLD LOAD PICKUP SCHEME LOGIC

5.7.1 CONTACT INPUTS

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨ CONTACT INPUTS

```
■ CONTACT INPUTS
■

        ■ CONTACT INPUT H5a
        ■

MESSAGE     CONTACT INPUT H5a ID:        Range: up to 12 alphanumeric characters
            Cont Ip 1

MESSAGE     CONTACT INPUT H5a            Range: 0.0 to 16.0 ms in steps of 0.5
            DEBNCE TIME: 2.0 ms

MESSAGE     CONTACT INPUT H5a            Range: Disabled, Enabled
            EVENTS: Disabled
        ↓

        ■ CONTACT INPUT xxx
        ■

        ■ CONTACT INPUT
        ■ THRESHOLDS

MESSAGE     Ips H5a,H5c,H6a,H6c          Range: 17, 33, 84, 166 Vdc
            THRESHOLD: 33 Vdc

MESSAGE     Ips H7a,H7c,H8a,H8c          Range: 17, 33, 84, 166 Vdc
            THRESHOLD: 33 Vdc
                    ↓

MESSAGE     Ips xxx,xxx,xxx,xxx          Range: 17, 33, 84, 166 Vdc
            THRESHOLD: 33 Vdc
```

The contact inputs menu contains configuration settings for each contact input as well as voltage thresholds for each group of four contact inputs. Upon startup, the relay processor determines (from an assessment of the installed modules) which contact inputs are available and then display settings for only those inputs.

An alphanumeric ID may be assigned to a contact input for diagnostic, setting, and event recording purposes. The CONTACT IP X On" (Logic 1) FlexLogic™ operand corresponds to contact input "X" being closed, while CONTACT IP X Off corresponds to contact input "X" being open. The **CONTACT INPUT DEBNCE TIME** defines the time required for the contact to overcome 'contact bouncing' conditions. As this time differs for different contact types and manufacturers, set it as a maximum contact debounce time (per manufacturer specifications) plus some margin to ensure proper operation. If **CONTACT INPUT EVENTS** is set to "Enabled", every change in the contact input state will trigger an event.

A raw status is scanned for all Contact Inputs synchronously at the constant rate of 0.5 ms as shown in the figure below. The DC input voltage is compared to a user-settable threshold. A new contact input state must be maintained for a user-settable debounce time in order for the F60 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.

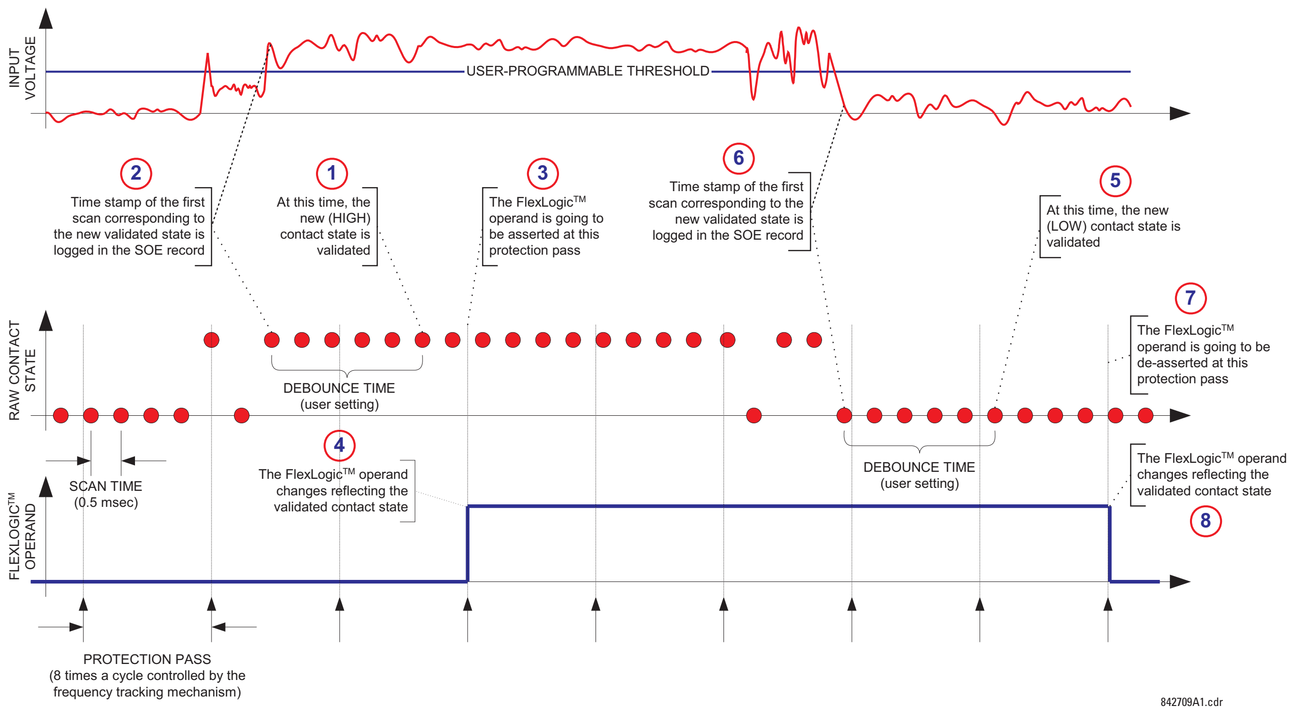


Figure 5–94: INPUT CONTACT DEBOUNCING MECHANISM AND TIME-STAMPING SAMPLE TIMING

Contact inputs are isolated in groups of four to allow connection of wet contacts from different voltage sources for each group. The **CONTACT INPUT THRESHOLDS** determine the minimum voltage required to detect a closed contact input. This value should be selected according to the following criteria: 17 for 24 V sources, 33 for 48 V sources, 84 for 110 to 125 V sources and 166 for 250 V sources.

For example, to use contact input H5a as a status input from the breaker 52b contact to seal-in the trip relay and record it in the Event Records menu, make the following settings changes:

CONTACT INPUT H5A ID: "Breaker Closed (52b)"
CONTACT INPUT H5A EVENTS: "Enabled"

Note that the 52b contact is closed when the breaker is open and open when the breaker is closed.

5.7.2 VIRTUAL INPUTS

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ VIRTUAL INPUTS ⇨ VIRTUAL INPUT 1(64)

■ VIRTUAL INPUT 1 ■	VIRTUAL INPUT 1 FUNCTION: Disabled	*Range: Disabled, Enabled*
MESSAGE	VIRTUAL INPUT 1 ID: Virt Ip 1	*Range: Up to 12 alphanumeric characters*
MESSAGE	VIRTUAL INPUT 1 TYPE: Latched	*Range: Self-Reset, Latched*
MESSAGE	VIRTUAL INPUT 1 EVENTS: Disabled	*Range: Disabled, Enabled*

There are 64 virtual inputs that can be individually programmed to respond to input signals from the keypad (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.

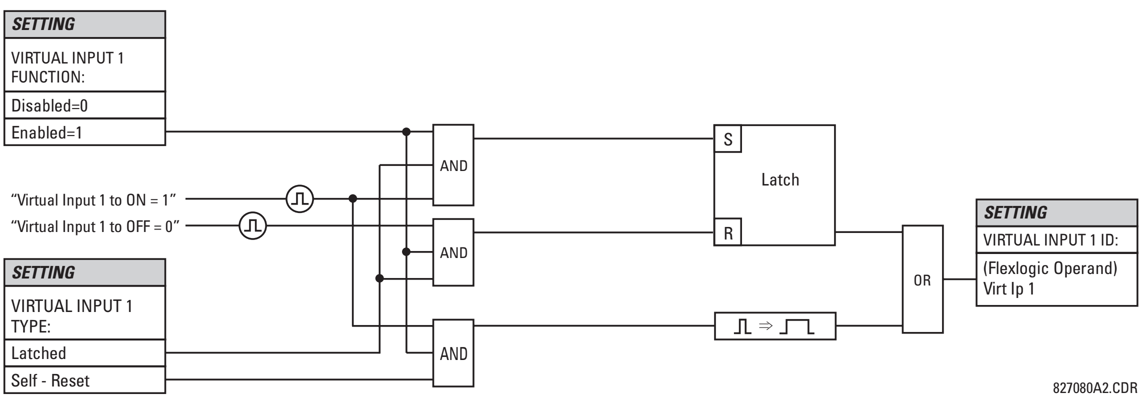


Figure 5–95: VIRTUAL INPUTS SCHEME LOGIC

5

5.7.3 CONTACT OUTPUTS

a) DIGITAL OUTPUTS

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ CONTACT OUTPUTS ⇨ CONTACT OUTPUT H1

■ CONTACT OUTPUT H1 ■	◁▷	CONTACT OUTPUT H1 ID Cont Op 1	Range: *Up to 12 alphanumeric characters*
MESSAGE	△▽	OUTPUT H1 OPERATE: Off	Range: *FlexLogic™ operand*
MESSAGE	△▽	OUTPUT H1 SEAL-IN: Off	Range: *FlexLogic™ operand*
MESSAGE	△	CONTACT OUTPUT H1 EVENTS: Enabled	Range: *Disabled, Enabled*

Upon startup of the relay, the main processor will determine from an assessment of the modules installed in the chassis which contact outputs are available and present the settings for only these outputs.

An ID may be assigned to each contact output. The signal that can **OPERATE** a contact output may be any FlexLogic™ operand (virtual output, element state, contact input, or virtual input). An additional FlexLogic™ operand may be used to **SEAL-IN** the relay. Any change of state of a contact output can be logged as an Event if programmed to do so.

For example, the trip circuit current is monitored by providing a current threshold detector in series with some Form-A contacts (see the trip circuit example in the *Digital Elements* section). The monitor will set a flag (see the specifications for Form-A). The name of the FlexLogic™ operand set by the monitor, consists of the output relay designation, followed by the name of the flag; e.g. 'Cont Op 1 IOn' or 'Cont Op 1 IOff'.

5

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 F60 using the 'Cont Op 1 IOn' FlexLogic™ operand to seal-in the contact output as follows:

CONTACT OUTPUT H1 ID: "Cont Op 1"
OUTPUT H1 OPERATE: *any suitable FlexLogic™ operand*
OUTPUT H1 SEAL-IN: "Cont Op 1 IOn"
CONTACT OUTPUT H1 EVENTS: "Enabled"

b) LATCHING OUTPUTS

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ CONTACT OUTPUTS ⇨ CONTACT OUTPUT H1a

■ CONTACT OUTPUT H1a ■	◁▷	OUTPUT H1a ID L-Cont Op 1	Range: *Up to 12 alphanumeric characters*
MESSAGE	△▽	OUTPUT H1a OPERATE: Off	Range: *FlexLogic™ operand*
MESSAGE	△▽	OUTPUT H1a RESET: Off	Range: *FlexLogic™ operand*
MESSAGE	△▽	OUTPUT H1a TYPE: Operate-dominant	Range: *Operate-dominant, Reset-dominant*
MESSAGE	△	OUTPUT H1a EVENTS: Disabled	Range: *Disabled, Enabled*

The F60 latching output contacts are mechanically bi-stable and controlled by two separate (open and close) coils. As such they retain their position even if the relay is not powered up. The relay recognizes all latching output contact cards and populates the setting menu accordingly. On power up, the relay reads positions of the latching contacts from the hardware before executing any other functions of the relay (such as protection and control features or FlexLogic™).

The latching output modules, either as a part of the relay or as individual modules, are shipped from the factory with all latching contacts opened. It is highly recommended to double-check the programming and positions of the latching contacts when replacing a module.

Since the relay asserts the output contact and reads back its position, it is possible to incorporate self-monitoring capabilities for the latching outputs. If any latching outputs exhibits a discrepancy, the **LATCHING OUTPUT ERROR** self-test error is declared. The error is signaled by the LATCHING OUT ERROR FlexLogic™ operand, event, and target message.

- **OUTPUT H1a OPERATE**: This setting specifies a FlexLogic™ operand to operate the 'close coil' of the contact. The relay will seal-in this input to safely close the contact. Once the contact is closed and the **RESET** input is logic 0 (off), any activity of the **OPERATE** input, such as subsequent chattering, will not have any effect. With both the **OPERATE** and **RESET** inputs active (logic 1), the response of the latching contact is specified by the **OUTPUT H1A TYPE** setting.
- **OUTPUT H1a RESET**: This setting specifies a FlexLogic™ operand to operate the 'trip coil' of the contact. The relay will seal-in this input to safely open the contact. Once the contact is opened and the **OPERATE** input is logic 0 (off), any activity of the **RESET** input, such as subsequent chattering, will not have any effect. With both the **OPERATE** and **RESET** inputs active (logic 1), the response of the latching contact is specified by the **OUTPUT H1A TYPE** setting.
- **OUTPUT H1a TYPE**: This setting specifies the contact response under conflicting control inputs; that is, when both the **OPERATE** and **RESET** signals are applied. With both control inputs applied simultaneously, the contact will close if set to "Operate-dominant" and will open if set to "Reset-dominant".

Application Example 1:

A latching output contact H1a is to be controlled from two user-programmable pushbuttons (buttons number 1 and 2). The following settings should be applied.

Program the Latching Outputs by making the following changes in the **SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ CONTACT OUTPUTS ⇨ CONTACT OUTPUT H1a** menu (assuming an H4L module):

OUTPUT H1a OPERATE: "PUSHBUTTON 1 ON"
OUTPUT H1a RESET: "PUSHBUTTON 2 ON"

Program the pushbuttons by making the following changes in the **PRODUCT SETUP ⇨⇩ USER-PROGRAMMABLE PUSHBUTTONS ⇨⇩ USER PUSHBUTTON 1** and **USER PUSHBUTTON 2** menus:

PUSHBUTTON 1 FUNCTION: "Self-reset"
PUSHBTN 1 DROP-OUT TIME: "0.00 s"

PUSHBUTTON 2 FUNCTION: "Self-reset"
PUSHBTN 2 DROP-OUT TIME: "0.00 s"

Application Example 2:

A relay, having two latching contacts H1a and H1c, is to be programmed. The H1a contact is to be a Type-a contact, while the H1c contact is to be a Type-b contact (Type-a means closed after exercising the operate input; Type-b means closed after exercising the reset input). The relay is to be controlled from virtual outputs: VO1 to operate and VO2 to reset.

Program the Latching Outputs by making the following changes in the **SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ CONTACT OUTPUTS ⇨ CONTACT OUTPUT H1a** and **CONTACT OUTPUT H1c** menus (assuming an H4L module):

OUTPUT H1a OPERATE: "VO1"
OUTPUT H1a RESET: "VO2"

OUTPUT H1c OPERATE: "VO2"
OUTPUT H1c RESET: "VO1"

Since the two physical contacts in this example are mechanically separated and have individual control inputs, they will not operate at exactly the same time. A discrepancy in the range of a fraction of a maximum operating time may occur. Therefore, a pair of contacts programmed to be a multi-contact relay will not guarantee any specific sequence of operation (such as make before break). If required, the sequence of operation must be programmed explicitly by delaying some of the control inputs as shown in the next application example.

Application Example 3:

A make before break functionality must be added to the preceding example. An overlap of 20 ms is required to implement this functionality as described below:

Write the following FlexLogic™ equation (EnerVista UR Setup example shown):

FlexLogic Equation Editor // D60 with Pushbuttons.urs : C:\Prog...

FLEXLOGIC ENTRY	TYPE	SYNTAX
View Graphic	View	View
FlexLogic Entry 1	Read Virtual Outputs On	Virt Op 1 On (VO1)
FlexLogic Entry 2	TIMER	Timer 1
FlexLogic Entry 3	Write Virtual Output[Assign]	= Virt Op 3 (VO3)
FlexLogic Entry 4	Read Virtual Outputs On	Virt Op 2 On (VO2)
FlexLogic Entry 5	TIMER	Timer 2
FlexLogic Entry 6	Write Virtual Output[Assign]	= Virt Op 4 (VO4)
FlexLogic Entry 7	End of List	

D60 with Pushbuttons.urs FlexLogic

Both timers (Timer 1 and Timer 2) should be set to 20 ms pickup and 0 ms dropout.

Program the Latching Outputs by making the following changes in the **SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ CONTACT OUTPUTS ⇨ CONTACT OUTPUT H1a** and **CONTACT OUTPUT H1c** menus (assuming an H4L module):

OUTPUT H1a OPERATE: "VO1"
OUTPUT H1a RESET: "VO4"

OUTPUT H1c OPERATE: "VO2"
OUTPUT H1c RESET: "VO3"

Application Example 4:

A latching contact H1a is to be controlled from a single virtual output VO1. The contact should stay closed as long as VO1 is high, and should stay opened when VO1 is low. Program the relay as follows.

Write the following FlexLogic™ equation (EnerVista UR Setup example shown):

FlexLogic Equation Editor // D60 with Pushbuttons.urs : C:\Prog...

FLEXLOGIC ENTRY	TYPE	SYNTAX
View Graphic	View	View
FlexLogic Entry 1	Read Virtual Outputs On	Virt Op 1 On (VO1)
FlexLogic Entry 2	NOT	1 Input
FlexLogic Entry 3	Write Virtual Output[Assign]	= Virt Op 2 (VO2)
FlexLogic Entry 4	End of List	

D60 with Pushbuttons.urs FlexLogic

5

Program the Latching Outputs by making the following changes in the **SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ CONTACT OUTPUTS ⇨ CONTACT OUTPUT H1a** menu (assuming an H4L module):

OUTPUT H1a OPERATE: "VO1"
OUTPUT H1a RESET: "VO2"

5.7.4 VIRTUAL OUTPUTS

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ VIRTUAL OUTPUTS ⇨ VIRTUAL OUTPUT 1(96)

■ VIRTUAL OUTPUT 1 ■		VIRTUAL OUTPUT 1 ID Virt Op 1	*Range: Up to 12 alphanumeric characters*
	MESSAGE	VIRTUAL OUTPUT 1 EVENTS: Disabled	*Range: Disabled, Enabled*

There are 96 virtual outputs that may be assigned via FlexLogic™. If not assigned, the output will be forced to 'OFF' (Logic 0). An ID may be assigned to each virtual output. Virtual outputs are resolved in each pass through the evaluation of the FlexLogic™ equations. Any change of state of a virtual output can be logged as an event if programmed to do so.

For example, if Virtual Output 1 is the trip signal from FlexLogic™ and the trip relay is used to signal events, the settings would be programmed as follows:

VIRTUAL OUTPUT 1 ID: "Trip"
VIRTUAL OUTPUT 1 EVENTS: "Disabled"

5.7.5 REMOTE DEVICES

a) REMOTE INPUTS/OUTPUTS OVERVIEW

Remote inputs and outputs provide a means of exchanging digital state information between Ethernet-networked devices. The IEC 61850 GSSE (Generic Substation State Event) and GOOSE (Generic Object Oriented Substation Event) standards are used.

NOTE

The IEC 61850 specification requires that communications between devices be implemented on Ethernet. For UR-series relays, Ethernet communications is provided only all CPU modules except type 9E.

The sharing of digital point state information between GSSE/GOOSE equipped relays is essentially an extension to FlexLogic™, allowing distributed FlexLogic™ by making operands available to/from devices on a common communications network. In addition to digital point states, GSSE/GOOSE messages identify the originator of the message and provide other information required by the communication specification. All devices listen to network messages and capture data only from messages that have originated in selected devices.

IEC 61850 GSSE messages are compatible with UCA GOOSE messages and contain a fixed set of digital points. IEC 61850 GOOSE messages can, in general, contain any configurable data items. When used by the remote input/output feature, IEC 61850 GOOSE messages contain the same data as GSSE messages.

Both GSSE and GOOSE messages are designed to be short, reliable, and high priority. GOOSE messages have additional advantages over GSSE messages due to their support of VLAN (virtual LAN) and Ethernet priority tagging functionality. The GSSE message structure contains space for 128 bit pairs representing digital point state information. The IEC 61850 specification provides 32 “DNA” bit pairs that represent the state of two pre-defined events and 30 user-defined events. All remaining bit pairs are “UserSt” bit pairs, which are status bits representing user-definable events. The F60 implementation provides 32 of the 96 available UserSt bit pairs.

The IEC 61850 specification includes features that are used to cope with the loss of communication between transmitting and receiving devices. Each transmitting device will send a GSSE/GOOSE message upon a successful power-up, when the state of any included point changes, or after a specified interval (the *default update* time) if a change-of-state has not occurred. The transmitting device also sends a ‘hold time’ which is set greater than three times the programmed default time required by the receiving device.

Receiving devices are constantly monitoring the communications network for messages they require, as recognized by the identification of the originating device carried in the message. Messages received from remote devices include the message *time allowed to live*. The receiving relay sets a timer assigned to the originating device to this time interval, and if it has not received another message from this device at time-out, the remote device is declared to be non-communicating, so it will use the programmed default state for all points from that specific remote device. If a message is received from a remote device before the *time allowed to live* expires, all points for that device are updated to the states contained in the message and the hold timer is restarted. The status of a remote device, where “Offline” indicates non-communicating, can be displayed.

The remote input/output facility provides for 32 remote inputs and 64 remote outputs.

b) LOCAL DEVICES: ID OF DEVICE FOR TRANSMITTING GSSE MESSAGES

In a F60 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 ■		REMOTE DEVICE 1 ID: Remote Device 1	Range: up to 20 alphanumeric characters
	MESSAGE	REMOTE DEVICE 1 VLAN ID: 0	Range: 0 to 4095 in steps of 1
	MESSAGE	REMOTE DEVICE 1 ETYPE APPID: 0	Range: 0 to 16383 in steps of 1

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.

The **REMOTE DEVICE 1(16) VLAN ID** and **REMOTE DEVICE 1(16) ETYPE APPID** settings are only used with GOOSE messages; they are not applicable to GSSE messages. The **REMOTE DEVICE 1(16) VLAN ID** setting identifies the virtual LAN on which the remote device is sending the GOOSE message. The **REMOTE DEVICE 1(16) ETYPE APPID** setting identifies the Ethernet application identification in the GOOSE message. These settings should match the corresponding settings on the sending device.

5.7.6 REMOTE INPUTS

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ REMOTE INPUTS ⇨ REMOTE INPUT 1(32)

■ REMOTE INPUT 1 ■		REMOTE INPUT 1 ID: Remote Ip 1	*Range: up to 12 alphanumeric characters*
	MESSAGE	REMOTE IN 1 DEVICE: Remote Device 1	*Range: 1 to 16 inclusive*
	MESSAGE	REMOTE IN 1 BIT PAIR: None	*Range: None, DNA-1 to DNA-32, UserSt-1 to UserSt-32*
	MESSAGE	REMOTE IN 1 DEFAULT STATE: Off	*Range: On, Off, Latest/On, Latest/Off*
	MESSAGE	REMOTE IN 1 EVENTS: Disabled	*Range: Disabled, Enabled*

Remote Inputs which create FlexLogic™ operands at the receiving relay, are extracted from GSSE/GOOSE 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/GOOSE message. A user must program a DNA point from the appropriate FlexLogic™ operand.

Remote Input 1 must be programmed to replicate the logic state of a specific signal from a specific remote device for local use. This programming is performed via the three settings shown above.

The **REMOTE INPUT 1 ID** setting allows the user to assign descriptive text to the remote input. The **REMOTE IN 1 DEVICE** setting selects the number (1 to 16) of the remote device which originates the required signal, as previously assigned to the remote device via the setting **REMOTE DEVICE *NN* ID** (see the *Remote Devices* section). **REMOTE IN 1 BIT PAIR** selects the specific bits of the GSSE/GOOSE message required.

The **REMOTE IN 1 DEFAULT STATE** setting selects the logic state for this point if the local relay has just completed startup or the remote device sending the point is declared to be non-communicating. The following choices are available:

- Setting **REMOTE IN 1 DEFAULT STATE** to "On" value defaults the input to Logic 1.
- Setting **REMOTE IN 1 DEFAULT STATE** to "Off" value defaults the input to Logic 0.
- Setting **REMOTE IN 1 DEFAULT STATE** to "Latest/On" freezes the input in case of lost communications. If the latest state is not known, such as after relay power-up but before the first communication exchange, the input will default to Logic 1. When communication resumes, the input becomes fully operational.
- Setting **REMOTE IN 1 DEFAULT STATE** to "Latest/Off" freezes the input in case of lost communications. If the latest state is not known, such as after relay power-up but before the first communication exchange, the input will default to Logic 0. When communication resumes, the input becomes fully operational.

NOTE

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

5.7.7 REMOTE OUTPUTS

a) DNA BIT PAIRS

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

```
■ REMOTE OUTPUTS           DNA- 1 OPERAND:        Range: FlexLogic™ operand
■ DNA- 1 BIT PAIR          Off

              MESSAGE      DNA- 1 EVENTS:         Range: Disabled, Enabled
                           Disabled
```

Remote outputs (1 to 32) are FlexLogic™ operands inserted into GSSE/GOOSE messages that are transmitted to remote devices on a LAN. Each digital point in the message must be programmed to carry the state of a specific FlexLogic™ operand. The above operand setting represents a specific DNA function (as shown in the following table) to be transmitted.

Table 5–23: IEC 61850 DNA ASSIGNMENTS

DNA	IEC 61850 DEFINITION	FLEXLOGIC™ OPERAND
1	Test	IEC 61850 TEST MODE
2	ConfRev	IEC 61850 CONF REV

b) USERST BIT PAIRS

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ REMOTE OUTPUTS UserSt BIT PAIRS ⇨ REMOTE OUTPUTS UserSt- 1(32) BIT PAIR

```
■ REMOTE OUTPUTS           UserSt- 1 OPERAND:     Range: FlexLogic™ operand
■ UserSt- 1 BIT PAIR       Off

              MESSAGE      UserSt- 1 EVENTS:      Range: Disabled, Enabled
                           Disabled
```

Remote outputs 1 to 32 originate as GSSE/GOOSE messages to be transmitted to remote devices. Each digital point in the message must be programmed to carry the state of a specific FlexLogic™ operand. The setting above is used to select the operand which represents a specific UserSt function (as selected by the user) to be transmitted.

The following setting represents the time between sending GSSE/GOOSE messages when there has been no change of state of any selected digital point. This setting is located in the PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ IEC 61850 PROTOCOL ⇨⇩ GSSE/GOOSE CONFIGURATION settings menu.

```
DEFAULT GSSE/GOOSE         Range: 1 to 60 s in steps of 1
UPDATE TIME: 60 s
```

The following setting determines whether remote input/output data is transported using IEC 61850 GSSE or IEC 61850 GOOSE messages. If GOOSE is selected, the VLAN and APPID settings should be set accordingly. If GSSE is selected, the VLAN and APPID settings are not relevant. This setting is located in the PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ IEC 61850 PROTOCOL ⇨⇩ GSSE/GOOSE CONFIGURATION menu.

```
REMOTE I/O TRANSFER        Range: GOOSE, GSSE, None
METHOD: GSSE
```

NOTE

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

5

5.7.8 RESETTING

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ RESETTING

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

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

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

5.7.9 DIRECT INPUTS/OUTPUTS

a) DIRECT INPUTS

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ DIRECT INPUTS ⇨ DIRECT INPUT 1(32)

■ DIRECT INPUT 1 ■	◀▶	DIRECT INPUT 1 NAME: Dir Ip 1	Range: up to 12 alphanumeric characters
MESSAGE	▲▼	DIRECT INPUT 1 DEVICE ID: 1	Range: 1 to 16
MESSAGE	▲▼	DIRECT INPUT 1 BIT NUMBER: 1	Range: 1 to 32
MESSAGE	▲▼	DIRECT INPUT 1 DEFAULT STATE: Off	Range: On, Off, Latest/On, Latest/Off
MESSAGE	▲	DIRECT INPUT 1 EVENTS: Disabled	Range: Enabled, Disabled

These settings specify how the direct input information is processed. The **DIRECT INPUT 1 NAME** setting allows the user to assign a descriptive name to the direct input. The **DIRECT INPUT 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 NAME: Dir Out 1	Range: *up to 12 alphanumeric characters*
MESSAGE	DIRECT OUT 1 OPERAND: Off	Range: *FlexLogic™ operand*
MESSAGE	DIRECT OUTPUT 1 EVENTS: Disabled	Range: *Enabled, Disabled*

The **DIRECT OUT 1 NAME** setting allows the user to assign a descriptive name to the direct output. The **DIR OUT 1 OPERAND** is the FlexLogic™ operand that determines the state of this direct output.

c) APPLICATION EXAMPLES

The examples introduced in the earlier *Direct Inputs/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 F60 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.

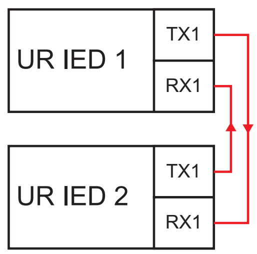


Figure 5–96: INPUT/OUTPUT EXTENSION VIA DIRECT INPUTS/OUTPUTS

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"
DIRECT INPUT 5 BIT NUMBER = "12"

UR IED 2: **DIRECT OUT 12 OPERAND** = "Cont Ip 1 On"

The Cont Ip 1 On operand of UR IED 2 is now available in UR IED 1 as DIRECT INPUT 5 ON.

EXAMPLE 2: INTERLOCKING BUSBAR PROTECTION

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

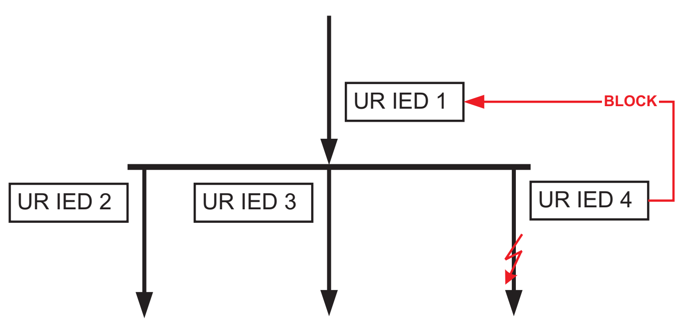


Figure 5–97: SAMPLE INTERLOCKING BUSBAR PROTECTION SCHEME

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").

5

EXAMPLE 2: PILOT-AIDED SCHEMES

Consider a three-terminal line protection application shown in the figure below.

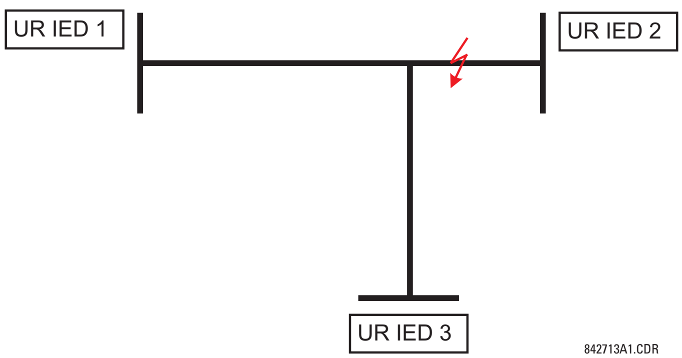


Figure 5–98: THREE-TERMINAL LINE APPLICATION

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.

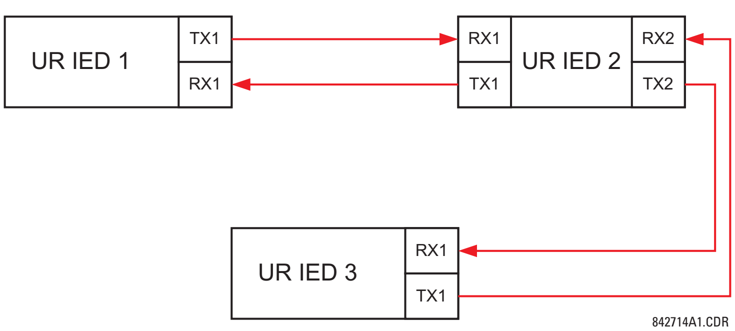


Figure 5–99: SINGLE-CHANNEL OPEN-LOOP CONFIGURATION

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:

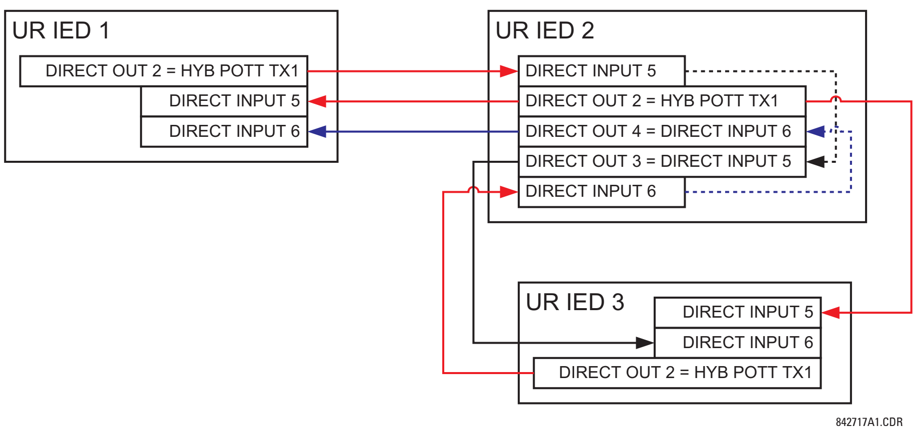


Figure 5–100: SIGNAL FLOW FOR DIRECT INPUT/OUTPUT EXAMPLE 3

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).

5.7.10 TELEPROTECTION INPUTS/OUTPUTS

a) OVERVIEW

The relay provides sixteen teleprotection inputs on communications channel 1 (numbered 1-1 through 1-16) and sixteen teleprotection inputs on communications channel 2 (on two-terminals two-channel and three-terminal systems only, numbered 2-1 through 2-16). The remote relay connected to channels 1 and 2 of the local relay is programmed by assigning FlexLogic™ operands to be sent via the selected communications channel. This allows the user to create distributed protection and control schemes via dedicated communications channels. Some examples are directional comparison pilot schemes and direct transfer tripping. It should be noted that failures of communications channels will affect teleprotection functionality. The teleprotection function must be enabled to utilize the inputs.

b) TELEPROTECTION INPUTS

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ TELEPROTECTION ⇨ TELEPROT INPUTS

■ TELEPROT INPUTS ■		TELEPROT INPUT 1-1 DEFAULT: Off	*Range: Off, On, Latest/Off, Latest/On*
	MESSAGE	TELEPROT INPUT 1-2 DEFAULT: Off	*Range: Off, On, Latest/Off, Latest/On*
		↓	
	MESSAGE	TELEPROT INPUT 1-16 DEFAULT: Off	*Range: Off, On, Latest/Off, Latest/On*
	MESSAGE	TELEPROT INPUT 2-1 DEFAULT: Off	*Range: Off, On, Latest/Off, Latest/On*
	MESSAGE	TELEPROT INPUT 2-2 DEFAULT: Off	*Range: Off, On, Latest/Off, Latest/On*
		↓	
	MESSAGE	TELEPROT INPUT 2-16 DEFAULT: Off	*Range: Off, On, Latest/Off, Latest/On*

Setting the **TELEPROT INPUT ~~ DEFAULT** setting to “On” defaults the input to logic 1 when the channel fails. A value of “Off” defaults the input to logic 0 when the channel fails.

The “Latest/On” and “Latest/Off” values freeze 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, then the input defaults to logic 1 for “Latest/On” and logic 0 for “Latest/Off”.

5

c) TELEPROTECTION OUTPUTS

PATH: SETTINGS ⇨⇩ INPUTS/OUTPUTS ⇨⇩ TELEPROTECTION ⇨⇩ TELEPROT OUTPUTS

■ TELEPROT OUTPUTS ■		TELEPROT OUTPUT 1-1: Off	Range: FlexLogic™ operand
MESSAGE		TELEPROT OUTPUT 1-2: Off	Range: FlexLogic™ operand
		↓	
MESSAGE		TELEPROT OUTPUT 1-16: Off	Range: FlexLogic™ operand
MESSAGE		TELEPROT OUTPUT 2-1: Off	Range: FlexLogic™ operand
MESSAGE		TELEPROT OUTPUT 2-2: Off	Range: FlexLogic™ operand
		↓	
MESSAGE		TELEPROT OUTPUT 2-16: Off	Range: FlexLogic™ operand

As the following figure demonstrates, processing of the teleprotection inputs/outputs is dependent on the number of communication channels and terminals. On two-terminal two-channel systems, they are processed continuously on each channel and mapped separately per channel. Therefore, to achieve redundancy, the user must assign the same operand on both channels (teleprotection outputs at the sending end or corresponding teleprotection inputs at the receiving end). On three-terminal two-channel systems, redundancy is achieved by programming signal re-transmittal in the case of channel failure between any pair of relays.

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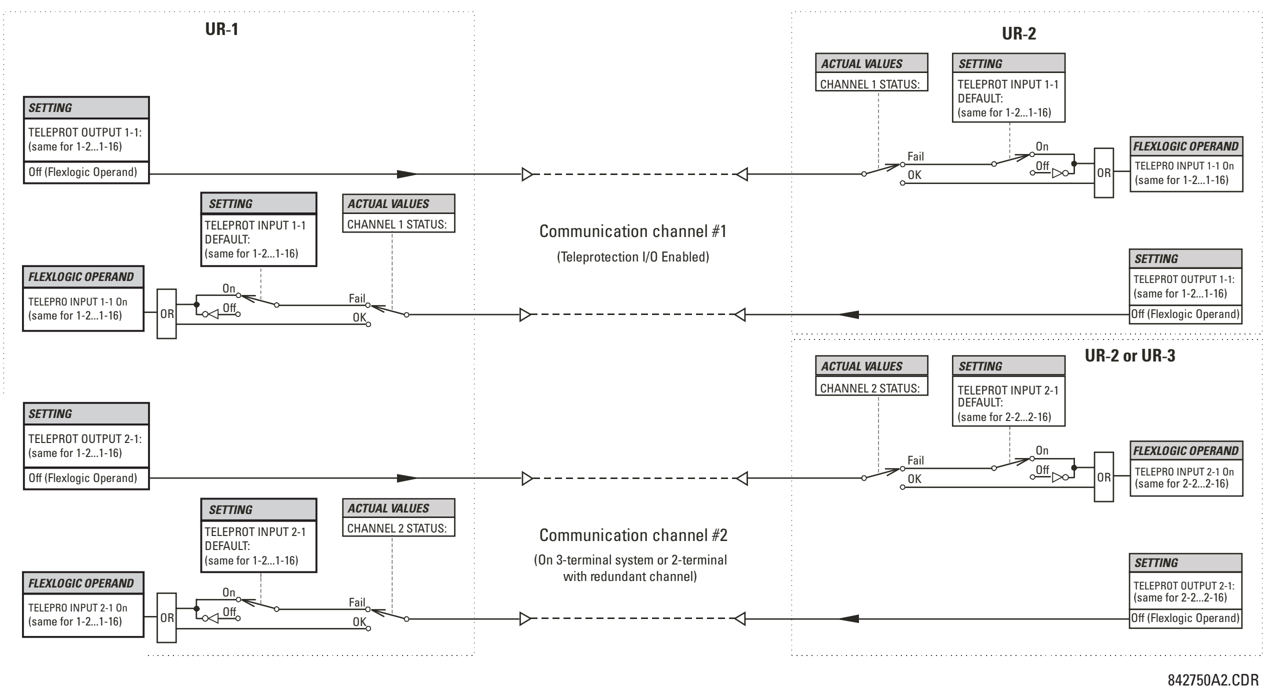

Figure 5–101: TELEPROTECTION INPUT/OUTPUT PROCESSING

5.8.1 DCMA INPUTS

PATH: SETTINGS ⇨⇩ TRANSDUCER I/O ⇨⇩ DCMA INPUTS ⇨ DCMA INPUT H1(W8)

■ DCMA INPUT H1 ■	◁▷	DCMA INPUT H1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	△▽	DCMA INPUT H1 ID: DCMA Ip 1	Range: up to 20 alphanumeric characters
MESSAGE	△▽	DCMA INPUT H1 UNITS: µA	Range: 6 alphanumeric characters
MESSAGE	△▽	DCMA INPUT H1 RANGE: 0 to -1 mA	Range: 0 to –1 mA, 0 to +1 mA, –1 to +1 mA, 0 to 5 mA, 0 to 10mA, 0 to 20 mA, 4 to 20 mA
MESSAGE	△▽	DCMA INPUT H1 MIN VALUE: 0.000	Range: –9999.999 to +9999.999 in steps of 0.001
MESSAGE	△	DCMA INPUT H1 MAX VALUE: 0.000	Range: –9999.999 to +9999.999 in steps of 0.001

Hardware and software is provided to receive signals from external transducers and convert these signals into a digital format for use as required. The relay will accept inputs in the range of –1 to +20 mA DC, suitable for use with most common transducer output ranges; all inputs are assumed to be linear over the complete range. Specific hardware details are contained in Chapter 3.

Before the dcmA input signal can be used, the value of the signal measured by the relay must be converted to the range and quantity of the external transducer primary input parameter, such as DC voltage or temperature. The relay simplifies this process by internally scaling the output from the external transducer and displaying the actual primary parameter.

dcmA input channels are arranged in a manner similar to CT and VT channels. The user configures individual channels with the settings shown here.

The channels are arranged in sub-modules of two channels, numbered from 1 through 8 from top to bottom. On power-up, the relay will automatically generate configuration settings for every channel, based on the order code, in the same general manner that is used for CTs and VTs. Each channel is assigned a slot letter followed by the row number, 1 through 8 inclusive, which is used as the channel number. The relay generates an actual value for each available input channel.

Settings are automatically generated for every channel available in the specific relay as shown above for the first channel of a type 5F transducer module installed in slot H.

The function of the channel may be either “Enabled” or “Disabled”. If “Disabled”, no actual values are created for the channel. An alphanumeric “ID” is assigned to each channel; this ID will be included in the channel actual value, along with the programmed units associated with the parameter measured by the transducer, such as volts, °C, megawatts, etc. This ID is also used to reference the channel as the input parameter to features designed to measure this type of parameter. The **DCMA INPUT H1 RANGE** setting specifies the mA DC range of the transducer connected to the input channel.

The **DCMA INPUT H1 MIN VALUE** and **DCMA INPUT H1 MAX VALUE** settings are used to program the span of the transducer in primary units. For example, a temperature transducer might have a span from 0 to 250°C; in this case the **DCMA INPUT H1 MIN VALUE** value is “0” and the **DCMA INPUT H1 MAX VALUE** value is “250”. Another example would be a watts transducer with a span from –20 to +180 MW; in this case the **DCMA INPUT H1 MIN VALUE** value would be “–20” and the **DCMA INPUT H1 MAX VALUE** value “180”. Intermediate values between the min and max values are scaled linearly.

5.8.2 RTD INPUTS

PATH: SETTINGS ⇨⇩ TRANSDUCER I/O ⇨⇩ RTD INPUTS ⇨ RTD INPUT H1(W8)

			Range
■ RTD INPUT H1 ■	◁▷	RTD INPUT H1 FUNCTION: Disabled	Range: *Disabled, Enabled*
MESSAGE	△▽	RTD INPUT H1 ID: RTD Ip 1	Range: *Up to 20 alphanumeric characters*
MESSAGE	△	RTD INPUT H1 TYPE: 100Ω Nickel	Range: *100Ω Nickel, 10Ω Copper, 100Ω Platinum, 120Ω Nickel*

Hardware and software is provided to receive signals from external resistance temperature detectors and convert these signals into a digital format for use as required. These channels are intended to be connected to any of the RTD types in common use. Specific hardware details are contained in Chapter 3.

RTD input channels are arranged in a manner similar to CT and VT channels. The user configures individual channels with the settings shown here.

The channels are arranged in sub-modules of two channels, numbered from 1 through 8 from top to bottom. On power-up, the relay will automatically generate configuration settings for every channel, based on the order code, in the same general manner that is used for CTs and VTs. Each channel is assigned a slot letter followed by the row number, 1 through 8 inclusive, which is used as the channel number. The relay generates an actual value for each available input channel.

Settings are automatically generated for every channel available in the specific relay as shown above for the first channel of a type 5C transducer module installed in 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)

			Range
■ DCMA OUTPUT H1 ■	◁▷	DCMA OUTPUT H1 SOURCE: Off	Range: *Off, any analog actual value parameter*
MESSAGE	△▽	DCMA OUTPUT H1 RANGE: –1 to 1 mA	Range: *–1 to 1 mA, 0 to 1 mA, 4 to 20 mA*
MESSAGE	△▽	DCMA OUTPUT H1 MIN VAL: 0.000 pu	Range: *–90.000 to 90.000 pu in steps of 0.001*
MESSAGE	△	DCMA OUTPUT H1 MAX VAL: 1.000 pu	Range: *–90.000 to 90.000 pu in steps of 0.001*

Hardware and software is provided to generate dcmA signals that allow interfacing with external equipment. Specific hardware details are contained in Chapter 3. The dcmA output channels are arranged in a manner similar to transducer input or CT and VT channels. The user configures individual channels with the settings shown below.

The channels are arranged in sub-modules of two channels, numbered 1 through 8 from top to bottom. On power-up, the relay automatically generates configuration settings for every channel, based on the order code, in the same manner used for CTs and VTs. Each channel is assigned a slot letter followed by the row number, 1 through 8 inclusive, which is used as the channel number.

Both the output range and a signal driving a given output are user-programmable via the following settings menu (an example for channel M5 is shown).

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:

$$I_{out} = \begin{cases} I_{min} & \text{if } x < \textbf{MIN VAL} \\ I_{max} & \text{if } x > \textbf{MAX VAL} \\ k(x - \textbf{MIN VAL}) + I_{min} & \text{otherwise} \end{cases} \quad \text{(EQ 5.23)}$$

where: x is a driving signal specified by the **SOURCE** setting
I_{min} and I_{max} are defined by the **RANGE** setting
k is a scaling constant calculated as:

$$k = \frac{I_{max} - I_{min}}{\textbf{MAX VAL} - \textbf{MIN VAL}} \quad \text{(EQ 5.24)}$$

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.

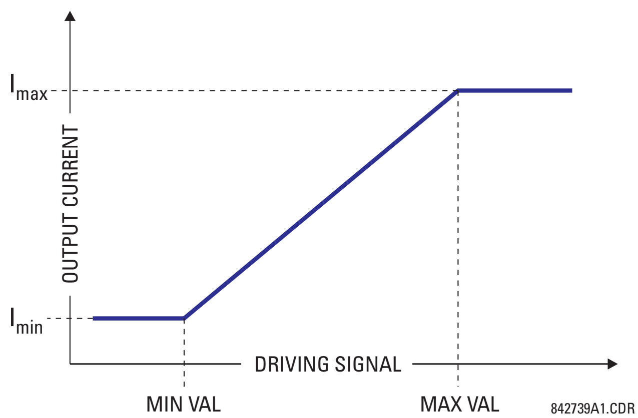

Figure 5–102: DCMA OUTPUT CHARACTERISTIC

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.

NOTE

The **DCMA OUTPUT H1 MIN VAL** and **DCMA OUTPUT H1 MAX VAL** settings are ignored for power factor base units (i.e. if the **DCMA OUTPUT H1 SOURCE** is set to FlexAnalog value based on power factor measurement).

Three application examples are described below.

EXAMPLE 1:

A three phase active power on a 13.8 kV system measured via UR-series relay source 1 is to be monitored by the dcmA H1 output of the range of –1 to 1 mA. The following settings are applied on the relay: CT ratio = 1200:5, VT secondary 115, VT connection is delta, and VT ratio = 120. The nominal current is 800 A primary and the nominal power factor is 0.90. The power is to be monitored in both importing and exporting directions and allow for 20% overload compared to the nominal.

The nominal three-phase power is:

$$P = \sqrt{3} \times 13.8\text{ kV} \times 0.8\text{ kA} \times 0.9 = 17.21\text{ MW} \quad \textbf{(EQ 5.25)}$$

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

$$P_{max} = 1.2 \times 17.21\text{ MW} = 20.65\text{ MW} \quad \textbf{(EQ 5.26)}$$

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

$$P_{BASE} = 115\text{ V} \times 120 \times 1.2\text{ kA} = 16.56\text{ MW} \quad \textbf{(EQ 5.27)}$$

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

$$\text{minimum power} = \frac{-20.65\text{ MW}}{16.56\text{ MW}} = -1.247\text{ pu}, \quad \text{maximum power} = \frac{20.65\text{ MW}}{16.56\text{ MW}} = 1.247\text{ pu} \quad \textbf{(EQ 5.28)}$$

The following settings should be entered:

DCMA OUTPUT H1 SOURCE: “SRC 1 P”
DCMA OUTPUT H1 RANGE: “–1 to 1 mA”
DCMA OUTPUT H1 MIN VAL: “–1.247 pu”
DCMA OUTPUT H1 MAX VAL: “1.247 pu”

With the above settings, the output will represent the power with the scale of 1 mA per 20.65 MW. The worst-case error for this application can be calculated by superimposing the following two sources of error:

- ±0.5% of the full scale for the analog output module, or $\pm 0.005 \times (1-(-1)) \times 20.65\text{ MW} = \pm 0.207\text{ MW}$
- ±1% of reading error for the active power at power factor of 0.9

For example at the reading of 20 MW, the worst-case error is 0.01 × 20 MW + 0.207 MW = 0.407 MW.

EXAMPLE 2:

The phase A current (true RMS value) is to be monitored via the H2 current output working with the range from 4 to 20 mA. The CT ratio is 5000:5 and the maximum load current is 4200 A. The current should be monitored from 0 A upwards, allowing for 50% overload.

The phase current with the 50% overload margin is:

$$I_{max} = 1.5 \times 4.2\text{ kA} = 6.3\text{ kA} \quad \textbf{(EQ 5.29)}$$

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

$$I_{BASE} = 5\text{ kA} \quad \textbf{(EQ 5.30)}$$

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

$$\text{minimum current} = \frac{0\text{ kA}}{5\text{ kA}} = 0\text{ pu}, \quad \text{maximum current} = \frac{6.3\text{ kA}}{5\text{ kA}} = 1.26\text{ pu} \quad \textbf{(EQ 5.31)}$$

The following settings should be entered:

DCMA OUTPUT H2 SOURCE: “SRC 1 Ia RMS”
DCMA OUTPUT H2 RANGE: “4 to 20 mA”
DCMA OUTPUT H2 MIN VAL: “0.000 pu”
DCMA OUTPUT H2 MAX VAL: “1.260 pu”

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

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

For example, at the reading of 4.2 kA, the worst-case error is max(0.0025 × 4.2 kA, 0.001 × 5 kA) + 0.504 kA = 0.515 kA.

EXAMPLE 3:

A positive-sequence voltage on a 400 kV system measured via Source 2 is to be monitored by the dcmA H3 output with a range of 0 to 1 mA. The VT secondary setting is 66.4 V, the VT ratio setting is 6024, and the VT connection setting is "Delta". The voltage should be monitored in the range from 70% to 110% of nominal.

The minimum and maximum positive-sequence voltages to be monitored are:

$$V_{min} = 0.7 \times \frac{400\text{ kV}}{\sqrt{3}} = 161.66\text{ kV}, \quad V_{max} = 1.1 \times \frac{400\text{ kV}}{\sqrt{3}} = 254.03\text{ kV} \quad \textbf{(EQ 5.32)}$$

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

$$V_{BASE} = 0.0664\text{ kV} \times 6024 = 400\text{ kV} \quad \textbf{(EQ 5.33)}$$

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

$$\text{minimum voltage} = \frac{161.66\text{ kV}}{400\text{ kV}} = 0.404\text{ pu}, \quad \text{maximum voltage} = \frac{254.03\text{ kV}}{400\text{ kV}} = 0.635\text{ pu} \quad \textbf{(EQ 5.34)}$$

The following settings should be entered:

DCMA OUTPUT H3 SOURCE: "SRC 2 V_1 mag"
DCMA OUTPUT H3 RANGE: "0 to 1 mA"
DCMA OUTPUT H3 MIN VAL: "0.404 pu"
DCMA OUTPUT H3 MAX VAL: "0.635 pu"

The limit settings differ from the expected 0.7 pu and 1.1 pu because the relay calculates the positive-sequence quantities scaled to the phase-to-ground voltages, even if the VTs are connected in "Delta" (refer to the *Metering Conventions* section in Chapter 6), while at the same time the VT nominal voltage is 1 pu for the settings. Consequently the settings required in this example differ from naturally expected by the factor of $\sqrt{3}$.

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

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

For example, under nominal conditions, the positive-sequence reads 230.94 kV and the worst-case error is 0.005 x 230.94 kV + 1.27 kV = 2.42 kV.

5.9 TESTING

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 F60 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.

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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.

5.9.3 FORCE CONTACT OUTPUTS

PATH: SETTINGS ⇨⇩ TESTING ⇨⇩ FORCE CONTACT OUTPUTS

■ FORCE CONTACT ■ OUTPUTS	◀▶	FORCE Cont Op 1 :Disabled	Range: *Disabled, Energized, De-energized, Freeze*
MESSAGE	▲▼	FORCE Cont Op 2 :Disabled	Range: *Disabled, Energized, De-energized, Freeze*
		↓	
MESSAGE	▲	FORCE Cont Op xx :Disabled	Range: *Disabled, Energized, De-energized, Freeze*

The relay contact outputs can be pre-programmed to respond to the Test Mode.

If set to “Disabled”, the contact output remains fully operational. If operates when its control operand is Logic 1 and will resets when its control operand is Logic 0. If set to “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.

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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 Equation Editor // D60 with Pushbuttons.urs : C:\Pro...

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”

6.1.1 ACTUAL VALUES MAIN MENU

■■ ACTUAL VALUES ■■ STATUS	■ CONTACT INPUTS ■	See page 6-3.
	■ VIRTUAL INPUTS ■	See page 6-3.
	■ REMOTE INPUTS ■	See page 6-3.
	■ TELEPROTECTION ■ INPUTS	See page 6-4.
	■ CONTACT OUTPUTS ■	See page 6-4.
	■ VIRTUAL OUTPUTS ■	See page 6-4.
	■ AUTORECLOSE ■	See page 6-5.
	■ REMOTE DEVICES ■ STATUS	See page 6-5.
	■ REMOTE DEVICES ■ STATISTICS	See page 6-5.
	■ DIGITAL COUNTERS ■	See page 6-6.
	■ SELECTOR SWITCHES ■	See page 6-6.
	■ FLEX STATES ■	See page 6-6.
	■ ETHERNET ■	See page 6-6.
	■ HIZ STATUS ■	See page 6-7.
	■ DIRECT INPUTS ■	See page 6-7.
	■ DIRECT DEVICES ■ STATUS	See page 6-8.
	■ EGD PROTOCOL ■ STATUS	See page 6-8.
	■ TELEPROT CH TESTS ■	See page 6-9.
■■ ACTUAL VALUES ■■ METERING	■ SOURCE SRC 1 ■	See page 6-13.
	■ SOURCE SRC 2 ■	See page 6-13.
	■ SENSITIVE ■ DIRECTIONAL POWER	See page 6-17.

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	■ SYNCHROCHECK ■	See page 6-18.
	■ TRACKING FREQUENCY ■	See page 6-18.
	■ FREQUENCY RATE ■ OF CHANGE	See page 6-18.
	■ FLEXELEMENTS ■	See page 6-19.
	■ TRANSDUCER I/O ■ DCMA INPUTS	See page 6-19.
	■ TRANSDUCER I/O ■ RTD INPUTS	See page 6-19.
■■ ACTUAL VALUES ■■ RECORDS	■ FAULT REPORTS ■	See page 6-20.
	■ EVENT RECORDS ■	See page 6-22.
	■ OSCILLOGRAPHY ■	See page 6-22.
	■ DATA LOGGER ■	See page 6-22.
	■ MAINTENANCE ■	See page 6-23.
	■ HIZ RECORDS ■	See page 6-23.
■■ ACTUAL VALUES ■■ PRODUCT INFO	■ MODEL INFORMATION ■	See page 6-24.
	■ FIRMWARE REVISIONS ■	See page 6-24.

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 64
                          Off
```

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

6.2.3 REMOTE INPUTS

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ REMOTE INPUTS

```
■ REMOTE INPUTS           REMOTE INPUT  1       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 TELEPROTECTION INPUTS

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ TELEPROTECTION INPUTS

■ TELEPROTECTION ■ INPUTS	◀▶	TELEPROTECTION INPUT 1-1: Off	*Range:* *Off, On*
MESSAGE	▲▼	TELEPROTECTION INPUT 1-2: Off	*Range:* *Off, On*
		↓	
MESSAGE	▲▼	TELEPROTECTION INPUT 1-16: Off	*Range:* *Off, On*
MESSAGE	▲▼	TELEPROTECTION INPUT 2-1: Off	*Range:* *Off, On*
MESSAGE	▲▼	TELEPROTECTION INPUT 2-2: Off	*Range:* *Off, On*
		↓	
MESSAGE	▲	TELEPROTECTION INPUT 2-16: Off	*Range:* *Off, On*

The present state of teleprotection inputs from communication channels 1 and 2 are shown here. The state displayed will be that of corresponding remote output unless the channel is declared failed.

6.2.5 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.

6.2.6 VIRTUAL OUTPUTS

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ VIRTUAL OUTPUTS

■ VIRTUAL OUTPUTS ■	◀▶	Virt Op 1 Off
		↓
MESSAGE	▲	Virt Op 96 Off

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

6.2.7 AUTORECLOSE

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ AUTORECLOSE ⇨ AUTORECLOSE 1

■ AUTORECLOSE 1 ■	◀▶	AUTORECLOSE 1 SHOT COUNT: 0	*Range: 0, 1, 2, 3, 4*

The automatic reclosure shot count is shown here.

6.2.8 REMOTE DEVICES

a) STATUS

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ REMOTE DEVICES STATUS

■ REMOTE DEVICES ■ STATUS	◀▶	All REMOTE DEVICES ONLINE: No	*Range: Yes, No*
MESSAGE	▲▼	REMOTE DEVICE 1 STATUS: Offline	*Range: Online, Offline*
		↓	
MESSAGE	▲	REMOTE DEVICE 16 STATUS: Offline	*Range: Online, 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.

6.2.9 DIGITAL COUNTERS

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

```
■ DIGITAL COUNTERS        Counter 1     ACCUM:
■ Counter 1                        0
                MESSAGE   Counter 1    FROZEN:
                                   0
                MESSAGE   Counter 1    FROZEN:
                          YYYY/MM/DD HH:MM:SS
                MESSAGE   Counter 1    MICROS:
                                   0
```

The present status of the 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.

6.2.10 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.

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6.2.11 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.

6.2.12 ETHERNET

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ ETHERNET

```
■ ETHERNET                ETHERNET PRI LINK      Range: Fail, OK
■                         STATUS: OK
                MESSAGE   ETHERNET SEC LINK      Range: Fail, OK
                          STATUS: OK
```

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

6.2.13 HI-Z STATUS

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ HIZ STATUS

■ HIZ STATUS ■	◁▷	HIZ STATUS: NORMAL	*Range: Normal, Coordination Timeout, Armed, Arcing, Down Conductor*
MESSAGE	△	ARC CONFIDENCE A:100 B:100 C:100 N:100 %	

6.2.14 DIRECT INPUTS

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ DIRECT INPUTS

■ DIRECT INPUTS ■	◁▷	AVG MSG RETURN TIME CH1: 0 ms
MESSAGE	△▽	UNRETURNED MSG COUNT CH1: 0
MESSAGE	△▽	CRC FAIL COUNT CH1: 0
MESSAGE	△▽	AVG MSG RETURN TIME CH2: 0 ms
MESSAGE	△▽	UNRETURNED MSG COUNT CH2: 0
MESSAGE	△▽	CRC FAIL COUNT CH2: 0
MESSAGE	△▽	DIRECT INPUT 1: On
		↓
MESSAGE	△	DIRECT INPUT 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.

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6.2.15 DIRECT DEVICES STATUS

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ DIRECT DEVICES STATUS

■ DIRECT DEVICES ■ STATUS		◁▷	DIRECT DEVICE 1 STATUS: Offline
	MESSAGE	△▽	DIRECT DEVICE 2 STATUS: Offline
			↓
	MESSAGE	△	DIRECT DEVICE 16 STATUS: Offline

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

6.2.16 EGD PROTOCOL STATUS

a) FAST EXCHANGE

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ EGD PROTOCOL STATUS ⇨ PRODUCER STATUS ⇨ FAST EXCHANGE 1

■ FAST EXCHANGE 1 ■		◁▷	FAST EXCHANGE 1 SIGNATURE: 0
	MESSAGE	△	FAST EXCHANGE 1 DATA LENGTH: 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 ■		◁▷	SLOW EXCHANGE 1 SIGNATURE: 0
	MESSAGE	△	SLOW EXCHANGE 1 DATA LENGTH: 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.

6.2.17 TELEPROTECTION CHANNEL TESTS

PATH: ACTUAL VALUES ⇨ STATUS ⇨⇩ TELEPROT CH TESTS

■ TELEPROT CH TESTS ■		CHANNEL 1 STATUS: n/a	*Range: n/a, FAIL, OK*
	MESSAGE	CHANNEL 1 LOST PACKETS: 1	*Range: 1 to 65535 in steps of 1*
	MESSAGE	CHANNEL 2 STATUS: n/a	*Range: n/a, FAIL, OK*
	MESSAGE	CHANNEL 2 LOST PACKETS: 1	*Range: 1 to 65535 in steps of 1*
	MESSAGE	VALIDITY OF CHANNEL CONFIGURATION: FAIL	*Range: n/a, FAIL, OK*

The status information for two channels is shown here.

- **CHANNEL 1(2) STATUS**: This represents the receiver status of each channel. If the value is "OK", teleprotection is enabled and data is being received from the remote terminal; If the value is "FAIL", teleprotection enabled and data is not being received from the remote terminal. If "n/a", teleprotection is disabled.
- **CHANNEL 1(2) LOST PACKETS**: Data is transmitted to the remote terminals in data packets at a rate of 2 packets per cycle. The number of lost packets represents data packets lost in transmission; this count can be reset to 0 through the **COMMANDS ⇨⇩ CLEAR RECORDS** menu.
- **VALIDITY OF CHANNEL CONFIGURATION**: This value displays the current state of the communications channel identification check, and hence validity. If a remote relay ID does not match the programmed ID at the local relay, the "FAIL" message will be displayed. The "N/A" value appears if the local relay ID is set to a default value of "0", the channel is failed, or if the teleprotection inputs/outputs are not enabled.

6.3.1 METERING CONVENTIONS

a) UR CONVENTION FOR MEASURING POWER AND ENERGY

The following figure illustrates the conventions established for use in UR-series relays.

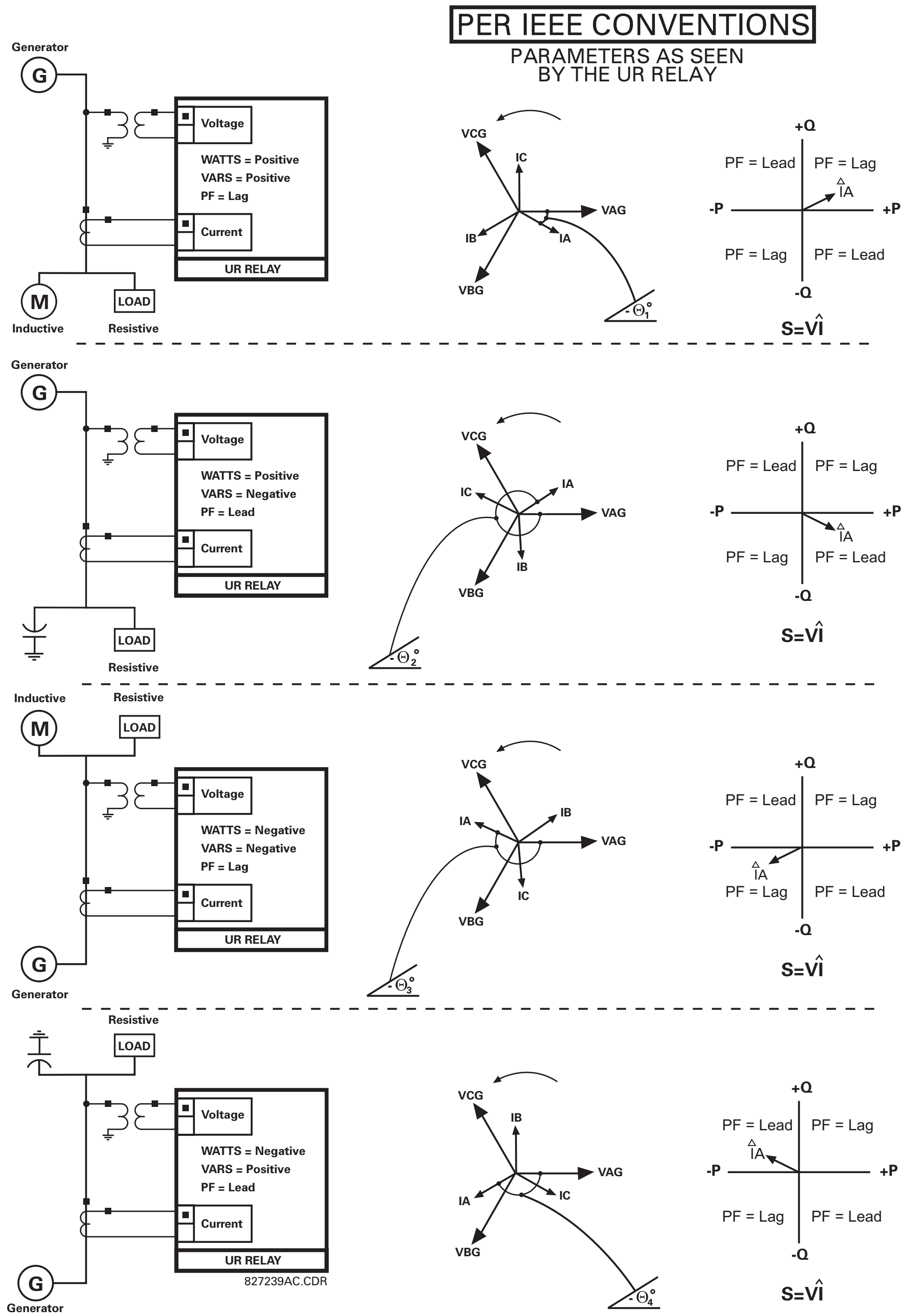

Figure 6–1: FLOW DIRECTION OF SIGNED VALUES FOR WATTS AND VARS

b) UR CONVENTION FOR MEASURING PHASE ANGLES

All phasors calculated by UR-series relays and used for protection, control and metering functions are rotating phasors that maintain the correct phase angle relationships with each other at all times.

For display and oscillography purposes, all phasor angles in a given relay are referred to an AC input channel pre-selected by the SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ POWER SYSTEM ⇨⇩ FREQUENCY AND PHASE REFERENCE setting. This setting defines a particular 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.

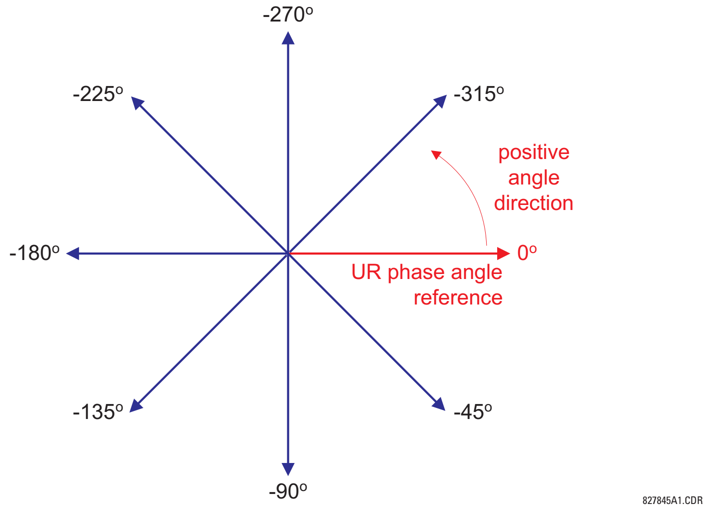

Figure 6–2: UR PHASE ANGLE MEASUREMENT CONVENTION

c) UR CONVENTION FOR SYMMETRICAL COMPONENTS

The UR-series of relays calculate voltage symmetrical components for the power system phase A line-to-neutral voltage, and symmetrical components of the currents for the power system phase A current. Owing to the above definition, phase angle relations between the symmetrical currents and voltages stay the same irrespective of the connection of instrument transformers. This is important for setting directional protection elements that use symmetrical voltages.

For display and oscillography purposes the phase angles of symmetrical components are referenced to a common reference as described in the previous sub-section.

WYE-CONNECTED INSTRUMENT TRANSFORMERS:

- ABC phase rotation:

$$V\_0 = \frac{1}{3}(V_{AG} + V_{BG} + V_{CG})$$

$$V\_1 = \frac{1}{3}(V_{AG} + aV_{BG} + a^2V_{CG})$$

$$V\_2 = \frac{1}{3}(V_{AG} + a^2V_{BG} + aV_{CG})$$

- ACB phase rotation:

$$V\_0 = \frac{1}{3}(V_{AG} + V_{BG} + V_{CG})$$

$$V\_1 = \frac{1}{3}(V_{AG} + a^2V_{BG} + aV_{CG})$$

$$V\_2 = \frac{1}{3}(V_{AG} + aV_{BG} + a^2V_{CG})$$

The above equations apply to currents as well.

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DELTA-CONNECTED INSTRUMENT TRANSFORMERS:

- ABC phase rotation:

$$\text{V\_0} = \text{N/A}$$

$$\text{V\_1} = \frac{1\angle -30°}{3\sqrt{3}}(V_{AB} + aV_{BC} + a^2V_{CA})$$

$$\text{V\_2} = \frac{1\angle 30°}{3\sqrt{3}}(V_{AB} + a^2V_{BC} + aV_{CA})$$

- ACB phase rotation:

$$\text{V\_0} = \text{N/A}$$

$$\text{V\_1} = \frac{1\angle 30°}{3\sqrt{3}}(V_{AB} + a^2V_{BC} + aV_{CA})$$

$$\text{V\_2} = \frac{1\angle -30°}{3\sqrt{3}}(V_{AB} + aV_{BC} + a^2V_{CA})$$

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

Table 6–1: SYMMETRICAL COMPONENTS CALCULATION EXAMPLE

SYSTEM VOLTAGES, SEC. V *						VT CONN.	RELAY INPUTS, SEC. V			SYMM. COMP, SEC. V		
V_{AG}	V_{BG}	V_{CG}	V_{AB}	V_{BC}	V_{CA}		F5AC	F6AC	F7AC	V_0	V_1	V_2
13.9 ∠0°	76.2 ∠–125°	79.7 ∠–250°	84.9 ∠–313°	138.3 ∠–97°	85.4 ∠–241°	WYE	13.9 ∠0°	76.2 ∠–125°	79.7 ∠–250°	19.5 ∠–192°	56.5 ∠–7°	23.3 ∠–187°
UNKNOWN (only V_1 and V_2 can be determined)			84.9 ∠0°	138.3 ∠–144°	85.4 ∠–288°	DELTA	84.9 ∠0°	138.3 ∠–144°	85.4 ∠–288°	N/A	56.5 ∠–54°	23.3 ∠–234°

* The power system voltages are phase-referenced – for simplicity – to *VAG* and *VAB*, respectively. This, however, is a relative matter. It is important to remember that the F60 displays are always referenced as specified under **SETTINGS ⇨⇩ SYSTEM SETUP ⇨⇩ POWER SYSTEM ⇨⇩ FREQUENCY AND PHASE REFERENCE**.

The example above is illustrated in the following figure.

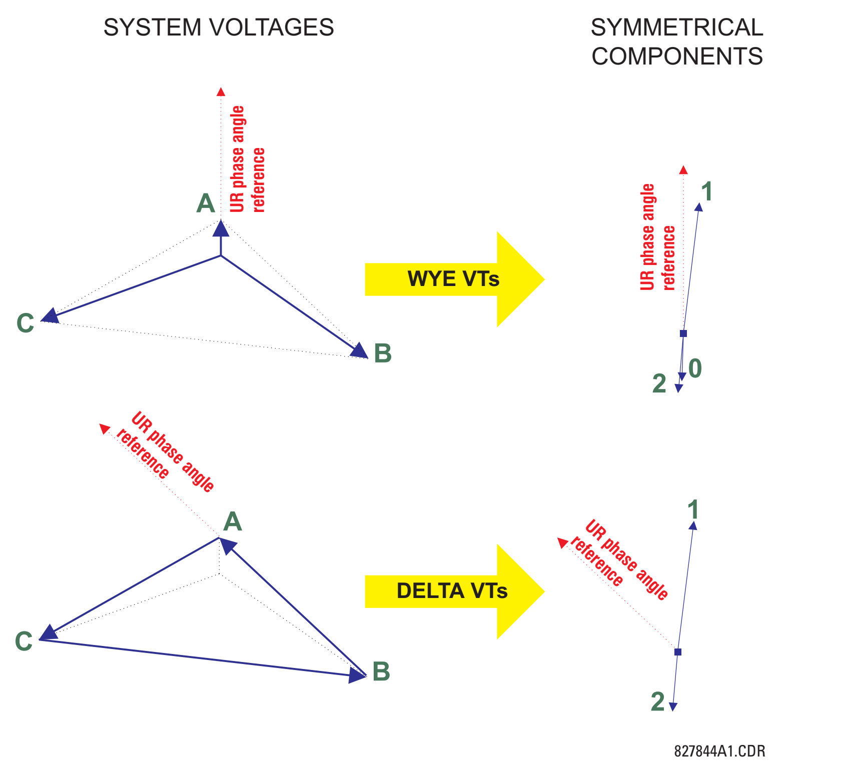

Figure 6–3: MEASUREMENT CONVENTION FOR SYMMETRICAL COMPONENTS

6.3.2 SOURCES

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 RMS Ia: 0.000
■ SRC 1                   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  RMS Ig:
■ SRC 1                    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  RMS Vag:
■ SRC 1                    0.00  V

              MESSAGE     SRC 1  RMS Vbg:
                           0.00  V

              MESSAGE     SRC 1  RMS Vcg:
                           0.00  V

              MESSAGE     SRC 1  PHASOR Vag:
                           0.000  V        0.0°
```

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MESSAGE		SRC 1 PHASOR Vbg: 0.000 V 0.0°
MESSAGE		SRC 1 PHASOR Vcg: 0.000 V 0.0°
MESSAGE		SRC 1 RMS Vab: 0.00 V
MESSAGE		SRC 1 RMS Vbc: 0.00 V
MESSAGE		SRC 1 RMS Vca: 0.00 V
MESSAGE		SRC 1 PHASOR Vab: 0.000 V 0.0°
MESSAGE		SRC 1 PHASOR Vbc: 0.000 V 0.0°
MESSAGE		SRC 1 PHASOR Vca: 0.000 V 0.0°
MESSAGE		SRC 1 ZERO SEQ V0: 0.000 V 0.0°
MESSAGE		SRC 1 POS SEQ V1: 0.000 V 0.0°
MESSAGE		SRC 1 NEG SEQ V2: 0.000 V 0.0°
■ AUXILIARY VOLTAGE ■ SRC 1		SRC 1 RMS Vx: 0.00 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

```
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  POS WATTHOUR:
■ SRC 1    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  DMD IA:
■ SRC 1    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
```

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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
■ CURRENT HARMONICS ■ SRC 1		SRC 1 THD Ia: 0.0 Ib: 0.0 Ic: 0.0%
MESSAGE		SRC 1 2ND Ia: 0.0 Ib: 0.0 Ic: 0.0%
MESSAGE		SRC 1 3RD Ia: 0.0 Ib: 0.0 Ic: 0.0%
		↓
MESSAGE		SRC 1 25TH Ia: 0.0 Ib: 0.0 Ic: 0.0%
■ VOLTAGE HARMONICS ■ SRC 1		SRC 1 THD Va: 0.0 Vb: 0.0 Vc: 0.0%
MESSAGE		SRC 1 2ND Va: 0.0 Vb: 0.0 Vc: 0.0%
MESSAGE		SRC 1 3RD Va: 0.0 Vb: 0.0 Vc: 0.0%
		↓
MESSAGE		SRC 1 25TH Va: 0.0 Vb: 0.0 Vc: 0.0%

Two 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**).

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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.

CURRENT HARMONICS are measured for each Source for the THD and 2nd to 25th harmonics per phase.

The technique used to extract the 2nd to 25th **VOLTAGE HARMONICS** is as follows. Each harmonic is computer per-phase, where:

N = 64 is the number of samples per cycle
$\omega_0 = 2\pi f$ is the angular frequency based on the system frequency (50 or 60 Hz)
k = 1, 2,..., N – 1 is the index over one cycle for the FFT
m is the last sample number for the sliding window
h = 1, 2,..., 25 is the harmonic number

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

$$F_{real}(m, h) = \frac{2}{N}\sum_k (f(m-k) \cdot \cos(h \cdot \omega_0 \cdot t(k)))$$
$$F_{imag}(m, h) = \frac{2}{N}\sum_k (f(m-k) \cdot \sin(h \cdot \omega_0 \cdot t(k)))$$
$$F_{ampl}(m, h) = \sqrt{F_{real}(m, h)^2 + F_{imag}(m, h)^2} \quad \textbf{(EQ 6.1)}$$

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

$$\mathrm{THD} = \sqrt{F_2^2 + F_3^2 + \ldots + F_{25}^2} \quad \textbf{(EQ 6.2)}$$

NOTE: Voltage harmonics are not available on F60 relays configured with the high-impedance fault detection (Hi-Z) feature.

NOTE: Voltage harmonics are calculated only for Wye connected phase VTs. Ensure the **SYSTEM SETUP ⇨ AC INPUTS ⇨⇩ VOLTAGE BANK F5 ⇨⇩ PHASE VT XX CONNECTION** setting is “Wye” for voltage harmonics metering.

6.3.3 SENSITIVE DIRECTIONAL POWER

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨⇩ SENSITIVE DIRECTIONAL POWER

```
■ SENSITIVE                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.

6.3.4 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.

6.3.5 TRACKING FREQUENCY

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨⇩ TRACKING FREQUENCY

■ TRACKING FREQUENCY ■		TRACKING FREQUENCY: 60.00 Hz

The tracking frequency is displayed here. The frequency is tracked based on configuration of the reference source. The **TRACKING FREQUENCY** is based upon positive sequence current phasors from all line terminals and is synchronously adjusted at all terminals. If currents are below 0.125 pu, then the **NOMINAL FREQUENCY** is used.

6.3.6 FREQUENCY RATE OF CHANGE

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨⇩ FREQUENCY RATE OF CHANGE

■ FREQUENCY RATE ■ OF CHANGE		FREQUENCY RATE OF CHANGE 1: 0.00 Hz/s
		↓
MESSAGE		FREQUENCY RATE OF CHANGE 4: 0.00 Hz/s

The metered frequency rate of change for the four elements is shown here.

6.3.7 FLEXELEMENTS™

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨⇩ FLEXELEMENTS ⇨ FLEXELEMENT 1(8)

```
■ FLEXELEMENT 1          FLEXELEMENT 1
■                        OpSig: 0.000 pu
```

The operating signals for the FlexElements™ are displayed in pu values using the following definitions of the base units.

Table 6–2: FLEXELEMENT™ BASE UNITS

BREAKER ARCING AMPS (Brk X Arc Amp A, B, and C)	BASE = 2000 $kA^2 \times$ cycle
dcmA	BASE = maximum value of the **DCMA INPUT MAX** setting for the two transducers configured under the +IN and –IN inputs.
FREQUENCY	f_{BASE} = 1 Hz
FREQUENCY RATE OF CHANGE	df/dt_{BASE} = 1 Hz/s
PHASE ANGLE	φ_{BASE} = 360 degrees (see the UR angle referencing convention)
POWER FACTOR	PF_{BASE} = 1.00
RTDs	BASE = 100°C
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 THD & HARMONICS	BASE = 100% of fundamental frequency component
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

6.3.8 TRANSDUCER INPUTS/OUTPUTS

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨⇩ TRANSDUCER I/O DCMA INPUTS ⇨ DCMA INPUT xx

```
■ DCMA INPUT xx          DCMA INPUT xx
■                        0.000 mA
```

Actual values for each dcmA input channel that is enabled are displayed with the top line as the programmed Channel ID and the bottom line as the value followed by the programmed units.

PATH: ACTUAL VALUES ⇨⇩ METERING ⇨⇩ TRANSDUCER I/O RTD INPUTS ⇨ RTD INPUT xx

```
■ RTD INPUT xx           RTD INPUT xx
■                        -50 °C
```

Actual values for each RTD input channel that is enabled are displayed with the top line as the programmed Channel ID and the bottom line as the value.

6.4.1 FAULT REPORTS

PATH: ACTUAL VALUES ⇨⇩ RECORDS ⇨ FAULT REPORTS ⇨ FAULT REPORT 1(15)

```
NO FAULTS TO REPORT
```

or

■ FAULT REPORT 1 ■		FAULT 1 LINE ID: SRC 1	*Range: SRC 1, SRC 2*
	MESSAGE	FAULT 1 DATE: 2000/08/11	*Range: YYYY/MM/DD*
	MESSAGE	FAULT 1 TIME: 00:00:00.000000	*Range: HH:MM:SS.ssssss*
	MESSAGE	FAULT 1 TYPE: ABG	*Range: not available if the source VTs are in the "Delta" configuration*
	MESSAGE	FAULT 1 LOCATION 00.0 km	*Range: not available if the source VTs are in the "Delta" configuration*
	MESSAGE	FAULT 1 RECLOSE SHOT: 0	*Range: where applicable*

The latest 15 fault reports can be stored. The most recent fault location calculation (when applicable) is displayed in this menu, along with the date and time stamp of the event which triggered the calculation. See the **SETTINGS ⇨ PRODUCT SETUP ⇨⇩ FAULT REPORTS ⇨ 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.

NOTE The fault locator does not report fault type or location if the source VTs are connected in the Delta configuration.

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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.

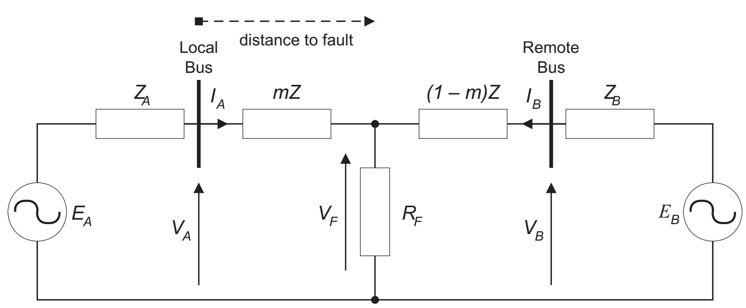

Figure 6–4: EQUIVALENT SYSTEM FOR FAULT LOCATION

The following equations hold true for this equivalent system.

$$V_A = m \cdot Z \cdot I_A + R_F \cdot (I_A + I_B) \quad \textbf{(EQ 6.3)}$$

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:

$$I_A = I_{AF} + I_{Apre} \quad \textbf{(EQ 6.4)}$$

and neglecting shunt parameters of the line:

$$I_B = I_{BF} - I_{Apre} \quad \text{(EQ 6.5)}$$

Inserting the I_A and I_B equations into the V_A equation and solving for the fault resistance yields:

$$R_F = \frac{V_A - m \cdot Z \cdot I_A}{I_{AF} \cdot \left(1 + \frac{I_{BF}}{I_{AF}}\right)} \quad \text{(EQ 6.6)}$$

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:

$$\text{Im}\left(\frac{V_A - m \cdot Z \cdot I_A}{I_{AF}}\right) = 0 \quad \text{(EQ 6.7)}$$

where: Im() represents the imaginary part of a complex number. Solving the above equation for the unknown *m* creates the following fault location algorithm:

$$m = \frac{\text{Im}(V_A \cdot I_{AF}^*)}{\text{Im}(Z \cdot I_A \cdot I_{AF}^*)} \quad \text{(EQ 6.8)}$$

where ***** denotes the complex conjugate and $I_{AF} = I_A - I_{Apre}$.

Depending on the fault type, appropriate voltage and current signals are selected from the phase quantities before applying the two equations above (the superscripts denote phases, the subscripts denote stations):

- For AG faults: $V_A = V_A^A$, $I_A = I_A^A + K_0 \cdot I_{0A}$
- 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.

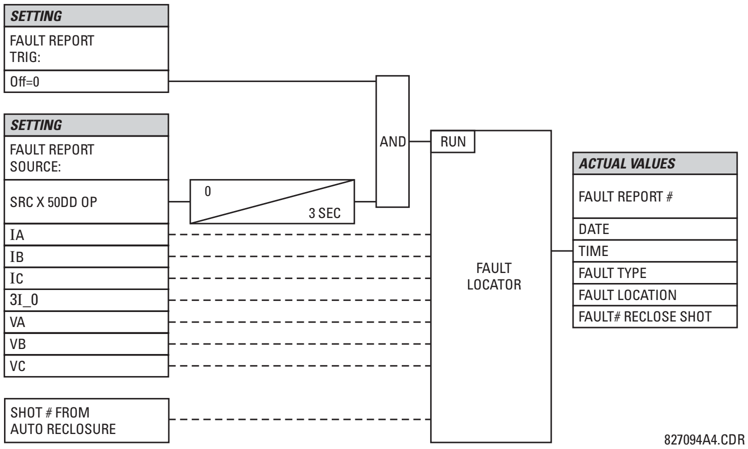

Figure 6–5: FAULT LOCATOR SCHEME

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6.4.2 EVENT RECORDS

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.

6.4.3 OSCILLOGRAPHY

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  15:40:16
```

This menu allows the user to view the number of triggers involved and number of oscillography traces available. The 'cycles per record' value is calculated to account for the fixed amount of data storage for oscillography. See the Oscillography section of Chapter 5 for 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.

6.4.4 DATA LOGGER

PATH: ACTUAL VALUES ⇨⇩ RECORDS ⇨⇩ DATA LOGGER

```
■ DATA LOGGER            OLDEST SAMPLE TIME:
■                        2000/01/14 13:45:51

MESSAGE                  NEWEST SAMPLE TIME:
                         2000/01/14 15:21:19
```

The **OLDEST SAMPLE TIME** 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.

6.4.5 BREAKER MAINTENANCE

PATH: ACTUAL VALUES ⇨⇩ RECORDS ⇨⇩ MAINTENANCE ⇨ BREAKER 1(2)

```
■ BREAKER 1
■
```

	BKR 1 ARCING AMP φA: 0.00 kA2-cyc
MESSAGE	BKR 1 ARCING AMP φB: 0.00 kA2-cyc
MESSAGE	BKR 1 ARCING AMP φC: 0.00 kA2-cyc
MESSAGE	BKR 1 OPERATING TIME φA: 0 ms
MESSAGE	BKR 1 OPERATING TIME φB: 0 ms
MESSAGE	BKR 1 OPERATING TIME φC: 0 ms
MESSAGE	BKR 1 OPERATING TIME: 0 ms

There is an identical menu for each of the breakers. The **BKR 1 ARCING AMP** values are in units of kA^2-cycles. Refer to the **COMMANDS ⇨⇩ CLEAR RECORDS** menu for clearing breaker arcing current records. The **BREAKER OPERATING TIME** is defined as the slowest operating time of breaker poles that were initiated to open.

6.4.6 HI-Z RECORDS

PATH: ACTUAL VALUES ⇨⇩ RECORDS ⇨⇩ HIZ RECORDS

```
■ HIZ RECORDS
■
```

	FORCE TRIGGER: No
MESSAGE	HIZ 1:NONE 1970/01/01 00:00:00
MESSAGE	HIZ 2:NONE 1970/01/01 00:00:00
MESSAGE	HIZ 3:NONE 1970/01/01 00:00:00
MESSAGE	HIZ 4:NONE 1970/01/01 00:00:00
MESSAGE	RMS 1:NONE 1970/01/01 00:00:00
MESSAGE	RMS 2:NONE 1970/01/01 00:00:00
MESSAGE	RMS 3:NONE 1970/01/01 00:00:00
MESSAGE	RMS 4:NONE 1970/01/01 00:00:00

6

6.5.1 MODEL INFORMATION

PATH: ACTUAL VALUES ⇨⇩ PRODUCT INFO ⇨ MODEL INFORMATION

■ MODEL INFORMATION ■		ORDER CODE LINE 1: F60-E00-HCH-F8F-H6A	*Example code shown*
	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: 0	*Range: YYYY/MM/DD HH:MM:SS*
	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

6

PATH: ACTUAL VALUES ⇨⇩ PRODUCT INFO ⇨⇩ FIRMWARE REVISIONS

■ FIRMWARE REVISIONS ■		F60 Feeder Relay REVISION: 4.40	*Range: 0.00 to 655.35* *Revision number of the application firmware.*
	MESSAGE	MODIFICATION FILE NUMBER: 0	*Range: 0 to 65535 (ID of the MOD FILE)* *Value is 0 for each standard firmware release.*
	MESSAGE	BOOT PROGRAM REVISION: 1.13	*Range: 0.00 to 655.35* *Revision number of the boot program firmware.*
	MESSAGE	FRONT PANEL PROGRAM REVISION: 0.08	*Range: 0.00 to 655.35* *Revision number of faceplate program firmware.*
	MESSAGE	COMPILE DATE: 2004/09/15 04:55:16	*Range: Any valid date and time.* *Date and time when product firmware was built.*
	MESSAGE	BOOT DATE: 2004/09/15 16:41:32	*Range: Any valid date and time.* *Date and time when the boot program was built.*

The shown data is illustrative only. A modification file number of 0 indicates that, currently, no modifications have been installed.

7.1.1 COMMANDS MENU

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 for details. The following flash message appears after successfully command entry:

```
COMMAND
EXECUTED
```

7.1.2 VIRTUAL INPUTS

PATH: COMMANDS ⇨ VIRTUAL INPUTS

```
■■ COMMANDS
■■ VIRTUAL INPUTS
```

```
Virt Ip 1
Off
```
Range: Off, On

↓
↓

MESSAGE
```
Virt Ip 64
Off
```
Range: Off, On

The states of up to 64 virtual inputs are changed here. The first line of the display indicates the ID of the virtual input. The second line indicates the current or selected status of the virtual input. This status will be a logical state ‘Off’ (0) or ‘On’ (1).

7.1.3 CLEAR RECORDS

PATH: COMMANDS ⇨⇩ CLEAR RECORDS

```
■■ COMMANDS
■■ CLEAR RECORDS
```

```
CLEAR FAULT REPORTS?
No
```
Range: No, Yes

```
CLEAR EVENT RECORDS?
No
```
Range: No, Yes

```
CLEAR OSCILLOGRAPHY?
No
```
Range: No, Yes

```
CLEAR DATA LOGGER?
No
```
Range: No, Yes

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CLEAR BREAKER 1 ARCING AMPS? No	*Range: No, Yes*
CLEAR BREAKER 2 ARCING AMPS? No	*Range: No, Yes*
CLEAR DEMAND RECORDS?: No	*Range: No, Yes*
CLEAR ENERGY? No	*Range: No, Yes*
CLEAR HIZ RECORDS? No	*Range: No, Yes*
CLEAR UNAUTHORIZED ACCESS? No	*Range: No, Yes*
CLEAR DIRECT I/O COUNTERS? No	*Range: No, Yes. Valid only for units with Direct Input/ Output module.*
CLEAR TELEPROTECT COUNTERS? No	*Range: No, Yes*
CLEAR ALL RELAY RECORDS? No	*Range: No, Yes*

This menu contains commands for clearing historical data such as the Event Records. Data is cleared by changing a command setting to “Yes” and pressing the ENTER key. After clearing data, the command setting automatically reverts to “No”.

7.1.4 SET DATE AND TIME

PATH: COMMANDS ⇨⇩ SET DATE AND TIME

■■ COMMANDS ■■ SET DATE AND TIME	SET DATE AND TIME: 2000/01/14 13:47:03	*(YYYY/MM/DD HH:MM:SS)*

The date and time can be entered here via the faceplate keypad only if the IRIG-B or SNTP signal is not in use. The time setting is based on the 24-hour clock. The complete date, as a minimum, must be entered to allow execution of this command. The new time will take effect at the moment the ENTER key is clicked.

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7.1.5 RELAY MAINTENANCE

PATH: COMMANDS ⇨⇩ RELAY MAINTENANCE

■■ COMMANDS ■■ RELAY MAINTENANCE	PERFORM LAMPTEST? No	*Range: No, Yes*
	UPDATE ORDER CODE? No	*Range: No, Yes*

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.

7.2.1 TARGETS MENU

MENU

```
TARGETS
```

⇩

MESSAGE ▼ `DIGITAL ELEMENT  1:` `LATCHED` — *Displayed only if targets for this element are active. Example shown.*

MESSAGE ▲▼ `DIGITAL ELEMENT 48:` `LATCHED` — *Displayed only if targets for this element are active. Example shown.*

MESSAGE ▲ ↓ ↓

The status of any active targets will be displayed in the Targets menu. If no targets are active, the display will read **No Active Targets**:

7.2.2 TARGET MESSAGES

When there are no active targets, the first target to become active will cause the display to immediately default to that message. If there are active targets and the user is navigating through other messages, and when the default message timer times out (i.e. the keypad has not been used for a determined period of time), the display will again default back to the target message.

The range of variables for the target messages is described below. Phase information will be included if applicable. If a target message status changes, the status with the highest priority will be displayed.

Table 7–1: TARGET MESSAGE PRIORITY STATUS

PRIORITY	ACTIVE STATUS	DESCRIPTION
1	OP	element operated and still picked up
2	PKP	element picked up and timed out
3	LATCHED	element had operated but has dropped out

If a self test error is detected, a message appears indicating the cause of the error. For example **UNIT NOT PROGRAMMED** indicates that the minimal relay settings have not been programmed.

7.2.3 RELAY SELF-TESTS

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 FlexLogic™ 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.

8.1.1 DESCRIPTION

The Hi-Z element accomplishes high-impedance fault detection using a variety of algorithms, all coordinated by an expert system. At the heart of the high-impedance fault-detection system is the identification of arcing on a feeder. If the Hi-Z element detects arcing, it then determines whether or not the arcing persists for a significant period of time. If it does, the Hi-Z element determines whether the persistent arcing is from a downed conductor or from an intact conductor and then generates an output to indicate either the detection of a downed conductor or the detection of arcing, respectively.

Distinction between an arcing intact conductor and an arcing downed conductor is determined by looking at patterns in the load current at the beginning of the fault. A downed conductor is indicated only when a precipitous loss of load or an overcurrent condition precedes arcing detection. Otherwise, the Hi-Z element assumes that the line is intact, even if arcing is present. In such a case, if the detected arcing can be classified as persistent, and an output contact is configured for 'arcing detected', the Hi-Z element will close that contact.

In some cases, arcing is determined to be present, but not persistent. For example, if it is caused by tree limb contact or insulator degradation, arcing will typically be present intermittently with relatively long periods of inactivity (e.g. minutes) interspersed. In such cases, arcing may be affected by such factors as the motion of a tree limb or the moisture and contamination on an insulator. Conditions such as these, characterized by a high number of brief occurrences of arcing over an extended period of time (e.g. from a fraction of an hour to one or two hours), lead the Hi-Z element to recognize and flag an “arcing suspected” event. None of these brief occurrences of arcing, if taken individually, are sufficient to indicate detection of a downed conductor or to set off an alarm indicating that persistent arcing has been detected. When considered cumulatively, however, they do indicate a need for attention. If an output contact is configured to indicate 'arcing suspected', the Hi-Z element recognition of such sporadic arcing will close that contact and appropriate actions can be taken.

If the Hi-Z element determines that a downed conductor exists, oscillography and fault data are captured. In addition, target messages and appropriate LEDs are activated on the relay faceplate.

The detection of a downed conductor or arcing condition is accomplished through the execution of the following algorithms:

- Energy Algorithm
- Randomness Algorithm
- Expert Arc Detector Algorithm
- Load Event Detector Algorithm
- Load Analysis Algorithm
- Load Extraction Algorithm
- Arc Burst Pattern Analysis Algorithm
- Spectral Analysis Algorithm
- Arcing-Suspected Identifier Algorithm
- Even Harmonic Restraint Algorithm
- Voltage Supervision Algorithm

8.1.2 ENERGY ALGORITHM

The Energy algorithm monitors a specific set of non-fundamental frequency component energies of phase and neutral current. After establishing an average value for a given component energy, the algorithm indicates arcing if it detects a sudden, sustained increase in the value of that component. The Hi-Z element runs the Energy algorithm on each of the following parameters for each phase current and for the neutral:

- even harmonics
- odd harmonics
- non-harmonics

On a 60 Hz system, the non-harmonic component consists of a sum of the 30, 90, 150,..., 750 Hz components, while on a 50 Hz system, it consists of a sum of the 25, 75, 125,..., 625 Hz components. If the Energy Algorithm detects a sudden, sustained increase in one of these component energies, it reports this to the Expert Arc Detector algorithm, resets itself, and continues to monitor for another sudden increase.

8.1.3 RANDOMNESS ALGORITHM

The Randomness algorithm monitors the same set of component energies as the Energy algorithm. However, rather than checking for a sudden, sustained increase in the value of the monitored component energy, it looks for a sudden increase in a component followed by highly erratic behavior. This type of highly erratic behavior is indicative of many arcing faults. Just as with the Energy algorithm, if the Randomness algorithm detects a suspicious event in one of its monitored components, it reports it to the Expert Arc Detector algorithm, resets itself, and continues to monitor for another suspicious event.

8.1.4 EXPERT ARC DETECTOR ALGORITHM

The purpose of the Expert Arc Detector Algorithm is to assimilate the outputs of the basic arc detection algorithms into one "arcing confidence" level per phase. Note that there are actually 24 independent basic arc detection algorithms, since both the Energy Algorithm and the Randomness Algorithm are run for the even harmonics, odd harmonics, and non-harmonics for each phase current and for the neutral. The assimilation performed by the Expert Arc Detector Algorithm, then, is accomplished by counting the number of arcing indications determined by any one of the twenty-four algorithms over a short period of time (e.g. the last 30 seconds). Also taken into account is the number of different basic algorithms that indicate arcing.

In the Expert Arc Detector Algorithm, the arcing confidence level for each phase increases as the number of basic algorithms that indicate arcing (per phase) increases. It also increases with increasing numbers of indications from any one basic algorithm. These increases in confidence levels occur because multiple, consecutive indications from a given algorithm and indications from multiple independent algorithms are more indicative of the presence of arcing than a single algorithm giving a single indication.

8.1.5 SPECTRAL ANALYSIS ALGORITHM

The Spectral Analysis algorithm is the third and final confirmation algorithm performed only when a high impedance condition is suspected.

The Spectral Analysis algorithm receives five seconds of averaged non-harmonic residual current spectrum data and compares it to an ideal $1 / f$ curve. Depending on the result, three percent can be added to the arcing confidence level generated by the Expert Arc Detector Algorithm.

8.1.6 LOAD EVENT DETECTOR ALGORITHM

The Load Event Detector Algorithm examines, on a per-phase basis, one reading of RMS values per two-cycle interval for each phase current and the neutral. It then sets flags for each phase current and for the neutral based on the following events:

- an overcurrent condition
- a precipitous loss of load
- a high rate-of-change
- a significant three-phase event
- a breaker open condition.

These flags are examined by the Load Analysis Algorithm. Their states contribute to that algorithm's differentiation between arcing downed conductors and arcing intact conductors, and inhibit the Expert Arc Detector Algorithm from indicating the need for an arcing alarm for a limited time following an overcurrent or breaker open condition.

Any of the above five flags will zero the Expert Arc Detector buffer, since the power system is in a state of change and the values being calculated for use by the Energy and Randomness algorithms are probably not valid.

An extremely high rate of change is not characteristic of most high impedance faults and is more indicative of a breaker closing, causing associated inrush. Since this type of inrush current causes substantial variations in the harmonics used by the high impedance algorithms, these algorithms ignore all data for several seconds following a high rate-of-change event that exceeds the associated rate-of-change threshold, in order to give the power system a chance to stabilize.

8.1.7 LOAD ANALYSIS ALGORITHM

The purpose of the Load Analysis algorithm is to differentiate between arcing downed conductors and arcing intact conductors by looking for a precipitous loss of load and/or an overcurrent disturbance at the beginning of an arcing episode. The presence of arcing on the system is determined based on the output of the Expert Arc Detector algorithm. If the Hi-Z element finds persistent arcing on the power system, the Load Analysis algorithm then considers the type of incident that initiated the arcing and classifies the arcing conductor as either downed or intact. Another function of the algorithm is to provide coordination between the Hi-Z element and the power system's conventional overcurrent protection by observing a timeout, via the **HI-Z OC PROTECTION COORD TIMEOUT** setting from the beginning of the arcing before giving an indication of arcing.

If the Load Analysis algorithm determines that a downed conductor or arcing exists, it attempts to determine the phase on which the high impedance fault condition exists. It does this in a hierarchical manner. First, if a significant loss of load triggered the Load Analysis algorithm, and if there was a significant loss on only one phase, that phase is identified. If there was not a single phase loss of load, and if an overcurrent condition on only one phase triggered the algorithm, that phase is identified. If both of these tests fail to identify the phase, the phase with a significantly higher confidence level (e.g. higher than the other two phases by at least 25%) is identified. Finally, if none of these tests provides phase identification, the result of the Arc Burst Pattern Analysis algorithm is checked. If that test fails, the phase is not identified.

8.1.8 LOAD EXTRACTION ALGORITHM

The Load Extraction Algorithm attempts to find a quiescent period during an arcing fault so that it can determine the background load current level in the neutral current. If it is successful in doing so, it then removes the load component from the total measured current, resulting in a signal which consists only of the fault component of the neutral current. This information is then provided as input to the Arc Burst Pattern Analysis Algorithm.

8.1.9 ARC BURST PATTERN ANALYSIS ALGORITHM

The Arc Burst Pattern Analysis algorithm attempts to provide faulted phase identification information based on a correlation between the fault component of the measured neutral current and the phase voltages. The phase identified will be the one whose phase voltage peak lines up with the neutral current burst. The fault component is received from the Load Extraction algorithm. The result of the analysis is checked by the Load Analysis algorithm if its other phase identification methods prove unsuccessful.

8.1.10 ARCING SUSPECTED ALGORITHM

The purpose of the Arcing Suspected Algorithm is to detect multiple, sporadic arcing events. If taken individually, such events are not sufficient to warrant an arcing alarm. When taken cumulatively, however, these events do warrant an alarm to system operators so that the cause of the recurrent arcing can be investigated.

8.1.11 OVERCURRENT DISTURBANCE MONITORING

This function is part of High Impedance Fault Detection and should not be confused with conventional overcurrent protection. The Hi-Z element monitors for an overcurrent condition on the feeder by establishing overcurrent thresholds for the phases and for the neutral and then checking for a single two-cycle RMS current that exceeds those thresholds. Oscillography and fault data are captured if it is determined that an overcurrent condition exists.

8

8.1.12 HI-Z EVEN HARMONIC RESTRAINT ALGORITHM

Every two-cycle interval the algorithm evaluates the even harmonic content of each phase current. The even harmonic content is evaluated as a percentage of the phase RMS current. If for any phase the percentage is greater than the **HI-Z EVEN HARMONIC RESTRAINT** setting, the algorithm will inhibit setting of the overcurrent flags. This is to prevent a cold-load pickup event from starting the Hi-Z logic sequence (which requires the overcurrent flag or the loss-of-load flag to be set at the beginning of an arcing event). The duration over which the algorithm inhibits the setting of the overcurrent flag(s) is from the time the even-harmonic level (as a percentage of RMS) increases above the threshold until one second after it falls back below the threshold.

8.1.13 HI-Z VOLTAGE SUPERVISION ALGORITHM

This algorithm was implemented to minimize the probability of a false Hi-Z indication due to bus voltage dips (e.g. from parallel feeder faults). A fault on a parallel line can cause voltage dips that will produce a decrease in the line load which can be mistaken by Hi-Z element as Loss of Load.

Every two cycle the voltage on each phase is checked against the **HI-Z V SUPV THRESHOLD**. If the voltage on any phase has dropped by a percentage greater then or equal to this setting, the Loss of Load flag will be blocked. The blocking is not done on a per- phase basis. If one phase voltage shows a dip, the block is applied for all phases. Also the High Impedance Oscillography will record that a voltage dip was experienced. The Oscillography record is phase specific.

Table A–1: FLEXANALOG DATA ITEMS (Sheet 1 of 12)

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
5856	Frequency Rate of Change 1 Actual	Freq Rate 1 Value
5860	Frequency Rate of Change 2 Actual	Freq Rate 2 Value
5864	Frequency Rate of Change 3 Actual	Freq Rate 3 Value
5868	Frequency Rate of Change 4 Actual	Freq Rate 4 Value
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

Table A–1: FLEXANALOG DATA ITEMS (Sheet 2 of 12)

ADDR	DATA ITEM	FLEXANALOG NAME
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
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
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

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Table A–1: FLEXANALOG DATA ITEMS (Sheet 3 of 12)

ADDR	DATA ITEM	FLEXANALOG NAME
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
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
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
7552	SRC 1 Frequency	SRC 1 Frequency
7553	SRC 2 Frequency	SRC 2 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

Table A–1: FLEXANALOG DATA ITEMS (Sheet 4 of 12)

ADDR	DATA ITEM	FLEXANALOG NAME
7704	SRC 2 Demand Var	SRC 2 Demand var
7706	SRC 2 Demand Va	SRC 2 Demand Va
8064	SRC 1 Va THD	SRC 1 Va THD
8065	SRC 1 Va Harmonics	SRC 1 Va Harm[0]
8066	SRC 1 Va Harmonics	SRC 1 Va Harm[1]
8067	SRC 1 Va Harmonics	SRC 1 Va Harm[2]
8068	SRC 1 Va Harmonics	SRC 1 Va Harm[3]
8069	SRC 1 Va Harmonics	SRC 1 Va Harm[4]
8070	SRC 1 Va Harmonics	SRC 1 Va Harm[5]
8071	SRC 1 Va Harmonics	SRC 1 Va Harm[6]
8072	SRC 1 Va Harmonics	SRC 1 Va Harm[7]
8073	SRC 1 Va Harmonics	SRC 1 Va Harm[8]
8074	SRC 1 Va Harmonics	SRC 1 Va Harm[9]
8075	SRC 1 Va Harmonics	SRC 1 Va Harm[10]
8076	SRC 1 Va Harmonics	SRC 1 Va Harm[11]
8077	SRC 1 Va Harmonics	SRC 1 Va Harm[12]
8078	SRC 1 Va Harmonics	SRC 1 Va Harm[13]
8079	SRC 1 Va Harmonics	SRC 1 Va Harm[14]
8080	SRC 1 Va Harmonics	SRC 1 Va Harm[15]
8081	SRC 1 Va Harmonics	SRC 1 Va Harm[16]
8082	SRC 1 Va Harmonics	SRC 1 Va Harm[17]
8083	SRC 1 Va Harmonics	SRC 1 Va Harm[18]
8084	SRC 1 Va Harmonics	SRC 1 Va Harm[19]
8085	SRC 1 Va Harmonics	SRC 1 Va Harm[20]
8086	SRC 1 Va Harmonics	SRC 1 Va Harm[21]
8087	SRC 1 Va Harmonics	SRC 1 Va Harm[22]
8088	SRC 1 Va Harmonics	SRC 1 Va Harm[23]
8089	SRC 1 Vb THD	SRC 1 Vb THD
8090	SRC 1 Vb Harmonics	SRC 1 Vb Harm[0]
8091	SRC 1 Vb Harmonics	SRC 1 Vb Harm[1]
8092	SRC 1 Vb Harmonics	SRC 1 Vb Harm[2]
8093	SRC 1 Vb Harmonics	SRC 1 Vb Harm[3]
8094	SRC 1 Vb Harmonics	SRC 1 Vb Harm[4]
8095	SRC 1 Vb Harmonics	SRC 1 Vb Harm[5]
8096	SRC 1 Vb Harmonics	SRC 1 Vb Harm[6]
8097	SRC 1 Vb Harmonics	SRC 1 Vb Harm[7]
8098	SRC 1 Vb Harmonics	SRC 1 Vb Harm[8]
8099	SRC 1 Vb Harmonics	SRC 1 Vb Harm[9]
8100	SRC 1 Vb Harmonics	SRC 1 Vb Harm[10]
8101	SRC 1 Vb Harmonics	SRC 1 Vb Harm[11]
8102	SRC 1 Vb Harmonics	SRC 1 Vb Harm[12]
8103	SRC 1 Vb Harmonics	SRC 1 Vb Harm[13]
8104	SRC 1 Vb Harmonics	SRC 1 Vb Harm[14]
8105	SRC 1 Vb Harmonics	SRC 1 Vb Harm[15]
8106	SRC 1 Vb Harmonics	SRC 1 Vb Harm[16]
8107	SRC 1 Vb Harmonics	SRC 1 Vb Harm[17]
8108	SRC 1 Vb Harmonics	SRC 1 Vb Harm[18]
8109	SRC 1 Vb Harmonics	SRC 1 Vb Harm[19]
8110	SRC 1 Vb Harmonics	SRC 1 Vb Harm[20]
8111	SRC 1 Vb Harmonics	SRC 1 Vb Harm[21]
8112	SRC 1 Vb Harmonics	SRC 1 Vb Harm[22]
8113	SRC 1 Vb Harmonics	SRC 1 Vb Harm[23]

Table A–1: FLEXANALOG DATA ITEMS (Sheet 5 of 12)

ADDR	DATA ITEM	FLEXANALOG NAME
8114	SRC 1 Vc THD	SRC 1 Vc THD
8115	SRC 1 Vc Harmonics	SRC 1 Vc Harm[0]
8116	SRC 1 Vc Harmonics	SRC 1 Vc Harm[1]
8117	SRC 1 Vc Harmonics	SRC 1 Vc Harm[2]
8118	SRC 1 Vc Harmonics	SRC 1 Vc Harm[3]
8119	SRC 1 Vc Harmonics	SRC 1 Vc Harm[4]
8120	SRC 1 Vc Harmonics	SRC 1 Vc Harm[5]
8121	SRC 1 Vc Harmonics	SRC 1 Vc Harm[6]
8122	SRC 1 Vc Harmonics	SRC 1 Vc Harm[7]
8123	SRC 1 Vc Harmonics	SRC 1 Vc Harm[8]
8124	SRC 1 Vc Harmonics	SRC 1 Vc Harm[9]
8125	SRC 1 Vc Harmonics	SRC 1 Vc Harm[10]
8126	SRC 1 Vc Harmonics	SRC 1 Vc Harm[11]
8127	SRC 1 Vc Harmonics	SRC 1 Vc Harm[12]
8128	SRC 1 Vc Harmonics	SRC 1 Vc Harm[13]
8129	SRC 1 Vc Harmonics	SRC 1 Vc Harm[14]
8130	SRC 1 Vc Harmonics	SRC 1 Vc Harm[15]
8131	SRC 1 Vc Harmonics	SRC 1 Vc Harm[16]
8132	SRC 1 Vc Harmonics	SRC 1 Vc Harm[17]
8133	SRC 1 Vc Harmonics	SRC 1 Vc Harm[18]
8134	SRC 1 Vc Harmonics	SRC 1 Vc Harm[19]
8135	SRC 1 Vc Harmonics	SRC 1 Vc Harm[20]
8136	SRC 1 Vc Harmonics	SRC 1 Vc Harm[21]
8137	SRC 1 Vc Harmonics	SRC 1 Vc Harm[22]
8138	SRC 1 Vc Harmonics	SRC 1 Vc Harm[23]
8139	SRC 2 Va THD	SRC 2 Va THD
8140	SRC 2 Va Harmonics	SRC 2 Va Harm[0]
8141	SRC 2 Va Harmonics	SRC 2 Va Harm[1]
8142	SRC 2 Va Harmonics	SRC 2 Va Harm[2]
8143	SRC 2 Va Harmonics	SRC 2 Va Harm[3]
8144	SRC 2 Va Harmonics	SRC 2 Va Harm[4]
8145	SRC 2 Va Harmonics	SRC 2 Va Harm[5]
8146	SRC 2 Va Harmonics	SRC 2 Va Harm[6]
8147	SRC 2 Va Harmonics	SRC 2 Va Harm[7]
8148	SRC 2 Va Harmonics	SRC 2 Va Harm[8]
8149	SRC 2 Va Harmonics	SRC 2 Va Harm[9]
8150	SRC 2 Va Harmonics	SRC 2 Va Harm[10]
8151	SRC 2 Va Harmonics	SRC 2 Va Harm[11]
8152	SRC 2 Va Harmonics	SRC 2 Va Harm[12]
8153	SRC 2 Va Harmonics	SRC 2 Va Harm[13]
8154	SRC 2 Va Harmonics	SRC 2 Va Harm[14]
8155	SRC 2 Va Harmonics	SRC 2 Va Harm[15]
8156	SRC 2 Va Harmonics	SRC 2 Va Harm[16]
8157	SRC 2 Va Harmonics	SRC 2 Va Harm[17]
8158	SRC 2 Va Harmonics	SRC 2 Va Harm[18]
8159	SRC 2 Va Harmonics	SRC 2 Va Harm[19]
8160	SRC 2 Va Harmonics	SRC 2 Va Harm[20]
8161	SRC 2 Va Harmonics	SRC 2 Va Harm[21]
8162	SRC 2 Va Harmonics	SRC 2 Va Harm[22]
8163	SRC 2 Va Harmonics	SRC 2 Va Harm[23]
8164	SRC 2 Vb THD	SRC 2 Vb THD
8165	SRC 2 Vb Harmonics	SRC 2 Vb Harm[0]

Table A–1: FLEXANALOG DATA ITEMS (Sheet 6 of 12)

ADDR	DATA ITEM	FLEXANALOG NAME
8166	SRC 2 Vb Harmonics	SRC 2 Vb Harm[1]
8167	SRC 2 Vb Harmonics	SRC 2 Vb Harm[2]
8168	SRC 2 Vb Harmonics	SRC 2 Vb Harm[3]
8169	SRC 2 Vb Harmonics	SRC 2 Vb Harm[4]
8170	SRC 2 Vb Harmonics	SRC 2 Vb Harm[5]
8171	SRC 2 Vb Harmonics	SRC 2 Vb Harm[6]
8172	SRC 2 Vb Harmonics	SRC 2 Vb Harm[7]
8173	SRC 2 Vb Harmonics	SRC 2 Vb Harm[8]
8174	SRC 2 Vb Harmonics	SRC 2 Vb Harm[9]
8175	SRC 2 Vb Harmonics	SRC 2 Vb Harm[10]
8176	SRC 2 Vb Harmonics	SRC 2 Vb Harm[11]
8177	SRC 2 Vb Harmonics	SRC 2 Vb Harm[12]
8178	SRC 2 Vb Harmonics	SRC 2 Vb Harm[13]
8179	SRC 2 Vb Harmonics	SRC 2 Vb Harm[14]
8180	SRC 2 Vb Harmonics	SRC 2 Vb Harm[15]
8181	SRC 2 Vb Harmonics	SRC 2 Vb Harm[16]
8182	SRC 2 Vb Harmonics	SRC 2 Vb Harm[17]
8183	SRC 2 Vb Harmonics	SRC 2 Vb Harm[18]
8184	SRC 2 Vb Harmonics	SRC 2 Vb Harm[19]
8185	SRC 2 Vb Harmonics	SRC 2 Vb Harm[20]
8186	SRC 2 Vb Harmonics	SRC 2 Vb Harm[21]
8187	SRC 2 Vb Harmonics	SRC 2 Vb Harm[22]
8188	SRC 2 Vb Harmonics	SRC 2 Vb Harm[23]
8189	SRC 2 Vc THD	SRC 2 Vc THD
8190	SRC 2 Vc Harmonics	SRC 2 Vc Harm[0]
8191	SRC 2 Vc Harmonics	SRC 2 Vc Harm[1]
8192	SRC 2 Vc Harmonics	SRC 2 Vc Harm[2]
8193	SRC 2 Vc Harmonics	SRC 2 Vc Harm[3]
8194	SRC 2 Vc Harmonics	SRC 2 Vc Harm[4]
8195	SRC 2 Vc Harmonics	SRC 2 Vc Harm[5]
8196	SRC 2 Vc Harmonics	SRC 2 Vc Harm[6]
8197	SRC 2 Vc Harmonics	SRC 2 Vc Harm[7]
8198	SRC 2 Vc Harmonics	SRC 2 Vc Harm[8]
8199	SRC 2 Vc Harmonics	SRC 2 Vc Harm[9]
8200	SRC 2 Vc Harmonics	SRC 2 Vc Harm[10]
8201	SRC 2 Vc Harmonics	SRC 2 Vc Harm[11]
8202	SRC 2 Vc Harmonics	SRC 2 Vc Harm[12]
8203	SRC 2 Vc Harmonics	SRC 2 Vc Harm[13]
8204	SRC 2 Vc Harmonics	SRC 2 Vc Harm[14]
8205	SRC 2 Vc Harmonics	SRC 2 Vc Harm[15]
8206	SRC 2 Vc Harmonics	SRC 2 Vc Harm[16]
8207	SRC 2 Vc Harmonics	SRC 2 Vc Harm[17]
8208	SRC 2 Vc Harmonics	SRC 2 Vc Harm[18]
8209	SRC 2 Vc Harmonics	SRC 2 Vc Harm[19]
8210	SRC 2 Vc Harmonics	SRC 2 Vc Harm[20]
8211	SRC 2 Vc Harmonics	SRC 2 Vc Harm[21]
8212	SRC 2 Vc Harmonics	SRC 2 Vc Harm[22]
8213	SRC 2 Vc Harmonics	SRC 2 Vc Harm[23]
8784	Hi-Z Status	HIZ Status
8785	Hi-Z Phase A Arc Confidence	HIZ Phase A Arc Conf
8786	Hi-Z Phase B Arc Confidence	HIZ Phase B Arc Conf
8787	Hi-Z Phase C Arc Confidence	HIZ Phase C Arc Conf

A

Table A–1: FLEXANALOG DATA ITEMS (Sheet 7 of 12)

ADDR	DATA ITEM	FLEXANALOG NAME
8788	Hi-Z Neutral Arc Confidence	HIZ Neutral Arc Conf
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]
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
10240	SRC 1 Ia THD	SRC 1 Ia THD
10241	SRC 1 Ia Harmonics	SRC 1 Ia Harm[0]
10242	SRC 1 Ia Harmonics	SRC 1 Ia Harm[1]
10243	SRC 1 Ia Harmonics	SRC 1 Ia Harm[2]
10244	SRC 1 Ia Harmonics	SRC 1 Ia Harm[3]
10245	SRC 1 Ia Harmonics	SRC 1 Ia Harm[4]
10246	SRC 1 Ia Harmonics	SRC 1 Ia Harm[5]
10247	SRC 1 Ia Harmonics	SRC 1 Ia Harm[6]
10248	SRC 1 Ia Harmonics	SRC 1 Ia Harm[7]
10249	SRC 1 Ia Harmonics	SRC 1 Ia Harm[8]
10250	SRC 1 Ia Harmonics	SRC 1 Ia Harm[9]
10251	SRC 1 Ia Harmonics	SRC 1 Ia Harm[10]
10252	SRC 1 Ia Harmonics	SRC 1 Ia Harm[11]
10253	SRC 1 Ia Harmonics	SRC 1 Ia Harm[12]
10254	SRC 1 Ia Harmonics	SRC 1 Ia Harm[13]
10255	SRC 1 Ia Harmonics	SRC 1 Ia Harm[14]
10256	SRC 1 Ia Harmonics	SRC 1 Ia Harm[15]
10257	SRC 1 Ia Harmonics	SRC 1 Ia Harm[16]
10258	SRC 1 Ia Harmonics	SRC 1 Ia Harm[17]

Table A–1: FLEXANALOG DATA ITEMS (Sheet 8 of 12)

ADDR	DATA ITEM	FLEXANALOG NAME
10259	SRC 1 Ia Harmonics	SRC 1 Ia Harm[18]
10260	SRC 1 Ia Harmonics	SRC 1 Ia Harm[19]
10261	SRC 1 Ia Harmonics	SRC 1 Ia Harm[20]
10262	SRC 1 Ia Harmonics	SRC 1 Ia Harm[21]
10263	SRC 1 Ia Harmonics	SRC 1 Ia Harm[22]
10264	SRC 1 Ia Harmonics	SRC 1 Ia Harm[23]
10273	SRC 1 Ib THD	SRC 1 Ib THD
10274	SRC 1 Ib Harmonics	SRC 1 Ib Harm[0]
10275	SRC 1 Ib Harmonics	SRC 1 Ib Harm[1]
10276	SRC 1 Ib Harmonics	SRC 1 Ib Harm[2]
10277	SRC 1 Ib Harmonics	SRC 1 Ib Harm[3]
10278	SRC 1 Ib Harmonics	SRC 1 Ib Harm[4]
10279	SRC 1 Ib Harmonics	SRC 1 Ib Harm[5]
10280	SRC 1 Ib Harmonics	SRC 1 Ib Harm[6]
10281	SRC 1 Ib Harmonics	SRC 1 Ib Harm[7]
10282	SRC 1 Ib Harmonics	SRC 1 Ib Harm[8]
10283	SRC 1 Ib Harmonics	SRC 1 Ib Harm[9]
10284	SRC 1 Ib Harmonics	SRC 1 Ib Harm[10]
10285	SRC 1 Ib Harmonics	SRC 1 Ib Harm[11]
10286	SRC 1 Ib Harmonics	SRC 1 Ib Harm[12]
10287	SRC 1 Ib Harmonics	SRC 1 Ib Harm[13]
10288	SRC 1 Ib Harmonics	SRC 1 Ib Harm[14]
10289	SRC 1 Ib Harmonics	SRC 1 Ib Harm[15]
10290	SRC 1 Ib Harmonics	SRC 1 Ib Harm[16]
10291	SRC 1 Ib Harmonics	SRC 1 Ib Harm[17]
10292	SRC 1 Ib Harmonics	SRC 1 Ib Harm[18]
10293	SRC 1 Ib Harmonics	SRC 1 Ib Harm[19]
10294	SRC 1 Ib Harmonics	SRC 1 Ib Harm[20]
10295	SRC 1 Ib Harmonics	SRC 1 Ib Harm[21]
10296	SRC 1 Ib Harmonics	SRC 1 Ib Harm[22]
10297	SRC 1 Ib Harmonics	SRC 1 Ib Harm[23]
10306	SRC 1 Ic THD	SRC 1 Ic THD
10307	SRC 1 Ic Harmonics	SRC 1 Ic Harm[0]
10308	SRC 1 Ic Harmonics	SRC 1 Ic Harm[1]
10309	SRC 1 Ic Harmonics	SRC 1 Ic Harm[2]
10310	SRC 1 Ic Harmonics	SRC 1 Ic Harm[3]
10311	SRC 1 Ic Harmonics	SRC 1 Ic Harm[4]
10312	SRC 1 Ic Harmonics	SRC 1 Ic Harm[5]
10313	SRC 1 Ic Harmonics	SRC 1 Ic Harm[6]
10314	SRC 1 Ic Harmonics	SRC 1 Ic Harm[7]
10315	SRC 1 Ic Harmonics	SRC 1 Ic Harm[8]
10316	SRC 1 Ic Harmonics	SRC 1 Ic Harm[9]
10317	SRC 1 Ic Harmonics	SRC 1 Ic Harm[10]
10318	SRC 1 Ic Harmonics	SRC 1 Ic Harm[11]
10319	SRC 1 Ic Harmonics	SRC 1 Ic Harm[12]
10320	SRC 1 Ic Harmonics	SRC 1 Ic Harm[13]
10321	SRC 1 Ic Harmonics	SRC 1 Ic Harm[14]
10322	SRC 1 Ic Harmonics	SRC 1 Ic Harm[15]
10323	SRC 1 Ic Harmonics	SRC 1 Ic Harm[16]
10324	SRC 1 Ic Harmonics	SRC 1 Ic Harm[17]
10325	SRC 1 Ic Harmonics	SRC 1 Ic Harm[18]
10326	SRC 1 Ic Harmonics	SRC 1 Ic Harm[19]

Table A–1: FLEXANALOG DATA ITEMS (Sheet 9 of 12)

ADDR	DATA ITEM	FLEXANALOG NAME
10327	SRC 1 Ic Harmonics	SRC 1 Ic Harm[20]
10328	SRC 1 Ic Harmonics	SRC 1 Ic Harm[21]
10329	SRC 1 Ic Harmonics	SRC 1 Ic Harm[22]
10330	SRC 1 Ic Harmonics	SRC 1 Ic Harm[23]
10339	SRC 2 Ia THD	SRC 2 Ia THD
10340	SRC 2 Ia Harmonics	SRC 2 Ia Harm[0]
10341	SRC 2 Ia Harmonics	SRC 2 Ia Harm[1]
10342	SRC 2 Ia Harmonics	SRC 2 Ia Harm[2]
10343	SRC 2 Ia Harmonics	SRC 2 Ia Harm[3]
10344	SRC 2 Ia Harmonics	SRC 2 Ia Harm[4]
10345	SRC 2 Ia Harmonics	SRC 2 Ia Harm[5]
10346	SRC 2 Ia Harmonics	SRC 2 Ia Harm[6]
10347	SRC 2 Ia Harmonics	SRC 2 Ia Harm[7]
10348	SRC 2 Ia Harmonics	SRC 2 Ia Harm[8]
10349	SRC 2 Ia Harmonics	SRC 2 Ia Harm[9]
10350	SRC 2 Ia Harmonics	SRC 2 Ia Harm[10]
10351	SRC 2 Ia Harmonics	SRC 2 Ia Harm[11]
10352	SRC 2 Ia Harmonics	SRC 2 Ia Harm[12]
10353	SRC 2 Ia Harmonics	SRC 2 Ia Harm[13]
10354	SRC 2 Ia Harmonics	SRC 2 Ia Harm[14]
10355	SRC 2 Ia Harmonics	SRC 2 Ia Harm[15]
10356	SRC 2 Ia Harmonics	SRC 2 Ia Harm[16]
10357	SRC 2 Ia Harmonics	SRC 2 Ia Harm[17]
10358	SRC 2 Ia Harmonics	SRC 2 Ia Harm[18]
10359	SRC 2 Ia Harmonics	SRC 2 Ia Harm[19]
10360	SRC 2 Ia Harmonics	SRC 2 Ia Harm[20]
10361	SRC 2 Ia Harmonics	SRC 2 Ia Harm[21]
10362	SRC 2 Ia Harmonics	SRC 2 Ia Harm[22]
10363	SRC 2 Ia Harmonics	SRC 2 Ia Harm[23]
10372	SRC 2 Ib THD	SRC 2 Ib THD
10373	SRC 2 Ib Harmonics	SRC 2 Ib Harm[0]
10374	SRC 2 Ib Harmonics	SRC 2 Ib Harm[1]
10375	SRC 2 Ib Harmonics	SRC 2 Ib Harm[2]
10376	SRC 2 Ib Harmonics	SRC 2 Ib Harm[3]
10377	SRC 2 Ib Harmonics	SRC 2 Ib Harm[4]
10378	SRC 2 Ib Harmonics	SRC 2 Ib Harm[5]
10379	SRC 2 Ib Harmonics	SRC 2 Ib Harm[6]
10380	SRC 2 Ib Harmonics	SRC 2 Ib Harm[7]
10381	SRC 2 Ib Harmonics	SRC 2 Ib Harm[8]
10382	SRC 2 Ib Harmonics	SRC 2 Ib Harm[9]
10383	SRC 2 Ib Harmonics	SRC 2 Ib Harm[10]
10384	SRC 2 Ib Harmonics	SRC 2 Ib Harm[11]
10385	SRC 2 Ib Harmonics	SRC 2 Ib Harm[12]
10386	SRC 2 Ib Harmonics	SRC 2 Ib Harm[13]
10387	SRC 2 Ib Harmonics	SRC 2 Ib Harm[14]
10388	SRC 2 Ib Harmonics	SRC 2 Ib Harm[15]
10389	SRC 2 Ib Harmonics	SRC 2 Ib Harm[16]
10390	SRC 2 Ib Harmonics	SRC 2 Ib Harm[17]
10391	SRC 2 Ib Harmonics	SRC 2 Ib Harm[18]
10392	SRC 2 Ib Harmonics	SRC 2 Ib Harm[19]
10393	SRC 2 Ib Harmonics	SRC 2 Ib Harm[20]
10394	SRC 2 Ib Harmonics	SRC 2 Ib Harm[21]

Table A–1: FLEXANALOG DATA ITEMS (Sheet 10 of 12)

ADDR	DATA ITEM	FLEXANALOG NAME
10395	SRC 2 Ib Harmonics	SRC 2 Ib Harm[22]
10396	SRC 2 Ib Harmonics	SRC 2 Ib Harm[23]
10405	SRC 2 Ic THD	SRC 2 Ic THD
10406	SRC 2 Ic Harmonics	SRC 2 Ic Harm[0]
10407	SRC 2 Ic Harmonics	SRC 2 Ic Harm[1]
10408	SRC 2 Ic Harmonics	SRC 2 Ic Harm[2]
10409	SRC 2 Ic Harmonics	SRC 2 Ic Harm[3]
10410	SRC 2 Ic Harmonics	SRC 2 Ic Harm[4]
10411	SRC 2 Ic Harmonics	SRC 2 Ic Harm[5]
10412	SRC 2 Ic Harmonics	SRC 2 Ic Harm[6]
10413	SRC 2 Ic Harmonics	SRC 2 Ic Harm[7]
10414	SRC 2 Ic Harmonics	SRC 2 Ic Harm[8]
10415	SRC 2 Ic Harmonics	SRC 2 Ic Harm[9]
10416	SRC 2 Ic Harmonics	SRC 2 Ic Harm[10]
10417	SRC 2 Ic Harmonics	SRC 2 Ic Harm[11]
10418	SRC 2 Ic Harmonics	SRC 2 Ic Harm[12]
10419	SRC 2 Ic Harmonics	SRC 2 Ic Harm[13]
10420	SRC 2 Ic Harmonics	SRC 2 Ic Harm[14]
10421	SRC 2 Ic Harmonics	SRC 2 Ic Harm[15]
10422	SRC 2 Ic Harmonics	SRC 2 Ic Harm[16]
10423	SRC 2 Ic Harmonics	SRC 2 Ic Harm[17]
10424	SRC 2 Ic Harmonics	SRC 2 Ic Harm[18]
10425	SRC 2 Ic Harmonics	SRC 2 Ic Harm[19]
10426	SRC 2 Ic Harmonics	SRC 2 Ic Harm[20]
10427	SRC 2 Ic Harmonics	SRC 2 Ic Harm[21]
10428	SRC 2 Ic Harmonics	SRC 2 Ic Harm[22]
10429	SRC 2 Ic Harmonics	SRC 2 Ic Harm[23]
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

A

Table A–1: FLEXANALOG DATA ITEMS (Sheet 11 of 12)

ADDR	DATA ITEM	FLEXANALOG NAME
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
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

Table A–1: FLEXANALOG DATA ITEMS (Sheet 12 of 12)

ADDR	DATA ITEM	FLEXANALOG NAME
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.

- **FUNCTION CODE:** This is one of the supported functions codes of the unit which tells the slave what action to perform. See the Supported Function Codes section for complete details. An exception response from the slave is indicated by setting the high order bit of the function code in the response packet. See the Exception Responses section for further details.
- **DATA:** This will be a variable number of bytes depending on the function code. This may include actual values, settings, or addresses sent by the master to the slave or by the slave to the master.
- **CRC:** This is a two byte error checking code. The RTU version of Modbus® includes a 16-bit cyclic redundancy check (CRC-16) with every packet which is an industry standard method used for error detection. If a Modbus slave device receives a packet in which an error is indicated by the CRC, the slave device will not act upon or respond to the packet thus preventing any erroneous operations. See the *CRC-16 Algorithm* section for details on calculating the CRC.
- **DEAD TIME:** A packet is terminated when no data is received for a period of 3.5 byte transmission times (about 15 ms at 2400 bps, 2 ms at 19200 bps, and 300 µs at 115200 bps). Consequently, the transmitting device must not allow gaps between bytes longer than this interval. Once the dead time has expired without a new byte transmission, all slaves start listening for a new packet from the master except for the addressed slave.

B.1.4 CRC-16 ALGORITHM

The CRC-16 algorithm essentially treats the entire data stream (data bits only; start, stop and parity ignored) as one continuous binary number. This number is first shifted left 16 bits and then divided by a characteristic polynomial (11000000000000101B). The 16 bit remainder of the division is appended to the end of the packet, MSByte first. The resulting packet including CRC, when divided by the same polynomial at the receiver will give a zero remainder if no transmission errors have occurred. This algorithm requires the characteristic polynomial to be reverse bit ordered. The most significant bit of the characteristic polynomial is dropped, since it does not affect the value of the remainder.

A C programming language implementation of the CRC algorithm will be provided upon request.

Table B–2: CRC-16 ALGORITHM

SYMBOLS:	-->	data transfer
	A	16 bit working register
	Alow	low order byte of A
	Ahigh	high order byte of A
	CRC	16 bit CRC-16 result
	i,j	loop counters
	(+)	logical EXCLUSIVE-OR operator
	N	total number of data bytes
	Di	i-th data byte (i = 0 to N-1)
	G	16 bit characteristic polynomial = 1010000000000001 (binary) with MSbit dropped and bit order reversed
	shr (x)	right shift operator (th LSbit of x is shifted into a carry flag, a '0' is shifted into the MSbit of x, all other bits are shifted right one location)

ALGORITHM:	1.	FFFF (hex) --> A	
	2.	0 --> i	
	3.	0 --> j	
	4.	Di (+) Alow --> Alow	
	5.	j + 1 --> j	
	6.	shr (A)	
	7.	Is there a carry?	No: go to 8; Yes: G (+) A --> A and continue.
	8.	Is j = 8?	No: go to 5; Yes: continue
	9.	i + 1 --> i	
	10.	Is i = N?	No: go to 3; Yes: continue
	11.	A --> CRC	

B.2.1 SUPPORTED FUNCTION CODES

Modbus® officially defines function codes from 1 to 127 though only a small subset is generally needed. The relay supports some of these functions, as summarized in the following table. Subsequent sections describe each function code in detail.

FUNCTION CODE		MODBUS DEFINITION	GE MULTILIN DEFINITION
HEX	DEC		
03	3	Read Holding Registers	Read Actual Values or Settings
04	4	Read Holding Registers	Read Actual Values or Settings
05	5	Force Single Coil	Execute Operation
06	6	Preset Single Register	Store Single Setting
10	16	Preset Multiple Registers	Store Multiple Settings

B.2.2 READ ACTUAL VALUES OR SETTINGS (FUNCTION CODE 03/04H)

This function code allows the master to read one or more consecutive data registers (actual values or settings) from a relay. Data registers are always 16 bit (two byte) values transmitted with high order byte first. The maximum number of registers that can be read in a single packet is 125. See the Modbus Memory Map table for exact details on the data registers.

Since some PLC implementations of Modbus® only support one of function codes 03h and 04h, the 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	
PACKET FORMAT	EXAMPLE (HEX)
SLAVE ADDRESS	11
FUNCTION CODE	04
DATA STARTING ADDRESS - high	40
DATA STARTING ADDRESS - low	50
NUMBER OF REGISTERS - high	00
NUMBER OF REGISTERS - low	03
CRC - low	A7
CRC - high	4A

SLAVE RESPONSE	
PACKET FORMAT	EXAMPLE (HEX)
SLAVE ADDRESS	11
FUNCTION CODE	04
BYTE COUNT	06
DATA #1 - high	00
DATA #1 - low	28
DATA #2 - high	01
DATA #2 - low	2C
DATA #3 - high	00
DATA #3 - low	00
CRC - low	0D
CRC - high	60

B

B.2.3 EXECUTE OPERATION (FUNCTION CODE 05H)

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

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

Table B–4: MASTER AND SLAVE DEVICE PACKET TRANSMISSION EXAMPLE

MASTER TRANSMISSION		SLAVE RESPONSE	
PACKET FORMAT	**EXAMPLE (HEX)**	**PACKET FORMAT**	**EXAMPLE (HEX)**
SLAVE ADDRESS	11	SLAVE ADDRESS	11
FUNCTION CODE	05	FUNCTION CODE	05
OPERATION CODE - high	00	OPERATION CODE - high	00
OPERATION CODE - low	01	OPERATION CODE - low	01
CODE VALUE - high	FF	CODE VALUE - high	FF
CODE VALUE - low	00	CODE VALUE - low	00
CRC - low	DF	CRC - low	DF
CRC - high	6A	CRC - high	6A

Table B–5: SUMMARY OF OPERATION CODES FOR FUNCTION 05H

OPERATION CODE (HEX)	DEFINITION	DESCRIPTION
0000	NO OPERATION	Does not do anything.
0001	RESET	Performs the same function as the faceplate RESET key.
0005	CLEAR EVENT RECORDS	Performs the same function as the faceplate **CLEAR EVENT RECORDS** menu command.
0006	CLEAR OSCILLOGRAPHY	Clears all oscillography records.
1000 to 103F	VIRTUAL IN 1 to 64 ON/OFF	Sets the states of Virtual Inputs 1 to 64 either "ON" or "OFF".

B.2.4 STORE SINGLE SETTING (FUNCTION CODE 06H)

This function code allows the master to modify the contents of a single setting register in an relay. Setting registers are always 16 bit (two byte) values transmitted high order byte first. The following table shows the format of the master and slave packets. The example shows a master device storing the value 200 at memory map address 4051h to slave device 11h (17 dec).

Table B–6: MASTER AND SLAVE DEVICE PACKET TRANSMISSION EXAMPLE

MASTER TRANSMISSION		SLAVE RESPONSE	
PACKET FORMAT	**EXAMPLE (HEX)**	**PACKET FORMAT**	**EXAMPLE (HEX)**
SLAVE ADDRESS	11	SLAVE ADDRESS	11
FUNCTION CODE	06	FUNCTION CODE	06
DATA STARTING ADDRESS - high	40	DATA STARTING ADDRESS - high	40
DATA STARTING ADDRESS - low	51	DATA STARTING ADDRESS - low	51
DATA - high	00	DATA - high	00
DATA - low	C8	DATA - low	C8
CRC - low	CE	CRC - low	CE
CRC - high	DD	CRC - high	DD

B.2.5 STORE MULTIPLE SETTINGS (FUNCTION CODE 10H)

This function code allows the master to modify the contents of a one or more consecutive setting registers in a relay. Setting registers are 16-bit (two byte) values transmitted high order byte first. The maximum number of setting registers that can be stored in a single packet is 60. The following table shows the format of the master and slave packets. The example shows a master device storing the value 200 at memory map address 4051h, and the value 1 at memory map address 4052h to slave device 11h (17 decimal).

Table B–7: MASTER AND SLAVE DEVICE PACKET TRANSMISSION EXAMPLE

MASTER TRANSMISSION	
PACKET FORMAT	**EXAMPLE (HEX)**
SLAVE ADDRESS	11
FUNCTION CODE	10
DATA STARTING ADDRESS - hi	40
DATA STARTING ADDRESS - lo	51
NUMBER OF SETTINGS - hi	00
NUMBER OF SETTINGS - lo	02
BYTE COUNT	04
DATA #1 - high order byte	00
DATA #1 - low order byte	C8
DATA #2 - high order byte	00
DATA #2 - low order byte	01
CRC - low order byte	12
CRC - high order byte	62

SLAVE RESPONSE	
PACKET FORMAT	**EXMAPLE (HEX)**
SLAVE ADDRESS	11
FUNCTION CODE	10
DATA STARTING ADDRESS - hi	40
DATA STARTING ADDRESS - lo	51
NUMBER OF SETTINGS - hi	00
NUMBER OF SETTINGS - lo	02
CRC - lo	07
CRC - hi	64

B.2.6 EXCEPTION RESPONSES

Programming or operation errors usually happen because of illegal data in a packet. These errors result in an exception response from the slave. The slave detecting one of these errors sends a response packet to the master with the high order bit of the function code set to 1.

The following table shows the format of the master and slave packets. The example shows a master device sending the unsupported function code 39h to slave device 11.

Table B–8: MASTER AND SLAVE DEVICE PACKET TRANSMISSION EXAMPLE

MASTER TRANSMISSION	
PACKET FORMAT	**EXAMPLE (HEX)**
SLAVE ADDRESS	11
FUNCTION CODE	39
CRC - low order byte	CD
CRC - high order byte	F2

SLAVE RESPONSE	
PACKET FORMAT	**EXAMPLE (HEX)**
SLAVE ADDRESS	11
FUNCTION CODE	B9
ERROR CODE	01
CRC - low order byte	93
CRC - high order byte	95

B

B.3.1 OBTAINING RELAY FILES VIA MODBUS

a) DESCRIPTION

The UR relay has a generic file transfer facility, meaning that you use the same method to obtain all of the different types of files from the unit. The Modbus registers that implement file transfer are found in the "Modbus File Transfer (Read/Write)" and "Modbus File Transfer (Read Only)" modules, starting at address 3100 in the Modbus Memory Map. To read a file from the UR relay, use the following steps:

1. Write the filename to the "Name of file to read" register using a write multiple registers command. If the name is shorter than 80 characters, you may write only enough registers to include all the text of the filename. Filenames are not case sensitive.
2. Repeatedly read all the registers in "Modbus File Transfer (Read Only)" using a read multiple registers command. It is not necessary to read the entire data block, since the UR relay will remember which was the last register you read. The "position" register is initially zero and thereafter indicates how many bytes (2 times the number of registers) you have read so far. The "size of..." register indicates the number of bytes of data remaining to read, to a maximum of 244.
3. Keep reading until the "size of..." register is smaller than the number of bytes you are transferring. This condition indicates end of file. Discard any bytes you have read beyond the indicated block size.
4. If you need to re-try a block, read only the "size of.." and "block of data", without reading the position. The file pointer is only incremented when you read the position register, so the same data block will be returned as was read in the previous operation. On the next read, check to see if the position is where you expect it to be, and discard the previous block if it is not (this condition would indicate that the UR relay did not process your original read request).

The UR relay retains connection-specific file transfer information, so files may be read simultaneously on multiple Modbus connections.

b) OTHER PROTOCOLS

All the files available via Modbus may also be retrieved using the standard file transfer mechanisms in other protocols (for example, TFTP or MMS).

c) COMTRADE, OSCILLOGRAPHY, AND DATA LOGGER FILES

Oscillography and data logger files are formatted using the COMTRADE file format per IEEE PC37.111 Draft 7c (02 September 1997). The files may be obtained in either text or binary COMTRADE format.

d) READING OSCILLOGRAPHY FILES

Familiarity with the oscillography feature is required to understand the following description. Refer to the Oscillography section in Chapter 5 for additional details.

The Oscillography Number of Triggers register is incremented by one every time a new oscillography file is triggered (captured) and cleared to zero when oscillography data is cleared. When a new trigger occurs, the associated oscillography file is assigned a file identifier number equal to the incremented value of this register; the newest file number is equal to the Oscillography_Number_of_Triggers register. This register can be used to determine if any new data has been captured by periodically reading it to see if the value has changed; if the number has increased then new data is available.

The Oscillography Number of Records register specifies the maximum number of files (and the number of cycles of data per file) that can be stored in memory of the relay. The Oscillography Available Records register specifies the actual number of files that are stored and still available to be read out of the relay.

Writing “Yes” (i.e. the value 1) to the Oscillography Clear Data register clears oscillography data files, clears both the Oscillography Number of Triggers and Oscillography Available Records registers to zero, and sets the Oscillography Last Cleared Date to the present date and time.

To read binary COMTRADE oscillography files, read the following filenames:

`OSCnnnn.CFG` and `OSCnnn.DAT`

Replace “nnn” with the desired oscillography trigger number. For ASCII format, use the following file names

`OSCAnnnn.CFG` and `OSCAnnn.DAT`

e) READING DATA LOGGER FILES

Familiarity with the data logger feature is required to understand this description. Refer to the Data Logger section of Chapter 5 for details. To read the entire data logger in binary COMTRADE format, read the following files.

`datalog.cfg` and `datalog.dat`

To read the entire data logger in ASCII COMTRADE format, read the following files.

`dataloga.cfg` and `dataloga.dat`

To limit the range of records to be returned in the COMTRADE files, append the following to the filename before writing it:

- To read from a specific time to the end of the log: <space> startTime
- To read a specific range of records: <space> startTime <space> endTime
- Replace <startTime> and <endTime> with Julian dates (seconds since Jan. 1 1970) as numeric text.

f) READING EVENT RECORDER FILES

To read the entire event recorder contents in ASCII format (the only available format), use the following filename:

`EVT.TXT`

To read from a specific record to the end of the log, use the following filename:

`EVTnnn.TXT` (replace `nnn` with the desired starting record number)

To read from a specific record to another specific record, use the following filename:

`EVT.TXT xxxxx yyyyy` (replace `xxxxx` with the starting record number and `yyyyy` with the ending record number)

g) READING FAULT REPORT FILES

Fault report data has been available via the F60 file retrieval mechanism since UR firmware version 2.00. The file name is **`faultReport#####.htm`**. The ##### refers to the fault report record number. The fault report number is a counter that indicates how many fault reports have ever occurred. The counter rolls over at a value of 65535. Only the last ten fault reports are available for retrieval; a request for a non-existent fault report file will yield a null file. The current value fault report counter is available in “Number of Fault Reports” Modbus register at location 0x3020.

For example, if 14 fault reports have occurred then the files `faultReport5.htm`, `faultReport6.htm`, up to `faultReport14.htm` are available to be read. The expected use of this feature has an external master periodically polling the “Number of Fault Reports' register. If the value changes, then the master reads all the new files.

The contents of the file is in standard HTML notation and can be viewed via any commercial browser.

B.3.2 MODBUS PASSWORD OPERATION

The 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.

Table B–9: MODBUS MEMORY MAP (Sheet 1 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
Product Information (Read Only)						
0000	UR Product Type	0 to 65535	---	1	F001	0
0002	Product Version	0 to 655.35	---	0.01	F001	1
Product Information (Read Only -- Written by Factory)						
0010	Serial Number	---	---	---	F203	"0"
0020	Manufacturing Date	0 to 4294967295	---	1	F050	0
0022	Modification Number	0 to 65535	---	1	F001	0
0040	Order Code	---	---	---	F204	"Order Code x"
0090	Ethernet MAC Address	---	---	---	F072	0
0093	Reserved (13 items)	---	---	---	F001	0
00A0	CPU Module Serial Number	---	---	---	F203	(none)
00B0	CPU Supplier Serial Number	---	---	---	F203	(none)
00C0	Ethernet Sub Module Serial Number (8 items)	---	---	---	F203	(none)
Self Test Targets (Read Only)						
0200	Self Test States (2 items)	0 to 4294967295	0	1	F143	0
Front Panel (Read Only)						
0204	LED Column *n* State, *n* = 1 to 10 (10 items)	0 to 65535	---	1	F501	0
0220	Display Message	---	---	---	F204	(none)
0248	Last Key Pressed	0 to 47	---	1	F530	0 (None)
Keypress Emulation (Read/Write)						
0280	Simulated keypress -- write zero before each keystroke	0 to 42	---	1	F190	0 (No key -- use between real keys)
Virtual Input Commands (Read/Write Command) (64 modules)						
0400	Virtual Input 1 State	0 to 1	---	1	F108	0 (Off)
0401	Virtual Input 2 State	0 to 1	---	1	F108	0 (Off)
0402	Virtual Input 3 State	0 to 1	---	1	F108	0 (Off)
0403	Virtual Input 4 State	0 to 1	---	1	F108	0 (Off)
0404	Virtual Input 5 State	0 to 1	---	1	F108	0 (Off)
0405	Virtual Input 6 State	0 to 1	---	1	F108	0 (Off)
0406	Virtual Input 7 State	0 to 1	---	1	F108	0 (Off)
0407	Virtual Input 8 State	0 to 1	---	1	F108	0 (Off)
0408	Virtual Input 9 State	0 to 1	---	1	F108	0 (Off)
0409	Virtual Input 10 State	0 to 1	---	1	F108	0 (Off)
040A	Virtual Input 11 State	0 to 1	---	1	F108	0 (Off)
040B	Virtual Input 12 State	0 to 1	---	1	F108	0 (Off)
040C	Virtual Input 13 State	0 to 1	---	1	F108	0 (Off)
040D	Virtual Input 14 State	0 to 1	---	1	F108	0 (Off)
040E	Virtual Input 15 State	0 to 1	---	1	F108	0 (Off)
040F	Virtual Input 16 State	0 to 1	---	1	F108	0 (Off)
0410	Virtual Input 17 State	0 to 1	---	1	F108	0 (Off)
0411	Virtual Input 18 State	0 to 1	---	1	F108	0 (Off)
0412	Virtual Input 19 State	0 to 1	---	1	F108	0 (Off)
0413	Virtual Input 20 State	0 to 1	---	1	F108	0 (Off)
0414	Virtual Input 21 State	0 to 1	---	1	F108	0 (Off)
0415	Virtual Input 22 State	0 to 1	---	1	F108	0 (Off)
0416	Virtual Input 23 State	0 to 1	---	1	F108	0 (Off)
0417	Virtual Input 24 State	0 to 1	---	1	F108	0 (Off)
0418	Virtual Input 25 State	0 to 1	---	1	F108	0 (Off)
0419	Virtual Input 26 State	0 to 1	---	1	F108	0 (Off)
041A	Virtual Input 27 State	0 to 1	---	1	F108	0 (Off)
041B	Virtual Input 28 State	0 to 1	---	1	F108	0 (Off)

Table B–9: MODBUS MEMORY MAP (Sheet 2 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
041C	Virtual Input 29 State	0 to 1	---	1	F108	0 (Off)
041D	Virtual Input 30 State	0 to 1	---	1	F108	0 (Off)
041E	Virtual Input 31 State	0 to 1	---	1	F108	0 (Off)
041F	Virtual Input 32 State	0 to 1	---	1	F108	0 (Off)
0420	Virtual Input 33 State	0 to 1	---	1	F108	0 (Off)
0421	Virtual Input 34 State	0 to 1	---	1	F108	0 (Off)
0422	Virtual Input 35 State	0 to 1	---	1	F108	0 (Off)
0423	Virtual Input 36 State	0 to 1	---	1	F108	0 (Off)
0424	Virtual Input 37 State	0 to 1	---	1	F108	0 (Off)
0425	Virtual Input 38 State	0 to 1	---	1	F108	0 (Off)
0426	Virtual Input 39 State	0 to 1	---	1	F108	0 (Off)
0427	Virtual Input 40 State	0 to 1	---	1	F108	0 (Off)
0428	Virtual Input 41 State	0 to 1	---	1	F108	0 (Off)
0429	Virtual Input 42 State	0 to 1	---	1	F108	0 (Off)
042A	Virtual Input 43 State	0 to 1	---	1	F108	0 (Off)
042B	Virtual Input 44 State	0 to 1	---	1	F108	0 (Off)
042C	Virtual Input 45 State	0 to 1	---	1	F108	0 (Off)
042D	Virtual Input 46 State	0 to 1	---	1	F108	0 (Off)
042E	Virtual Input 47 State	0 to 1	---	1	F108	0 (Off)
042F	Virtual Input 48 State	0 to 1	---	1	F108	0 (Off)
0430	Virtual Input 49 State	0 to 1	---	1	F108	0 (Off)
0431	Virtual Input 50 State	0 to 1	---	1	F108	0 (Off)
0432	Virtual Input 51 State	0 to 1	---	1	F108	0 (Off)
0433	Virtual Input 52 State	0 to 1	---	1	F108	0 (Off)
0434	Virtual Input 53 State	0 to 1	---	1	F108	0 (Off)
0435	Virtual Input 54 State	0 to 1	---	1	F108	0 (Off)
0436	Virtual Input 55 State	0 to 1	---	1	F108	0 (Off)
0437	Virtual Input 56 State	0 to 1	---	1	F108	0 (Off)
0438	Virtual Input 57 State	0 to 1	---	1	F108	0 (Off)
0439	Virtual Input 58 State	0 to 1	---	1	F108	0 (Off)
043A	Virtual Input 59 State	0 to 1	---	1	F108	0 (Off)
043B	Virtual Input 60 State	0 to 1	---	1	F108	0 (Off)
043C	Virtual Input 61 State	0 to 1	---	1	F108	0 (Off)
043D	Virtual Input 62 State	0 to 1	---	1	F108	0 (Off)
043E	Virtual Input 63 State	0 to 1	---	1	F108	0 (Off)
043F	Virtual Input 64 State	0 to 1	---	1	F108	0 (Off)
Digital Counter States (Read Only Non-Volatile) (8 modules)						
0800	Digital Counter 1 Value	-2147483647 to 2147483647	---	1	F004	0
0802	Digital Counter 1 Frozen	-2147483647 to 2147483647	---	1	F004	0
0804	Digital Counter 1 Frozen Time Stamp	0 to 4294967295	---	1	F050	0
0806	Digital Counter 1 Frozen Time Stamp us	0 to 4294967295	---	1	F003	0
0808	...Repeated for Digital Counter 2					
0810	...Repeated for Digital Counter 3					
0818	...Repeated for Digital Counter 4					
0820	...Repeated for Digital Counter 5					
0828	...Repeated for Digital Counter 6					
0830	...Repeated for Digital Counter 7					
0838	...Repeated for Digital Counter 8					
FlexStates (Read Only)						
0900	FlexState Bits (16 items)	0 to 65535	---	1	F001	0
Element States (Read Only)						
1000	Element Operate States (64 items)	0 to 65535	---	1	F502	0

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Table B–9: MODBUS MEMORY MAP (Sheet 3 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
User Displays Actuals (Read Only)						
1080	Formatted user-definable displays (16 items)	---	---	---	F200	(none)
Modbus User Map Actuals (Read Only)						
1200	User Map Values (256 items)	0 to 65535	---	1	F001	0
Element Targets (Read Only)						
14C0	Target Sequence	0 to 65535	---	1	F001	0
14C1	Number of Targets	0 to 65535	---	1	F001	0
Element Targets (Read/Write)						
14C2	Target to Read	0 to 65535	---	1	F001	0
Element Targets (Read Only)						
14C3	Target Message	---	---	---	F200	“.”
Digital Input/Output States (Read Only)						
1500	Contact Input States (6 items)	0 to 65535	---	1	F500	0
1508	Virtual Input States (8 items)	0 to 65535	---	1	F500	0
1510	Contact Output States (4 items)	0 to 65535	---	1	F500	0
1518	Contact Output Current States (4 items)	0 to 65535	---	1	F500	0
1520	Contact Output Voltage States (4 items)	0 to 65535	---	1	F500	0
1528	Virtual Output States (6 items)	0 to 65535	---	1	F500	0
1530	Contact Output Detectors (4 items)	0 to 65535	---	1	F500	0
Remote Input/Output States (Read Only)						
1540	Remote Device 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 Remote Device 2					
1559	...Repeated for Remote Device 3					
155D	...Repeated for Remote Device 4					
1561	...Repeated for Remote Device 5					
1565	...Repeated for Remote Device 6					
1569	...Repeated for Remote Device 7					
156D	...Repeated for Remote Device 8					
1571	...Repeated for Remote Device 9					
1575	...Repeated for Remote Device 10					
1579	...Repeated for Remote Device 11					
157D	...Repeated for Remote Device 12					
1581	...Repeated for Remote Device 13					
1585	...Repeated for Remote Device 14					
1589	...Repeated for Remote Device 15					
158D	...Repeated for Remote Device 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)

Table B–9: MODBUS MEMORY MAP (Sheet 4 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
Data Logger Actuals (Read Only)						
1618	Data logger channel count	0 to 16	channel	1	F001	0
1619	Time of oldest available samples	0 to 4294967295	seconds	1	F050	0
161B	Time of newest available samples	0 to 4294967295	seconds	1	F050	0
161D	Data logger duration	0 to 999.9	days	0.1	F001	0
Sensitive Directional Power Actuals (Read Only) (2 modules)						
1680	Sensitive Directional Power 1 Power	-2147483647 to 2147483647	W	1	F060	0
1682	Sensitive Directional Power 2 Power	-2147483647 to 2147483647	W	1	F060	0
Frequency Rate of Change Actuals (Read Only) (4 modules)						
16E0	Frequency Rate of Change 1	-327.67 to 327.67	Hz/s	0.01	F002	0
16E1	Reserved (3 items)	0 to 65535	---	1	F001	0
16E4	...Repeated for Frequency Rate of Change 2					
16E8	...Repeated for Frequency Rate of Change 3					
16EC	...Repeated for Frequency Rate of Change 4					
Source Current (Read Only) (6 modules)						
1800	Source 1 Phase A Current RMS	0 to 999999.999	A	0.001	F060	0
1802	Source 1 Phase B Current RMS	0 to 999999.999	A	0.001	F060	0
1804	Source 1 Phase C Current RMS	0 to 999999.999	A	0.001	F060	0
1806	Source 1 Neutral Current RMS	0 to 999999.999	A	0.001	F060	0
1808	Source 1 Phase A Current Magnitude	0 to 999999.999	A	0.001	F060	0
180A	Source 1 Phase A Current Angle	-359.9 to 0	degrees	0.1	F002	0
180B	Source 1 Phase B Current Magnitude	0 to 999999.999	A	0.001	F060	0
180D	Source 1 Phase B Current Angle	-359.9 to 0	degrees	0.1	F002	0
180E	Source 1 Phase C Current Magnitude	0 to 999999.999	A	0.001	F060	0
1810	Source 1 Phase C Current Angle	-359.9 to 0	degrees	0.1	F002	0
1811	Source 1 Neutral Current Magnitude	0 to 999999.999	A	0.001	F060	0
1813	Source 1 Neutral Current Angle	-359.9 to 0	degrees	0.1	F002	0
1814	Source 1 Ground Current RMS	0 to 999999.999	A	0.001	F060	0
1816	Source 1 Ground Current Magnitude	0 to 999999.999	A	0.001	F060	0
1818	Source 1 Ground Current Angle	-359.9 to 0	degrees	0.1	F002	0
1819	Source 1 Zero Sequence Current Magnitude	0 to 999999.999	A	0.001	F060	0
181B	Source 1 Zero Sequence Current Angle	-359.9 to 0	degrees	0.1	F002	0
181C	Source 1 Positive Sequence Current Magnitude	0 to 999999.999	A	0.001	F060	0
181E	Source 1 Positive Sequence Current Angle	-359.9 to 0	degrees	0.1	F002	0
181F	Source 1 Negative Sequence Current Magnitude	0 to 999999.999	A	0.001	F060	0
1821	Source 1 Negative Sequence Current Angle	-359.9 to 0	degrees	0.1	F002	0
1822	Source 1 Differential Ground Current Magnitude	0 to 999999.999	A	0.001	F060	0
1824	Source 1 Differential Ground Current Angle	-359.9 to 0	degrees	0.1	F002	0
1825	Reserved (27 items)	---	---	---	F001	0
1840	...Repeated for Source 2					
1880	...Repeated for Source 3					
18C0	...Repeated for Source 4					
1900	...Repeated for Source 5					
1940	...Repeated for Source 6					
Source Voltage (Read Only) (6 modules)						
1A00	Source 1 Phase AG Voltage RMS	0 to 999999.999	V	0.001	F060	0
1A02	Source 1 Phase BG Voltage RMS	0 to 999999.999	V	0.001	F060	0
1A04	Source 1 Phase CG Voltage RMS	0 to 999999.999	V	0.001	F060	0
1A06	Source 1 Phase AG Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A08	Source 1 Phase AG Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
1A09	Source 1 Phase BG Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A0B	Source 1 Phase BG Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
1A0C	Source 1 Phase CG Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A0E	Source 1 Phase CG Voltage Angle	-359.9 to 0	degrees	0.1	F002	0

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Table B–9: MODBUS MEMORY MAP (Sheet 5 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
1A0F	Source 1 Phase AB or AC Voltage RMS	0 to 999999.999	V	0.001	F060	0
1A11	Source 1 Phase BC or BA Voltage RMS	0 to 999999.999	V	0.001	F060	0
1A13	Source 1 Phase CA or CB Voltage RMS	0 to 999999.999	V	0.001	F060	0
1A15	Source 1 Phase AB or AC Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A17	Source 1 Phase AB or AC Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
1A18	Source 1 Phase BC or BA Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A1A	Source 1 Phase BC or BA Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
1A1B	Source 1 Phase CA or CB Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A1D	Source 1 Phase CA or CB Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
1A1E	Source 1 Auxiliary Voltage RMS	0 to 999999.999	V	0.001	F060	0
1A20	Source 1 Auxiliary Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A22	Source 1 Auxiliary Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
1A23	Source 1 Zero Sequence Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A25	Source 1 Zero Sequence Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
1A26	Source 1 Positive Sequence Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A28	Source 1 Positive Sequence Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
1A29	Source 1 Negative Sequence Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A2B	Source 1 Negative Sequence Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
1A2C	Reserved (20 items)	---	---	---	F001	0
1A40	...Repeated for Source 2					
1A80	...Repeated for Source 3					
1AC0	...Repeated for Source 4					
1B00	...Repeated for Source 5					
1B40	...Repeated for Source 6					
Source Power (Read Only) (6 modules)						
1C00	Source 1 Three Phase Real Power	-1000000000000 to 1000000000000	W	0.001	F060	0
1C02	Source 1 Phase A Real Power	-1000000000000 to 1000000000000	W	0.001	F060	0
1C04	Source 1 Phase B Real Power	-1000000000000 to 1000000000000	W	0.001	F060	0
1C06	Source 1 Phase C Real Power	-1000000000000 to 1000000000000	W	0.001	F060	0
1C08	Source 1 Three Phase Reactive Power	-1000000000000 to 1000000000000	var	0.001	F060	0
1C0A	Source 1 Phase A Reactive Power	-1000000000000 to 1000000000000	var	0.001	F060	0
1C0C	Source 1 Phase B Reactive Power	-1000000000000 to 1000000000000	var	0.001	F060	0
1C0E	Source 1 Phase C Reactive Power	-1000000000000 to 1000000000000	var	0.001	F060	0
1C10	Source 1 Three Phase Apparent Power	-1000000000000 to 1000000000000	VA	0.001	F060	0
1C12	Source 1 Phase A Apparent Power	-1000000000000 to 1000000000000	VA	0.001	F060	0
1C14	Source 1 Phase B Apparent Power	-1000000000000 to 1000000000000	VA	0.001	F060	0
1C16	Source 1 Phase C Apparent Power	-1000000000000 to 1000000000000	VA	0.001	F060	0
1C18	Source 1 Three Phase Power Factor	-0.999 to 1	---	0.001	F013	0
1C19	Source 1 Phase A Power Factor	-0.999 to 1	---	0.001	F013	0
1C1A	Source 1 Phase B Power Factor	-0.999 to 1	---	0.001	F013	0
1C1B	Source 1 Phase C Power Factor	-0.999 to 1	---	0.001	F013	0
1C1C	Reserved (4 items)	---	---	---	F001	0
1C20	...Repeated for Source 2					
1C40	...Repeated for Source 3					
1C60	...Repeated for Source 4					
1C80	...Repeated for Source 5					

Table B–9: MODBUS MEMORY MAP (Sheet 6 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
1CA0	...Repeated for Source 6					
Source Energy (Read Only Non-Volatile) (6 modules)						
1D00	Source 1 Positive Watthour	0 to 1000000000000	Wh	0.001	F060	0
1D02	Source 1 Negative Watthour	0 to 1000000000000	Wh	0.001	F060	0
1D04	Source 1 Positive Varhour	0 to 1000000000000	varh	0.001	F060	0
1D06	Source 1 Negative Varhour	0 to 1000000000000	varh	0.001	F060	0
1D08	Reserved (8 items)	---	---	---	F001	0
1D10	...Repeated for Source 2					
1D20	...Repeated for Source 3					
1D30	...Repeated for Source 4					
1D40	...Repeated for Source 5					
1D50	...Repeated for Source 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 for Source 1	2.000 to 90.000	Hz	0.001	F003	0
1D81	Frequency for Source 2	2.000 to 90.000	Hz	0.001	F003	0
1D82	Frequency for Source 3	2.000 to 90.000	Hz	0.001	F003	0
1D83	Frequency for Source 4	2.000 to 90.000	Hz	0.001	F003	0
1D84	Frequency for Source 5	2.000 to 90.000	Hz	0.001	F003	0
1D85	Frequency for Source 6	2.000 to 90.000	Hz	0.001	F003	0
Source Demand (Read Only) (6 modules)						
1E00	Source 1 Demand Ia	0 to 999999.999	A	0.001	F060	0
1E02	Source 1 Demand Ib	0 to 999999.999	A	0.001	F060	0
1E04	Source 1 Demand Ic	0 to 999999.999	A	0.001	F060	0
1E06	Source 1 Demand Watt	0 to 999999.999	W	0.001	F060	0
1E08	Source 1 Demand Var	0 to 999999.999	var	0.001	F060	0
1E0A	Source 1 Demand Va	0 to 999999.999	VA	0.001	F060	0
1E0C	Reserved (4 items)	---	---	---	F001	0
1E10	...Repeated for Source 2					
1E20	...Repeated for Source 3					
1E30	...Repeated for Source 4					
1E40	...Repeated for Source 5					
1E50	...Repeated for Source 6					
Source Demand Peaks (Read Only Non-Volatile) (6 modules)						
1E80	Source 1 Demand Ia Maximum	0 to 999999.999	A	0.001	F060	0
1E82	Source 1 Demand Ia Maximum Date	0 to 4294967295	---	1	F050	0
1E84	Source 1 Demand Ib Maximum	0 to 999999.999	A	0.001	F060	0
1E86	Source 1 Demand Ib Maximum Date	0 to 4294967295	---	1	F050	0
1E88	Source 1 Demand Ic Maximum	0 to 999999.999	A	0.001	F060	0
1E8A	Source 1 Demand Ic Maximum Date	0 to 4294967295	---	1	F050	0
1E8C	Source 1 Demand Watt Maximum	0 to 999999.999	W	0.001	F060	0
1E8E	Source 1 Demand Watt Maximum Date	0 to 4294967295	---	1	F050	0
1E90	Source 1 Demand Var	0 to 999999.999	var	0.001	F060	0
1E92	Source 1 Demand Var Maximum Date	0 to 4294967295	---	1	F050	0
1E94	Source 1 Demand Va Maximum	0 to 999999.999	VA	0.001	F060	0
1E96	Source 1 Demand Va Maximum Date	0 to 4294967295	---	1	F050	0
1E98	Reserved (8 items)	---	---	---	F001	0
1EA0	...Repeated for Source 2					
1EC0	...Repeated for Source 3					
1EE0	...Repeated for Source 4					
1F00	...Repeated for Source 5					
1F20	...Repeated for Source 6					

Table B–9: MODBUS MEMORY MAP (Sheet 7 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
Source Voltage THD And Harmonics (Read Only) (6 modules)						
1F80	Source 1 Va THD	0 to 99.9	---	0.1	F001	0
1F81	Source 1 Va Harmonics - 2nd to 25th (24 items)	0 to 99.9	---	0.1	F001	0
1F99	Source 1 Vb THD	0 to 99.9	---	0.1	F001	0
1F9A	Source 1 Vb Harmonics - 2nd to 25th (24 items)	0 to 99.9	---	0.1	F001	0
1FB2	Source 1 Vc THD	0 to 99.9	---	0.1	F001	0
1FB3	Source 1 Vc Harmonics - 2nd to 25th (24 items)	0 to 99.9	---	0.1	F001	0
1FCB	...Repeated for Source 2					
2016	...Repeated for Source 3					
2061	...Repeated for Source 4					
20AC	...Repeated for Source 5					
20F7	...Repeated for Source 6					
Breaker Flashover (Read/Write Setting) (2 modules)						
21A6	Breaker 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 Breaker 2 Flashover	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 Breaker Arcing Current 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	Breaker 2 Arcing Current Clear Command	0 to 1	---	1	F126	0 (No)
Passwords Unauthorized Access (Read/Write Command)						
2230	Reset Unauthorized Access	0 to 1	---	1	F126	0 (No)
Hi-Z (High Impedance Fault Detection) Commands (Read/Write Command)						
2240	Hi-Z Clear Oscillography	0 to 1	---	1	F126	0 (No)
2241	Hi-Z Oscillography Force Trigger	0 to 1	---	1	F126	0 (No)
2242	Hi-Z Oscillography Force Algorithm Capture	0 to 1	---	1	F126	0 (No)
2243	Hi-Z Reset Sigma Values	0 to 1	---	1	F126	0 (No)
Hi-Z (High Impedance Fault Detection) Status (Read Only)						
2250	Hi-Z Status	0 to 9	---	1	F187	0 (NORMAL)
2251	Hi-Z Phase A Arc Confidence	0 to 100		1	F001	0
2252	Hi-Z Phase B Arc Confidence	0 to 100		1	F001	0

Table B–9: MODBUS MEMORY MAP (Sheet 8 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
2253	Hi-Z Phase C Arc Confidence	0 to 100		1	F001	0
2254	Hi-Z Neutral Arc Confidence	0 to 100	---	1	F001	0
Hi-Z (High Impedance Fault Detection) Records (Read Only) (4 modules)						
2260	Hi-Z Capture 1 Trigger Type	0 to 6	---	1	F188	0 (NONE)
2261	Hi-Z Capture 1 Time	0 to 1	---	1	F050	0
2263	...Repeated for Hi-Z Capture 2					
2266	...Repeated for Hi-Z Capture 3					
2269	...Repeated for Hi-Z Capture 4					
Hi-Z (High Impedance Fault Detection) RMS Records (Read Only) (4 modules)						
2270	Hi-Z RMS Capture 1 Trigger Type	0 to 6	---	1	F188	0 (NONE)
2271	Hi-Z RMS Capture 1 Time	0 to 1	---	1	F050	0
2273	...Repeated for Hi-Z RMS Capture 2					
2276	...Repeated for Hi-Z RMS Capture 3					
2279	...Repeated for Hi-Z RMS Capture 4					
Fault Location (Read Only) (5 modules)						
2340	Fault 1 Prefault Phase A Current Magnitude	0 to 999999.999	A	0.001	F060	0
2342	Fault 1 Prefault Phase A Current Angle	-359.9 to 0	degrees	0.1	F002	0
2343	Fault 1 Prefault Phase B Current Magnitude	0 to 999999.999	A	0.001	F060	0
2345	Fault 1 Prefault Phase B Current Angle	-359.9 to 0	degrees	0.1	F002	0
2346	Fault 1 Prefault Phase C Current Magnitude	0 to 999999.999	A	0.001	F060	0
2348	Fault 1 Prefault Phase C Current Angle	-359.9 to 0	degrees	0.1	F002	0
2349	Fault 1 Prefault Phase A Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
234B	Fault 1 Prefault Phase A Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
234C	Fault 1 Prefault Phase B Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
234E	Fault 1 Prefault Phase B Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
234F	Fault 1 Prefault Phase C Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
2351	Fault 1 Prefault Phase C Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
2352	Fault 1 Phase A Current Magnitude	0 to 999999.999	A	0.001	F060	0
2354	Fault 1 Phase A Current Angle	-359.9 to 0	degrees	0.1	F002	0
2355	Fault 1 Phase B Current Magnitude	0 to 999999.999	A	0.001	F060	0
2357	Fault 1 Phase B Current Angle	-359.9 to 0	degrees	0.1	F002	0
2358	Fault 1 Phase C Current Magnitude	0 to 999999.999	A	0.001	F060	0
235A	Fault 1 Phase C Current Angle	-359.9 to 0	degrees	0.1	F002	0
235B	Fault 1 Phase A Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
235D	Fault 1 Phase A Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
235E	Fault 1 Phase B Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
2360	Fault 1 Phase B Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
2361	Fault 1 Phase C Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
2363	Fault 1 Phase C Voltage Angle	-359.9 to 0	degrees	0.1	F002	0
2364	Fault 1 Type	0 to 11	---	1	F148	0 (NA)
2365	Fault 1 Location based on Line length units (km or miles)	-3276.7 to 3276.7	---	0.1	F002	0
2366	...Repeated for Fault 2					
238C	...Repeated for Fault 3					
23B2	...Repeated for Fault 4					
23D8	...Repeated for Fault 5					
Synchrocheck Actuals (Read Only) (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 179.9	degrees	0.1	F001	0
2404	...Repeated for Synchrocheck 2					
Autoreclose Status (Read Only) (6 modules)						
2410	Autoreclose 1 Count	0 to 65535	---	1	F001	0
2411	Autoreclose 2 Count	0 to 65535	---	1	F001	0

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Table B–9: MODBUS MEMORY MAP (Sheet 9 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
2412	Autoreclose 3 Count	0 to 65535	---	1	F001	0
2413	Autoreclose 4 Count	0 to 65535	---	1	F001	0
2414	Autoreclose 5 Count	0 to 65535	---	1	F001	0
2415	Autoreclose 6 Count	0 to 65535	---	1	F001	0
Source Current THD And Harmonics (Read Only) (6 modules)						
2800	Ia THD for Source 1	0 to 99.9	---	0.1	F001	0
2801	Ia Harmonics for Source 1 - 2nd to 25th (24 items)	0 to 99.9	---	0.1	F001	0
2821	Ib THD for Source 1	0 to 99.9	---	0.1	F001	0
2822	Ib Harmonics for Source 1 - 2nd to 25th (24 items)	0 to 99.9	---	0.1	F001	0
283A	Reserved (8 items)	0 to 0.1	---	0.1	F001	0
2842	Ic THD for Source 1	0 to 99.9	---	0.1	F001	0
2843	Ic Harmonics for Source 1 - 2nd to 25th (24 items)	0 to 99.9	---	0.1	F001	0
285B	Reserved (8 items)	0 to 0.1	---	0.1	F001	0
2863	...Repeated for Source 2					
28C6	...Repeated for Source 3					
2929	...Repeated for Source 4					
298C	...Repeated for Source 5					
29EF	...Repeated for Source 6					
Expanded FlexStates (Read Only)						
2B00	FlexStates, one per register (256 items)	0 to 1	---	1	F108	0 (Off)
Expanded Digital Input/Output states (Read Only)						
2D00	Contact Input States, one per register (96 items)	0 to 1	---	1	F108	0 (Off)
2D80	Contact Output States, one per register (64 items)	0 to 1	---	1	F108	0 (Off)
2E00	Virtual Output States, one per register (96 items)	0 to 1	---	1	F108	0 (Off)
Expanded Remote Input/Output Status (Read Only)						
2F00	Remote Device States, one per register (16 items)	0 to 1	---	1	F155	0 (Offline)
2F80	Remote Input States, one per register (64 items)	0 to 1	---	1	F108	0 (Off)
Oscillography Values (Read Only)						
3000	Oscillography Number of Triggers	0 to 65535	---	1	F001	0
3001	Oscillography Available Records	0 to 65535	---	1	F001	0
3002	Oscillography Last Cleared Date	0 to 400000000	---	1	F050	0
3004	Oscillography Number Of Cycles Per Record	0 to 65535	---	1	F001	0
Oscillography Commands (Read/Write Command)						
3005	Oscillography Force Trigger	0 to 1	---	1	F126	0 (No)
3011	Oscillography Clear Data	0 to 1	---	1	F126	0 (No)
Fault Report Indexing (Read Only Non-Volatile)						
3020	Number of Fault Reports	0 to 65535	---	1	F001	0
Fault Report Actuals (Read Only Non-Volatile) (15 modules)						
3030	Fault Report 1 Time	0 to 4294967295	---	1	F050	0
3032	Fault Report 2 Time	0 to 4294967295	---	1	F050	0
3034	Fault Report 3 Time	0 to 4294967295	---	1	F050	0
3036	Fault Report 4 Time	0 to 4294967295	---	1	F050	0
3038	Fault Report 5 Time	0 to 4294967295	---	1	F050	0
303A	Fault Report 6 Time	0 to 4294967295	---	1	F050	0
303C	Fault Report 7 Time	0 to 4294967295	---	1	F050	0
303E	Fault Report 8 Time	0 to 4294967295	---	1	F050	0
3040	Fault Report 9 Time	0 to 4294967295	---	1	F050	0
3042	Fault Report 10 Time	0 to 4294967295	---	1	F050	0
3044	Fault Report 11 Time	0 to 4294967295	---	1	F050	0
3046	Fault Report 12 Time	0 to 4294967295	---	1	F050	0
3048	Fault Report 13 Time	0 to 4294967295	---	1	F050	0
304A	Fault Report 14 Time	0 to 4294967295	---	1	F050	0
304C	Fault Report 15 Time	0 to 4294967295	---	1	F050	0

Table B–9: MODBUS MEMORY MAP (Sheet 10 of 47)

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

Table B–9: MODBUS MEMORY MAP (Sheet 11 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
3500	RTD Input 17 Value	-32768 to 32767	°C	1	F002	0
3501	RTD Input 18 Value	-32768 to 32767	°C	1	F002	0
3502	RTD Input 19 Value	-32768 to 32767	°C	1	F002	0
3503	RTD Input 20 Value	-32768 to 32767	°C	1	F002	0
3504	RTD Input 21 Value	-32768 to 32767	°C	1	F002	0
3505	RTD Input 22 Value	-32768 to 32767	°C	1	F002	0
3506	RTD Input 23 Value	-32768 to 32767	°C	1	F002	0
3507	RTD Input 24 Value	-32768 to 32767	°C	1	F002	0
3508	RTD Input 25 Value	-32768 to 32767	°C	1	F002	0
3509	RTD Input 26 Value	-32768 to 32767	°C	1	F002	0
350A	RTD Input 27 Value	-32768 to 32767	°C	1	F002	0
350B	RTD Input 28 Value	-32768 to 32767	°C	1	F002	0
350C	RTD Input 29 Value	-32768 to 32767	°C	1	F002	0
350D	RTD Input 30 Value	-32768 to 32767	°C	1	F002	0
350E	RTD Input 31 Value	-32768 to 32767	°C	1	F002	0
350F	RTD Input 32 Value	-32768 to 32767	°C	1	F002	0
3510	RTD Input 33 Value	-32768 to 32767	°C	1	F002	0
3511	RTD Input 34 Value	-32768 to 32767	°C	1	F002	0
3512	RTD Input 35 Value	-32768 to 32767	°C	1	F002	0
3513	RTD Input 36 Value	-32768 to 32767	°C	1	F002	0
3514	RTD Input 37 Value	-32768 to 32767	°C	1	F002	0
3515	RTD Input 38 Value	-32768 to 32767	°C	1	F002	0
3516	RTD Input 39 Value	-32768 to 32767	°C	1	F002	0
3517	RTD Input 40 Value	-32768 to 32767	°C	1	F002	0
3518	RTD Input 41 Value	-32768 to 32767	°C	1	F002	0
3519	RTD Input 42 Value	-32768 to 32767	°C	1	F002	0
351A	RTD Input 43 Value	-32768 to 32767	°C	1	F002	0
351B	RTD Input 44 Value	-32768 to 32767	°C	1	F002	0
351C	RTD Input 45 Value	-32768 to 32767	°C	1	F002	0
351D	RTD Input 46 Value	-32768 to 32767	°C	1	F002	0
351E	RTD Input 47 Value	-32768 to 32767	°C	1	F002	0
351F	RTD Input 48 Value	-32768 to 32767	°C	1	F002	0
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)
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)						
404F	Language	0 to 3	---	1	F531	0 (English)
4050	Flash Message Time	0.5 to 10	s	0.1	F001	10
4051	Default Message Timeout	10 to 900	s	1	F001	300

Table B–9: MODBUS MEMORY MAP (Sheet 12 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
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
409A	DNP Channel 1 Port	0 to 4	---	1	F177	0 (None)
409B	DNP Channel 2 Port	0 to 4	---	1	F177	0 (None)
409C	DNP Address	0 to 65519	---	1	F001	1
409D	Reserved	0 to 1	---	1	F001	0
409E	DNP Client Addresses (2 items)	0 to 4294967295	---	1	F003	0
40A3	TCP Port Number for the Modbus protocol	1 to 65535	---	1	F001	502
40A4	TCP/UDP Port Number for the DNP Protocol	1 to 65535	---	1	F001	20000
40A5	TCP Port Number for the HTTP (Web Server) Protocol	1 to 65535	---	1	F001	80
40A6	Main UDP Port Number for the TFTP Protocol	1 to 65535	---	1	F001	69
40A7	Data Transfer UDP Port Numbers for the TFTP Protocol (zero means “automatic”) (2 items)	0 to 65535	---	1	F001	0
40A9	DNP Unsolicited Responses Function	0 to 1	---	1	F102	0 (Disabled)
40AA	DNP Unsolicited Responses Timeout	0 to 60	s	1	F001	5
40AB	DNP Unsolicited Responses Max Retries	1 to 255	---	1	F001	10
40AC	DNP Unsolicited Responses Destination Address	0 to 65519	---	1	F001	1
40AD	Ethernet Operation Mode	0 to 1	---	1	F192	0 (Half-Duplex)
40AE	DNP Current Scale Factor	0 to 8	---	1	F194	2 (1)
40AF	DNP Voltage Scale Factor	0 to 8	---	1	F194	2 (1)
40B0	DNP Power Scale Factor	0 to 8	---	1	F194	2 (1)
40B1	DNP Energy Scale Factor	0 to 8	---	1	F194	2 (1)
40B2	DNP 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 Number of Paired Binary Output Control Points	0 to 16	---	1	F001	0
40C1	Reserved (31 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

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Table B–9: MODBUS MEMORY MAP (Sheet 13 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
40E4	IEC 60870-5-104 Current Default Threshold	0 to 65535	---	1	F001	30000
40E5	IEC 60870-5-104 Voltage Default Threshold	0 to 65535	---	1	F001	30000
40E6	IEC 60870-5-104 Power Default Threshold	0 to 65535	---	1	F001	30000
40E7	IEC 60870-5-104 Energy Default Threshold	0 to 65535	---	1	F001	30000
40E8	IEC 60870-5-104 Other Default Threshold	0 to 65535	---	1	F001	30000
40E9	IEC 60870-5-104 Client Address (5 items)	0 to 4294967295	---	1	F003	0
40FD	IEC 60870-5-104 Communications Reserved (60 items)	0 to 1	---	1	F001	0
4140	DNP Object 1 Default Variation	1 to 2	---	1	F001	2
4141	DNP Object 2 Default Variation	1 to 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)						
4181	Data Logger Channel Settings (16 items)	---	---	---	F600	0
4191	Data Logger Mode	0 to 1	---	1	F260	0 (continuous)
4192	Data Logger Trigger	0 to 65535	---	1	F300	0
4193	Data Logger Rate	15 to 3600000	ms	1	F003	60000
Clock (Read/Write Command)						
41A0	Real Time Clock Set Time	0 to 235959	---	1	F050	0
Clock (Read/Write Setting)						
41A2	SR Date Format	0 to 4294967295	---	1	F051	0
41A4	SR Time Format	0 to 4294967295	---	1	F052	0
41A6	IRIG-B Signal Type	0 to 2	---	1	F114	0 (None)
41A7	Clock Events Enable / Disable	0 to 1	---	1	F102	0 (Disabled)
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 User-Programmable LED 2					
4284	...Repeated for User-Programmable LED 3					
4286	...Repeated for User-Programmable LED 4					
4288	...Repeated for User-Programmable LED 5					
428A	...Repeated for User-Programmable LED 6					

Table B–9: MODBUS MEMORY MAP (Sheet 14 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
428C	...Repeated for User-Programmable LED 7					
428E	...Repeated for User-Programmable LED 8					
4290	...Repeated for User-Programmable LED 9					
4292	...Repeated for User-Programmable LED 10					
4294	...Repeated for User-Programmable LED 11					
4296	...Repeated for User-Programmable LED 12					
4298	...Repeated for User-Programmable LED 13					
429A	...Repeated for User-Programmable LED 14					
429C	...Repeated for User-Programmable LED 15					
429E	...Repeated for User-Programmable LED 16					
42A0	...Repeated for User-Programmable LED 17					
42A2	...Repeated for User-Programmable LED 18					
42A4	...Repeated for User-Programmable LED 19					
42A6	...Repeated for User-Programmable LED 20					
42A8	...Repeated for User-Programmable LED 21					
42AA	...Repeated for User-Programmable LED 22					
42AC	...Repeated for User-Programmable LED 23					
42AE	...Repeated for User-Programmable LED 24					
42B0	...Repeated for User-Programmable LED 25					
42B2	...Repeated for User-Programmable LED 26					
42B4	...Repeated for User-Programmable LED 27					
42B6	...Repeated for User-Programmable LED 28					
42B8	...Repeated for User-Programmable LED 29					
42BA	...Repeated for User-Programmable LED 30					
42BC	...Repeated for User-Programmable LED 31					
42BE	...Repeated for User-Programmable LED 32					
42C0	...Repeated for User-Programmable LED 33					
42C2	...Repeated for User-Programmable LED 34					
42C4	...Repeated for User-Programmable LED 35					
42C6	...Repeated for User-Programmable LED 36					
42C8	...Repeated for User-Programmable LED 37					
42CA	...Repeated for User-Programmable LED 38					
42CC	...Repeated for User-Programmable LED 39					
42CE	...Repeated for User-Programmable LED 40					
42D0	...Repeated for User-Programmable LED 41					
42D2	...Repeated for User-Programmable LED 42					
42D4	...Repeated for User-Programmable LED 43					
42D6	...Repeated for User-Programmable LED 44					
42D8	...Repeated for User-Programmable LED 45					
42DA	...Repeated for User-Programmable LED 46					
42DC	...Repeated for User-Programmable LED 47					
42DE	...Repeated for User-Programmable LED 48					
Installation (Read/Write Setting)						
43E0	Relay Programmed State	0 to 1	---	1	F133	0 (Not Programmed)
43E1	Relay Name	---	---	---	F202	“Relay-1”
User Programmable Self Tests (Read/Write Setting)						
4441	User Programmable Detect Ring Break Function	0 to 1	---	1	F102	1 (Enabled)
4442	User Programmable Direct Device Off Function	0 to 1	---	1	F102	1 (Enabled)
4443	User Programmable Remote Device Off Function	0 to 1	---	1	F102	1 (Enabled)
4444	User Programmable Primary Ethernet Fail Function	0 to 1	---	1	F102	0 (Disabled)
4445	User Programmable Secondary Ethernet Fail Function	0 to 1	---	1	F102	0 (Disabled)
4446	User Programmable Battery Fail Function	0 to 1	---	1	F102	1 (Enabled)
4447	User Programmable SNTP Fail Function	0 to 1	---	1	F102	1 (Enabled)
4448	User Programmable IRIG-B Fail Function	0 to 1	---	1	F102	1 (Enabled)

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Table B–9: MODBUS MEMORY MAP (Sheet 15 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
CT Settings (Read/Write Setting) (6 modules)						
4480	Phase CT 1 Primary	1 to 65000	A	1	F001	1
4481	Phase CT 1 Secondary	0 to 1	---	1	F123	0 (1 A)
4482	Ground CT 1 Primary	1 to 65000	A	1	F001	1
4483	Ground CT 1 Secondary	0 to 1	---	1	F123	0 (1 A)
4484	...Repeated for CT Bank 2					
4488	...Repeated for CT Bank 3					
448C	...Repeated for CT Bank 4					
4490	...Repeated for CT Bank 5					
4494	...Repeated for CT Bank 6					
VT Settings (Read/Write Setting) (3 modules)						
4500	Phase VT 1 Connection	0 to 1	---	1	F100	0 (Wye)
4501	Phase VT 1 Secondary	50 to 240	V	0.1	F001	664
4502	Phase VT 1 Ratio	1 to 24000	:1	1	F060	1
4504	Auxiliary VT 1 Connection	0 to 6	---	1	F166	1 (Vag)
4505	Auxiliary VT 1 Secondary	50 to 240	V	0.1	F001	664
4506	Auxiliary VT 1 Ratio	1 to 24000	:1	1	F060	1
4508	...Repeated for VT Bank 2					
4510	...Repeated for VT Bank 3					
Source Settings (Read/Write Setting) (6 modules)						
4580	Source 1 Name	---	---	---	F206	“SRC 1"
4583	Source 1 Phase CT	0 to 63	---	1	F400	0
4584	Source 1 Ground CT	0 to 63	---	1	F400	0
4585	Source 1 Phase VT	0 to 63	---	1	F400	0
4586	Source 1 Auxiliary VT	0 to 63	---	1	F400	0
4587	...Repeated for Source 2					
458E	...Repeated for Source 3					
4595	...Repeated for Source 4					
459C	...Repeated for Source 5					
45A3	...Repeated for Source 6					
Power System (Read/Write Setting)						
4600	Nominal Frequency	25 to 60	Hz	1	F001	60
4601	Phase Rotation	0 to 1	---	1	F106	0 (ABC)
4602	Frequency And Phase Reference	0 to 5	---	1	F167	0 (SRC 1)
4603	Frequency Tracking Function	0 to 1	---	1	F102	1 (Enabled)
Breaker Control (Read/Write 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 Out Of Service	0 to 65535	---	1	F300	0
4711	Breaker 1 IEC 61850 XCBR.ST.Loc Status operand	0 to 65535	---	1	F300	0
4712	Reserved (6 items)	0 to 65535	s	1	F001	0
4718	...Repeated for Breaker 2					
Synchrocheck (Read/Write Setting) (2 modules)						
4780	Synchrocheck 1 Function	0 to 1	---	1	F102	0 (Disabled)

Table B–9: MODBUS MEMORY MAP (Sheet 16 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
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 400000	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 Synchrocheck 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-Definable Display 1 Top Line Text	---	---	---	F202	“ “
4C0A	User-Definable Display 1 Bottom Line Text	---	---	---	F202	““
4C14	Modbus Addresses of Display 1 Items (5 items)	0 to 65535	---	1	F001	0
4C19	Reserved (7 items)	---	---	---	F001	0
4C20	...Repeated for User-Definable Display 2					
4C40	...Repeated for User-Definable Display 3					
4C60	...Repeated for User-Definable Display 4					
4C80	...Repeated for User-Definable Display 5					
4CA0	...Repeated for User-Definable Display 6					
4CC0	...Repeated for User-Definable Display 7					
4CE0	...Repeated for User-Definable Display 8					
4D00	...Repeated for User-Definable Display 9					
4D20	...Repeated for User-Definable Display 10					
4D40	...Repeated for User-Definable Display 11					
4D60	...Repeated for User-Definable Display 12					
4D80	...Repeated for User-Definable Display 13					
4DA0	...Repeated for User-Definable Display 14					
4DC0	...Repeated for User-Definable Display 15					
4DE0	...Repeated for User-Definable Display 16					
User Programmable Pushbuttons (Read/Write Setting) (12 modules)						
4E00	User Programmable Pushbutton 1 Function	0 to 2	---	1	F109	2 (Disabled)
4E01	User Programmable Pushbutton 1 Top Line	---	---	---	F202	(none)
4E0B	User Programmable Pushbutton 1 On Text	---	---	---	F202	(none)
4E15	User Programmable Pushbutton 1 Off Text	---	---	---	F202	(none)
4E1F	User Programmable Pushbutton 1 Drop-Out Time	0 to 60	s	0.05	F001	0
4E20	User Programmable Pushbutton 1 Target	0 to 2	---	1	F109	0 (Self-reset)

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Table B–9: MODBUS MEMORY MAP (Sheet 17 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
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 User Programmable Pushbutton 2					
4E48	...Repeated for User Programmable Pushbutton 3					
4E6C	...Repeated for User Programmable Pushbutton 4					
4E90	...Repeated for User Programmable Pushbutton 5					
4EB4	...Repeated for User Programmable Pushbutton 6					
4ED8	...Repeated for User Programmable Pushbutton 7					
4EFC	...Repeated for User Programmable Pushbutton 8					
4F20	...Repeated for User Programmable Pushbutton 9					
4F44	...Repeated for User Programmable Pushbutton 10					
4F68	...Repeated for User Programmable Pushbutton 11					
4F8C	...Repeated for User Programmable Pushbutton 12					
Flexlogic (Read/Write Setting)						
5000	FlexLogic™ Entry (512 items)	0 to 65535	---	1	F300	16384
Flexlogic Timers (Read/Write Setting) (32 modules)						
5800	FlexLogic™ Timer 1 Type	0 to 2	---	1	F129	0 (millisecond)
5801	FlexLogic™ Timer 1 Pickup Delay	0 to 60000	---	1	F001	0
5802	FlexLogic™ Timer 1 Dropout Delay	0 to 60000	---	1	F001	0
5803	Reserved (5 items)	0 to 65535	---	1	F001	0
5808	...Repeated for FlexLogic™ Timer 2					
5810	...Repeated for FlexLogic™ Timer 3					
5818	...Repeated for FlexLogic™ Timer 4					
5820	...Repeated for FlexLogic™ Timer 5					
5828	...Repeated for FlexLogic™ Timer 6					
5830	...Repeated for FlexLogic™ Timer 7					
5838	...Repeated for FlexLogic™ Timer 8					
5840	...Repeated for FlexLogic™ Timer 9					
5848	...Repeated for FlexLogic™ Timer 10					
5850	...Repeated for FlexLogic™ Timer 11					
5858	...Repeated for FlexLogic™ Timer 12					
5860	...Repeated for FlexLogic™ Timer 13					
5868	...Repeated for FlexLogic™ Timer 14					
5870	...Repeated for FlexLogic™ Timer 15					
5878	...Repeated for FlexLogic™ Timer 16					
5880	...Repeated for FlexLogic™ Timer 17					
5888	...Repeated for FlexLogic™ Timer 18					
5890	...Repeated for FlexLogic™ Timer 19					
5898	...Repeated for FlexLogic™ Timer 20					
58A0	...Repeated for FlexLogic™ Timer 21					
58A8	...Repeated for FlexLogic™ Timer 22					
58B0	...Repeated for FlexLogic™ Timer 23					
58B8	...Repeated for FlexLogic™ Timer 24					
58C0	...Repeated for FlexLogic™ Timer 25					
58C8	...Repeated for FlexLogic™ Timer 26					
58D0	...Repeated for FlexLogic™ Timer 27					
58D8	...Repeated for FlexLogic™ Timer 28					
58E0	...Repeated for FlexLogic™ Timer 29					
58E8	...Repeated for FlexLogic™ Timer 30					
58F0	...Repeated for FlexLogic™ Timer 31					
58F8	...Repeated for FlexLogic™ Timer 32					
Phase Time Overcurrent (Read/Write Grouped Setting) (6 modules)						
5900	Phase Time Overcurrent 1 Function	0 to 1	---	1	F102	0 (Disabled)
5901	Phase Time Overcurrent 1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)

Table B–9: MODBUS MEMORY MAP (Sheet 18 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
5902	Phase Time Overcurrent 1 Input	0 to 1	---	1	F122	0 (Phasor)
5903	Phase Time Overcurrent 1 Pickup	0 to 30	pu	0.001	F001	1000
5904	Phase Time Overcurrent 1 Curve	0 to 16	---	1	F103	0 (IEEE Mod Inv)
5905	Phase Time Overcurrent 1 Multiplier	0 to 600	---	0.01	F001	100
5906	Phase Time Overcurrent 1 Reset	0 to 1	---	1	F104	0 (Instantaneous)
5907	Phase Time Overcurrent 1 Voltage Restraint	0 to 1	---	1	F102	0 (Disabled)
5908	Phase TOC 1 Block For Each Phase (3 items)	0 to 65535	---	1	F300	0
590B	Phase Time Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
590C	Phase Time Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
590D	Reserved (3 items)	0 to 1	---	1	F001	0
5910	...Repeated for Phase Time Overcurrent 2					
5920	...Repeated for Phase Time Overcurrent 3					
5930	...Repeated for Phase Time Overcurrent 4					
5940	...Repeated for Phase Time Overcurrent 5					
5950	...Repeated for Phase Time Overcurrent 6					
Phase Instantaneous Overcurrent (Read/Write Grouped Setting) (12 modules)						
5A00	Phase Instantaneous Overcurrent 1 Function	0 to 1	---	1	F102	0 (Disabled)
5A01	Phase Instantaneous Overcurrent 1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
5A02	Phase Instantaneous Overcurrent 1 Pickup	0 to 30	pu	0.001	F001	1000
5A03	Phase Instantaneous Overcurrent 1 Delay	0 to 600	s	0.01	F001	0
5A04	Phase Instantaneous Overcurrent 1 Reset Delay	0 to 600	s	0.01	F001	0
5A05	Phase IOC1 Block For Each Phase (3 items)	0 to 65535	---	1	F300	0
5A08	Phase Instantaneous Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
5A09	Phase Instantaneous Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
5A0A	Reserved (6 items)	0 to 1	---	1	F001	0
5A10	...Repeated for Phase Instantaneous Overcurrent 2					
5A20	...Repeated for Phase Instantaneous Overcurrent 3					
5A30	...Repeated for Phase Instantaneous Overcurrent 4					
5A40	...Repeated for Phase Instantaneous Overcurrent 5					
5A50	...Repeated for Phase Instantaneous Overcurrent 6					
5A60	...Repeated for Phase Instantaneous Overcurrent 7					
5A70	...Repeated for Phase Instantaneous Overcurrent 8					
5A80	...Repeated for Phase Instantaneous Overcurrent 9					
5A90	...Repeated for Phase Instantaneous Overcurrent 10					
5AA0	...Repeated for Phase Instantaneous Overcurrent 11					
5AB0	...Repeated for Phase Instantaneous Overcurrent 12					
Neutral Time Overcurrent (Read/Write Grouped Setting) (6 modules)						
5B00	Neutral Time Overcurrent 1 Function	0 to 1	---	1	F102	0 (Disabled)
5B01	Neutral Time Overcurrent 1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
5B02	Neutral Time Overcurrent 1 Input	0 to 1	---	1	F122	0 (Phasor)
5B03	Neutral Time Overcurrent 1 Pickup	0 to 30	pu	0.001	F001	1000
5B04	Neutral Time Overcurrent 1 Curve	0 to 16	---	1	F103	0 (IEEE Mod Inv)
5B05	Neutral Time Overcurrent 1 Multiplier	0 to 600	---	0.01	F001	100
5B06	Neutral Time Overcurrent 1 Reset	0 to 1	---	1	F104	0 (Instantaneous)
5B07	Neutral Time Overcurrent 1 Block	0 to 65535	---	1	F300	0
5B08	Neutral Time Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
5B09	Neutral Time Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
5B0A	Reserved (6 items)	0 to 1	---	1	F001	0
5B10	...Repeated for Neutral Time Overcurrent 2					
5B20	...Repeated for Neutral Time Overcurrent 3					
5B30	...Repeated for Neutral Time Overcurrent 4					
5B40	...Repeated for Neutral Time Overcurrent 5					
5B50	...Repeated for Neutral Time Overcurrent 6					

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Table B–9: MODBUS MEMORY MAP (Sheet 19 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
Neutral Instantaneous Overcurrent (Read/Write Grouped Setting) (12 modules)						
5C00	Neutral Instantaneous Overcurrent 1 Function	0 to 1	---	1	F102	0 (Disabled)
5C01	Neutral Instantaneous Overcurrent 1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
5C02	Neutral Instantaneous Overcurrent 1 Pickup	0 to 30	pu	0.001	F001	1000
5C03	Neutral Instantaneous Overcurrent 1 Delay	0 to 600	s	0.01	F001	0
5C04	Neutral Instantaneous Overcurrent 1 Reset Delay	0 to 600	s	0.01	F001	0
5C05	Neutral Instantaneous Overcurrent 1 Block	0 to 65535	---	1	F300	0
5C06	Neutral Instantaneous Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
5C07	Neutral Instantaneous Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
5C08	Reserved (8 items)	0 to 1	---	1	F001	0
5C10	...Repeated for Neutral Instantaneous Overcurrent 2					
5C20	...Repeated for Neutral Instantaneous Overcurrent 3					
5C30	...Repeated for Neutral Instantaneous Overcurrent 4					
5C40	...Repeated for Neutral Instantaneous Overcurrent 5					
5C50	...Repeated for Neutral Instantaneous Overcurrent 6					
5C60	...Repeated for Neutral Instantaneous Overcurrent 7					
5C70	...Repeated for Neutral Instantaneous Overcurrent 8					
5C80	...Repeated for Neutral Instantaneous Overcurrent 9					
5C90	...Repeated for Neutral Instantaneous Overcurrent 10					
5CA0	...Repeated for Neutral Instantaneous Overcurrent 11					
5CB0	...Repeated for Neutral Instantaneous Overcurrent 12					
Ground Time Overcurrent (Read/Write Grouped Setting) (6 modules)						
5D00	Ground Time Overcurrent 1 Function	0 to 1	---	1	F102	0 (Disabled)
5D01	Ground Time Overcurrent 1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
5D02	Ground Time Overcurrent 1 Input	0 to 1	---	1	F122	0 (Phasor)
5D03	Ground Time Overcurrent 1 Pickup	0 to 30	pu	0.001	F001	1000
5D04	Ground Time Overcurrent 1 Curve	0 to 16	---	1	F103	0 (IEEE Mod Inv)
5D05	Ground Time Overcurrent 1 Multiplier	0 to 600	---	0.01	F001	100
5D06	Ground Time Overcurrent 1 Reset	0 to 1	---	1	F104	0 (Instantaneous)
5D07	Ground Time Overcurrent 1 Block	0 to 65535	---	1	F300	0
5D08	Ground Time Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
5D09	Ground Time Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
5D0A	Reserved (6 items)	0 to 1	---	1	F001	0
5D10	...Repeated for Ground Time Overcurrent 2					
5D20	...Repeated for Ground Time Overcurrent 3					
5D30	...Repeated for Ground Time Overcurrent 4					
5D40	...Repeated for Ground Time Overcurrent 5					
5D50	...Repeated for Ground Time Overcurrent 6					
Ground Instantaneous Overcurrent (Read/Write Grouped Setting) (12 modules)						
5E00	Ground Instantaneous Overcurrent 1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
5E01	Ground Instantaneous Overcurrent 1 Function	0 to 1	---	1	F102	0 (Disabled)
5E02	Ground Instantaneous Overcurrent 1 Pickup	0 to 30	pu	0.001	F001	1000
5E03	Ground Instantaneous Overcurrent 1 Delay	0 to 600	s	0.01	F001	0
5E04	Ground Instantaneous Overcurrent 1 Reset Delay	0 to 600	s	0.01	F001	0
5E05	Ground Instantaneous Overcurrent 1 Block	0 to 65535	---	1	F300	0
5E06	Ground Instantaneous Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
5E07	Ground Instantaneous Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
5E08	Reserved (8 items)	0 to 1	---	1	F001	0
5E10	...Repeated for Ground Instantaneous Overcurrent 2					
5E20	...Repeated for Ground Instantaneous Overcurrent 3					
5E30	...Repeated for Ground Instantaneous Overcurrent 4					
5E40	...Repeated for Ground Instantaneous Overcurrent 5					
5E50	...Repeated for Ground Instantaneous Overcurrent 6					
5E60	...Repeated for Ground Instantaneous Overcurrent 7					

Table B–9: MODBUS MEMORY MAP (Sheet 20 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
5E70	...Repeated for Ground Instantaneous Overcurrent 8					
5E80	...Repeated for Ground Instantaneous Overcurrent 9					
5E90	...Repeated for Ground Instantaneous Overcurrent 10					
5EA0	...Repeated for Ground Instantaneous Overcurrent 11					
5EB0	...Repeated for Ground Instantaneous Overcurrent 12					
Setting Groups (Read/Write Setting)						
5F80	Setting Group for Modbus Comms (0 means group 1)	0 to 5	---	1	F001	0
5F81	Setting Groups Block	0 to 65535	---	1	F300	0
5F82	FlexLogic to Activate Groups 2 through 6 (5 items)	0 to 65535	---	1	F300	0
5F89	Setting Group Function	0 to 1	---	1	F102	0 (Disabled)
5F8A	Setting Group Events	0 to 1	---	1	F102	0 (Disabled)
Setting Groups (Read Only)						
5F8B	Current Setting Group	0 to 5	---	1	F001	0
Setting Group Names (Read/Write Setting)						
5F8C	Setting Group 1 Name	---	---	---	F203	(none)
5494	Setting Group 2 Name	---	---	---	F203	(none)
5F9C	Setting Group 3 Name	---	---	---	F203	(none)
5FA4	Setting Group 4 Name	---	---	---	F203	(none)
5FAC	Setting Group 5 Name	---	---	---	F203	(none)
5FB4	Setting Group 6 Name	---	---	---	F203	(none)
Autoreclose (Read/Write Setting) (6 modules)						
6240	Autoreclose 1 Function	0 to 1	---	1	F102	0 (Disabled)
6241	Autoreclose 1 Initiate	0 to 65535	---	1	F300	0
6242	Autoreclose 1 Block	0 to 65535	---	1	F300	0
6243	Autoreclose 1 Max Number of Shots	1 to 4	---	1	F001	1
6244	Autoreclose 1 Manual Close	0 to 65535	---	1	F300	0
6245	Autoreclose 1 Manual Reset from LO	0 to 65535	---	1	F300	0
6246	Autoreclose 1 Reset Lockout if Breaker Closed	0 to 1	---	1	F108	0 (Off)
6247	Autoreclose 1 Reset Lockout On Manual Close	0 to 1	---	1	F108	0 (Off)
6248	Autoreclose 1 Breaker Closed	0 to 65535	---	1	F300	0
6249	Autoreclose 1 Breaker Open	0 to 65535	---	1	F300	0
624A	Autoreclose 1 Block Time Upon Manual Close	0 to 655.35	s	0.01	F001	1000
624B	Autoreclose 1 Dead Time Shot 1	0 to 655.35	s	0.01	F001	100
624C	Autoreclose 1 Dead Time Shot 2	0 to 655.35	s	0.01	F001	200
624D	Autoreclose 1 Dead Time Shot 3	0 to 655.35	s	0.01	F001	300
624E	Autoreclose 1 Dead Time Shot 4	0 to 655.35	s	0.01	F001	400
624F	Autoreclose 1 Reset Lockout Delay	0 to 655.35	s	0.01	F001	6000
6250	Autoreclose 1 Reset Time	0 to 655.35	s	0.01	F001	6000
6251	Autoreclose 1 Incomplete Sequence Time	0 to 655.35	s	0.01	F001	500
6252	Autoreclose 1 Events	0 to 1	---	1	F102	0 (Disabled)
6253	Autoreclose 1 Reduce Max 1	0 to 65535	---	1	F300	0
6254	Autoreclose 1 Reduce Max 2	0 to 65535	---	1	F300	0
6255	Autoreclose 1 Reduce Max 3	0 to 65535	---	1	F300	0
6256	Autoreclose 1 Add Delay 1	0 to 65535	---	1	F300	0
6257	Autoreclose 1 Delay 1	0 to 655.35	s	0.01	F001	0
6258	Autoreclose 1 Add Delay 2	0 to 65535	---	1	F300	0
6259	Autoreclose 1 Delay 2	0 to 655.35	s	0.01	F001	0
625A	Reserved (4 items)	0 to 0.001	---	0.001	F001	0
625E	...Repeated for Autoreclose 2					
627C	...Repeated for Autoreclose 3					
629A	...Repeated for Autoreclose 4					
62B8	...Repeated for Autoreclose 5					
62D6	...Repeated for Autoreclose 6					

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Table B–9: MODBUS MEMORY MAP (Sheet 21 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
Negative Sequence Time Overcurrent (Read/Write Grouped Setting) (2 modules)						
6300	Negative Sequence Time Overcurrent 1 Function	0 to 1	---	1	F102	0 (Disabled)
6301	Negative Sequence Time Overcurrent 1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
6302	Negative Sequence Time Overcurrent 1 Pickup	0 to 30	pu	0.001	F001	1000
6303	Negative Sequence Time Overcurrent 1 Curve	0 to 16	---	1	F103	0 (IEEE Mod Inv)
6304	Negative Sequence Time Overcurrent 1 Multiplier	0 to 600	---	0.01	F001	100
6305	Negative Sequence Time Overcurrent 1 Reset	0 to 1	---	1	F104	0 (Instantaneous)
6306	Negative Sequence Time Overcurrent 1 Block	0 to 65535	---	1	F300	0
6307	Negative Sequence Time Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
6308	Negative Sequence Time Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
6309	Reserved (7 items)	0 to 1	---	1	F001	0
6310	...Repeated for Negative Sequence Time Overcurrent 2					
Negative Sequence Instantaneous Overcurrent (Read/Write Grouped Setting) (2 modules)						
6400	Negative Sequence Instantaneous OC 1 Function	0 to 1	---	1	F102	0 (Disabled)
6401	Negative Sequence Instantaneous OC 1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
6402	Negative Sequence Instantaneous Overcurrent 1 Pickup	0 to 30	pu	0.001	F001	1000
6403	Negative Sequence Instantaneous Overcurrent 1 Delay	0 to 600	s	0.01	F001	0
6404	Negative Sequence Instantaneous OC 1 Reset Delay	0 to 600	s	0.01	F001	0
6405	Negative Sequence Instantaneous Overcurrent 1 Block	0 to 65535	---	1	F300	0
6406	Negative Sequence Instantaneous Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
6407	Negative Sequence Instantaneous Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
6408	Reserved (8 items)	0 to 1	---	1	F001	0
6410	...Repeated for Negative Sequence Instantaneous OC 2					
Negative Sequence Overvoltage (Read/Write Grouped Setting)						
64A0	Negative Sequence Overvoltage Function	0 to 1	---	1	F102	0 (Disabled)
64A1	Negative Sequence Overvoltage Source	0 to 5	---	1	F167	0 (SRC 1)
64A2	Negative Sequence Overvoltage Pickup	0 to 1.25	pu	0.001	F001	300
64A3	Negative Sequence Overvoltage Pickup Delay	0 to 600	s	0.01	F001	50
64A4	Negative Sequence Overvoltage Reset Delay	0 to 600	s	0.01	F001	50
64A5	Negative Sequence Overvoltage Block	0 to 65535	---	1	F300	0
64A6	Negative Sequence Overvoltage Target	0 to 2	---	1	F109	0 (Self-reset)
64A7	Negative Sequence Overvoltage Events	0 to 1	---	1	F102	0 (Disabled)
Overfrequency (Read/Write Setting) (4 modules)						
64D0	Overfrequency 1 Function	0 to 1	---	1	F102	0 (Disabled)
64D1	Overfrequency 1 Block	0 to 65535	---	1	F300	0
64D2	Overfrequency 1 Source	0 to 5	---	1	F167	0 (SRC 1)
64D3	Overfrequency 1 Pickup	20 to 65	Hz	0.01	F001	6050
64D4	Overfrequency 1 Pickup Delay	0 to 65.535	s	0.001	F001	500
64D5	Overfrequency 1 Reset Delay	0 to 65.535	s	0.001	F001	500
64D6	Overfrequency 1 Target	0 to 2	---	1	F109	0 (Self-reset)
64D7	Overfrequency 1 Events	0 to 1	---	1	F102	0 (Disabled)
64D8	Reserved (4 items)	0 to 1	---	1	F001	0
64DC	...Repeated for Overfrequency 2					
64E8	...Repeated for Overfrequency 3					
64F4	...Repeated for Overfrequency 4					
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

Table B–9: MODBUS MEMORY MAP (Sheet 22 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
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	Reserved (5 items)	0 to 65535	---	1	F001	0
66B0	...Repeated for Sensitive Directional Power 2					
Load Encroachment (Read/Write Grouped Setting)						
6700	Load Encroachment Function	0 to 1	---	1	F102	0 (Disabled)
6701	Load Encroachment Source	0 to 5	---	1	F167	0 (SRC 1)
6702	Load Encroachment Minimum Voltage	0 to 3	pu	0.001	F001	250
6703	Load Encroachment Reach	0.02 to 250	ohms	0.01	F001	100
6704	Load Encroachment Angle	5 to 50	degrees	1	F001	30
6705	Load Encroachment Pickup Delay	0 to 65.535	s	0.001	F001	0
6706	Load Encroachment Reset Delay	0 to 65.535	s	0.001	F001	0
6707	Load Encroachment Block	0 to 65535	---	1	F300	0
6708	Load Encroachment Target	0 to 2	---	1	F109	0 (Self-reset)
6709	Load Encroachment Events	0 to 1	---	1	F102	0 (Disabled)
670A	Reserved (6 items)	0 to 65535	---	1	F001	0
Phase Undervoltage (Read/Write Grouped Setting) (2 modules)						
7000	Phase Undervoltage 1 Function	0 to 1	---	1	F102	0 (Disabled)
7001	Phase Undervoltage 1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
7002	Phase Undervoltage 1 Pickup	0 to 3	pu	0.001	F001	1000
7003	Phase Undervoltage 1 Curve	0 to 1	---	1	F111	0 (Definite Time)
7004	Phase Undervoltage 1 Delay	0 to 600	s	0.01	F001	100
7005	Phase Undervoltage 1 Minimum Voltage	0 to 3	pu	0.001	F001	100
7006	Phase Undervoltage 1 Block	0 to 65535	---	1	F300	0
7007	Phase Undervoltage 1 Target	0 to 2	---	1	F109	0 (Self-reset)
7008	Phase Undervoltage 1 Events	0 to 1	---	1	F102	0 (Disabled)
7009	Phase Undervoltage 1 Measurement Mode	0 to 1	---	1	F186	0 (Phase to Ground)
700A	Reserved (6 items)	0 to 1	---	1	F001	0
7013	...Repeated for Phase Undervoltage 2					
Phase Overvoltage (Read/Write Grouped Setting)						
7040	Phase Overvoltage 1 Function	0 to 1	---	1	F102	0 (Disabled)
7041	Phase Overvoltage 1 Source	0 to 5	---	1	F167	0 (SRC 1)
7042	Phase Overvoltage 1 Pickup	0 to 3	pu	0.001	F001	1000
7043	Phase Overvoltage 1 Delay	0 to 600	s	0.01	F001	100
7044	Phase Overvoltage 1 Reset Delay	0 to 600	s	0.01	F001	100
7045	Phase Overvoltage 1 Block	0 to 65535	---	1	F300	0
7046	Phase Overvoltage 1 Target	0 to 2	---	1	F109	0 (Self-reset)
7047	Phase Overvoltage 1 Events	0 to 1	---	1	F102	0 (Disabled)
7048	Reserved (8 items)	0 to 1	---	1	F001	0
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

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Table B–9: MODBUS MEMORY MAP (Sheet 23 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
7213	Breaker Failure 1 Use Timer 3	0 to 1	---	1	F126	1 (Yes)
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 Breaker Failure 2					
Phase Directional Overcurrent (Read/Write Grouped Setting) (2 modules)						
7260	Phase Directional Overcurrent 1 Function	0 to 1	---	1	F102	0 (Disabled)
7261	Phase Directional Overcurrent 1 Source	0 to 5	---	1	F167	0 (SRC 1)
7262	Phase Directional Overcurrent 1 Block	0 to 65535	---	1	F300	0
7263	Phase Directional Overcurrent 1 ECA	0 to 359	---	1	F001	30
7264	Phase Directional Overcurrent 1 Pol V Threshold	0 to 3	pu	0.001	F001	700
7265	Phase Directional Overcurrent 1 Block Overcurrent	0 to 1	---	1	F126	0 (No)
7266	Phase Directional Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
7267	Phase Directional Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
7268	Reserved (8 items)	0 to 1	---	1	F001	0
7270	...Repeated for Phase Directional Overcurrent 2					
Neutral Directional Overcurrent (Read/Write Grouped Setting) (2 modules)						
7280	Neutral Directional Overcurrent 1 Function	0 to 1	---	1	F102	0 (Disabled)
7281	Neutral Directional Overcurrent 1 Source	0 to 5	---	1	F167	0 (SRC 1)
7282	Neutral Directional Overcurrent 1 Polarizing	0 to 2	---	1	F230	0 (Voltage)
7283	Neutral Directional Overcurrent 1 Forward ECA	-90 to 90	° Lag	1	F002	75
7284	Neutral Directional Overcurrent 1 Forward Limit Angle	40 to 90	degrees	1	F001	90
7285	Neutral Directional Overcurrent 1 Forward Pickup	0.002 to 30	pu	0.001	F001	50
7286	Neutral Directional Overcurrent 1 Reverse Limit Angle	40 to 90	degrees	1	F001	90
7287	Neutral Directional Overcurrent 1 Reverse Pickup	0.002 to 30	pu	0.001	F001	50
7288	Neutral Directional Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
7289	Neutral Directional Overcurrent 1 Block	0 to 65535	---	1	F300	0
728A	Neutral Directional Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
728B	Neutral Directional Overcurrent 1 Polarizing Voltage	0 to 1	---	1	F231	0 (Calculated V0)
728C	Neutral Directional Overcurrent 1 Op Current	0 to 1	---	1	F196	0 (Calculated 3I0)
728D	Neutral Directional Overcurrent 1 Offset	0 to 250	ohms	0.01	F001	0
728E	Neutral Directional Overcurrent 1 Pos Seq Restraint	0 to 0.5	---	0.001	F001	63
728F	Reserved	0 to 1	---	1	F001	0
7290	...Repeated for Neutral Directional Overcurrent 2					
Negative Sequence Directional Overcurrent (Read/Write Grouped Setting) (2 modules)						
72A0	Negative Sequence Directional Overcurrent 1 Function	0 to 1	---	1	F102	0 (Disabled)
72A1	Negative Sequence Directional Overcurrent 1 Source	0 to 5	---	1	F167	0 (SRC 1)
72A2	Negative Sequence Directional Overcurrent 1 Type	0 to 1	---	1	F179	0 (Neg Sequence)

Table B–9: MODBUS MEMORY MAP (Sheet 24 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
72A3	Neg Sequence Directional Overcurrent 1 Forward ECA	0 to 90	° Lag	1	F002	75
72A4	Neg Seq Directional Overcurrent 1 Forward Limit Angle	40 to 90	degrees	1	F001	90
72A5	Neg Sequence Directional Overcurrent 1 Forward Pickup	0.05 to 30	pu	0.01	F001	5
72A6	Neg Seq Directional Overcurrent 1 Reverse Limit Angle	40 to 90	degrees	1	F001	90
72A7	Neg Sequence Directional Overcurrent 1 Reverse Pickup	0.05 to 30	pu	0.01	F001	5
72A8	Negative Sequence Directional Overcurrent 1 Target	0 to 2	---	1	F109	0 (Self-reset)
72A9	Negative Sequence Directional Overcurrent 1 Block	0 to 65535	---	1	F300	0
72AA	Negative Sequence Directional Overcurrent 1 Events	0 to 1	---	1	F102	0 (Disabled)
72AB	Negative Sequence Directional Overcurrent 1 Offset	0 to 250	ohms	0.01	F001	0
72AC	Neg Seq Directional Overcurrent 1 Pos Seq Restraint	0 to 0.5	---	0.001	F001	63
72AD	Reserved (3 items)	0 to 1	---	1	F001	0
72B0	...Repeated for Neg Seq Directional Overcurrent 2					
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 Breaker 2 Arcing Current					
DCMA Inputs (Read/Write Setting) (24 modules)						
7300	dcmA Inputs 1 Function	0 to 1	---	1	F102	0 (Disabled)
7301	dcmA Inputs 1 ID	---	---	---	F205	“DCMA I 1"
7307	Reserved 1 (4 items)	0 to 65535	---	1	F001	0
730B	dcmA Inputs 1 Units	---	---	---	F206	“mA”
730E	dcmA Inputs 1 Range	0 to 6	---	1	F173	6 (4 to 20 mA)
730F	dcmA Inputs 1 Minimum Value	-9999.999 to 9999.999	---	0.001	F004	4000
7311	dcmA Inputs 1 Maximum Value	-9999.999 to 9999.999	---	0.001	F004	20000
7313	Reserved (5 items)	0 to 65535	---	1	F001	0
7318	...Repeated for dcmA Inputs 2					
7330	...Repeated for dcmA Inputs 3					
7348	...Repeated for dcmA Inputs 4					
7360	...Repeated for dcmA Inputs 5					
7378	...Repeated for dcmA Inputs 6					
7390	...Repeated for dcmA Inputs 7					
73A8	...Repeated for dcmA Inputs 8					
73C0	...Repeated for dcmA Inputs 9					
73D8	...Repeated for dcmA Inputs 10					
73F0	...Repeated for dcmA Inputs 11					
7408	...Repeated for dcmA Inputs 12					
7420	...Repeated for dcmA Inputs 13					
7438	...Repeated for dcmA Inputs 14					
7450	...Repeated for dcmA Inputs 15					
7468	...Repeated for dcmA Inputs 16					
7480	...Repeated for dcmA Inputs 17					
7498	...Repeated for dcmA Inputs 18					
74B0	...Repeated for dcmA Inputs 19					
74C8	...Repeated for dcmA Inputs 20					
74E0	...Repeated for dcmA Inputs 21					
74F8	...Repeated for dcmA Inputs 22					

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Table B–9: MODBUS MEMORY MAP (Sheet 25 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
7510	...Repeated for dcmA Inputs 23					
7528	...Repeated for dcmA Inputs 24					
RTD Inputs (Read/Write Setting) (48 modules)						
7540	RTD Input 1 Function	0 to 1	---	1	F102	0 (Disabled)
7541	RTD Input 1 ID	---	---	---	F205	“RTD Ip 1“
7547	Reserved (4 items)	0 to 65535	---	1	F001	0
754B	RTD Input 1 Type	0 to 3	---	1	F174	0 (100 Ohm Platinum)
754C	Reserved (4 items)	0 to 65535	---	1	F001	0
7550	...Repeated for RTD Input 2					
7560	...Repeated for RTD Input 3					
7570	...Repeated for RTD Input 4					
7580	...Repeated for RTD Input 5					
7590	...Repeated for RTD Input 6					
75A0	...Repeated for RTD Input 7					
75B0	...Repeated for RTD Input 8					
75C0	...Repeated for RTD Input 9					
75D0	...Repeated for RTD Input 10					
75E0	...Repeated for RTD Input 11					
75F0	...Repeated for RTD Input 12					
7600	...Repeated for RTD Input 13					
7610	...Repeated for RTD Input 14					
7620	...Repeated for RTD Input 15					
7630	...Repeated for RTD Input 16					
7640	...Repeated for RTD Input 17					
7650	...Repeated for RTD Input 18					
7660	...Repeated for RTD Input 19					
7670	...Repeated for RTD Input 20					
7680	...Repeated for RTD Input 21					
7690	...Repeated for RTD Input 22					
76A0	...Repeated for RTD Input 23					
76B0	...Repeated for RTD Input 24					
76C0	...Repeated for RTD Input 25					
76D0	...Repeated for RTD Input 26					
76E0	...Repeated for RTD Input 27					
76F0	...Repeated for RTD Input 28					
7700	...Repeated for RTD Input 29					
7710	...Repeated for RTD Input 30					
7720	...Repeated for RTD Input 31					
7730	...Repeated for RTD Input 32					
7740	...Repeated for RTD Input 33					
7750	...Repeated for RTD Input 34					
7760	...Repeated for RTD Input 35					
7770	...Repeated for RTD Input 36					
7780	...Repeated for RTD Input 37					
7790	...Repeated for RTD Input 38					
77A0	...Repeated for RTD Input 39					
77B0	...Repeated for RTD Input 40					
77C0	...Repeated for RTD Input 41					
77D0	...Repeated for RTD Input 42					
77E0	...Repeated for RTD Input 43					
77F0	...Repeated for RTD Input 44					
7800	...Repeated for RTD Input 45					
7810	...Repeated for RTD Input 46					
7820	...Repeated for RTD Input 47					

Table B–9: MODBUS MEMORY MAP (Sheet 26 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
7830	...Repeated for RTD Input 48					
High Impedance Fault Detection (Hi-Z) Settings (Read/Write Setting)						
7A00	Hi-Z Function	0 to 1	---	1	F102	0 (Disabled)
7A01	Hi-Z Signal Source	0 to 5	---	1	F167	0 (SRC 1)
7A03	Hi-Z Arcing Sensitivity	1 to 10	---	1	F001	5
7A04	Hi-Z Phase Event Count	10 to 250	---	1	F001	30
7A05	Hi-Z Ground Event Count	10 to 500	---	1	F001	30
7A06	Hi-Z Event Count Time	5 to 180	min	1	F001	15
7A07	Hi-Z Overcurrent Protection Coordination Timeout	10 to 200	s	1	F001	15
7A08	Hi-Z Phase Overcurrent Minimum Pickup	0.01 to 10	pu	0.01	F001	150
7A09	Hi-Z Neutral Overcurrent Minimum Pickup	0.01 to 10	pu	0.01	F001	100
7A0A	Hi-Z Phase Rate of Change	1 to 999	A/2cycle	1	F001	150
7A0B	Hi-Z Neutral Rate of Change	1 to 999	A/2cycle	1	F001	150
7A0C	Hi-Z Loss of Load Threshold	5 to 100	%	1	F001	15
7A0D	Hi-Z 3-Phase Event Threshold	1 to 1000	A	1	F001	25
7A0E	Hi-Z Voltage Supervision Threshold	0 to 100	%	1	F001	5
7A0F	Hi-Z Voltage Supervision Delay	0 to 300	cycles	2	F001	60
7A10	HIZ Even Harmonic Restraint	0 to 100	%	1	F001	20
7A11	Hi-Z Target	0 to 2	---	1	F109	0 (Self-reset)
7A12	Hi-Z Events	0 to 1	---	1	F102	0 (Disabled)
Underfrequency (Read/Write Setting) (6 modules)						
7E00	Underfrequency Function	0 to 1	---	1	F102	0 (Disabled)
7E01	Underfrequency 1 Block	0 to 65535	---	1	F300	0
7E02	Underfrequency 1 Minimum Current	0.1 to 1.25	pu	0.01	F001	10
7E03	Underfrequency 1 Pickup	20 to 65	Hz	0.01	F001	5950
7E04	Underfrequency 1 Pickup Delay	0 to 65.535	s	0.001	F001	2000
7E05	Underfrequency 1 Reset Delay	0 to 65.535	s	0.001	F001	2000
7E06	Underfrequency 1 Source	0 to 5	---	1	F167	0 (SRC 1)
7E07	Underfrequency 1 Events	0 to 1	---	1	F102	0 (Disabled)
7E08	Underfrequency 1 Target	0 to 2	---	1	F109	0 (Self-reset)
7E09	Reserved (8 items)	0 to 1	---	1	F001	0
7E11	...Repeated for Underfrequency 2					
7E22	...Repeated for Underfrequency 3					
7E33	...Repeated for Underfrequency 4					
7E44	...Repeated for Underfrequency 5					
7E55	...Repeated for Underfrequency 6					
Neutral Overvoltage (Read/Write Grouped Setting) (3 modules)						
7F00	Neutral Overvoltage 1 Function	0 to 1	---	1	F102	0 (Disabled)
7F01	Neutral Overvoltage 1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
7F02	Neutral Overvoltage 1 Pickup	0 to 3.00	pu	0.001	F001	300
7F03	Neutral Overvoltage 1 Pickup Delay	0 to 600	s	0.01	F001	100
7F04	Neutral Overvoltage 1 Reset Delay	0 to 600	s	0.01	F001	100
7F05	Neutral Overvoltage 1 Block	0 to 65535	---	1	F300	0
7F06	Neutral Overvoltage 1 Target	0 to 2	---	1	F109	0 (Self-reset)
7F07	Neutral Overvoltage 1 Events	0 to 1	---	1	F102	0 (Disabled)
7F08	Neutral Overvoltage 1 Curves	0 to 3	---	1	F116	0 (Definite Time)
7F09	Reserved (8 items)	0 to 65535	---	1	F001	0
7F10	...Repeated for Neutral Overvoltage 2					
7F20	...Repeated for Neutral Overvoltage 3					
Auxiliary Overvoltage (Read/Write Grouped Setting) (3 modules)						
7F30	Auxiliary Overvoltage 1 Function	0 to 1	---	1	F102	0 (Disabled)
7F31	Auxiliary Overvoltage 1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
7F32	Auxiliary Overvoltage 1 Pickup	0 to 3	pu	0.001	F001	300
7F33	Auxiliary Overvoltage 1 Pickup Delay	0 to 600	s	0.01	F001	100

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Table B–9: MODBUS MEMORY MAP (Sheet 27 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
7F34	Auxiliary Overvoltage 1 Reset Delay	0 to 600	s	0.01	F001	100
7F35	Auxiliary Overvoltage 1 Block	0 to 65535	---	1	F300	0
7F36	Auxiliary Overvoltage 1 Target	0 to 2	---	1	F109	0 (Self-reset)
7F37	Auxiliary Overvoltage 1 Events	0 to 1	---	1	F102	0 (Disabled)
7F38	Reserved (8 items)	0 to 65535	---	1	F001	0
7F40	...Repeated for Auxiliary Overvoltage 2					
7F50	...Repeated for Auxiliary Overvoltage 3					
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	Reserved (7 items)	0 to 65535	---	1	F001	0
7F70	...Repeated for Auxiliary Undervoltage 2					
7F80	...Repeated for Auxiliary Undervoltage 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
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 EGD Exchange 2					
FlexState Settings (Read/Write Setting)						
8800	FlexState Parameters (256 items)	---	---	---	F300	0
Digital Elements (Read/Write Setting) (48 modules)						
8A00	Digital Element 1 Function	0 to 1	---	1	F102	0 (Disabled)
8A01	Digital Element 1 Name	---	---	---	F203	"Dig Element 1"
8A09	Digital Element 1 Input	0 to 65535	---	1	F300	0
8A0A	Digital Element 1 Pickup Delay	0 to 999999.999	s	0.001	F003	0
8A0C	Digital Element 1 Reset Delay	0 to 999999.999	s	0.001	F003	0
8A0E	Digital Element 1 Block	0 to 65535	---	1	F300	0
8A0F	Digital Element 1 Target	0 to 2	---	1	F109	0 (Self-reset)

Table B–9: MODBUS MEMORY MAP (Sheet 28 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
8A10	Digital Element 1 Events	0 to 1	---	1	F102	0 (Disabled)
8A11	Digital Element 1 Pickup LED	0 to 1	---	1	F102	1 (Enabled)
8A12	Reserved (2 items)	---	---	---	F001	0
8A14	...Repeated for Digital Element 2					
8A28	...Repeated for Digital Element 3					
8A3C	...Repeated for Digital Element 4					
8A50	...Repeated for Digital Element 5					
8A64	...Repeated for Digital Element 6					
8A78	...Repeated for Digital Element 7					
8A8C	...Repeated for Digital Element 8					
8AA0	...Repeated for Digital Element 9					
8AB4	...Repeated for Digital Element 10					
8AC8	...Repeated for Digital Element 11					
8ADC	...Repeated for Digital Element 12					
8AF0	...Repeated for Digital Element 13					
8B04	...Repeated for Digital Element 14					
8B18	...Repeated for Digital Element 15					
8B2C	...Repeated for Digital Element 16					
8B40	...Repeated for Digital Element 17					
8B54	...Repeated for Digital Element 18					
8B68	...Repeated for Digital Element 19					
8B7C	...Repeated for Digital Element 20					
8B90	...Repeated for Digital Element 21					
8BA4	...Repeated for Digital Element 22					
8BB8	...Repeated for Digital Element 23					
8BCC	...Repeated for Digital Element 24					
8BE0	...Repeated for Digital Element 25					
8BF4	...Repeated for Digital Element 26					
8C08	...Repeated for Digital Element 27					
8C1C	...Repeated for Digital Element 28					
8C30	...Repeated for Digital Element 29					
8C44	...Repeated for Digital Element 30					
8C58	...Repeated for Digital Element 31					
8C6C	...Repeated for Digital Element 32					
8C80	...Repeated for Digital Element 33					
8C94	...Repeated for Digital Element 34					
8CA8	...Repeated for Digital Element 35					
8CBC	...Repeated for Digital Element 36					
8CD0	...Repeated for Digital Element 37					
8CE4	...Repeated for Digital Element 38					
8CF8	...Repeated for Digital Element 39					
8D0C	...Repeated for Digital Element 40					
8D20	...Repeated for Digital Element 41					
8D34	...Repeated for Digital Element 42					
8D48	...Repeated for Digital Element 43					
8D5C	...Repeated for Digital Element 44					
8D70	...Repeated for Digital Element 45					
8D84	...Repeated for Digital Element 46					
8D98	...Repeated for Digital Element 47					
8DAC	...Repeated for Digital Element 48					
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

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Table B–9: MODBUS MEMORY MAP (Sheet 29 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
9005	FlexElement™ 1 InputM	0 to 65535	---	1	F600	0
9006	FlexElement™ 1 Compare	0 to 1	---	1	F516	0 (LEVEL)
9007	FlexElement™ 1 Input	0 to 1	---	1	F515	0 (SIGNED)
9008	FlexElement™ 1 Direction	0 to 1	---	1	F517	0 (OVER)
9009	FlexElement™ 1 Hysteresis	0.1 to 50	%	0.1	F001	30
900A	FlexElement™ 1 Pickup	-90 to 90	pu	0.001	F004	1000
900C	FlexElement™ 1 DeltaT Units	0 to 2	---	1	F518	0 (Milliseconds)
900D	FlexElement™ 1 DeltaT	20 to 86400	---	1	F003	20
900F	FlexElement™ 1 Pickup Delay	0 to 65.535	s	0.001	F001	0
9010	FlexElement™ 1 Reset Delay	0 to 65.535	s	0.001	F001	0
9011	FlexElement™ 1 Block	0 to 65535	---	1	F300	0
9012	FlexElement™ 1 Target	0 to 2	---	1	F109	0 (Self-reset)
9013	FlexElement™ 1 Events	0 to 1	---	1	F102	0 (Disabled)
9014	...Repeated for FlexElement™ 2					
9028	...Repeated for FlexElement™ 3					
903C	...Repeated for FlexElement™ 4					
9050	...Repeated for FlexElement™ 5					
9064	...Repeated for FlexElement™ 6					
9078	...Repeated for FlexElement™ 7					
908C	...Repeated for FlexElement™ 8					
90A0	...Repeated for FlexElement™ 9					
90B4	...Repeated for FlexElement™ 10					
90C8	...Repeated for FlexElement™ 11					
90DC	...Repeated for FlexElement™ 12					
90F0	...Repeated for FlexElement™ 13					
9104	...Repeated for FlexElement™ 14					
9118	...Repeated for FlexElement™ 15					
912C	...Repeated for FlexElement™ 16					
Fault Report Settings (Read/Write Setting) (5 modules)						
9200	Fault Report 1 Source	0 to 5	---	1	F167	0 (SRC 1)
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 Fault Report 2					
9210	...Repeated for Fault Report 3					
9218	...Repeated for Fault Report 4					
9220	...Repeated for Fault Report 5					
DCMA Outputs (Read/Write Setting) (24 modules)						
9300	dcmA Output 1 Source	0 to 65535	---	1	F600	0
9301	dcmA Output 1 Range	0 to 2	---	1	F522	0 (–1 to 1 mA)
9302	dcmA Output 1 Minimum	–90 to 90	pu	0.001	F004	0
9304	dcmA Output 1 Maximum	–90 to 90	pu	0.001	F004	1000
9306	...Repeated for dcmA Output 2					
930C	...Repeated for dcmA Output 3					
9312	...Repeated for dcmA Output 4					
9318	...Repeated for dcmA Output 5					
931E	...Repeated for dcmA Output 6					
9324	...Repeated for dcmA Output 7					
932A	...Repeated for dcmA Output 8					
9330	...Repeated for dcmA Output 9					

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Table B–9: MODBUS MEMORY MAP (Sheet 30 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
9336	...Repeated for dcmA Output 10					
933C	...Repeated for dcmA Output 11					
9342	...Repeated for dcmA Output 12					
9348	...Repeated for dcmA Output 13					
934E	...Repeated for dcmA Output 14					
9354	...Repeated for dcmA Output 15					
935A	...Repeated for dcmA Output 16					
9360	...Repeated for dcmA Output 17					
9366	...Repeated for dcmA Output 18					
936C	...Repeated for dcmA Output 19					
9372	...Repeated for dcmA Output 20					
9378	...Repeated for dcmA Output 21					
937E	...Repeated for dcmA Output 22					
9384	...Repeated for dcmA Output 23					
938A	...Repeated for dcmA Output 24					
Direct Input/Output Names (Read/Write Setting) (96 modules)						
9400	Direct Input 1 Name	0 to 96	---	1	F205	“Dir Ip 1”
9406	Direct Output 1 Name	1 to 96	---	1	F205	“Dir Out 1”
940C	...Repeated for Direct Input/Output 2					
9418	...Repeated for Direct Input/Output 3					
9424	...Repeated for Direct Input/Output 4					
9430	...Repeated for Direct Input/Output 5					
943C	...Repeated for Direct Input/Output 6					
9448	...Repeated for Direct Input/Output 7					
9454	...Repeated for Direct Input/Output 8					
9460	...Repeated for Direct Input/Output 9					
946C	...Repeated for Direct Input/Output 10					
9478	...Repeated for Direct Input/Output 11					
9484	...Repeated for Direct Input/Output 12					
9490	...Repeated for Direct Input/Output 13					
949C	...Repeated for Direct Input/Output 14					
94A8	...Repeated for Direct Input/Output 15					
94B4	...Repeated for Direct Input/Output 16					
94C0	...Repeated for Direct Input/Output 17					
94CC	...Repeated for Direct Input/Output 18					
94D8	...Repeated for Direct Input/Output 19					
94E4	...Repeated for Direct Input/Output 20					
94F0	...Repeated for Direct Input/Output 21					
94FC	...Repeated for Direct Input/Output 22					
9508	...Repeated for Direct Input/Output 23					
9514	...Repeated for Direct Input/Output 24					
9520	...Repeated for Direct Input/Output 25					
952C	...Repeated for Direct Input/Output 26					
9538	...Repeated for Direct Input/Output 27					
9544	...Repeated for Direct Input/Output 28					
9550	...Repeated for Direct Input/Output 29					
955C	...Repeated for Direct Input/Output 30					
9568	...Repeated for Direct Input/Output 31					
9574	...Repeated for Direct Input/Output 32					
FlexElement Actuals (Read Only) (16 modules)						
9A01	FlexElement™ 1 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
9A03	FlexElement™ 2 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
9A05	FlexElement™ 3 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
9A07	FlexElement™ 4 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0

Table B–9: MODBUS MEMORY MAP (Sheet 31 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
9A09	FlexElement™ 5 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
9A0B	FlexElement™ 6 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
9A0D	FlexElement™ 7 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
9A0F	FlexElement™ 8 Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
Teleprotection Inputs/Outputs (Read/Write Settings)						
9B00	Teleprotection Function	0 to 1	---	1	F102	0 (Disabled)
9B01	Teleprotection Number of Terminals	2 to 3	---	1	F001	2
9B02	Teleprotection Number of Channels	1 to 2	---	1	F001	1
9B03	Teleprotection Local Relay ID	0 to 255	---	1	F001	0
9B04	Teleprotection Terminal 1 ID	0 to 255	---	1	F001	0
9B05	Teleprotection Terminal 2 ID	0 to 255	---	1	F001	0
9B06	Reserved (10 items)	0 to 1	---	---	F001	0
9B10	Teleprotection Input 1-n Default States (16 items)	0 to 3	---	1	F086	0 (Off)
9B30	Teleprotection Input 2-n Default States (16 items)	0 to 3	---	1	F086	0 (Off)
9B50	Teleprotection Output 1-n Operand (16 items)	0 to 65535	---	1	F300	0
9B70	Teleprotection Output 2-n Operand (16 items)	0 to 65535	---	1	F300	0
Teleprotection Inputs/Outputs Commands (Read/Write Command)						
9B90	Teleprotection Clear Lost Packets	0 to 1	---	1	F126	0 (No)
Teleprotection Channel Tests (Read Only)						
9B91	Teleprotection Channel 1 Status	0 to 2	---	1	F134	1 (OK)
9B92	Teleprotection Channel 1 Number of Lost Packets	0 to 65535	---	1	F001	0
9B93	Teleprotection Channel 2 Status	0 to 2	---	1	F134	1 (OK)
9B94	Teleprotection Channel 2 Number of Lost Packets	0 to 65535	---	1	F001	0
9B95	Teleprotection Network Status	0 to 2	---	1	F134	2 (n/a)
9BA0	Teleprotection Channel 1 Input States	0 to 1	---	1	F500	0
9BA1	Teleprotection Channel 2 Input States	0 to 1	---	1	F500	0
9BB0	Teleprotection Input 1 States, 1 per register (16 items)	0 to 1	---	1	F108	0 (Off)
9BC0	Teleprotection Input 2 States, 1 per register (16 items)	0 to 1	---	1	F108	0 (Off)
Cold Load Pickup (Read/Write Setting) (2 modules)						
A010	Cold Load Pickup 1 Function	0 to 1	---	1	F102	0 (Disabled)
A011	Cold Load Pickup 1 Initiate	0 to 65535	---	1	F300	0
A012	Cold Load Pickup 1 Block	0 to 65535	---	1	F300	0
A013	Outage Time Before Cold Load Pickup 1	0 to 1000	s	1	F001	1000
A014	On Load Time Before Reset 1	0 to 1000000	s	0.001	F003	100000
A016	Cold Load Pickup 1 Source	0 to 5	---	1	F167	0 (SRC 1)
A017	Cold Load Pickup 1 Reserved	0 to 65535	---	1	F001	0
A018	...Repeated for Cold Load Pickup 2					
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

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Table B–9: MODBUS MEMORY MAP (Sheet 32 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
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	Reserved (10 items)	---	---	1	F001	0
A428	...Repeated for Selector 2					
DNP/IEC Points (Read/Write Setting)						
A500	DNP/IEC 60870-5-104 Binary Input Points (256 items)	0 to 65535	---	1	F300	0
A600	DNP/IEC 60870-5-104 Analog Input Points (256 items)	0 to 65535	---	1	F300	0
Flexcurves C and D (Read/Write Setting)						
A900	FlexCurve C (120 items)	0 to 65535	ms	1	F011	0
A978	FlexCurve D (120 items)	0 to 65535	ms	1	F011	0
Non Volatile Latches (Read/Write Setting) (16 modules)						
AA00	Non-Volatile Latch 1 Function	0 to 1	---	1	F102	0 (Disabled)
AA01	Non-Volatile Latch 1 Type	0 to 1	---	1	F519	0 (Reset Dominant)
AA02	Non-Volatile Latch 1 Set	0 to 65535	---	1	F300	0
AA03	Non-Volatile Latch 1 Reset	0 to 65535	---	1	F300	0
AA04	Non-Volatile Latch 1 Target	0 to 2	---	1	F109	0 (Self-reset)
AA05	Non-Volatile Latch 1 Events	0 to 1	---	1	F102	0 (Disabled)
AA06	Reserved (4 items)	---	---	---	F001	0
AA0A	...Repeated for Non-Volatile Latch 2					
AA14	...Repeated for Non-Volatile Latch 3					
AA1E	...Repeated for Non-Volatile Latch 4					
AA28	...Repeated for Non-Volatile Latch 5					
AA32	...Repeated for Non-Volatile Latch 6					
AA3C	...Repeated for Non-Volatile Latch 7					
AA46	...Repeated for Non-Volatile Latch 8					
AA50	...Repeated for Non-Volatile Latch 9					
AA5A	...Repeated for Non-Volatile Latch 10					
AA64	...Repeated for Non-Volatile Latch 11					
AA6E	...Repeated for Non-Volatile Latch 12					
AA78	...Repeated for Non-Volatile Latch 13					
AA82	...Repeated for Non-Volatile Latch 14					
AA8C	...Repeated for Non-Volatile Latch 15					
AA96	...Repeated for Non-Volatile Latch 16					
Digital Counter (Read/Write Setting) (8 modules)						
AB00	Digital Counter 1 Function	0 to 1	---	1	F102	0 (Disabled)
AB01	Digital Counter 1 Name	---	---	---	F205	“Counter 1"
AB07	Digital Counter 1 Units	---	---	---	F206	(none)
AB0A	Digital Counter 1 Block	0 to 65535	---	1	F300	0
AB0B	Digital Counter 1 Up	0 to 65535	---	1	F300	0
AB0C	Digital Counter 1 Down	0 to 65535	---	1	F300	0
AB0D	Digital Counter 1 Preset	-2147483647 to 2147483647	---	1	F004	0
AB0F	Digital Counter 1 Compare	-2147483647 to 2147483647	---	1	F004	0
AB11	Digital Counter 1 Reset	0 to 65535	---	1	F300	0
AB12	Digital Counter 1 Freeze/Reset	0 to 65535	---	1	F300	0
AB13	Digital Counter 1 Freeze/Count	0 to 65535	---	1	F300	0
AB14	Digital Counter 1 Set To Preset	0 to 65535	---	1	F300	0
AB15	Reserved (11 items)	---	---	---	F001	0
AB20	...Repeated for Digital Counter 2					

B

Table B–9: MODBUS MEMORY MAP (Sheet 33 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
AB40	...Repeated for Digital Counter 3					
AB60	...Repeated for Digital Counter 4					
AB80	...Repeated for Digital Counter 5					
ABA0	...Repeated for Digital Counter 6					
ABC0	...Repeated for Digital Counter 7					
ABE0	...Repeated for Digital Counter 8					
Frequency Rate of Change (Read/Write Setting) (4 modules)						
AC00	Frequency Rate of Change 1 Function	0 to 1	---	1	F102	0 (Disabled)
AC01	Frequency Rate of Change 1 OC Supervision	0 to 30	pu	0.001	F001	200
AC02	Frequency Rate of Change 1 Min	20 to 80	Hz	0.01	F001	4500
AC03	Frequency Rate of Change 1 Max	20 to 80	Hz	0.01	F001	6500
AC04	Frequency Rate of Change 1 Pickup Delay	0 to 65.535	s	0.001	F001	0
AC05	Frequency Rate of Change 1 Reset Delay	0 to 65.535	s	0.001	F001	0
AC06	Frequency Rate of Change 1 Block	0 to 65535	---	1	F300	0
AC07	Frequency Rate of Change 1 Target	0 to 2	---	1	F109	0 (Self-reset)
AC08	Frequency Rate of Change 1 Events	0 to 1	---	1	F102	0 (Disabled)
AC09	Frequency Rate of Change 1 Source	0 to 5	---	1	F167	0 (SRC 1)
AC0A	Frequency Rate of Change 1 Trend	0 to 2	---	1	F224	0 (Increasing)
AC0B	Frequency Rate of Change 1 Pickup	0.1 to 15	Hz/s	0.01	F001	50
AC0C	Frequency Rate of Change 1 OV Supervision	0.1 to 3	pu	0.001	F001	700
AC0D	Frequency Rate of Change 1 Reserved (3 items)	0 to 1	---	1	F001	0
AC10	...Repeated for Frequency Rate of Change 2					
AC20	...Repeated for Frequency Rate of Change 3					
AC30	...Repeated for Frequency Rate of Change 4					
IEC 61850 GSSE Configuration (Read/Write Setting)						
AD80	Default GSSE Update Time	1 to 60	s	1	F001	60
AD81	Remote Input/Output Transfer Method	0 to 2	---	1	F226	1 (GSSE)
AD82	IEC 61850 GOOSE VLAN Transmit Priority	0 to 7	---	1	F001	4
AD83	IEC 61850 GOOSE VLAN ID	0 to 4095	---	1	F001	0
AD84	IEC 61850 GOOSE ETYPE APPID	0 to 16383	---	1	F001	0
AD85	Reserved (22 items)	0 to 1	---	1	F001	0
IEC 61850 Server Configuration (Read/Write Settings/Commands)						
ADA0	TCP Port Number for the IEC 61850 Protocol	1 to 65535	---	1	F001	102
ADA1	IEC 61850 Logical Device Name	---	---	---	F213	“IECDevice”
ADB1	Include Non-IEC 61850 Data	0 to 1	---	1	F102	1 (Enabled)
ADB2	Number of Status Indications in GGIO1	8 to 128	---	8	F001	8
ADB3	IEC 61850 Server Data Scanning Function	0 to 1	---	1	F102	0 (Disabled)
ADB4	Command to Clear XCBR1 OpCnt Counter	0 to 1	---	1	F126	0 (No)
ADB5	Command to Clear XCBR2 OpCnt Counter	0 to 1	---	1	F126	0 (No)
ADB6	Reserved (10 items)	0 to 1	---	1	F001	0
IEC 61850 Logical Node Name Prefixes (Read/Write Setting)						
AE00	IEC 61850 Logical Node PIOCx Name Prefix (72 items)	0 to 65534	---	1	F206	(None)
AED8	IEC 61850 Logical Node PTOCx Name Prefix (24 items)	0 to 65534	---	1	F206	(None)
AF20	IEC 61850 Logical Node PTUVx Name Prefix (12 items)	0 to 65534	---	1	F206	(None)
AF44	IEC 61850 Logical Node PTOVx Name Prefix (8 items)	0 to 65534	---	1	F206	(None)
AF5C	IEC 61850 Logical Node PDISx Name Prefix (10 items)	0 to 65534	---	1	F206	(None)
AF7A	IEC 61850 Logical Node RRBFx Name Prefix (24 items)	0 to 65534	---	1	F206	(None)
AFC2	IEC 61850 Logical Node RPSBx Name Prefix	0 to 65534	---	1	F206	(None)
AFC5	IEC 61850 Logical Node RRECx Name Prefix (6 items)	0 to 65534	---	1	F206	(None)
AFD7	IEC 61850 Logical Node MMXUx Name Prefix (6 items)	0 to 65534	---	1	F206	(None)
AFE9	IEC 61850 Logical Node GGIOx Name Prefix (2 items)	0 to 65534	---	1	F206	(None)
AFEF	IEC 61850 Logical Node RFLOx Name Prefix (5 items)	0 to 65534	---	1	F206	(None)
AFFE	IEC 61850 Logical Node XCBRx Name Prefix (2 items)	0 to 65534	---	1	F206	(None)
B004	IEC 61850 Logical Node PTRCx Name Prefix (2 items)	0 to 65534	---	1	F206	(None)

Table B–9: MODBUS MEMORY MAP (Sheet 34 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
B00A	IEC 61850 Logical Node PDIFx Name Prefix (4 items)	0 to 65534	---	1	F206	(None)
B016	IEC 61850 Logical Node MMXNx Name Prefix (37 items)	0 to 65534	---	1	F206	(None)
IEC 61850 MMXU Deadbands (Read/Write Setting) (6 modules)						
B100	IEC 61850 MMXU TotW Deadband 1	0.001 to 100	%	0.001	F003	10000
B102	IEC 61850 MMXU TotVAr Deadband 1	0.001 to 100	%	0.001	F003	10000
B104	IEC 61850 MMXU TotVA Deadband 1	0.001 to 100	%	0.001	F003	10000
B106	IEC 61850 MMXU TotPF Deadband 1	0.001 to 100	%	0.001	F003	10000
B108	IEC 61850 MMXU Hz Deadband 1	0.001 to 100	%	0.001	F003	10000
B10A	IEC 61850 MMXU PPV.phsAB Deadband 1	0.001 to 100	%	0.001	F003	10000
B10C	IEC 61850 MMXU PPV.phsBC Deadband 1	0.001 to 100	%	0.001	F003	10000
B10E	IEC 61850 MMXU PPV.phsCA Deadband 1	0.001 to 100	%	0.001	F003	10000
B110	IEC 61850 MMXU PhV.phsADeadband 1	0.001 to 100	%	0.001	F003	10000
B112	IEC 61850 MMXU PhV.phsB Deadband 1	0.001 to 100	%	0.001	F003	10000
B114	IEC 61850 MMXU PhV.phsC Deadband 1	0.001 to 100	%	0.001	F003	10000
B116	IEC 61850 MMXU A.phsA Deadband 1	0.001 to 100	%	0.001	F003	10000
B118	IEC 61850 MMXU A.phsB Deadband 1	0.001 to 100	%	0.001	F003	10000
B11A	IEC 61850 MMXU A.phsC Deadband 1	0.001 to 100	%	0.001	F003	10000
B11C	IEC 61850 MMXU A.neut Deadband 1	0.001 to 100	%	0.001	F003	10000
B11E	IEC 61850 MMXU W.phsA Deadband 1	0.001 to 100	%	0.001	F003	10000
B120	IEC 61850 MMXU W.phsB Deadband 1	0.001 to 100	%	0.001	F003	10000
B122	IEC 61850 MMXU W.phsC Deadband 1	0.001 to 100	%	0.001	F003	10000
B124	IEC 61850 MMXU VAr.phsA Deadband 1	0.001 to 100	%	0.001	F003	10000
B126	IEC 61850 MMXU VAr.phsB Deadband 1	0.001 to 100	%	0.001	F003	10000
B128	IEC 61850 MMXU VAr.phsC Deadband 1	0.001 to 100	%	0.001	F003	10000
B12A	IEC 61850 MMXU VA.phsA Deadband 1	0.001 to 100	%	0.001	F003	10000
B12C	IEC 61850 MMXU VA.phsB Deadband 1	0.001 to 100	%	0.001	F003	10000
B12E	IEC 61850 MMXU VA.phsC Deadband 1	0.001 to 100	%	0.001	F003	10000
B130	IEC 61850 MMXU PF.phsA Deadband 1	0.001 to 100	%	0.001	F003	10000
B132	IEC 61850 MMXU PF.phsB Deadband 1	0.001 to 100	%	0.001	F003	10000
B134	IEC 61850 MMXU PF.phsC Deadband 1	0.001 to 100	%	0.001	F003	10000
B136	...Repeated for Deadband 2					
B16C	...Repeated for Deadband 3					
B1A2	...Repeated for Deadband 4					
B1D8	...Repeated for Deadband 5					
B20E	...Repeated for Deadband 6					
IEC 61850 GGIO2 Control Configuration (Read/Write Setting) (64 modules)						
B300	IEC 61850 GGIO2.CF.SPCSO1.ctlModel Value	0 to 2	---	1	F001	2
B301	IEC 61850 GGIO2.CF.SPCSO2.ctlModel Value	0 to 2	---	1	F001	2
B302	IEC 61850 GGIO2.CF.SPCSO3.ctlModel Value	0 to 2	---	1	F001	2
B303	IEC 61850 GGIO2.CF.SPCSO4.ctlModel Value	0 to 2	---	1	F001	2
B304	IEC 61850 GGIO2.CF.SPCSO5.ctlModel Value	0 to 2	---	1	F001	2
B305	IEC 61850 GGIO2.CF.SPCSO6.ctlModel Value	0 to 2	---	1	F001	2
B306	IEC 61850 GGIO2.CF.SPCSO7.ctlModel Value	0 to 2	---	1	F001	2
B307	IEC 61850 GGIO2.CF.SPCSO8.ctlModel Value	0 to 2	---	1	F001	2
B308	IEC 61850 GGIO2.CF.SPCSO9.ctlModel Value	0 to 2	---	1	F001	2
B309	IEC 61850 GGIO2.CF.SPCSO10.ctlModel Value	0 to 2	---	1	F001	2
B30A	IEC 61850 GGIO2.CF.SPCSO11.ctlModel Value	0 to 2	---	1	F001	2
B30B	IEC 61850 GGIO2.CF.SPCSO12.ctlModel Value	0 to 2	---	1	F001	2
B30C	IEC 61850 GGIO2.CF.SPCSO13.ctlModel Value	0 to 2	---	1	F001	2
B30D	IEC 61850 GGIO2.CF.SPCSO14.ctlModel Value	0 to 2	---	1	F001	2
B30E	IEC 61850 GGIO2.CF.SPCSO15.ctlModel Value	0 to 2	---	1	F001	2
B30F	IEC 61850 GGIO2.CF.SPCSO16.ctlModel Value	0 to 2	---	1	F001	2
B310	IEC 61850 GGIO2.CF.SPCSO17.ctlModel Value	0 to 2	---	1	F001	2
B311	IEC 61850 GGIO2.CF.SPCSO18.ctlModel Value	0 to 2	---	1	F001	2

Table B–9: MODBUS MEMORY MAP (Sheet 35 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
B312	IEC 61850 GGIO2.CF.SPCSO19.ctlModel Value	0 to 2	---	1	F001	2
B313	IEC 61850 GGIO2.CF.SPCSO20.ctlModel Value	0 to 2	---	1	F001	2
B314	IEC 61850 GGIO2.CF.SPCSO21.ctlModel Value	0 to 2	---	1	F001	2
B315	IEC 61850 GGIO2.CF.SPCSO22.ctlModel Value	0 to 2	---	1	F001	2
B316	IEC 61850 GGIO2.CF.SPCSO23.ctlModel Value	0 to 2	---	1	F001	2
B317	IEC 61850 GGIO2.CF.SPCSO24.ctlModel Value	0 to 2	---	1	F001	2
B318	IEC 61850 GGIO2.CF.SPCSO25.ctlModel Value	0 to 2	---	1	F001	2
B319	IEC 61850 GGIO2.CF.SPCSO26.ctlModel Value	0 to 2	---	1	F001	2
B31A	IEC 61850 GGIO2.CF.SPCSO27.ctlModel Value	0 to 2	---	1	F001	2
B31B	IEC 61850 GGIO2.CF.SPCSO28.ctlModel Value	0 to 2	---	1	F001	2
B31C	IEC 61850 GGIO2.CF.SPCSO29.ctlModel Value	0 to 2	---	1	F001	2
B31D	IEC 61850 GGIO2.CF.SPCSO30.ctlModel Value	0 to 2	---	1	F001	2
B31E	IEC 61850 GGIO2.CF.SPCSO31.ctlModel Value	0 to 2	---	1	F001	2
B31F	IEC 61850 GGIO2.CF.SPCSO32.ctlModel Value	0 to 2	---	1	F001	2
BC20	IEC 61850 GGIO2.CF.SPCSO33.ctlModel Value	0 to 2	---	1	F001	2
BC21	IEC 61850 GGIO2.CF.SPCSO34.ctlModel Value	0 to 2	---	1	F001	2
BC22	IEC 61850 GGIO2.CF.SPCSO35.ctlModel Value	0 to 2	---	1	F001	2
BC23	IEC 61850 GGIO2.CF.SPCSO36.ctlModel Value	0 to 2	---	1	F001	2
BC24	IEC 61850 GGIO2.CF.SPCSO37.ctlModel Value	0 to 2	---	1	F001	2
BC25	IEC 61850 GGIO2.CF.SPCSO38.ctlModel Value	0 to 2	---	1	F001	2
BC26	IEC 61850 GGIO2.CF.SPCSO39.ctlModel Value	0 to 2	---	1	F001	2
BC27	IEC 61850 GGIO2.CF.SPCSO40.ctlModel Value	0 to 2	---	1	F001	2
BC28	IEC 61850 GGIO2.CF.SPCSO41.ctlModel Value	0 to 2	---	1	F001	2
BC29	IEC 61850 GGIO2.CF.SPCSO42.ctlModel Value	0 to 2	---	1	F001	2
BC2A	IEC 61850 GGIO2.CF.SPCSO43.ctlModel Value	0 to 2	---	1	F001	2
BC2B	IEC 61850 GGIO2.CF.SPCSO44.ctlModel Value	0 to 2	---	1	F001	2
BC2C	IEC 61850 GGIO2.CF.SPCSO45.ctlModel Value	0 to 2	---	1	F001	2
BC2D	IEC 61850 GGIO2.CF.SPCSO46.ctlModel Value	0 to 2	---	1	F001	2
BC2E	IEC 61850 GGIO2.CF.SPCSO47.ctlModel Value	0 to 2	---	1	F001	2
BC2F	IEC 61850 GGIO2.CF.SPCSO48.ctlModel Value	0 to 2	---	1	F001	2
BC30	IEC 61850 GGIO2.CF.SPCSO49.ctlModel Value	0 to 2	---	1	F001	2
BC31	IEC 61850 GGIO2.CF.SPCSO50.ctlModel Value	0 to 2	---	1	F001	2
BC32	IEC 61850 GGIO2.CF.SPCSO51.ctlModel Value	0 to 2	---	1	F001	2
BC33	IEC 61850 GGIO2.CF.SPCSO52.ctlModel Value	0 to 2	---	1	F001	2
BC34	IEC 61850 GGIO2.CF.SPCSO53.ctlModel Value	0 to 2	---	1	F001	2
BC35	IEC 61850 GGIO2.CF.SPCSO54.ctlModel Value	0 to 2	---	1	F001	2
BC36	IEC 61850 GGIO2.CF.SPCSO55.ctlModel Value	0 to 2	---	1	F001	2
BC37	IEC 61850 GGIO2.CF.SPCSO56.ctlModel Value	0 to 2	---	1	F001	2
BC38	IEC 61850 GGIO2.CF.SPCSO57.ctlModel Value	0 to 2	---	1	F001	2
BC39	IEC 61850 GGIO2.CF.SPCSO58.ctlModel Value	0 to 2	---	1	F001	2
BC3A	IEC 61850 GGIO2.CF.SPCSO59.ctlModel Value	0 to 2	---	1	F001	2
BC3B	IEC 61850 GGIO2.CF.SPCSO60.ctlModel Value	0 to 2	---	1	F001	2
BC3C	IEC 61850 GGIO2.CF.SPCSO61.ctlModel Value	0 to 2	---	1	F001	2
BC3D	IEC 61850 GGIO2.CF.SPCSO62.ctlModel Value	0 to 2	---	1	F001	2
BC3E	IEC 61850 GGIO2.CF.SPCSO63.ctlModel Value	0 to 2	---	1	F001	2
BC3F	IEC 61850 GGIO2.CF.SPCSO64.ctlModel Value	0 to 2	---	1	F001	2
Contact Inputs (Read/Write Setting) (96 modules)						
BB00	Contact Input 1 Name	---	---	---	F205	“Cont Ip 1“
BB06	Contact Input 1 Events	0 to 1	---	1	F102	0 (Disabled)
BB07	Contact Input 1 Debounce Time	0 to 16	ms	0.5	F001	20
BB08	...Repeated for Contact Input 2					
BB10	...Repeated for Contact Input 3					
BB18	...Repeated for Contact Input 4					
BB20	...Repeated for Contact Input 5					

B

Table B–9: MODBUS MEMORY MAP (Sheet 36 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
BB28	...Repeated for Contact Input 6					
BB30	...Repeated for Contact Input 7					
BB38	...Repeated for Contact Input 8					
BB40	...Repeated for Contact Input 9					
BB48	...Repeated for Contact Input 10					
BB50	...Repeated for Contact Input 11					
BB58	...Repeated for Contact Input 12					
BB60	...Repeated for Contact Input 13					
BB68	...Repeated for Contact Input 14					
BB70	...Repeated for Contact Input 15					
BB78	...Repeated for Contact Input 16					
BB80	...Repeated for Contact Input 17					
BB88	...Repeated for Contact Input 18					
BB90	...Repeated for Contact Input 19					
BB98	...Repeated for Contact Input 20					
BBA0	...Repeated for Contact Input 21					
BBA8	...Repeated for Contact Input 22					
BBB0	...Repeated for Contact Input 23					
BBB8	...Repeated for Contact Input 24					
BBC0	...Repeated for Contact Input 25					
BBC8	...Repeated for Contact Input 26					
BBD0	...Repeated for Contact Input 27					
BBD8	...Repeated for Contact Input 28					
BBE0	...Repeated for Contact Input 29					
BBE8	...Repeated for Contact Input 30					
BBF0	...Repeated for Contact Input 31					
BBF8	...Repeated for Contact Input 32					
BC00	...Repeated for Contact Input 33					
BC08	...Repeated for Contact Input 34					
BC10	...Repeated for Contact Input 35					
BC18	...Repeated for Contact Input 36					
BC20	...Repeated for Contact Input 37					
BC28	...Repeated for Contact Input 38					
BC30	...Repeated for Contact Input 39					
BC38	...Repeated for Contact Input 40					
BC40	...Repeated for Contact Input 41					
BC48	...Repeated for Contact Input 42					
BC50	...Repeated for Contact Input 43					
BC58	...Repeated for Contact Input 44					
BC60	...Repeated for Contact Input 45					
BC68	...Repeated for Contact Input 46					
BC70	...Repeated for Contact Input 47					
BC78	...Repeated for Contact Input 48					
BC80	...Repeated for Contact Input 49					
BC88	...Repeated for Contact Input 50					
BC90	...Repeated for Contact Input 51					
BC98	...Repeated for Contact Input 52					
BCA0	...Repeated for Contact Input 53					
BCA8	...Repeated for Contact Input 54					
BCB0	...Repeated for Contact Input 55					
BCB8	...Repeated for Contact Input 56					
BCC0	...Repeated for Contact Input 57					
BCC8	...Repeated for Contact Input 58					
BCD0	...Repeated for Contact Input 59					

B

Table B–9: MODBUS MEMORY MAP (Sheet 37 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
BCD8	...Repeated for Contact Input 60					
BCE0	...Repeated for Contact Input 61					
BCE8	...Repeated for Contact Input 62					
BCF0	...Repeated for Contact Input 63					
BCF8	...Repeated for Contact Input 64					
BD00	...Repeated for Contact Input 65					
BD08	...Repeated for Contact Input 66					
BD10	...Repeated for Contact Input 67					
BD18	...Repeated for Contact Input 68					
BD20	...Repeated for Contact Input 69					
BD28	...Repeated for Contact Input 70					
BD30	...Repeated for Contact Input 71					
BD38	...Repeated for Contact Input 72					
BD40	...Repeated for Contact Input 73					
BD48	...Repeated for Contact Input 74					
BD50	...Repeated for Contact Input 75					
BD58	...Repeated for Contact Input 76					
BD60	...Repeated for Contact Input 77					
BD68	...Repeated for Contact Input 78					
BD70	...Repeated for Contact Input 79					
BD78	...Repeated for Contact Input 80					
BD80	...Repeated for Contact Input 81					
BD88	...Repeated for Contact Input 82					
BD90	...Repeated for Contact Input 83					
BD98	...Repeated for Contact Input 84					
BDA0	...Repeated for Contact Input 85					
BDA8	...Repeated for Contact Input 86					
BDB0	...Repeated for Contact Input 87					
BDB8	...Repeated for Contact Input 88					
BDC0	...Repeated for Contact Input 89					
BDC8	...Repeated for Contact Input 90					
BDD0	...Repeated for Contact Input 91					
BDD8	...Repeated for Contact Input 92					
BDE0	...Repeated for Contact Input 93					
BDE8	...Repeated for Contact Input 94					
BDF0	...Repeated for Contact Input 95					
BDF8	...Repeated for Contact Input 96					
Contact Input Thresholds (Read/Write Setting)						
BE00	Contact Input *n* Threshold, *n* = 1 to 24 (24 items)	0 to 3	---	1	F128	1 (33 Vdc)
Virtual Inputs (Read/Write Setting) (64 modules)						
BE90	Virtual Input 1 Function	0 to 1	---	1	F102	0 (Disabled)
BE91	Virtual Input 1 Name	---	---	---	F205	“Virt Ip 1“
BE9B	Virtual Input 1 Programmed Type	0 to 1	---	1	F127	0 (Latched)
BE9C	Virtual Input 1 Events	0 to 1	---	1	F102	0 (Disabled)
BE9D	Reserved (3 items)	---	---	---	F001	0
BEA0	...Repeated for Virtual Input 2					
BEB0	...Repeated for Virtual Input 3					
BEC0	...Repeated for Virtual Input 4					
BED0	...Repeated for Virtual Input 5					
BEE0	...Repeated for Virtual Input 6					
BEF0	...Repeated for Virtual Input 7					
BF00	...Repeated for Virtual Input 8					
BF10	...Repeated for Virtual Input 9					
BF20	...Repeated for Virtual Input 10					

Table B–9: MODBUS MEMORY MAP (Sheet 38 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
BF30	...Repeated for Virtual Input 11					
BF40	...Repeated for Virtual Input 12					
BF50	...Repeated for Virtual Input 13					
BF60	...Repeated for Virtual Input 14					
BF70	...Repeated for Virtual Input 15					
BF80	...Repeated for Virtual Input 16					
BF90	...Repeated for Virtual Input 17					
BFA0	...Repeated for Virtual Input 18					
BFB0	...Repeated for Virtual Input 19					
BFC0	...Repeated for Virtual Input 20					
BFD0	...Repeated for Virtual Input 21					
BFE0	...Repeated for Virtual Input 22					
BFF0	...Repeated for Virtual Input 23					
C000	...Repeated for Virtual Input 24					
C010	...Repeated for Virtual Input 25					
C020	...Repeated for Virtual Input 26					
C030	...Repeated for Virtual Input 27					
C040	...Repeated for Virtual Input 28					
C050	...Repeated for Virtual Input 29					
C060	...Repeated for Virtual Input 30					
C070	...Repeated for Virtual Input 31					
C080	...Repeated for Virtual Input 32					
C090	...Repeated for Virtual Input 33					
C0A0	...Repeated for Virtual Input 34					
C0B0	...Repeated for Virtual Input 35					
C0C0	...Repeated for Virtual Input 36					
C0D0	...Repeated for Virtual Input 37					
C0E0	...Repeated for Virtual Input 38					
C0F0	...Repeated for Virtual Input 39					
C100	...Repeated for Virtual Input 40					
C110	...Repeated for Virtual Input 41					
C120	...Repeated for Virtual Input 42					
C130	...Repeated for Virtual Input 43					
C140	...Repeated for Virtual Input 44					
C150	...Repeated for Virtual Input 45					
C160	...Repeated for Virtual Input 46					
C170	...Repeated for Virtual Input 47					
C180	...Repeated for Virtual Input 48					
C190	...Repeated for Virtual Input 49					
C1A0	...Repeated for Virtual Input 50					
C1B0	...Repeated for Virtual Input 51					
C1C0	...Repeated for Virtual Input 52					
C1D0	...Repeated for Virtual Input 53					
C1E0	...Repeated for Virtual Input 54					
C1F0	...Repeated for Virtual Input 55					
C200	...Repeated for Virtual Input 56					
C210	...Repeated for Virtual Input 57					
C220	...Repeated for Virtual Input 58					
C230	...Repeated for Virtual Input 59					
C240	...Repeated for Virtual Input 60					
C250	...Repeated for Virtual Input 61					
C260	...Repeated for Virtual Input 62					
C270	...Repeated for Virtual Input 63					
C280	...Repeated for Virtual Input 64					

B

Table B–9: MODBUS MEMORY MAP (Sheet 39 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
Virtual Outputs (Read/Write Setting) (96 modules)						
C130	Virtual Output 1 Name	---	---	---	F205	“Virt Op 1 “
C136	Virtual Output 1 Events	0 to 1	---	1	F102	0 (Disabled)
C137	Reserved	---	---	---	F001	0
C138	...Repeated for Virtual Output 2					
C140	...Repeated for Virtual Output 3					
C148	...Repeated for Virtual Output 4					
C150	...Repeated for Virtual Output 5					
C158	...Repeated for Virtual Output 6					
C160	...Repeated for Virtual Output 7					
C168	...Repeated for Virtual Output 8					
C170	...Repeated for Virtual Output 9					
C178	...Repeated for Virtual Output 10					
C180	...Repeated for Virtual Output 11					
C188	...Repeated for Virtual Output 12					
C190	...Repeated for Virtual Output 13					
C198	...Repeated for Virtual Output 14					
C1A0	...Repeated for Virtual Output 15					
C1A8	...Repeated for Virtual Output 16					
C1B0	...Repeated for Virtual Output 17					
C1B8	...Repeated for Virtual Output 18					
C1C0	...Repeated for Virtual Output 19					
C1C8	...Repeated for Virtual Output 20					
C1D0	...Repeated for Virtual Output 21					
C1D8	...Repeated for Virtual Output 22					
C1E0	...Repeated for Virtual Output 23					
C1E8	...Repeated for Virtual Output 24					
C1F0	...Repeated for Virtual Output 25					
C1F8	...Repeated for Virtual Output 26					
C200	...Repeated for Virtual Output 27					
C208	...Repeated for Virtual Output 28					
C210	...Repeated for Virtual Output 29					
C218	...Repeated for Virtual Output 30					
C220	...Repeated for Virtual Output 31					
C228	...Repeated for Virtual Output 32					
C230	...Repeated for Virtual Output 33					
C238	...Repeated for Virtual Output 34					
C240	...Repeated for Virtual Output 35					
C248	...Repeated for Virtual Output 36					
C250	...Repeated for Virtual Output 37					
C258	...Repeated for Virtual Output 38					
C260	...Repeated for Virtual Output 39					
C268	...Repeated for Virtual Output 40					
C270	...Repeated for Virtual Output 41					
C278	...Repeated for Virtual Output 42					
C280	...Repeated for Virtual Output 43					
C288	...Repeated for Virtual Output 44					
C290	...Repeated for Virtual Output 45					
C298	...Repeated for Virtual Output 46					
C2A0	...Repeated for Virtual Output 47					
C2A8	...Repeated for Virtual Output 48					
C2B0	...Repeated for Virtual Output 49					
C2B8	...Repeated for Virtual Output 50					
C2C0	...Repeated for Virtual Output 51					

Table B–9: MODBUS MEMORY MAP (Sheet 40 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
C2C8	...Repeated for Virtual Output 52					
C2D0	...Repeated for Virtual Output 53					
C2D8	...Repeated for Virtual Output 54					
C2E0	...Repeated for Virtual Output 55					
C2E8	...Repeated for Virtual Output 56					
C2F0	...Repeated for Virtual Output 57					
C2F8	...Repeated for Virtual Output 58					
C300	...Repeated for Virtual Output 59					
C308	...Repeated for Virtual Output 60					
C310	...Repeated for Virtual Output 61					
C318	...Repeated for Virtual Output 62					
C320	...Repeated for Virtual Output 63					
C328	...Repeated for Virtual Output 64					
C330	...Repeated for Virtual Output 65					
C338	...Repeated for Virtual Output 66					
C340	...Repeated for Virtual Output 67					
C348	...Repeated for Virtual Output 68					
C350	...Repeated for Virtual Output 69					
C358	...Repeated for Virtual Output 70					
C360	...Repeated for Virtual Output 71					
C368	...Repeated for Virtual Output 72					
C370	...Repeated for Virtual Output 73					
C378	...Repeated for Virtual Output 74					
C380	...Repeated for Virtual Output 75					
C388	...Repeated for Virtual Output 76					
C390	...Repeated for Virtual Output 77					
C398	...Repeated for Virtual Output 78					
C3A0	...Repeated for Virtual Output 79					
C3A8	...Repeated for Virtual Output 80					
C3B0	...Repeated for Virtual Output 81					
C3B8	...Repeated for Virtual Output 82					
C3C0	...Repeated for Virtual Output 83					
C3C8	...Repeated for Virtual Output 84					
C3D0	...Repeated for Virtual Output 85					
C3D8	...Repeated for Virtual Output 86					
C3E0	...Repeated for Virtual Output 87					
C3E8	...Repeated for Virtual Output 88					
C3F0	...Repeated for Virtual Output 89					
C3F8	...Repeated for Virtual Output 90					
C400	...Repeated for Virtual Output 91					
C408	...Repeated for Virtual Output 92					
C410	...Repeated for Virtual Output 93					
C418	...Repeated for Virtual Output 94					
C420	...Repeated for Virtual Output 95					
C428	...Repeated for Virtual Output 96					
Mandatory (Read/Write Setting)						
C430	Test Mode Function	0 to 1	---	1	F102	0 (Disabled)
C431	Force VFD and LED	0 to 1	---	1	F126	0 (No)
C432	Test Mode Initiate	0 to 65535	---	1	F300	1
Mandatory (Read/Write Command)						
C433	Clear All Relay Records Command	0 to 1	---	1	F126	0 (No)
Contact Outputs (Read/Write Setting) (64 modules)						
C440	Contact Output 1 Name	---	---	---	F205	“Cont Op 1"
C446	Contact Output 1 Operation	0 to 65535	---	1	F300	0

B

Table B–9: MODBUS MEMORY MAP (Sheet 41 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
C447	Contact Output 1 Seal In	0 to 65535	---	1	F300	0
C448	Latching Output 1 Reset	0 to 65535	---	1	F300	0
C449	Contact Output 1 Events	0 to 1	---	1	F102	1 (Enabled)
C44A	Latching Output 1 Type	0 to 1	---	1	F090	0 (Operate-dominant)
C44B	Reserved	---	---	---	F001	0
C44C	...Repeated for Contact Output 2					
C458	...Repeated for Contact Output 3					
C464	...Repeated for Contact Output 4					
C470	...Repeated for Contact Output 5					
C47C	...Repeated for Contact Output 6					
C488	...Repeated for Contact Output 7					
C494	...Repeated for Contact Output 8					
C4A0	...Repeated for Contact Output 9					
C4AC	...Repeated for Contact Output 10					
C4B8	...Repeated for Contact Output 11					
C4C4	...Repeated for Contact Output 12					
C4D0	...Repeated for Contact Output 13					
C4DC	...Repeated for Contact Output 14					
C4E8	...Repeated for Contact Output 15					
C4F4	...Repeated for Contact Output 16					
C500	...Repeated for Contact Output 17					
C50C	...Repeated for Contact Output 18					
C518	...Repeated for Contact Output 19					
C524	...Repeated for Contact Output 20					
C530	...Repeated for Contact Output 21					
C53C	...Repeated for Contact Output 22					
C548	...Repeated for Contact Output 23					
C554	...Repeated for Contact Output 24					
C560	...Repeated for Contact Output 25					
C56C	...Repeated for Contact Output 26					
C578	...Repeated for Contact Output 27					
C584	...Repeated for Contact Output 28					
C590	...Repeated for Contact Output 29					
C59C	...Repeated for Contact Output 30					
C5A8	...Repeated for Contact Output 31					
C5B4	...Repeated for Contact Output 32					
C5C0	...Repeated for Contact Output 33					
C5CC	...Repeated for Contact Output 34					
C5D8	...Repeated for Contact Output 35					
C5E4	...Repeated for Contact Output 36					
C5F0	...Repeated for Contact Output 37					
C5FC	...Repeated for Contact Output 38					
C608	...Repeated for Contact Output 39					
C614	...Repeated for Contact Output 40					
C620	...Repeated for Contact Output 41					
C62C	...Repeated for Contact Output 42					
C638	...Repeated for Contact Output 43					
C644	...Repeated for Contact Output 44					
C650	...Repeated for Contact Output 45					
C65C	...Repeated for Contact Output 46					
C668	...Repeated for Contact Output 47					
C674	...Repeated for Contact Output 48					
C680	...Repeated for Contact Output 49					
C68C	...Repeated for Contact Output 50					

Table B–9: MODBUS MEMORY MAP (Sheet 42 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
C698	...Repeated for Contact Output 51					
C6A4	...Repeated for Contact Output 52					
C6B0	...Repeated for Contact Output 53					
C6BC	...Repeated for Contact Output 54					
C6C8	...Repeated for Contact Output 55					
C6D4	...Repeated for Contact Output 56					
C6E0	...Repeated for Contact Output 57					
C6EC	...Repeated for Contact Output 58					
C6F8	...Repeated for Contact Output 59					
C704	...Repeated for Contact Output 60					
C710	...Repeated for Contact Output 61					
C71C	...Repeated for Contact Output 62					
C728	...Repeated for Contact Output 63					
C734	...Repeated for Contact Output 64					
Reset (Read/Write Setting)						
C750	FlexLogic™ operand which initiates a reset	0 to 65535	---	1	F300	0
Control Pushbuttons (Read/Write Setting) (7 modules)						
C760	Control Pushbutton 1 Function	0 to 1	---	1	F102	0 (Disabled)
C761	Control Pushbutton 1 Events	0 to 1	---	1	F102	0 (Disabled)
C762	...Repeated for Control Pushbutton 2					
C764	...Repeated for Control Pushbutton 3					
C766	...Repeated for Control Pushbutton 4					
C768	...Repeated for Control Pushbutton 5					
C76A	...Repeated for Control Pushbutton 6					
C76C	...Repeated for Control Pushbutton 7					
Clear Records (Read/Write Setting)						
C770	Clear Fault Reports operand	0 to 65535	---	1	F300	0
C772	Clear Event Records operand	0 to 65535	---	1	F300	0
C773	Clear Oscillography operand	0 to 65535	---	1	F300	0
C774	Clear Data Logger operand	0 to 65535	---	1	F300	0
C775	Clear Breaker 1 Arcing Current operand	0 to 65535	---	1	F300	0
C776	Clear Breaker 2 Arcing Current operand	0 to 65535	---	1	F300	0
C77B	Clear Demand operand	0 to 65535	---	1	F300	0
C77D	Clear Energy operand	0 to 65535	---	1	F300	0
C77E	Clear Hi-Z Records operand	0 to 65535	---	1	F300	0
C77F	Clear Unauthorized Access operand	0 to 65535	---	1	F300	0
C781	Clear Platform Direct Input/Output Statistics operand	0 to 65535	---	1	F300	0
C782	Reserved (13 items)	---	---	---	F001	0
Force Contact Inputs/Outputs (Read/Write Settings)						
C7A0	Force Contact Input *x* State (96 items)	0 to 2	---	1	F144	0 (Disabled)
C800	Force Contact Output *x* State (64 items)	0 to 3	---	1	F131	0 (Disabled)
Direct Inputs/Outputs (Read/Write Setting)						
C880	Direct Device ID	1 to 16	---	1	F001	1
C881	Direct I/O Channel 1 Ring Configuration Function	0 to 1	---	1	F126	0 (No)
C882	Platform Direct I/O Data Rate	64 to 128	kbps	64	F001	64
C883	Direct I/O Channel 2 Ring Configuration Function	0 to 1	---	1	F126	0 (No)
C884	Platform Direct I/O Crossover Function	0 to 1	---	1	F102	0 (Disabled)
Direct input/output commands (Read/Write Command)						
C888	Direct input/output clear counters command	0 to 1	---	1	F126	0 (No)
Direct inputs (Read/Write Setting) (96 modules)						
C890	Direct Input 1 Device Number	0 to 16	---	1	F001	0
C891	Direct Input 1 Number	0 to 96	---	1	F001	0
C892	Direct Input 1 Default State	0 to 3	---	1	F086	0 (Off)
C893	Direct Input 1 Events	0 to 1	---	1	F102	0 (Disabled)

B

Table B–9: MODBUS MEMORY MAP (Sheet 43 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
C894	...Repeated for Direct Input 2					
C898	...Repeated for Direct Input 3					
C89C	...Repeated for Direct Input 4					
C8A0	...Repeated for Direct Input 5					
C8A4	...Repeated for Direct Input 6					
C8A8	...Repeated for Direct Input 7					
C8AC	...Repeated for Direct Input 8					
C8B0	...Repeated for Direct Input 9					
C8B4	...Repeated for Direct Input 10					
C8B8	...Repeated for Direct Input 11					
C8BC	...Repeated for Direct Input 12					
C8C0	...Repeated for Direct Input 13					
C8C4	...Repeated for Direct Input 14					
C8C8	...Repeated for Direct Input 15					
C8CC	...Repeated for Direct Input 16					
C8D0	...Repeated for Direct Input 17					
C8D4	...Repeated for Direct Input 18					
C8D8	...Repeated for Direct Input 19					
C8DC	...Repeated for Direct Input 20					
C8E0	...Repeated for Direct Input 21					
C8E4	...Repeated for Direct Input 22					
C8E8	...Repeated for Direct Input 23					
C8EC	...Repeated for Direct Input 24					
C8F0	...Repeated for Direct Input 25					
C8F4	...Repeated for Direct Input 26					
C8F8	...Repeated for Direct Input 27					
C8FC	...Repeated for Direct Input 28					
C900	...Repeated for Direct Input 29					
C904	...Repeated for Direct Input 30					
C908	...Repeated for Direct Input 31					
C90C	...Repeated for Direct Input 32					
Platform Direct Outputs (Read/Write Setting) (96 modules)						
CA10	Direct Output 1 Operand	0 to 65535	---	1	F300	0
CA11	Direct Output 1 Events	0 to 1	---	1	F102	0 (Disabled)
CA12	...Repeated for Direct Output 2					
CA14	...Repeated for Direct Output 3					
CA16	...Repeated for Direct Output 4					
CA18	...Repeated for Direct Output 5					
CA1A	...Repeated for Direct Output 6					
CA1C	...Repeated for Direct Output 7					
CA1E	...Repeated for Direct Output 8					
CA20	...Repeated for Direct Output 9					
CA22	...Repeated for Direct Output 10					
CA24	...Repeated for Direct Output 11					
CA26	...Repeated for Direct Output 12					
CA28	...Repeated for Direct Output 13					
CA2A	...Repeated for Direct Output 14					
CA2C	...Repeated for Direct Output 15					
CA2E	...Repeated for Direct Output 16					
CA30	...Repeated for Direct Output 17					
CA32	...Repeated for Direct Output 18					
CA34	...Repeated for Direct Output 19					
CA36	...Repeated for Direct Output 20					
CA38	...Repeated for Direct Output 21					

B

Table B–9: MODBUS MEMORY MAP (Sheet 44 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
CA3A	...Repeated for Direct Output 22					
CA3C	...Repeated for Direct Output 23					
CA3E	...Repeated for Direct Output 24					
CA40	...Repeated for Direct Output 25					
CA42	...Repeated for Direct Output 26					
CA44	...Repeated for Direct Output 27					
CA46	...Repeated for Direct Output 28					
CA48	...Repeated for Direct Output 29					
CA4A	...Repeated for Direct Output 30					
CA4C	...Repeated for Direct Output 31					
CA4E	...Repeated for Direct Output 32					
Direct Input/Output Alarms (Read/Write Setting)						
CAD0	Direct Input/Output Channel 1 CRC Alarm Function	0 to 1	---	1	F102	0 (Disabled)
CAD1	Direct I/O Channel 1 CRC Alarm Message Count	100 to 10000	---	1	F001	600
CAD2	Direct Input/Output Channel 1 CRC Alarm Threshold	1 to 1000	---	1	F001	10
CAD3	Direct Input/Output Channel 1 CRC Alarm Events	0 to 1	---	1	F102	0 (Disabled)
CAD4	Reserved (4 items)	1 to 1000	---	1	F001	10
CAD8	Direct Input/Output Channel 2 CRC Alarm Function	0 to 1	---	1	F102	0 (Disabled)
CAD9	Direct I/O Channel 2 CRC Alarm Message Count	100 to 10000	---	1	F001	600
CADA	Direct Input/Output Channel 2 CRC Alarm Threshold	1 to 1000	---	1	F001	10
CADB	Direct Input/Output Channel 2 CRC Alarm Events	0 to 1	---	1	F102	0 (Disabled)
CADC	Reserved (4 items)	1 to 1000	---	1	F001	10
CAE0	Direct I/O Ch 1 Unreturned Messages Alarm Function	0 to 1	---	1	F102	0 (Disabled)
CAE1	Direct I/O Ch 1 Unreturned Messages Alarm Msg Count	100 to 10000	---	1	F001	600
CAE2	Direct I/O Ch 1 Unreturned Messages Alarm Threshold	1 to 1000	---	1	F001	10
CAE3	Direct I/O Ch 1 Unreturned Messages Alarm Events	0 to 1	---	1	F102	0 (Disabled)
CAE4	Reserved (4 items)	1 to 1000	---	1	F001	10
CAE8	Direct IO Ch 2 Unreturned Messages Alarm Function	0 to 1	---	1	F102	0 (Disabled)
CAE9	Direct I/O Ch 2 Unreturned Messages Alarm Msg Count	100 to 10000	---	1	F001	600
CAEA	Direct I/O Ch 2 Unreturned Messages Alarm Threshold	1 to 1000	---	1	F001	10
CAEB	Direct I/O Channel 2 Unreturned Messages Alarm Events	0 to 1	---	1	F102	0 (Disabled)
CAEC	Reserved (4 items)	1 to 1000	---	1	F001	10
Remote Devices (Read/Write Setting) (16 modules)						
CB00	Remote Device 1 ID	---	---	---	F202	“Remote Device 1“
CB08	Remote Device 1 Virtual LAN Identifier	0 to 4095	---	1	F001	0
CB09	Remote Device 1 Ethernet APPID	0 to 16383	---	1	F001	0
CB0A	...Repeated for Device 2					
CB14	...Repeated for Device 3					
CB1E	...Repeated for Device 4					
CB28	...Repeated for Device 5					
CB32	...Repeated for Device 6					
CB3C	...Repeated for Device 7					
CB46	...Repeated for Device 8					
CB50	...Repeated for Device 9					
CB5A	...Repeated for Device 10					
CB64	...Repeated for Device 11					
CB6E	...Repeated for Device 12					
CB78	...Repeated for Device 13					
CB82	...Repeated for Device 14					
CB8C	...Repeated for Device 15					
CB96	...Repeated for Device 16					
Remote Inputs (Read/Write Setting) (64 modules)						
CBA0	Remote Input 1 Device	1 to 16	---	1	F001	1
CBA1	Remote Input 1 Bit Pair	0 to 64	---	1	F156	0 (None)

B

Table B–9: MODBUS MEMORY MAP (Sheet 45 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
CBA2	Remote Input 1 Default State	0 to 3	---	1	F086	0 (Off)
CBA3	Remote Input 1 Events	0 to 1	---	1	F102	0 (Disabled)
CBA4	Remote Input 1 Name	1 to 64	---	1	F205	“Rem Ip 1”
CBAA	...Repeated for Remote Input 2					
CBB4	...Repeated for Remote Input 3					
CBBE	...Repeated for Remote Input 4					
CBC8	...Repeated for Remote Input 5					
CBD2	...Repeated for Remote Input 6					
CBDC	...Repeated for Remote Input 7					
CBE6	...Repeated for Remote Input 8					
CBF0	...Repeated for Remote Input 9					
CBFA	...Repeated for Remote Input 10					
CC04	...Repeated for Remote Input 11					
CC0E	...Repeated for Remote Input 12					
CC18	...Repeated for Remote Input 13					
CC22	...Repeated for Remote Input 14					
CC2C	...Repeated for Remote Input 15					
CC36	...Repeated for Remote Input 16					
CC40	...Repeated for Remote Input 17					
CC4A	...Repeated for Remote Input 18					
CC54	...Repeated for Remote Input 19					
CC5E	...Repeated for Remote Input 20					
CC68	...Repeated for Remote Input 21					
CC72	...Repeated for Remote Input 22					
CC7C	...Repeated for Remote Input 23					
CC86	...Repeated for Remote Input 24					
CC90	...Repeated for Remote Input 25					
CC9A	...Repeated for Remote Input 26					
CCA4	...Repeated for Remote Input 27					
CCAE	...Repeated for Remote Input 28					
CCB8	...Repeated for Remote Input 29					
CCC2	...Repeated for Remote Input 30					
CCCC	...Repeated for Remote Input 31					
CCD6	...Repeated for Remote Input 32					
CCE0	...Repeated for Remote Input 33					
CCEA	...Repeated for Remote Input 34					
CCF4	...Repeated for Remote Input 35					
CCFE	...Repeated for Remote Input 36					
CD08	...Repeated for Remote Input 37					
CD12	...Repeated for Remote Input 38					
CD1C	...Repeated for Remote Input 39					
CD26	...Repeated for Remote Input 40					
CD30	...Repeated for Remote Input 41					
CD3A	...Repeated for Remote Input 42					
CD44	...Repeated for Remote Input 43					
CD4E	...Repeated for Remote Input 44					
CD58	...Repeated for Remote Input 45					
CD62	...Repeated for Remote Input 46					
CD6C	...Repeated for Remote Input 47					
CD76	...Repeated for Remote Input 48					
CD80	...Repeated for Remote Input 49					
CD8A	...Repeated for Remote Input 50					
CD94	...Repeated for Remote Input 51					
CD9E	...Repeated for Remote Input 52					

Table B–9: MODBUS MEMORY MAP (Sheet 46 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
CDA8	...Repeated for Remote Input 53					
CDB2	...Repeated for Remote Input 54					
CDBC	...Repeated for Remote Input 55					
CDC6	...Repeated for Remote Input 56					
CDD0	...Repeated for Remote Input 57					
CDDA	...Repeated for Remote Input 58					
CDE4	...Repeated for Remote Input 59					
CDEE	...Repeated for Remote Input 60					
CDF8	...Repeated for Remote Input 61					
CE02	...Repeated for Remote Input 62					
CE0C	...Repeated for Remote Input 63					
CE16	...Repeated for Remote Input 64					
Remote Output DNA Pairs (Read/Write Setting) (32 modules)						
CE20	Remote Output DNA 1 Operand	0 to 65535	---	1	F300	0
CE21	Remote Output DNA 1 Events	0 to 1	---	1	F102	0 (Disabled)
CE22	Reserved (2 items)	0 to 1	---	1	F001	0
CE24	...Repeated for Remote Output 2					
CE28	...Repeated for Remote Output 3					
CE2C	...Repeated for Remote Output 4					
CE30	...Repeated for Remote Output 5					
CE34	...Repeated for Remote Output 6					
CE38	...Repeated for Remote Output 7					
CE3C	...Repeated for Remote Output 8					
CE40	...Repeated for Remote Output 9					
CE44	...Repeated for Remote Output 10					
CE48	...Repeated for Remote Output 11					
CE4C	...Repeated for Remote Output 12					
CE50	...Repeated for Remote Output 13					
CE54	...Repeated for Remote Output 14					
CE58	...Repeated for Remote Output 15					
CE5C	...Repeated for Remote Output 16					
CE60	...Repeated for Remote Output 17					
CE64	...Repeated for Remote Output 18					
CE68	...Repeated for Remote Output 19					
CE6C	...Repeated for Remote Output 20					
CE70	...Repeated for Remote Output 21					
CE74	...Repeated for Remote Output 22					
CE78	...Repeated for Remote Output 23					
CE7C	...Repeated for Remote Output 24					
CE80	...Repeated for Remote Output 25					
CE84	...Repeated for Remote Output 26					
CE88	...Repeated for Remote Output 27					
CE8C	...Repeated for Remote Output 28					
CE90	...Repeated for Remote Output 29					
CE94	...Repeated for Remote Output 30					
CE98	...Repeated for Remote Output 31					
CE9C	...Repeated for Remote Output 32					
Remote Output UserSt Pairs (Read/Write Setting) (32 modules)						
CEA0	Remote Output UserSt 1 Operand	0 to 65535	---	1	F300	0
CEA1	Remote Output UserSt 1 Events	0 to 1	---	1	F102	0 (Disabled)
CEA2	Reserved (2 items)	0 to 1	---	1	F001	0
CEA4	...Repeated for Remote Output 2					
CEA8	...Repeated for Remote Output 3					
CEAC	...Repeated for Remote Output 4					

Table B–9: MODBUS MEMORY MAP (Sheet 47 of 47)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
CEB0	...Repeated for Remote Output 5					
CEB4	...Repeated for Remote Output 6					
CEB8	...Repeated for Remote Output 7					
CEBC	...Repeated for Remote Output 8					
CEC0	...Repeated for Remote Output 9					
CEC4	...Repeated for Remote Output 10					
CEC8	...Repeated for Remote Output 11					
CECC	...Repeated for Remote Output 12					
CED0	...Repeated for Remote Output 13					
CED4	...Repeated for Remote Output 14					
CED8	...Repeated for Remote Output 15					
CEDC	...Repeated for Remote Output 16					
CEE0	...Repeated for Remote Output 17					
CEE4	...Repeated for Remote Output 18					
CEE8	...Repeated for Remote Output 19					
CEEC	...Repeated for Remote Output 20					
CEF0	...Repeated for Remote Output 21					
CEF4	...Repeated for Remote Output 22					
CEF8	...Repeated for Remote Output 23					
CEFC	...Repeated for Remote Output 24					
CF00	...Repeated for Remote Output 25					
CF04	...Repeated for Remote Output 26					
CF08	...Repeated for Remote Output 27					
CF0C	...Repeated for Remote Output 28					
CF10	...Repeated for Remote Output 29					
CF14	...Repeated for Remote Output 30					
CF18	...Repeated for Remote Output 31					
CF1C	...Repeated for Remote Output 32					

B.4.2 DATA FORMATS

F001
UR_UINT16 UNSIGNED 16 BIT INTEGER

F002
UR_SINT16 SIGNED 16 BIT INTEGER

F003
UR_UINT32 UNSIGNED 32 BIT INTEGER (2 registers)

High order word is stored in the first register.
Low order word is stored in the second register.

F004
UR_SINT32 SIGNED 32 BIT INTEGER (2 registers)

High order word is stored in the first register/
Low order word is stored in the second register.

F005
UR_UINT8 UNSIGNED 8 BIT INTEGER

F006
UR_SINT8 SIGNED 8 BIT INTEGER

F011
UR_UINT16 FLEXCURVE DATA (120 points)

A FlexCurve is an array of 120 consecutive data points (x, y) which are interpolated to generate a smooth curve. The y-axis is the user defined trip or operation time setting; the x-axis is the pickup ratio and is pre-defined. Refer to format F119 for a listing of the pickup ratios; the enumeration value for the pickup ratio indicates the offset into the FlexCurve base address where the corresponding time value is stored.

F012
DISPLAY_SCALE DISPLAY SCALING
(unsigned 16-bit integer)

MSB indicates the SI units as a power of ten. LSB indicates the number of decimal points to display.

Example: Current values are stored as 32 bit numbers with three decimal places and base units in Amps. If the retrieved value is 12345.678 A and the display scale equals 0x0302 then the displayed value on the unit is 12.35 kA.

F013
POWER_FACTOR (SIGNED 16 BIT INTEGER)

Positive values indicate lagging power factor; negative values indicate leading.

F040
UR_UINT48 48-BIT UNSIGNED INTEGER

F050
UR_UINT32 TIME and DATE (UNSIGNED 32 BIT INTEGER)

Gives the current time in seconds elapsed since 00:00:00 January 1, 1970.

F051
UR_UINT32 DATE in SR format (alternate format for F050)

First 16 bits are Month/Day (MM/DD/xxxx). Month: 1=January, 2=February,...,12=December; Day: 1 to 31 in steps of 1
Last 16 bits are Year (xx/xx/YYYY): 1970 to 2106 in steps of 1

F052
UR_UINT32 TIME in SR format (alternate format for F050)

First 16 bits are Hours/Minutes (HH:MM:xx.xxx).
Hours: 0=12am, 1=1am,...,12=12pm,...23=11pm;
Minutes: 0 to 59 in steps of 1

Last 16 bits are Seconds (xx:xx:.SS.SSS): 0=00.000s, 1=00.001,...,59999=59.999s)

F060
FLOATING_POINT IEEE FLOATING POINT (32 bits)

F070
HEX2 2 BYTES - 4 ASCII DIGITS

F071
HEX4 4 BYTES - 8 ASCII DIGITS

F072
HEX6 6 BYTES - 12 ASCII DIGITS

F073
HEX8 8 BYTES - 16 ASCII DIGITS

F074
HEX20 20 BYTES - 40 ASCII DIGITS

F080
ENUMERATION: AUTORECLOSE MODE

0 = 1 & 3 Pole, 1 = 1 Pole, 2 = 3 Pole-A, 3 = 3 Pole-B

F083
ENUMERATION: SELECTOR MODES

0 = Time-Out, 1 = Acknowledge

F084
ENUMERATION: SELECTOR POWER UP

0 = Restore, 1 = Synchronize, 2 = Sync/Restore

F086
ENUMERATION: DIGITAL INPUT DEFAULT STATE

0 = Off, 1 = On, 2= Latest/Off, 3 = Latest/On

F090
ENUMERATION: LATCHING OUTPUT TYPE

0 = Operate-dominant, 1 = Reset-dominant

F100
ENUMERATION: VT CONNECTION TYPE

0 = Wye; 1 = Delta

F101
ENUMERATION: MESSAGE DISPLAY INTENSITY

0 = 25%, 1 = 50%, 2 = 75%, 3 = 100%

B

F102
ENUMERATION: DISABLED/ENABLED

0 = Disabled; 1 = Enabled

F103
ENUMERATION: CURVE SHAPES

bitmask	curve shape
0	IEEE Mod Inv
1	IEEE Very Inv
2	IEEE Ext Inv
3	IEC Curve A
4	IEC Curve B
5	IEC Curve C
6	IEC Short Inv
7	IAC Ext Inv
8	IAC Very Inv

bitmask	curve shape
9	IAC Inverse
10	IAC Short Inv
11	I2t
12	Definite Time
13	FlexCurve™ A
14	FlexCurve™ B
15	FlexCurve™ C
16	FlexCurve™ D

F104
ENUMERATION: RESET TYPE

0 = Instantaneous, 1 = Timed, 2 = Linear

F105
ENUMERATION: LOGIC INPUT

0 = Disabled, 1 = Input 1, 2 = Input 2

F106
ENUMERATION: PHASE ROTATION

0 = ABC, 1 = ACB

F108
ENUMERATION: OFF/ON

0 = Off, 1 = On

F109
ENUMERATION: CONTACT OUTPUT OPERATION

0 = Self-reset, 1 = Latched, 2 = Disabled

F110
ENUMERATION: CONTACT OUTPUT LED CONTROL

0 = Trip, 1 = Alarm, 2 = None

F111
ENUMERATION: UNDERVOLTAGE CURVE SHAPES

0 = Definite Time, 1 = Inverse Time

F112
ENUMERATION: RS485 BAUD RATES

bitmask	value
0	300
1	1200
2	2400
3	4800

bitmask	value
4	9600
5	19200
6	38400
7	57600

bitmask	value
8	115200
9	14400
10	28800
11	33600

F113
ENUMERATION: PARITY

0 = None, 1 = Odd, 2 = Even

F114
ENUMERATION: IRIG-B SIGNAL TYPE

0 = None, 1 = DC Shift, 2 = Amplitude Modulated

F115
ENUMERATION: BREAKER STATUS

0 = Auxiliary A, 1 = Auxiliary B

F116
ENUMERATION: NEUTRAL OVERVOLTAGE CURVES

0 = Definite Time, 1 = FlexCurve™ A, 2 = FlexCurve™ B,
3 = FlexCurve™ C

F117
ENUMERATION: NUMBER OF OSCILLOGRAPHY RECORDS

0 = 1×72 cycles, 1 = 3×36 cycles, 2 = 7×18 cycles, 3 = 15×9 cycles

F118
ENUMERATION: OSCILLOGRAPHY MODE

0 = Automatic Overwrite, 1 = Protected

F119
ENUMERATION: FLEXCURVE™ PICKUP RATIOS

mask	value	mask	value	mask	value	mask	value
0	0.00	30	0.88	60	2.90	90	5.90
1	0.05	31	0.90	61	3.00	91	6.00
2	0.10	32	0.91	62	3.10	92	6.50
3	0.15	33	0.92	63	3.20	93	7.00
4	0.20	34	0.93	64	3.30	94	7.50
5	0.25	35	0.94	65	3.40	95	8.00
6	0.30	36	0.95	66	3.50	96	8.50
7	0.35	37	0.96	67	3.60	97	9.00
8	0.40	38	0.97	68	3.70	98	9.50
9	0.45	39	0.98	69	3.80	99	10.00
10	0.48	40	1.03	70	3.90	100	10.50
11	0.50	41	1.05	71	4.00	101	11.00
12	0.52	42	1.10	72	4.10	102	11.50
13	0.54	43	1.20	73	4.20	103	12.00
14	0.56	44	1.30	74	4.30	104	12.50
15	0.58	45	1.40	75	4.40	105	13.00
16	0.60	46	1.50	76	4.50	106	13.50
17	0.62	47	1.60	77	4.60	107	14.00
18	0.64	48	1.70	78	4.70	108	14.50
19	0.66	49	1.80	79	4.80	109	15.00
20	0.68	50	1.90	80	4.90	110	15.50
21	0.70	51	2.00	81	5.00	111	16.00
22	0.72	52	2.10	82	5.10	112	16.50
23	0.74	53	2.20	83	5.20	113	17.00
24	0.76	54	2.30	84	5.30	114	17.50
25	0.78	55	2.40	85	5.40	115	18.00
26	0.80	56	2.50	86	5.50	116	18.50
27	0.82	57	2.60	87	5.60	117	19.00
28	0.84	58	2.70	88	5.70	118	19.50
29	0.86	59	2.80	89	5.80	119	20.00

F122
ENUMERATION: ELEMENT INPUT SIGNAL TYPE

0 = Phasor, 1 = RMS

F123
ENUMERATION: CT SECONDARY

0 = 1 A, 1 = 5 A

F124
ENUMERATION: LIST OF ELEMENTS

bitmask	element
0	Phase Instantaneous Overcurrent 1
1	Phase Instantaneous Overcurrent 2
2	Phase Instantaneous Overcurrent 3
3	Phase Instantaneous Overcurrent 4
4	Phase Instantaneous Overcurrent 5

bitmask	element
5	Phase Instantaneous Overcurrent 6
6	Phase Instantaneous Overcurrent 7
7	Phase Instantaneous Overcurrent 8
8	Phase Instantaneous Overcurrent 9
9	Phase Instantaneous Overcurrent 10
10	Phase Instantaneous Overcurrent 11
11	Phase Instantaneous Overcurrent 12
16	Phase Time Overcurrent 1
17	Phase Time Overcurrent 2
18	Phase Time Overcurrent 3
19	Phase Time Overcurrent 4
20	Phase Time Overcurrent 5
21	Phase Time Overcurrent 6
24	Phase Directional Overcurrent 1
25	Phase Directional Overcurrent 2
32	Neutral Instantaneous Overcurrent 1
33	Neutral Instantaneous Overcurrent 2
34	Neutral Instantaneous Overcurrent 3
35	Neutral Instantaneous Overcurrent 4
36	Neutral Instantaneous Overcurrent 5
37	Neutral Instantaneous Overcurrent 6
38	Neutral Instantaneous Overcurrent 7
39	Neutral Instantaneous Overcurrent 8
40	Neutral Instantaneous Overcurrent 9
41	Neutral Instantaneous Overcurrent 10
42	Neutral Instantaneous Overcurrent 11
43	Neutral Instantaneous Overcurrent 12
48	Neutral Time Overcurrent 1
49	Neutral Time Overcurrent 2
50	Neutral Time Overcurrent 3
51	Neutral Time Overcurrent 4
52	Neutral Time Overcurrent 5
53	Neutral Time Overcurrent 6
56	Neutral Directional Overcurrent 1
57	Neutral Directional Overcurrent 2
60	Negative Sequence Directional Overcurrent 1
61	Negative Sequence Directional Overcurrent 2
64	Ground Instantaneous Overcurrent 1
65	Ground Instantaneous Overcurrent 2
66	Ground Instantaneous Overcurrent 3
67	Ground Instantaneous Overcurrent 4
68	Ground Instantaneous Overcurrent 5
69	Ground Instantaneous Overcurrent 6
70	Ground Instantaneous Overcurrent 7
71	Ground Instantaneous Overcurrent 8
72	Ground Instantaneous Overcurrent 9
73	Ground Instantaneous Overcurrent 10
74	Ground Instantaneous Overcurrent 11
75	Ground Instantaneous Overcurrent 12
80	Ground Time Overcurrent 1
81	Ground Time Overcurrent 2
82	Ground Time Overcurrent 3
83	Ground Time Overcurrent 4

bitmask	element
84	Ground Time Overcurrent 5
85	Ground Time Overcurrent 6
96	Negative Sequence Instantaneous Overcurrent 1
97	Negative Sequence Instantaneous Overcurrent 2
112	Negative Sequence Time Overcurrent 1
113	Negative Sequence Time Overcurrent 2
120	Negative Sequence Overvoltage
128	High Impedance Fault Detection (Hi-Z)
140	Auxiliary Undervoltage 1
144	Phase Undervoltage 1
145	Phase Undervoltage 2
148	Auxiliary Overvoltage 1
152	Phase Overvoltage 1
156	Neutral Overvoltage 1
180	Load Enchroachment
190	Power Swing Detect
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
232	SRC1 50DD (Disturbance Detection)
233	SRC2 50DD (Disturbance Detection)
234	SRC3 50DD (Disturbance Detection)
235	SRC4 50DD (Disturbance Detection)
236	SRC5 50DD (Disturbance Detection)
237	SRC6 50DD (Disturbance Detection)
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
320	Cold Load Pickup 1
321	Cold Load Pickup 2
336	Setting Group

bitmask	element
337	Reset
344	Overfrequency 1
345	Overfrequency 2
346	Overfrequency 3
347	Overfrequency 4
352	Underfrequency 1
353	Underfrequency 2
354	Underfrequency 3
355	Underfrequency 4
356	Underfrequency 5
357	Underfrequency 6
375	Autoreclose
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
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
530	Frequency Rate of Change 1
531	Frequency Rate of Change 2
532	Frequency Rate of Change 3
533	Frequency Rate of Change 4
544	Digital Counter 1
545	Digital Counter 2
546	Digital Counter 3
547	Digital Counter 4

bitmask	element
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
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
692	Digital Element 1
693	Digital Element 2
694	Digital Element 3
695	Digital Element 4
696	Digital Element 5
697	Digital Element 6
698	Digital Element 7
699	Digital Element 8
700	Digital Element 9
701	Digital Element 10
702	Digital Element 11
703	Digital Element 12
704	Digital Element 13
705	Digital Element 14
706	Digital Element 15
707	Digital Element 16
708	Digital Element 17
709	Digital Element 18
710	Digital Element 19
711	Digital Element 20
712	Digital Element 21
713	Digital Element 22
714	Digital Element 23
715	Digital Element 24
716	Digital Element 25
717	Digital Element 26
718	Digital Element 27
719	Digital Element 28
720	Digital Element 29
721	Digital Element 30
722	Digital Element 31
723	Digital Element 32
724	Digital Element 33
725	Digital Element 34
726	Digital Element 35
727	Digital Element 36
728	Digital Element 37
729	Digital Element 38
730	Digital Element 39
731	Digital Element 40
732	Digital Element 41
733	Digital Element 42
734	Digital Element 43
735	Digital Element 44
736	Digital Element 45
737	Digital Element 46
738	Digital Element 47
739	Digital Element 48

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

B

F134
ENUMERATION: PASS/FAIL

0 = Fail, 1 = OK, 2 = n/a

F135
ENUMERATION: GAIN CALIBRATION

0 = 0x1, 1 = 1x16

F136
ENUMERATION: NUMBER OF OSCILLOGRAPHY RECORDS

0 = 31 x 8 cycles, 1 = 15 x 16 cycles, 2 = 7 x 32 cycles
3 = 3 x 64 cycles, 4 = 1 x 128 cycles

F138
ENUMERATION: OSCILLOGRAPHY FILE TYPE

0 = Data File, 1 = Configuration File, 2 = Header File

F139
ENUMERATION: DEMAND CALCULATIONS

0 = Thermal Exponential, 1 = Block Interval, 2 = Rolling Demand

F140
ENUMERATION: CURRENT, SENS CURRENT, VOLTAGE, DISABLED

0 = Disabled, 1 = Current 46 A, 2 = Voltage 280 V,
3 = Current 4.6 A, 4 = Current 2 A, 5 = Notched 4.6 A,
6 = Notched 2 A

F141
ENUMERATION: SELF TEST 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
29	Direct Ring Break
30	Any Minor Error
31	Any Major Error

F142
ENUMERATION: EVENT RECORDER ACCESS FILE TYPE

0 = All Record Data, 1 = Headers Only, 2 = Numeric Event Cause

F143
UR_UINT32: 32 BIT ERROR CODE (F141 specifies bit number)

A bit value of 0 = no error, 1 = error

F144
ENUMERATION: FORCED CONTACT INPUT STATE

0 = Disabled, 1 = Open, 2 = Closed

F145
ENUMERATION: ALPHABET LETTER

bitmask	type	bitmask	type	bitmask	type	bitmask	type
0	null	7	G	14	N	21	U
1	A	8	H	15	O	22	V
2	B	9	I	16	P	23	W
3	C	10	J	17	Q	24	X
4	D	11	K	18	R	25	Y
5	E	12	L	19	S	26	Z
6	F	13	M	20	T		

F146
ENUMERATION: MISCELLANEOUS EVENT CAUSES

bitmask	definition
0	Events Cleared
1	Oscillography Triggered
2	Date/time Changed
3	Default Settings Loaded
4	Test Mode On
5	Test Mode Off
6	Power On
7	Power Off
8	Relay In Service
9	Relay Out Of Service
10	Watchdog Reset
11	Oscillography Clear
12	Reboot Command
13	Led Test Initiated
14	Flash Programming
15	Fault Report Trigger

bitmask	definition
16	User Programmable Fault Report Trigger
17	Corrupt DSP Program
18	Reload DSP Settings

F147
ENUMERATION: LINE LENGTH UNITS

0 = km, 1 = miles

F148
ENUMERATION: FAULT TYPE

bitmask	fault type	bitmask	fault type
0	NA	6	AC
1	AG	7	ABG
2	BG	8	BCG
3	CG	9	ACG
4	AB	10	ABC
5	BC	11	ABCG

F151
ENUMERATION: RTD SELECTION

bitmask	RTD#	bitmask	RTD#	bitmask	RTD#
0	NONE	17	RTD 17	33	RTD 33
1	RTD 1	18	RTD 18	34	RTD 34
2	RTD 2	19	RTD 19	35	RTD 35
3	RTD 3	20	RTD 20	36	RTD 36
4	RTD 4	21	RTD 21	37	RTD 37
5	RTD 5	22	RTD 22	38	RTD 38
6	RTD 6	23	RTD 23	39	RTD 39
7	RTD 7	24	RTD 24	40	RTD 40
8	RTD 8	25	RTD 25	41	RTD 41
9	RTD 9	26	RTD 26	42	RTD 42
10	RTD 10	27	RTD 27	43	RTD 43
11	RTD 11	28	RTD 28	44	RTD 44
12	RTD 12	29	RTD 29	45	RTD 45
13	RTD 13	30	RTD 30	46	RTD 46
14	RTD 14	31	RTD 31	47	RTD 47
15	RTD 15	32	RTD 32	48	RTD 48
16	RTD 16				

F152
ENUMERATION: SETTING GROUP

0 = Active Group, 1 = Group 1, 2 = Group 2, 3 = Group 3
4 = Group 4, 5 = Group 5, 6 = Group 6

F155
ENUMERATION: REMOTE DEVICE STATE

0 = Offline, 1 = Online

F156
ENUMERATION: REMOTE INPUT BIT PAIRS

bitmask	value	bitmask	value	bitmask	value
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

B

F170
ENUMERATION: LOW/HIGH OFFSET and GAIN TRANSDUCER INPUT/OUTPUT SELECTION

0 = LOW, 1 = HIGH

F171
ENUMERATION: TRANSDUCER CHANNEL INPUT TYPE

0 = dcmA IN, 1 = Ohms IN, 2 = RTD IN, 3 = dcmA OUT

F172
ENUMERATION: SLOT LETTERS

bitmask	slot	bitmask	slot	bitmask	slot	bitmask	slot
0	F	4	K	8	P	12	U
1	G	5	L	9	R	13	V
2	H	6	M	10	S	14	W
3	J	7	N	11	T	15	X

F173
ENUMERATION: DCMA INPUT/OUTPUT RANGE

bitmask	dcmA input/output range
0	0 to –1 mA
1	0 to 1 mA
2	–1 to 1 mA
3	0 to 5 mA
4	0 to 10 mA
5	0 to 20 mA
6	4 to 20 mA

F174
ENUMERATION: TRANSDUCER RTD INPUT TYPE

0 = 100 Ohm Platinum, 1 = 120 Ohm Nickel,
2 = 100 Ohm Nickel, 3 = 10 Ohm Copper

F175
ENUMERATION: PHASE LETTERS

0 = A, 1 = B, 2 = C

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 - TCP, 5 = Network - UDP

F178
ENUMERATION: DATA LOGGER RATES

0 = 1 sec, 1 = 1 min, 2 = 5 min, 3 = 10 min, 4 = 15 min,
5 = 20 min, 6 = 30 min, 7 = 60 min, 8 = 15 ms, 9 = 30 ms,
10 = 100 ms, 11 = 500 ms

F179
ENUMERATION: NEGATIVE SEQUENCE DIRECTIONAL OVERCURRENT TYPE

0 = Neg Sequence, 1 = Zero Sequence

F180
ENUMERATION: PHASE/GROUND

0 = PHASE, 1 = GROUND

F181
ENUMERATION: ODD/EVEN/NONE

0 = ODD, 1 = EVEN, 2 = NONE

F182
ENUMERATION: LOSS OF LOAD / ARCING SUSPECTED / ARCING / OVERCURRENT DOWNED CONDUCTOR / EXTERNAL

bitmask	definition
0	LOSS OF LOAD
1	ARCING SUSPECTED
2	ARCING
3	OVERCURRENT
4	DOWNED CONDUCTOR
5	EXTERNAL

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

F187
ENUMERATION: HI-Z STATES

bitmask	Hi-Z State
0	NORMAL
1	COORDINAT ION TIMEOUT
2	ARMED
5	ARCING
9	DOWNED CONDUCTOR

F188
ENUMERATION: HI-Z CAPTURE TRIGGER TYPES

bitmask	trigger type
0	None
1	Loss Of Load
2	Arc Suspected
3	Arcing
4	Overcurrent
5	Down Conductor
6	External

F190
ENUMERATION: SIMULATED KEYPRESS

bitmsk	keypress
0	--- use between real keys
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	0
11	Decimal Pt
12	Plus/Minus
13	Value Up
14	Value Down
15	Message Up
16	Message Down
17	Message Left
18	Message Right
19	Menu
20	Help

bitmsk	keypress
21	Escape
22	Enter
23	Reset
24	User 1
25	User 2
26	User 3
27	User-programmable key 1
28	User-programmable key 2
29	User-programmable key 3
30	User-programmable key 4
31	User-programmable key 5
32	User-programmable key 6
33	User-programmable key 7
34	User-programmable key 8
35	User-programmable key 9
36	User-programmable key 10
37	User-programmable key 11
38	User-programmable key 12
39	User 4 (control pushbutton)
40	User 5 (control pushbutton)
41	User 6 (control pushbutton)
42	User 7 (control pushbutton)

F191
ENUMERATION: HI-Z ENERGY/RANDOM STATE

bitmask	HI-Z Energy/Random State
0	REINSTATE
1	INITSTATE
2	NORMALSTATE
3	EVENTSTATE
4	SERIOUSSTATE

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

F196
ENUMERATION: NEUTRAL DIRECTIONAL OVERCURRENT OPERATING CURRENT

0 = Calculated 3I0, 1 = Measured IG

F199
ENUMERATION: DISABLED/ENABLED/CUSTOM

0 = Disabled, 1 = Enabled, 2 = Custom

F200
TEXT40: 40-CHARACTER ASCII TEXT

20 registers, 16 Bits: 1st Char MSB, 2nd Char. LSB

F201
TEXT8: 8-CHARACTER ASCII PASSCODE

4 registers, 16 Bits: 1st Char MSB, 2nd Char. LSB

F202
TEXT20: 20-CHARACTER ASCII TEXT

10 registers, 16 Bits: 1st Char MSB, 2nd Char. LSB

F203
TEXT16: 16-CHARACTER ASCII TEXT

F204
TEXT80: 80-CHARACTER ASCII TEXT

F205
TEXT12: 12-CHARACTER ASCII TEXT

B

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

F224
ENUMERATION: RATE TREND FOR FREQ RATE OF CHANGE

0 = Increasing, 1 = Decreasing, 2 = Bidirectional

F226
ENUMERATION: REMOTE INPUT/OUTPUT TRANSFER METHOD

0 = None, 1 = GSSE, 2 = GOOSE

F227
ENUMERATION: RELAY SERVICE STATUS

0 = Unknown, 1 = Relay In Service, 2 = Relay Out Of Service

F230
ENUMERATION: DIRECTIONAL POLARIZING

0 = Voltage, 1 = Current, 2 = Dual

F231
ENUMERATION: POLARIZING VOLTAGE

0 = Calculated V0, 1 = Measured VX

F260
ENUMERATION: DATA LOGGER MODE

0 = Continuous, 1 = Trigger

F300
UR_UINT16: FLEXLOGIC™ BASE TYPE (6-bit type)

The FlexLogic™ BASE type is 6 bits and is combined with a 9 bit descriptor and 1 bit for protection element to form a 16 bit value. The combined bits are of the form: PTTTTTTDDDDDDDDD, where P bit if set, indicates that the FlexLogic™ type is associated with a protection element state and T represents bits for the BASE type, and D represents bits for the descriptor.

The values in square brackets indicate the base type with P prefix [PTTTTTT] and the values in round brackets indicate the descriptor range.

[0] Off(0) – this is boolean FALSE value
[0] On (1) – this is boolean TRUE value
[2] CONTACT INPUTS (1 to 96)
[3] CONTACT INPUTS OFF (1 to 96)
[4] VIRTUAL INPUTS (1 to 64)
[6] VIRTUAL OUTPUTS (1 to 96)
[10] CONTACT OUTPUTS VOLTAGE DETECTED (1 to 64)
[11] CONTACT OUTPUTS VOLTAGE OFF DETECTED (1 to 64)
[12] CONTACT OUTPUTS CURRENT DETECTED (1 to 64)
[13] CONTACT OUTPUTS CURRENT OFF DETECTED (1 to 64)
[14] REMOTE INPUTS (1 to 32)
[28] INSERT (via keypad only)
[32] END
[34] NOT (1 INPUT)
[36] 2 INPUT XOR (0)
[38] LATCH SET/RESET (2 inputs)
[40] OR (2 to 16 inputs)
[42] AND (2 to 16 inputs)
[44] NOR (2 to 16 inputs)
[46] NAND (2 to 16 inputs)
[48] TIMER (1 to 32)
[50] ASSIGN VIRTUAL OUTPUT (1 to 96)
[52] SELF-TEST ERROR (see F141 for range)
[56] ACTIVE SETTING GROUP (1 to 6)
[62] MISCELLANEOUS EVENTS (see F146 for range)
[64 to 127] ELEMENT STATES

F400
UR_UINT16: CT/VT BANK SELECTION

bitmask	bank selection
0	Card 1 Contact 1 to 4
1	Card 1 Contact 5 to 8
2	Card 2 Contact 1 to 4
3	Card 2 Contact 5 to 8
4	Card 3 Contact 1 to 4
5	Card 3 Contact 5 to 8

F500
UR_UINT16: PACKED BITFIELD

First register indicates input/output state with bits 0 (MSB) to 15 (LSB) corresponding to input/output state 1 to 16. The second register indicates input/output state with bits 0 to 15 corresponding to input/output state 17 to 32 (if required) The third register indicates input/output state with bits 0 to 15 corresponding to input/output state 33 to 48 (if required). The fourth register indicates input/output state with bits 0 to 15 corresponding to input/output state 49 to 64 (if required).

The number of registers required is determined by the specific data item. A bit value of 0 = Off and 1 = On.

F501
UR_UINT16: LED STATUS

Low byte of register indicates LED status with bit 0 representing the top LED and bit 7 the bottom LED. A bit value of 1 indicates the LED is on, 0 indicates the LED is off.

F502
BITFIELD: ELEMENT OPERATE STATES

Each bit contains the operate state for an element. See the F124 format code for a list of element IDs. The operate bit for element ID X is bit [X mod 16] in register [X/16].

F504
BITFIELD: 3-PHASE ELEMENT STATE

bitmask	element state
0	Pickup
1	Operate
2	Pickup Phase A
3	Pickup Phase B
4	Pickup Phase C
5	Operate Phase A
6	Operate Phase B
7	Operate Phase C

F505
BITFIELD: CONTACT OUTPUT STATE

0 = Contact State, 1 = Voltage Detected, 2 = Current Detected

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

F512
ENUMERATION: HARMONIC NUMBER

bitmask	harmonic
0	2ND
1	3RD
2	4TH
3	5TH
4	6TH
5	7TH
6	8TH
7	9TH
8	10TH
9	11TH
10	12TH
11	13TH

bitmask	harmonic
12	14TH
13	15TH
14	16TH
15	17TH
16	18TH
17	19TH
18	20TH
19	21ST
20	22ND
21	23RD
22	24TH
23	25TH

F515
ENUMERATION ELEMENT INPUT MODE

0 = Signed, 1 = Absolute

F516
ENUMERATION ELEMENT COMPARE MODE

0 = Level, 1 = Delta

F517
ENUMERATION: ELEMENT DIRECTION OPERATION

0 = Over, 1 = Under

F518
ENUMERATION: FLEXELEMENT™ UNITS

0 = Milliseconds, 1 = Seconds, 2 = Minutes

F519
ENUMERATION: NON-VOLATILE LATCH

0 = Reset-Dominant, 1 = Set-Dominant

F522
ENUMERATION: TRANSDUCER DCMA OUTPUT RANGE

0 = –1 to 1 mA; 1 = 0 to 1 mA; 2 = 4 to 20 mA

F523
ENUMERATION: DNP OBJECTS 20, 22, AND 23 DEFAULT VARIATION

bitmask	default variation
0	1
1	2
2	5
3	6

B

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
0	None
1	Menu
2	Message Up
3	7
4	8
5	9
6	Help
7	Message Left
8	4
9	5
10	6
11	Escape
12	Message Right
13	1
14	2
15	3
16	Enter
17	Message Down
18	0
19	Decimal
20	+/–
21	Value Up

bitmask	keypress
22	Value Down
23	Reset
24	User 1
25	User 2
26	User 3
31	User PB 1
32	User PB 2
33	User PB 3
34	User PB 4
35	User PB 5
36	User PB 6
37	User PB 7
38	User PB 8
39	User PB 9
40	User PB 10
41	User PB 11
42	User PB 12
44	User 4
45	User 5
46	User 6
47	User 7

F531
ENUMERATION: LANGUAGE

0 = English, 1 = French, 2 = Chinese, 3 = Russian

F600
UR_UINT16: FLEXANALOG PARAMETER

Corresponds to the modbus address of the value used when this parameter is selected. Only certain values may be used as FlexAnalogs (basically all metering quantities used in protection).

C.1.1 OVERVIEW

The IEC 61850 standard is the result of years of work by electric utilities and vendors of electronic equipment to produce standardized communications systems. IEC 61850 is a series of standards describing client/server and peer-to-peer communications, substation design and configuration, testing, environmental and project standards. The complete set includes:

- IEC 61850-1: Introduction and overview
- IEC 61850-2: Glossary
- IEC 61850-3: General requirements
- IEC 61850-4: System and project management
- IEC 61850-5: Communications and requirements for functions and device models
- IEC 61850-6: Configuration description language for communication in electrical substations related to IEDs
- IEC 61850-7-1: Basic communication structure for substation and feeder equipment - Principles and models
- IEC 61850-7-2: Basic communication structure for substation and feeder equipment - Abstract communication service interface (ACSI)
- IEC 61850-7-3: Basic communication structure for substation and feeder equipment – Common data classes
- IEC 61850-7-4: Basic communication structure for substation and feeder equipment – Compatible logical node classes and data classes
- IEC 61850-8-1: Specific Communication Service Mapping (SCSM) – Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3
- IEC 61850-9-1: Specific Communication Service Mapping (SCSM) – Sampled values over serial unidirectional multi-drop point to point link
- IEC 61850-9-2: Specific Communication Service Mapping (SCSM) – Sampled values over ISO/IEC 8802-3
- IEC 61850-10: Conformance testing

These documents can be obtained from the IEC (http://www.iec.ch). It is strongly recommended that all those involved with any IEC 61850 implementation obtain this document set.

C.1.2 COMMUNICATION PROFILES

The F60 relay supports IEC 61850 server services over both TCP/IP and TP4/CLNP (OSI) communication protocol stacks. The TP4/CLNP profile requires the F60 to have a network address or Network Service Access Point (NSAP) to establish a communication link. The TCP/IP profile requires the F60 to have an IP address to establish communications. These addresses are located in the **SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ NETWORK** menu. Note that the F60 supports IEC 61850 over the TP4/CLNP or TCP/IP stacks, and also operation over both stacks simultaneously. It is possible to have up to four simultaneous connections (in addition to DNP and Modbus/TCP (non-IEC 61850) connections).

C.1.3 MMS PROTOCOL

IEC 61850 specifies the use of the Manufacturing Message Specification (MMS) at the upper (application) layer for transfer of real-time data. This protocol has been in existence for a number of years and provides a set of services suitable for the transfer of data within a substation LAN environment. Actual MMS protocol services are mapped to IEC 61850 abstract services in IEC 61850-8-1.

C.1.4 PEER-TO-PEER COMMUNICATION

Peer-to-peer communication of digital state information (remote inputs/outputs) is supported using the IEC 61850 GSSE and GOOSE services. This feature allows digital points to be exchanged between IEC 61850 conforming devices.

C.1.5 FILE SERVICES

MMS file services are supported to allow transfer of oscillography, event record, or other files from a F60 relay.

C.1.6 COMMUNICATION SOFTWARE UTILITIES

The exact structure and values of the supported IEC 61850 logical nodes can be seen by connecting to a F60 relay with an MMS browser, such as the “MMS Object Explorer and AXS4-MMS” DDE/OPC server from Sisco Inc.

C.1.7 NON-IEC 61850 DATA

The F60 relay makes available a number of non-IEC 61850 data items. These data items can be accessed through the “UR” MMS domain. IEC 61850 data can be accessed through the “IECDevice” MMS domain (IEC 61850 logical device).

C.1.8 TCP CONNECTION TIMING

A built-in TCP/IP connection timeout of two minutes is employed by the F60 to detect ‘dead’ connections. If there is no data traffic on a TCP connection for greater than two minutes, the connection will be aborted by the F60. This frees up the connection to be used by other clients. Therefore, when using IEC 61850 reporting, clients should configure report control block items such that an integrity report will be issued at least every 2 minutes (120000 ms). This ensures that the F60 will not abort the connection. If other MMS data is being polled on the same connection at least once every 2 minutes, this timeout will not apply.

C.1.9 LOGICAL NODE MMXU DATA MAPPING

The mapping of F60 relay data to IEC 61850 MMXU data is performed on a per-source basis. MMXU1 data originates from F60 source 1, MMXU2 data originates from F60 source 2, etc.

C.1.10 LOGICAL NODE GGIO DATA MAPPING

Logical node GGIO1 data is mapped using the F60 Flexstate parameters. Each single point indication in GGIO1 can be selected using the corresponding Flexstate parameter setting. For example, the value of GGIO1 point “Ind3” is determined from the FlexLogic™ operand selected in the Flexstate parameter 3 setting. Thus, GGIO1 data can originate as any FlexLogic™ parameter.

Logical node GGIO2 data is mapped to the F60 virtual inputs. Each single point control in GGIO2 is mapped to a virtual input. For example, GGIO2 control point SPCSO3 is mapped to virtual input 3.

C.1.11 OTHER LOGICAL NODE MAPPING

All other IEC 61850 logical nodes (with the exception of PTRC) are associated with standard UR-series relay protection elements and features. The following mapping is used (for applicable elements):

- PIOC: phase instantaneous overcurrent, neutral instantaneous overcurrent, ground instantaneous overcurrent, negative sequence instantaneous overcurrent
- PTOC: phase time overcurrent, neutral time overcurrent, ground time overcurrent, negative sequence time overcurrent, neutral directional overcurrent, negative sequence directional overcurrent
- PTUV: phase undervoltage, auxiliary undervoltage, third harmonic neutral undervoltage
- PTOV: phase overvoltage, neutral overvoltage, auxiliary overvoltage, negative sequence overvoltage
- RBRF: breaker failure
- RREC: autoreclosure
- RFLO: fault locator
- XCBR: breaker control

C.2.1 ACSI BASIC CONFORMANCE STATEMENT

SERVICES		SERVER/ PUBLISHER	UR-FAMILY
CLIENT-SERVER ROLES			
B11	**Server** side (of two-party application-association)	**c1**	**Yes**
B12	**Client** side (of two-party application-association)	**---**	
SCSMS SUPPORTED			
B21	**SCSM**: IEC 61850-8-1 used		**Yes**
B22	**SCSM**: IEC 61850-9-1 used		
B23	**SCSM**: IEC 61850-9-2 used		
B24	**SCSM**: other		
GENERIC SUBSTATION EVENT MODEL (GSE)			
B31	**Publisher** side	**O**	**Yes**
B32	**Subscriber** side	**---**	**Yes**
TRANSMISSION OF SAMPLED VALUE MODEL (SVC)			
B41	**Publisher** side	**O**	
B42	**Subscriber** side	**---**	

NOTE

c1: shall be "M" if support for LOGICAL-DEVICE model has been declared
O: Optional
M: Mandatory

C.2.2 ACSI MODELS CONFORMANCE STATEMENT

SERVICES		SERVER/ PUBLISHER	UR-FAMILY
IF SERVER SIDE (B11) SUPPORTED			
M1	**Logical device**	**c2**	**Yes**
M2	**Logical node**	**c3**	**Yes**
M3	**Data**	**c4**	**Yes**
M4	**Data set**	**c5**	**Yes**
M5	**Substitution**	**O**	
M6	**Setting group control**	**O**	
	REPORTING		
M7	**Buffered report control**	**O**	**Yes**
M7-1	sequence-number		
M7-2	report-time-stamp		
M7-3	reason-for-inclusion		
M7-4	data-set-name		
M7-5	data-reference		
M7-6	buffer-overflow		
M7-7	entryID		
M7-8	BufTm		
M7-9	IntgPd		
M7-10	GI		
M8	**Unbuffered report control**	**O**	**Yes**
M8-1	sequence-number		
M8-2	report-time-stamp		
M8-3	reason-for-inclusion		

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SERVICES		SERVER/ PUBLISHER	UR-FAMILY
M8-4	data-set-name		
M8-5	data-reference		
M8-6	BufTm		
M8-7	IntgPd		
M8-8	GI		
	Logging	**O**	
M9	**Log control**	**O**	
M9-1	IntgPd		
M10	**Log**	**O**	
M11	**Control**	**M**	**Yes**
IF GSE (B31/32) IS SUPPORTED			
	GOOSE	**O**	**Yes**
M12-1	entryID		
M12-2	DataReflnc		
M13	**GSSE**	**O**	**Yes**
IF SVC (B41/B42) IS SUPPORTED			
M14	Multicast SVC	**O**	
M15	Unicast SVC	**O**	
M16	**Time**	**M**	**Yes**
M17	**File transfer**	**O**	**Yes**

NOTE

c2: shall be "M" if support for LOGICAL-NODE model has been declared
c3: shall be "M" if support for DATA model has been declared
c4: shall be "M" if support for DATA-SET, Substitution, Report, Log Control, or Time models has been declared
c5: shall be "M" if support for Report, GSE, or SMV models has been declared
M: Mandatory

C.2.3 ACSI SERVICES CONFORMANCE STATEMENT

In the table below, the acronym AA refers to Application Associations (TP: Two Party / MC: Multicast). The c6 to c10 entries are defined in the notes following the table.

SERVICES		AA: TP/MC	SERVER/ PUBLISHER	UR FAMILY
SERVER (CLAUSE 6)				
S1	ServerDirectory	TP	M	Yes
APPLICATION ASSOCIATION (CLAUSE 7)				
S2	Associate		M	Yes
S3	Abort		M	Yes
S4	Release		M	Yes
LOGICAL DEVICE (CLAUSE 8)				
S5	LogicalDeviceDirectory	TP	M	Yes
LOGICAL NODE (CLAUSE 9)				
S6	LogicalNodeDirectory	TP	M	Yes
S7	GetAllDataValues	TP	M	Yes
DATA (CLAUSE 10)				
S8	GetDataValues	TP	M	Yes
S9	SetDataValues	TP	O	Yes
S10	GetDataDirectory	TP	M	Yes
S11	GetDataDefinition	TP	M	Yes

SERVICES		AA: TP/MC	SERVER/ PUBLISHER	UR FAMILY
DATA SET (CLAUSE 11)				
S12	GetDataSetValues	TP	M	Yes
S13	SetDataSetValues	TP	O	
S14	CreateDataSet	TP	O	
S15	DeleteDataSet	TP	O	
S16	GetDataSetDirectory	TP	O	Yes
SUBSTITUTION (CLAUSE 12)				
S17	SetDataValues	TP	M	
SETTING GROUP CONTROL (CLAUSE 13)				
S18	SelectActiveSG	TP	O	
S19	SelectEditSG	TP	O	
S20	SetSGValues	TP	O	
S21	ConfirmEditSGValues	TP	O	
S22	GetSGValues	TP	O	
S23	GetSGCBValues	TP	O	
REPORTING (CLAUSE 14)				
	BUFFERED REPORT CONTROL BLOCK (BRCB)			
S24	Report	TP	c6	Yes
S24-1	data-change (dchg)			Yes
S24-2	qchg-change (qchg)			
S24-3	data-update (dupd)			
S25	GetBRCBValues	TP	c6	Yes
S26	SetBRCBValues	TP	c6	Yes
UNBUFFERED REPORT CONTROL BLOCK (URCB)				
S27	Report	TP	c6	Yes
S27-1	data-change (dchg)			Yes
S27-2	qchg-change (qchg)			
S27-3	data-update (dupd)			
S28	GetURCBValues	TP	c6	Yes
S29	SetURCBValues	TP	c6	Yes
LOGGING (CLAUSE 14)				
	LOG CONTROL BLOCK			
S30	GetLCBValues	TP	M	
S31	SetLCBValues	TP	M	
	LOG			
S32	QueryLogByTime	TP	M	
S33	QueryLogByEntry	TP	M	
S34	GetLogStatusValues	TP	M	
GENERIC SUBSTATION EVENT MODEL (GSE) (CLAUSE 14.3.5.3.4)				
	GOOSE-CONTROL-BLOCK			
S35	SendGOOSEMessage	MC	c8	Yes
S36	GetReference	TP	c9	
S37	GetGOOSEElementNumber	TP	c9	
S38	GetGoCBValues	TP	O	Yes
S39	SetGoCBValues	TP	O	Yes
	GSSE-CONTROL-BLOCK			
S40	SendGSSEMessage	MC	c8	Yes
S41	GetReference	TP	c9	

C

SERVICES		AA: TP/MC	SERVER/ PUBLISHER	UR FAMILY
S42	GetGSSEElementNumber	TP	c9	
S43	GetGsCBValues	TP	O	Yes
S44	SetGsCBValues	TP	O	Yes
TRANSMISSION OF SAMPLE VALUE MODEL (SVC) (CLAUSE 16)				
	MULTICAST SVC			
S45	SendMSVMessage	MC	c10	
S46	GetMSVCBValues	TP	O	
S47	SetMSVCBValues	TP	O	
	UNICAST SVC			
S48	SendUSVMessage	MC	c10	
S49	GetUSVCBValues	TP	O	
S50	SetUSVCBValues	TP	O	
CONTROL (CLAUSE 16.4.8)				
S51	Select		O	Yes
S52	SelectWithValue	TP	O	
S53	Cancel	TP	O	Yes
S54	Operate	TP	M	Yes
S55	Command-Termination	TP	O	
S56	TimeActivated-Operate	TP	O	
FILE TRANSFER (CLAUSE 20)				
S57	GetFile	TP	M	Yes
S58	SetFile	TP	O	
S59	DeleteFile	TP	O	
S60	GetFileAttributeValues	TP	M	Yes
TIME (CLAUSE 5.5)				
T1	Time resolution of internal clock (nearest negative power of 2 in seconds)			20
T2	Time accuracy of internal clock			
T3	supported TimeStamp resolution (nearest value of 2^{-n} in seconds, accoridng to 5.5.3.7.3.3)			20

NOTE

c6: shall declare support for at least one (BRCB or URCB)
c7: shall declare support for at least one (QueryLogByTime or QueryLogAfter)
c8: shall declare support for at least one (SendGOOSEMessage or SendGSSEMessage)
c9: shall declare support if TP association is available
c10: shall declare support for at least one (SendMSVMessage or SendUSVMessage)

C.3.1 LOGICAL NODES TABLE

The UR-series of relays supports IEC 61850 logical nodes as indicated in the following table. Note that the actual instantiation of each logical node is determined by the product order code. For example. the logical node "PDIS" (distance protection) is available only in the D60 Line Distance Relay.

NODES	UR-FAMILY
L: SYSTEM LOGICAL NODES	
LPHD: Physical device information	**Yes**
LLN0: Logical node zero	**Yes**
P: LOGICAL NODES FOR PROTECTION FUNCTIONS	
PDIF: Differential	**Yes**
PDIR: Direction comparison	---
PDIS: Distance	**Yes**
PDOP: Directional overpower	---
PDUP: Directional underpower	---
PFRC: Rate of change of frequency	---
PHAR: Harmonic restraint	---
PHIZ: Ground detector	---
PIOC: Instantaneous overcurrent	**Yes**
PMRI Motor restart inhibition	---
PMSS: Motor starting time supervision	---
POPF: Over power factor	---
PPAM: Phase angle measuring	---
PSCH: Protection scheme	---
PSDE: Sensitive directional earth fault	---
PTEF: Transient earth fault	---
PTOC: Time overcurrent	**Yes**
PTOF: Overfrequency	---
PTOV: Overvoltage	**Yes**
PTRC: Protection trip conditioning	**Yes**
PTTR: Thermal overload	**Yes**
PTUC: Undercurrent	---
PTUV: Undervoltage	**Yes**
PUPF: Underpower factor	---
PTUF: Underfrequency	---
PVOC: Voltage controlled time overcurrent	---
PVPH: Volts per Hz	---
PZSU: Zero speed or underspeed	---
R: LOGICAL NODES FOR PROTECTION RELATED FUNCTIONS	
RDRE: Disturbance recorder function	---
RADR: Disturbance recorder channel analogue	---
RBDR: Disturbance recorder channel binary	---
RDRS: Disturbance record handling	---
RBRF: Breaker failure	**Yes**
RDIR: Directional element	---
RFLO: Fault locator	**Yes**
RPSB: Power swing detection/blocking	**Yes**
RREC: Autoreclosing	**Yes**

NODES	UR-FAMILY
RSYN: Synchronism-check or synchronizing	---
C: LOGICAL NODES FOR CONTROL	
CALH: Alarm handling	---
CCGR: Cooling group control	---
CILO: Interlocking	---
CPOW: Point-on-wave switching	---
CSWI: Switch controller	---
G: LOGICAL NODES FOR GENERIC REFERENCES	
GAPC: Generic automatic process control	---
GGIO: Generic process I/O	Yes
GSAL: Generic security application	---
I: LOGICAL NODES FOR INTERFACING AND ARCHIVING	
IARC: Archiving	---
IHMI: Human machine interface	---
ITCI: Telecontrol interface	---
ITMI: Telemonitoring interface	---
A: LOGICAL NODES FOR AUTOMATIC CONTROL	
ANCR: Neutral current regulator	---
ARCO: Reactive power control	---
ATCC: Automatic tap changer controller	---
AVCO: Voltage control	---
M: LOGICAL NODES FOR METERING AND MEASUREMENT	
MDIF: Differential measurements	---
MHAI: Harmonics or interharmonics	---
MHAN: Non phase related harmonics or interharmonic	---
MMTR: Metering	---
MMXN: Non phase related measurement	**Yes**
MMXU: Measurement	**Yes**
MSQI: Sequence and imbalance	---
MSTA: Metering statistics	---
S: LOGICAL NODES FOR SENSORS AND MONITORING	
SARC: Monitoring and diagnostics for arcs	---
SIMG: Insulation medium supervision (gas)	---
SIML: Insulation medium supervision (liquid)	---
SPDC: Monitoring and diagnostics for partial discharges	---
X: LOGICAL NODES FOR SWITCHGEAR	
XCBR: Circuit breaker	**Yes**
XSWI: Circuit switch	---
T: LOGICAL NODES FOR INSTRUMENT TRANSFORMERS	
TCTR: Current transformer	---
TVTR: Voltage transformer	---

C

NODES	UR-FAMILY
Y: LOGICAL NODES FOR POWER TRANSFORMERS	
YEFN: Earth fault neutralizer (Peterson coil)	---
YLTC: Tap changer	---
YPSH: Power shunt	---
YPTR: Power transformer	---
Z: LOGICAL NODES FOR FURTHER POWER SYSTEM EQUIPMENT	
ZAXN: Auxiliary network	---
ZBAT: Battery	---
ZBSH: Bushing	---
ZCAB: Power cable	---
ZCAP: Capacitor bank	---
ZCON: Converter	---
ZGEN: Generator	---
ZGIL: Gas insulated line	---
ZLIN: Power overhead line	---
ZMOT: Motor	---
ZREA: Reactor	---
ZRRC: Rotating reactive component	---
ZSAR: Surge arrestor	---
ZTCF: Thyristor controlled frequency converter	---
ZTRC: Thyristor controlled reactive component	---

D.1.1 INTEROPERABILITY DOCUMENT

This document is adapted from the IEC 60870-5-104 standard. For ths section the boxes indicate the following: ☒ – used in standard direction; ❐ – not used; ■ – cannot be selected in IEC 60870-5-104 standard.

1. SYSTEM OR DEVICE:

❐ System Definition

❐ Controlling Station Definition (Master)

☒ **Controlled Station Definition (Slave)**

2. NETWORK CONFIGURATION:

■ ~~Point-to-Point~~ ■ ~~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~~
- ■ ~~Two Octets~~
- ☒ Three Octets
- ☒ Structured
- ☒ Unstructured

Cause of Transmission:

- ■ ~~One Octet~~
- ☒ Two Octets (with originator address). Originator address is set to zero if not used.

Maximum Length of APDU: 253 (the maximum length may be reduced by the system.

Selection of standard ASDUs:

For the following lists, the boxes indicate the following: ☒ – used in standard direction; ☐ – not used; ■ – cannot be selected in IEC 60870-5-104 standard.

Process information in monitor direction

☒	<1> := Single-point information	M_SP_NA_1
■	~~<2> := Single-point information with time tag~~	~~M_SP_TA_1~~
☐	<3> := Double-point information	M_DP_NA_1
■	~~<4> := Double-point information with time tag~~	~~M_DP_TA_1~~
☐	<5> := Step position information	M_ST_NA_1
■	~~<6> := Step position information with time tag~~	~~M_ST_TA_1~~
☐	<7> := Bitstring of 32 bits	M_BO_NA_1
■	~~<8> := Bitstring of 32 bits with time tag~~	~~M_BO_TA_1~~
☐	<9> := Measured value, normalized value	M_ME_NA_1
■	~~<10> := Measured value, normalized value with time tag~~	~~M_NE_TA_1~~
☐	<11> := Measured value, scaled value	M_ME_NB_1
■	~~<12> := Measured value, scaled value with time tag~~	~~M_NE_TB_1~~
☒	<13> := Measured value, short floating point value	M_ME_NC_1
■	~~<14> := Measured value, short floating point value with time tag~~	~~M_NE_TC_1~~
☒	<15> := Integrated totals	M_IT_NA_1
■	~~<16> := Integrated totals with time tag~~	~~M_IT_TA_1~~
■	~~<17> := Event of protection equipment with time tag~~	~~M_EP_TA_1~~
■	~~<18> := Packed start events of protection equipment with time tag~~	~~M_EP_TB_1~~
■	~~<19> := Packed output circuit information of protection equipment with time tag~~	~~M_EP_TC_1~~
☐	<20> := Packed single-point information with status change detection	M_SP_NA_1

☐	<21> := Measured value, normalized value without quantity descriptor	M_ME_ND_1
☒	<30> := Single-point information with time tag CP56Time2a	M_SP_TB_1
☐	<31> := Double-point information wiht time tag CP56Time2a	M_DP_TB_1
☐	<32> := Step position information with time tag CP56Time2a	M_ST_TB_1
☐	<33> := Bitstring of 32 bits with time tag CP56Time2a	M_BO_TB_1
☐	<34> := Measured value, normalized value with time tag CP56Time2a	M_ME_TD_1
☐	<35> := Measured value, scaled value with time tag CP56Time2a	M_ME_TE_1
☐	<36> := Measured value, short floating point value with time tag CP56Time2a	M_ME_TF_1
☒	<37> := Integrated totals with time tag CP56Time2a	M_IT_TB_1
☐	<38> := Event of protection equipment with time tag CP56Time2a	M_EP_TD_1
☐	<39> := Packed start events of protection equipment with time tag CP56Time2a	M_EP_TE_1
☐	<40> := Packed output circuit information of protection equipment with time tag CP56Time2a	M_EP_TF_1

Either the ASDUs of the set <2>, <4>, <6>, <8>, <10>, <12>, <14>, <16>, <17>, <18>, and <19> or of the set <30> to <40> are used.

Process information in control direction

☒	<45> := Single command	C_SC_NA_1
☐	<46> := Double command	C_DC_NA_1
☐	<47> := Regulating step command	C_RC_NA_1
☐	<48> := Set point command, normalized value	C_SE_NA_1
☐	<49> := Set point command, scaled value	C_SE_NB_1
☐	<50> := Set point command, short floating point value	C_SE_NC_1
☐	<51> := Bitstring of 32 bits	C_BO_NA_1
☒	<58> := Single command with time tag CP56Time2a	C_SC_TA_1
☐	<59> := Double command with time tag CP56Time2a	C_DC_TA_1
☐	<60> := Regulating step command with time tag CP56Time2a	C_RC_TA_1
☐	<61> := Set point command, normalized value with time tag CP56Time2a	C_SE_TA_1
☐	<62> := Set point command, scaled value with time tag CP56Time2a	C_SE_TB_1
☐	<63> := Set point command, short floating point value with time tag CP56Time2a	C_SE_TC_1
☐	<64> := Bitstring of 32 bits with time tag CP56Time2a	C_BO_TA_1

Either the ASDUs of the set <45> to <51> or of the set <58> to <64> are used.

System information in monitor direction

☒	<70> := End of initialization	M_EI_NA_1

System information in control direction

☒	<100> := Interrogation command	C_IC_NA_1
☒	<101> := Counter interrogation command	C_CI_NA_1
☒	<102> := Read command	C_RD_NA_1
☒	<103> := Clock synchronization command (see Clause 7.6 in standard)	C_CS_NA_1
■	~~<104> := Test command~~	~~C_TS_NA_1~~
☒	<105> := Reset process command	C_RP_NA_1
■	<106> := Delay acquisition command	C_CD_NA_1
☒	<107> := Test command with time tag CP56Time2a	C_TS_TA_1

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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

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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																		
		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
<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																			

D

TYPE IDENTIFICATION		CAUSE OF TRANSMISSION																		
		PERIODIC, CYCLIC	BACKGROUND SCAN	SPONTANEOUS	INITIALIZED	REQUEST OR REQUESTED	ACTIVATION	ACTIVATION CONFIRMATION	DEACTIVATION	DEACTIVATION CONFIRMATION	ACTIVATION TERMINATION	RETURN INFO CAUSED BY LOCAL CMD	FILE TRANSFER	INTERROGATED BY GROUP <NUMBER>	REQUEST BY GROUP <N> COUNTER REQ	UNKNOWN TYPE IDENTIFICATION	UNKNOWN CAUSE OF TRANSMISSION	UNKNOWN COMMON ADDRESS OF ADSU	UNKNOWN INFORMATION OBJECT ADDR	UNKNOWN INFORMATION OBJECT ADDR
NO.	MNEMONIC	1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<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*)																			

6. BASIC APPLICATION FUNCTIONS

Station Initialization:

☒ Remote initialization

Cyclic Data Transmission:

☒ Cyclic data transmission

Read Procedure:

☒ Read procedure

Spontaneous Transmission:

☒ Spontaneous transmission

Double transmission of information objects with cause of transmission spontaneous:

The following type identifications may be transmitted in succession caused by a single status change of an information object. The particular information object addresses for which double transmission is enabled are defined in a project-specific list.

☐ Single point information: M_SP_NA_1, M_SP_TA_1, M_SP_TB_1, and M_PS_NA_1

☐ Double point information: M_DP_NA_1, M_DP_TA_1, and M_DP_TB_1

☐ Step position information: M_ST_NA_1, M_ST_TA_1, and M_ST_TB_1

☐ Bitstring of 32 bits: M_BO_NA_1, M_BO_TA_1, and M_BO_TB_1 (if defined for a specific project)

☐ Measured value, normalized value: M_ME_NA_1, M_ME_TA_1, M_ME_ND_1, and M_ME_TD_1

☐ Measured value, scaled value: M_ME_NB_1, M_ME_TB_1, and M_ME_TE_1

☐ Measured value, short floating point number: M_ME_NC_1, M_ME_TC_1, and M_ME_TF_1

Station interrogation:

☒ Global

☒ Group 1	☒ Group 5	☒ Group 9	☒ Group 13
☒ Group 2	☒ Group 6	☒ Group 10	☒ Group 14
☒ Group 3	☒ Group 7	☒ Group 11	☒ Group 15
☒ Group 4	☒ Group 8	☒ Group 12	☒ Group 16

Clock synchronization:

☒ Clock synchronization (optional, see Clause 7.6)

Command transmission:

☒ Direct command transmission

☐ Direct setpoint command transmission

☒ Select and execute command

☐ Select and execute setpoint command

☒ C_SE ACTTERM used

☒ No additional definition

☒ Short pulse duration (duration determined by a system parameter in the outstation)

☒ Long pulse duration (duration determined by a system parameter in the outstation)

☒ Persistent output

☒ Supervision of maximum delay in command direction of commands and setpoint commands

Maximum allowable delay of commands and setpoint commands: **10 s**

Transmission of integrated totals:

- ☒ Mode A: Local freeze with spontaneous transmission
- ☒ Mode B: Local freeze with counter interrogation
- ☒ Mode C: Freeze and transmit by counter-interrogation commands
- ☒ Mode D: Freeze by counter-interrogation command, frozen values reported simultaneously

- ☒ Counter read
- ☒ Counter freeze without reset
- ☒ Counter freeze with reset
- ☒ Counter reset

- ☒ General request counter
- ☒ Request counter group 1
- ☒ Request counter group 2
- ☒ Request counter group 3
- ☒ Request counter group 4

Parameter loading:

- ☒ Threshold value
- ☐ Smoothing factor
- ☐ Low limit for transmission of measured values
- ☐ High limit for transmission of measured values

Parameter activation:

- ☐ Activation/deactivation of persistent cyclic or periodic transmission of the addressed object

Test procedure:

- ☐ Test procedure

File transfer:

File transfer in monitor direction:

- ☐ Transparent file
- ☐ Transmission of disturbance data of protection equipment
- ☐ Transmission of sequences of events
- ☐ Transmission of sequences of recorded analog values

File transfer in control direction:

- ☐ Transparent file

Background scan:

- ☐ Background scan

Acquisition of transmission delay:

- ■ ~~Acquisition of transmission delay~~

Definition of time outs:

PARAMETER	DEFAULT VALUE	REMARKS	SELECTED VALUE
t_0	30 s	Timeout of connection establishment	120 s
t_1	15 s	Timeout of send or test APDUs	15 s
t_2	10 s	Timeout for acknowlegements in case of no data messages $t_2 < t_1$	10 s
t_3	20 s	Timeout for sending test frames in case of a long idle state	20 s

Maximum range of values for all time outs: 1 to 255 s, accuracy 1 s

Maximum number of outstanding I-format APDUs *k* and latest acknowledge APDUs (*w*):

PARAMETER	DEFAULT VALUE	REMARKS	SELECTED VALUE
k	12 APDUs	Maximum difference receive sequence number to send state variable	12 APDUs
w	8 APDUs	Latest acknowledge after receiving w I-format APDUs	8 APDUs

Maximum range of values k: 1 to 32767 ($2^{15} - 1$) APDUs, accuracy 1 APDU

Maximum range of values w: 1 to 32767 APDUs, accuracy 1 APDU
Recommendation: w should not exceed two-thirds of k.

Portnumber:

PARAMETER	VALUE	REMARKS
Portnumber	2404	In all cases

RFC 2200 suite:

RFC 2200 is an official Internet Standard which describes the state of standardization of protocols used in the Internet as determined by the Internet Architecture Board (IAB). It offers a broad spectrum of actual standards used in the Internet. The suitable selection of documents from RFC 2200 defined in this standard for given projects has to be chosen by the user of this standard.

☒ Ethernet 802.3

❐ Serial X.21 interface

❐ Other selection(s) from RFC 2200 (list below if selected)

D

D.1.2 IEC 60870-5-104 POINT LIST

The IEC 60870-5-104 data points are configured through the **SETTINGS ⇨ PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ DNP / IEC104 POINT LISTS** menu. Refer to the *Communications* section of Chapter 5 for additional details.

D

E.1.1 DNP V3.00 DEVICE PROFILE

The following table provides a ‘Device Profile Document’ in the standard format defined in the DNP 3.0 Subset Definitions Document.

Table E–1: DNP V3.00 DEVICE PROFILE (Sheet 1 of 3)

(Also see the IMPLEMENTATION TABLE in the following section)	
Vendor Name: **General Electric Multilin**	
Device Name: **UR Series Relay**	
Highest DNP Level Supported: For Requests: **Level 2** For Responses: **Level 2**	**Device Function:** ☐ Master ☒ **Slave**
Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the attached table): **Binary Inputs (Object 1)** **Binary Input Changes (Object 2)** **Binary Outputs (Object 10)** **Binary Counters (Object 20)** **Frozen Counters (Object 21)** **Counter Change Event (Object 22)** **Frozen Counter Event (Object 23)** **Analog Inputs (Object 30)** **Analog Input Changes (Object 32)** **Analog Deadbands (Object 34)** **File Transfer (Object 70)**	
Maximum Data Link Frame Size (octets): Transmitted: **292** Received: **292**	**Maximum Application Fragment Size (octets):** Transmitted: **240** Received: **2048**
Maximum Data Link Re-tries: ☐ **None** ☒ Fixed at 2 ☐ Configurable	**Maximum Application Layer Re-tries:** ☒ None ☐ Configurable
Requires Data Link Layer Confirmation: ☒ Never ☐ Always ☐ Sometimes ☐ Configurable	

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Table E–1: DNP V3.00 DEVICE PROFILE (Sheet 2 of 3)

Requires Application Layer Confirmation:

- ☐ Never
- ☐ Always
- ☒ When reporting Event Data
- ☒ When sending multi-fragment responses
- ☐ Sometimes
- ☐ Configurable

Timeouts while waiting for:

Data Link Confirm:	☐ None	☒ **Fixed at 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 E–1: DNP V3.00 DEVICE PROFILE (Sheet 3 of 3)

Reports Binary Input Change Events when no specific variation requested: ❐ Never ☒ **Only time-tagged** ❐ Only non-time-tagged ❐ Configurable	**Reports time-tagged Binary Input Change Events when no specific variation requested:** ❐ Never ☒ Binary Input Change With Time ❐ Binary Input Change With Relative Time ❐ Configurable (attach explanation)
Sends Unsolicited Responses: ❐ **Never** ☒ Configurable ❐ Only certain objects ❐ Sometimes (attach explanation) ☒ ENABLE/DISABLE unsolicited Function codes supported	**Sends Static Data in Unsolicited Responses:** ☒ Never ❐ When Device Restarts ❐ When Status Flags Change No other options are permitted.
Default Counter Object/Variation: ❐ No Counters Reported ❐ Configurable (attach explanation) ☒ **Default Object: 20** **Default Variation: 1** ☒ **Point-by-point list attached**	**Counters Roll Over at:** ❐ No Counters Reported ❐ Configurable (attach explanation) ☒ **16 Bits (Counter 8)** ☒ **32 Bits (Counters 0 to 7, 9)** ❐ Other Value: _____ ☒ **Point-by-point list attached**
Sends Multi-Fragment Responses: ☒ **Yes** ❐ No	

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E.1.2 IMPLEMENTATION TABLE

The following table identifies the variations, function codes, and qualifiers supported by the F60 in both request messages and in response messages. For static (non-change-event) objects, requests sent with qualifiers 00, 01, 06, 07, or 08, will be responded with qualifiers 00 or 01. Static object requests sent with qualifiers 17 or 28 will be responded with qualifiers 17 or 28. For change-event objects, qualifiers 17 or 28 are always responded.

Table E–2: IMPLEMENTATION TABLE (Sheet 1 of 4)

OBJECT			REQUEST		RESPONSE	
OBJECT NO.	VARIATION NO.	DESCRIPTION	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)
1	0	Binary Input (Variation 0 is used to request default variation)	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)		
	1	Binary Input	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
	2	Binary Input with Status	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
2	0	Binary Input Change (Variation 0 is used to request default variation)	1 (read)	06 (no range, or all) 07, 08 (limited quantity)		
	1	Binary Input Change without Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	2	Binary Input Change with Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response 130 (unsol. resp.)	17, 28 (index)
	3 (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 F60 is not restarted, but the DNP process is restarted.

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Table E–2: IMPLEMENTATION TABLE (Sheet 2 of 4)

OBJECT			REQUEST		RESPONSE	
OBJECT NO.	VARIATION NO.	DESCRIPTION	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)
20 cont'd	2	16-Bit Binary Counter	1 (read) 7 (freeze) 8 (freeze noack) 9 (freeze clear) 10 (frz. cl. noack) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
	5	32-Bit Binary Counter without Flag	1 (read) 7 (freeze) 8 (freeze noack) 9 (freeze clear) 10 (frz. cl. noack) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
	6	16-Bit Binary Counter without Flag	1 (read) 7 (freeze) 8 (freeze noack) 9 (freeze clear) 10 (frz. cl. noack) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
21	0	Frozen Counter (Variation 0 is used to request default variation)	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)		
	1	32-Bit Frozen Counter	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
	2	16-Bit Frozen Counter	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
	9	32-Bit Frozen Counter without Flag	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
	10	16-Bit Frozen Counter without Flag	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
22	0	Counter Change Event (Variation 0 is used to request default variation)	1 (read)	06 (no range, or all) 07, 08 (limited quantity)		
	1	32-Bit Counter Change Event	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	2	16-Bit Counter Change Event	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	5	32-Bit Counter Change Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	6	16-Bit Counter Change Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
23	0	Frozen Counter Event (Variation 0 is used to request default variation)	1 (read)	06 (no range, or all) 07, 08 (limited quantity)		
	1	32-Bit Frozen Counter Event	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	2	16-Bit Frozen Counter Event	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)

Note 1: A default variation refers to the variation responded when variation 0 is requested and/or in class 0, 1, 2, or 3 scans. The default variations for object types 1, 2, 20, 21, 22, 23, 30, and 32 are selected via relay settings. Refer to the *Communications* section in Chapter 5 for details. This optimizes the class 0 poll data size.

Note 2: For static (non-change-event) objects, qualifiers 17 or 28 are only responded when a request is sent with qualifiers 17 or 28, respectively. Otherwise, static object requests sent with qualifiers 00, 01, 06, 07, or 08, will be responded with qualifiers 00 or 01 (for change-event objects, qualifiers 17 or 28 are always responded.)

Note 3: Cold restarts are implemented the same as warm restarts – the F60 is not restarted, but the DNP process is restarted.

Table E–2: IMPLEMENTATION TABLE (Sheet 3 of 4)

OBJECT			REQUEST		RESPONSE	
OBJECT NO.	VARIATION NO.	DESCRIPTION	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)
23 cont'd	5	32-Bit Frozen Counter Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	6	16-Bit Frozen Counter Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
30	0	Analog Input (Variation 0 is used to request default variation)	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)		
	1	32-Bit Analog Input	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
	2	16-Bit Analog Input	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
	3	32-Bit Analog Input without Flag	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
	4	16-Bit Analog Input without Flag	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
	5	short floating point	1 (read) 22 (assign class)	00, 01 (start-stop) 06(no range, or all) 07, 08(limited quantity) 17, 28(index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
32	0	Analog Change Event (Variation 0 is used to request default variation)	1 (read)	06 (no range, or all) 07, 08 (limited quantity)		
	1	32-Bit Analog Change Event without Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	2	16-Bit Analog Change Event without Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	3	32-Bit Analog Change Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	4	16-Bit Analog Change Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	5	short floating point Analog Change Event without Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
	7	short floating point Analog Change Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	17, 28 (index)
34	0	Analog Input Reporting Deadband (Variation 0 is used to request default variation)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)		
	1	16-bit Analog Input Reporting Deadband (default – see Note 1)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
			2 (write)	00, 01 (start-stop) 07, 08 (limited quantity) 17, 28 (index)		

Note 1: A default variation refers to the variation responded when variation 0 is requested and/or in class 0, 1, 2, or 3 scans. The default variations for object types 1, 2, 20, 21, 22, 23, 30, and 32 are selected via relay settings. Refer to the *Communications* section in Chapter 5 for details. This optimizes the class 0 poll data size.

Note 2: For static (non-change-event) objects, qualifiers 17 or 28 are only responded when a request is sent with qualifiers 17 or 28, respectively. Otherwise, static object requests sent with qualifiers 00, 01, 06, 07, or 08, will be responded with qualifiers 00 or 01 (for change-event objects, qualifiers 17 or 28 are always responded.)

Note 3: Cold restarts are implemented the same as warm restarts – the F60 is not restarted, but the DNP process is restarted.

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Table E–2: IMPLEMENTATION TABLE (Sheet 4 of 4)

OBJECT			REQUEST		RESPONSE	
OBJECT NO.	VARIATION NO.	DESCRIPTION	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)
34 cont'd	2	32-bit Analog Input Reporting Deadband	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
			2 (write)	00, 01 (start-stop) 07, 08 (limited quantity) 17, 28 (index)		
	3	Short floating point Analog Input Reporting Deadband	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
50	1	Time and Date (default – see Note 1)	1 (read) 2 (write)	00, 01 (start-stop) 06 (no range, or all) 07 (limited qty=1) 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) *(see Note 2)*
52	2	Time Delay Fine			129 (response)	07 (limited quantity) (quantity = 1)
60	0	Class 0, 1, 2, and 3 Data	1 (read) 20 (enable unsol) 21 (disable unsol) 22 (assign class)	06 (no range, or all)		
	1	Class 0 Data	1 (read) 22 (assign class)	06 (no range, or all)		
	2	Class 1 Data	1 (read) 20 (enable unsol) 21 (disable unsol) 22 (assign class)	06 (no range, or all) 07, 08 (limited quantity)		
	3	Class 2 Data				
	4	Class 3 Data				
70	1	File identifier	2 (write)	1b (free format)	129 (response)	1b (free format)
	3	File command	25 (open) 27 (delete)	5b (free format)		
	4	File command status	1 (read) 22 (assign class) 26 (close) 30 (abort)	06 (no range, or all) 07, 08 (limited quantity) 5b (free format)	129 (response) 130 (unsol. resp.)	5b (free format)
	5	File transfer	1 (read) 2 (write) 22 (assign class)	06 (no range, or all) 07, 08 (limited quantity) 5b (free format)	129 (response) 130 (unsol. resp.)	5b (free format)
	6	File transfer status	1 (read) 22 (assign class)	06 (no range, or all) 07, 08 (limited quantity)	129 (response) 130 (unsol. resp.)	5b (free format)
	7	File descriptor	1 (read) 22 (assign class) 28 (get file info.)	06 (no range, or all) 07, 08 (limited quantity) 5b (free format)	129 (response) 130 (unsol. resp.)	5b (free format)
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 F60 is not restarted, but the DNP process is restarted.

E.2.1 BINARY INPUT POINTS

The DNP binary input data points are configured through the **PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ DNP / IEC104 POINT LISTS ⇨ BINARY INPUT / MSP POINTS** menu. Refer to the *Communications* section of Chapter 5 for additional details. When a freeze function is performed on a binary counter point, the frozen value is available in the corresponding frozen counter point.

BINARY INPUT POINTS

Static (Steady-State) Object Number: **1**

Change Event Object Number: **2**

Request Function Codes supported: **1 (read), 22 (assign class)**

Static Variation reported when variation 0 requested: **2 (Binary Input with status)**

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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E.2.2 BINARY AND CONTROL RELAY OUTPUT

Supported Control Relay Output Block fields: Pulse On, Pulse Off, Latch On, Latch Off, Paired Trip, Paired Close.

BINARY OUTPUT STATUS POINTS
Object Number: **10**
Request Function Codes supported: **1 (read)**
Default Variation reported when Variation 0 requested: **2 (Binary Output Status)**
CONTROL RELAY OUTPUT BLOCKS
Object Number: **12**
Request Function Codes supported: **3 (select), 4 (operate), 5 (direct operate), 6 (direct operate, noack)**

Table E–3: BINARY/CONTROL OUTPUTS

POINT	NAME/DESCRIPTION
0	Virtual Input 1
1	Virtual Input 2
2	Virtual Input 3
3	Virtual Input 4
4	Virtual Input 5
5	Virtual Input 6
6	Virtual Input 7
7	Virtual Input 8
8	Virtual Input 9
9	Virtual Input 10
10	Virtual Input 11
11	Virtual Input 12
12	Virtual Input 13
13	Virtual Input 14
14	Virtual Input 15
15	Virtual Input 16
16	Virtual Input 17
17	Virtual Input 18
18	Virtual Input 19
19	Virtual Input 20
20	Virtual Input 21
21	Virtual Input 22
22	Virtual Input 23
23	Virtual Input 24
24	Virtual Input 25
25	Virtual Input 26
26	Virtual Input 27
27	Virtual Input 28
28	Virtual Input 29
29	Virtual Input 30
30	Virtual Input 31
31	Virtual Input 32

Table E–3: BINARY/CONTROL OUTPUTS

POINT	NAME/DESCRIPTION
32	Virtual Input 33
33	Virtual Input 34
34	Virtual Input 35
35	Virtual Input 36
36	Virtual Input 37
37	Virtual Input 38
38	Virtual Input 39
39	Virtual Input 40
40	Virtual Input 41
41	Virtual Input 42
42	Virtual Input 43
43	Virtual Input 44
44	Virtual Input 45
45	Virtual Input 46
46	Virtual Input 47
47	Virtual Input 48
48	Virtual Input 49
49	Virtual Input 50
50	Virtual Input 51
51	Virtual Input 52
52	Virtual Input 53
53	Virtual Input 54
54	Virtual Input 55
55	Virtual Input 56
56	Virtual Input 57
57	Virtual Input 58
58	Virtual Input 59
59	Virtual Input 60
60	Virtual Input 61
61	Virtual Input 62
62	Virtual Input 63
63	Virtual Input 64

E.2.3 COUNTERS

The following table lists both Binary Counters (Object 20) and Frozen Counters (Object 21). When a freeze function is performed on a Binary Counter point, the frozen value is available in the corresponding Frozen Counter point.

BINARY COUNTERS

Static (Steady-State) Object Number: **20**

Change Event Object Number: **22**

Request Function Codes supported: **1 (read), 7 (freeze), 8 (freeze noack), 9 (freeze and clear), 10 (freeze and clear, noack), 22 (assign class)**

Static Variation reported when variation 0 requested: **1 (32-Bit Binary Counter with Flag)**

Change Event Variation reported when variation 0 requested: **1 (32-Bit Counter Change Event without time)**

Change Event Buffer Size: **10**

Default Class for all points: **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 E–4: BINARY AND FROZEN COUNTERS

POINT INDEX	NAME/DESCRIPTION
0	Digital Counter 1
1	Digital Counter 2
2	Digital Counter 3
3	Digital Counter 4
4	Digital Counter 5
5	Digital Counter 6
6	Digital Counter 7
7	Digital Counter 8
8	Oscillography Trigger Count
9	Events Since Last Clear

A counter freeze command has no meaning for counters 8 and 9. F60 Digital Counter values are represented as 32-bit integers. The DNP 3.0 protocol defines counters to be unsigned integers. Care should be taken when interpreting negative counter values.

E.2.4 ANALOG INPUTS

The DNP analog input data points are configured through the **PRODUCT SETUP ⇨⇩ COMMUNICATIONS ⇨⇩ DNP / IEC104 POINT LISTS ⇨ ANALOG INPUT / MME POINTS** menu. Refer to the *Communications* section of Chapter 5 for additional details.

It is important to note that 16-bit and 32-bit variations of analog inputs are transmitted through DNP as signed numbers. Even for analog input points that are not valid as negative values, the maximum positive representation is 32767 for 16-bit values and 2147483647 for 32-bit values. This is a DNP requirement.

The deadbands for all Analog Input points are in the same units as the Analog Input quantity. For example, an Analog Input quantity measured in volts has a corresponding deadband in units of volts. This is in conformance with DNP Technical Bulletin 9809-001: Analog Input Reporting Deadband. Relay settings are available to set default deadband values according to data type. Deadbands for individual Analog Input Points can be set using DNP Object 34.

Static (Steady-State) Object Number: **30**

Change Event Object Number: **32**

Request Function Codes supported: **1 (read), 2 (write, deadbands only), 22 (assign class)**

Static Variation reported when variation 0 requested: **1 (32-Bit Analog Input)**

Change Event Variation reported when variation 0 requested: **1 (Analog Change Event without Time)**

Change Event Scan Rate: defaults to **500 ms**

Change Event Buffer Size: **800**

Default Class for all Points: **1**

F.1.1 REVISION HISTORY

MANUAL P/N	F60 REVISION	RELEASE DATE	ECO
1601-0093-A1	1.5x	23 March 1999	N/A
1601-0093-A2	1.6x	10 August 1999	URF-012
1601-0093-A3	1.8x	29 October 1999	URF-014
1601-0093-A4	1.8x	15 November 1999	URF-015
1601-0093-A5	2.0x	17 December 1999	URF-016
1601-0093-A6	2.2x	12 May 2000	URF-017
1601-0093-A7	2.2x	14 June 2000	URF-020
1601-0093-A7a	2.2x	28 June 2000	URF-020a
1601-0093-B1	2.4x	08 September 2000	URF-022
1601-0093-B2	2.4x	03 November 2000	URF-024
1601-0093-B3	2.6x	09 March 2001	URF-025
1601-0093-B4	2.8x	28 September 2001	URF-027
1601-0093-B5	2.9x	03 December 2001	URF-030
1601-0093-B6	2.6x	27 February 2004	URX-120
1601-0093-C1	3.0x	02 July 2002	URF-032
1601-0093-C2	3.1x	30 August 2002	URF-034
1601-0093-C3	3.0x	18 November 2002	URF-036
1601-0093-C4	3.1x	18 November 2002	URF-038
1601-0093-C5	3.0x	11 February 2003	URF-040
1601-0093-C6	3.1x	11 February 2003	URF-042
1601-0093-D1	3.2x	11 February 2003	URF-044
1601-0093-D2	3.2x	02 June 2003	URX-084
1601-0093-E1	3.3x	01 May 2003	URX-080
1601-0093-E2	3.3x	29 May 2003	URX-083
1601-0093-F1	3.4x	10 December 2003	URX-111
1601-0093-F2	3.4x	09 February 2004	URX-115
1601-0093-G1	4.0x	23 March 2004	URX-123
1601-0093-G2	4.0x	17 May 2004	URX-136
1601-0093-H1	4.2x	30 June 2004	URX-145
1601-0093-H2	4.2x	23 July 2004	URX-151
1601-0093-J1	4.4x	15 September 2004	URX-156
1601-0093-K1	4.6x	15 February 2005	URX-176
1601-0093-L1	4.8x	05 August 2005	URX-202
1601-0093-M1	4.9x	15 December 2005	URX-208
1601-0093-M2	4.9x	27 February 2006	URX-214

F.1.2 CHANGES TO THE F60 MANUAL

Table F–1: MAJOR UPDATES FOR F60 MANUAL REVISION M2

PAGE (M1)	PAGE (M2)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0093-M2
3-30	3-30	Update	Updated RS422 INTERFACE section
4-14	4-14	Update	Updated INVALID PASSWORD ENTRY sub-section
5-8	5-8	Update	Updated PASSWORD SECURITY section

Table F–2: MAJOR UPDATES FOR F60 MANUAL REVISION M1

PAGE (L1)	PAGE (M1)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0093-M1
2-2	2-2	Update	Updated ORDERING section
4-4	4-4	Update	Updated FACEPLATE section
5-17	5-18	Update	Updated IEC 61850 PROTOCOL sub-section
5-120	5-120	Update	Updated NEUTRAL OVERVOLTAGE sub-section
B-8	B-8	Update	Updated MODBUS MEMORY MAP for revision 4.9x

Table F–3: MAJOR UPDATES FOR F60 MANUAL REVISION L1 (Sheet 1 of 2)

PAGE (K1)	PAGE (L1)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0093-L1
2-3	2-3	Update	Updated F60 ORDER CODES table
2-4	2-4	Update	Updated ORDER CODES FOR REPLACEMENT MODULES table
2-10	2-10	Update	Updated INPUTS specifications section
2-12	2-12	Update	Updated COMMUNICATIONS specifications section
3-9	3-9	Update	Updated CONTROL POWER section
3-12	3-12	Update	Updated CONTACT INPUTS/OUTPUTS section
3-20	3-20	Update	Updated CPU COMMUNICATIONS PORTS section
3-21	3-22	Update	Updated RS485 SERIAL CONNECTION diagram
3-26	3-27	Update	Updated G.703 INTERFACE section
3-31	3-32	Update	Updated RS422 AND FIBER INTERFACE CONNECTION drawing
---	3-35	Add	Added C37.94SM INTERFACE section
---	4-14	Add	Added INVALID PASSWORD ENTRY section
5-14	5-14	Update	Updated DNP PROTOCOL sub-section
---	5-16	Add	Added DNP / IEC 60870-5-104 POINT LISTS sub-section
5-16	5-17	Update	Updated IEC 61850 PROTOCOL sub-section
5-19	5-20	Update	Updated IEC 60870-5-104 PROTOCOL sub-section
5-26	5-27	Update	Updated DATA LOGGER section
---	5-44	Add	Added TELEPROTECTION section
5-49	5-52	Update	Updated DUAL BREAKER CONTROL LOGIC diagram to 827061AN
5-59	5-62	Update	Updated FLEXLOGIC™ OPERANDS table

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Table F–3: MAJOR UPDATES FOR F60 MANUAL REVISION L1 (Sheet 2 of 2)

PAGE (K1)	PAGE (L1)	CHANGE	DESCRIPTION
5-105	5-108	Update	Updated BREAKER FAILURE section
5-124	5-127	Update	Updated SETTING GROUPS section
5-125	5-128	Update	Updated SELECTOR SWITCH section
5-138	5-142	Update	Updated AUTORECLOSE section
5-157	5-161	Update	Updated BREAKER FLASHOVER sub-section
5-160	5-164	Update	Updated VT FUSE FAILURE sub-section
5-170	5-174	Update	Updated REMOTE INPUTS section
5-172	5-176	Update	Updated DIRECT INPUTS/OUTPUTS section
---	5-180	Add	Added TELEPROTECTION INPUTS/OUTPUTS section
---	6-4	Add	Added TELEPROTECTION INPUTS section
---	6-9	Add	Added TELEPROTECTION CHANNEL TESTS section
B-8	B-8	Update	Updated MODBUS MEMORY MAP for release 4.8x
D-9	D-9	Update	Updated IEC 60870-5-104 POINT LIST sub-section
E-8	E-8	Update	Updated BINARY INPUT POINTS section
E-14	E-9	Update	Updated BINARY AND CONTROL RELAY OUTPUT POINTS section
E-16	E-11	Update	Updated ANALOG INPUTS section

Table F–4: MAJOR UPDATES FOR F60 MANUAL REVISION K1

PAGE (J1)	PAGE (K1)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0093-K1
2-3	2-3	Update	Updated F60 ORDER CODES table
3-6	3-6	Update	Updated TYPICAL WIRING DIAGRAM to 832769A3
3-21	3-21	Update	Updated RS485 SERIAL CONNECTION diagram to 827757A7
5-9	5-9	Update	Updated DISPLAY PROPERTIES section
5-14	5-14	Update	Updated DNP PROTOCOL sub-section
5-16	5-16	Update	Updated IEC 61850 PROTOCOL sub-section
5-143	5-144	Update	Updated DIGITAL ELEMENTS section
5-165	5-165	Update	The LATCHING OUTPUTS section is now a sub-section of the CONTACT OUTPUTS
5-168	5-169	Update	Updated REMOTE DEVICES section
5-170	5-171	Update	Updated REMOTE OUTPUTS section
B-8	B-8	Update	Updated MODBUS MEMORY MAP for firmware release 4.6x
---	C-1	Add	Added IEC 61850 appendix
D-4	E-4	Update	Updated DNP IMPLEMENTATION section

F.2.1 STANDARD ABBREVIATIONS

A.................... Ampere
AC .... Alternating Current
A/D .... Analog to Digital
AE .... Accidental Energization, Application Entity
AMP .... Ampere
ANG .... Angle
ANSI............... American National Standards Institute
AR .... Automatic Reclosure
ASDU .... Application-layer Service Data Unit
ASYM .... Asymmetry
AUTO .... Automatic
AUX................ Auxiliary
AVG................ Average

BER................ Bit Error Rate
BF................... Breaker Fail
BFI.................. Breaker Failure Initiate
BKR................ Breaker
BLK .... Block
BLKG.............. Blocking
BPNT.............. Breakpoint of a characteristic
BRKR .... Breaker

CAP................ Capacitor
CC.................. Coupling Capacitor
CCVT .... Coupling Capacitor Voltage Transformer
CFG............... Configure / Configurable
.CFG............... Filename extension for oscillography files
CHK................ Check
CHNL .... Channel
CLS .... Close
CLSD.............. Closed
CMND .... Command
CMPRSN........ Comparison
CO.................. Contact Output
COM............... Communication
COMM............ Communications
COMP .... Compensated, Comparison
CONN............. Connection
CONT............. Continuous, Contact
CO-ORD......... Coordination
CPU................ Central Processing Unit
CRC .... Cyclic Redundancy Code
CRT, CRNT .... Current
CSA................ Canadian Standards Association
CT .... Current Transformer
CVT .... Capacitive Voltage Transformer

D/A .... Digital to Analog
DC (dc)........... Direct Current
DD .... Disturbance Detector
DFLT .... Default
DGNST........... Diagnostics
DI.................... Digital Input
DIFF .... Differential
DIR .... Directional
DISCREP .... Discrepancy
DIST .... Distance
DMD .... Demand
DNP................ Distributed Network Protocol
DPO .... Dropout
DSP................ Digital Signal Processor
dt .... Rate of Change
DTT .... Direct Transfer Trip
DUTT.............. Direct Under-reaching Transfer Trip

ENCRMNT ..... Encroachment
EPRI............... Electric Power Research Institute
.EVT .... Filename extension for event recorder files
EXT .... Extension, External

F..................... Field
FAIL................ Failure
FD .... Fault Detector
FDH................ Fault Detector high-set
FDL .... Fault Detector low-set
FLA................. Full Load Current
FO .... Fiber Optic

FREQ............. Frequency
FSK................ Frequency-Shift Keying
FTP .... File Transfer Protocol
FxE .... FlexElement™
FWD.............. Forward

G .... Generator
GE.................. General Electric
GND............... Ground
GNTR............. Generator
GOOSE.......... General Object Oriented Substation Event
GPS .... Global Positioning System

HARM .... Harmonic / Harmonics
HCT .... High Current Time
HGF .... High-Impedance Ground Fault (CT)
HIZ .... High-Impedance and Arcing Ground
HMI .... Human-Machine Interface
HTTP .... Hyper Text Transfer Protocol
HYB .... Hybrid

I...................... Instantaneous
I_0.................. Zero Sequence current
I_1.................. Positive Sequence current
I_2.................. Negative Sequence current
IA .... Phase A current
IAB .... Phase A minus B current
IB .... Phase B current
IBC................. Phase B minus C current
IC .... Phase C current
ICA................. Phase C minus A current
ID .... Identification
IED................. Intelligent Electronic Device
IEC................. International Electrotechnical Commission
IEEE............... Institute of Electrical and Electronic Engineers
IG .... Ground (not residual) current
Igd .... Differential Ground current
IN .... CT Residual Current (3Io) or Input
INC SEQ .... Incomplete Sequence
INIT .... Initiate
INST............... Instantaneous
INV................. Inverse
I/O .... Input/Output
IOC .... Instantaneous Overcurrent
IOV................. Instantaneous Overvoltage
IRIG .... Inter-Range Instrumentation Group
ISO................. International Standards Organization
IUV................. Instantaneous Undervoltage

K0 .... Zero Sequence Current Compensation
kA................... kiloAmpere
kV................... kiloVolt

LED................ Light Emitting Diode
LEO................ Line End Open
LFT BLD .... Left Blinder
LOOP............. Loopback
LPU................ Line Pickup
LRA................ Locked-Rotor Current
LTC .... Load Tap-Changer

M.................... Machine
mA .... MilliAmpere
MAG............... Magnitude
MAN............... Manual / Manually
MAX .... Maximum
MIC .... Model Implementation Conformance
MIN .... Minimum, Minutes
MMI................ Man Machine Interface
MMS .... Manufacturing Message Specification
MRT .... Minimum Response Time
MSG............... Message
MTA................ Maximum Torque Angle
MTR .... Motor
MVA .... MegaVolt-Ampere (total 3-phase)
MVA_A........... MegaVolt-Ampere (phase A)
MVA_B........... MegaVolt-Ampere (phase B)
MVA_C........... MegaVolt-Ampere (phase C)

MVAR .... MegaVar (total 3-phase)
MVAR_A......... MegaVar (phase A)
MVAR_B......... MegaVar (phase B)
MVAR_C .... MegaVar (phase C)
MVARH .... MegaVar-Hour
MW................. MegaWatt (total 3-phase)
MW_A .... MegaWatt (phase A)
MW_B .... MegaWatt (phase B)
MW_C .... MegaWatt (phase C)
MWH .... MegaWatt-Hour

N..................... Neutral
N/A, n/a .... Not Applicable
NEG .... Negative
NMPLT .... Nameplate
NOM............... Nominal
NSAP .... Network Service Access Protocol
NTR................ Neutral

O .... Over
OC, O/C .... Overcurrent
O/P, Op........... Output
OP .... Operate
OPER .... Operate
OPERATG...... Operating
O/S .... Operating System
OSI .... Open Systems Interconnect
OSB................ Out-of-Step Blocking
OUT................ Output
OV .... Overvoltage
OVERFREQ ... Overfrequency
OVLD .... Overload

P..................... Phase
PC .... Phase Comparison, Personal Computer
PCNT .... Percent
PF................... Power Factor (total 3-phase)
PF_A .... Power Factor (phase A)
PF_B .... Power Factor (phase B)
PF_C .... Power Factor (phase C)
PFLL............... Phase and Frequency Lock Loop
PHS................ Phase
PICS............... Protocol Implementation & Conformance Statement
PKP .... Pickup
PLC .... Power Line Carrier
POS................ Positive
POTT.............. Permissive Over-reaching Transfer Trip
PRESS........... Pressure
PRI .... Primary
PROT .... Protection
PSEL.............. Presentation Selector
pu .... Per Unit
PUIB............... Pickup Current Block
PUIT .... Pickup Current Trip
PUSHBTN ...... Pushbutton
PUTT.............. Permissive Under-reaching Transfer Trip
PWM .... Pulse Width Modulated
PWR............... Power

QUAD............. Quadrilateral

R..................... Rate, Reverse
RCA................ Reach Characteristic Angle
REF .... Reference
REM .... Remote
REV................ Reverse
RI.................... Reclose Initiate
RIP .... Reclose In Progress
RGT BLD........ Right Blinder
ROD .... Remote Open Detector
RST .... Reset
RSTR .... Restrained
RTD................ Resistance Temperature Detector
RTU................ Remote Terminal Unit
RX (Rx) .... Receive, Receiver

s .... second
S..................... Sensitive

SAT ....CT Saturation
SBO ....Select Before Operate
SCADA ....Supervisory Control and Data Acquisition
SEC ....Secondary
SEL ....Select / Selector / Selection
SENS ....Sensitive
SEQ ....Sequence
SIR..................Source Impedance Ratio
SNTP ....Simple Network Time Protocol
SRC ....Source
SSB.................Single Side Band
SSEL...............Session Selector
STATS.............Statistics
SUPN..............Supervision
SUPV ....Supervise / Supervision
SV ....Supervision, Service
SYNC..............Synchrocheck
SYNCHCHK....Synchrocheck

T......................Time, transformer
TC ....Thermal Capacity
TCP.................Transmission Control Protocol
TCU ....Thermal Capacity Used
TD MULT ....Time Dial Multiplier
TEMP..............Temperature
TFTP...............Trivial File Transfer Protocol
THD ....Total Harmonic Distortion
TMR ....Timer
TOC ....Time Overcurrent
TOV ....Time Overvoltage
TRANS............Transient
TRANSF ....Transfer
TSEL...............Transport Selector
TUC ....Time Undercurrent
TUV.................Time Undervoltage
TX (Tx)............Transmit, Transmitter

U ....Under
UC...................Undercurrent
UCA ....Utility Communications Architecture
UDP ....User Datagram Protocol
UL ....Underwriters Laboratories
UNBAL............Unbalance
UR...................Universal Relay
URC................Universal Recloser Control
.URS ....Filename extension for settings files
UV...................Undervoltage

V/Hz ....Volts per Hertz
V_0 ....Zero Sequence voltage
V_1 ....Positive Sequence voltage
V_2 ....Negative Sequence voltage
VA ....Phase A voltage
VAB.................Phase A to B voltage
VAG ....Phase A to Ground voltage
VARH ....Var-hour voltage
VB ....Phase B voltage
VBA.................Phase B to A voltage
VBG ....Phase B to Ground voltage
VC...................Phase C voltage
VCA ....Phase C to A voltage
VCG ....Phase C to Ground voltage
VF ....Variable Frequency
VIBR ....Vibration
VT ....Voltage Transformer
VTFF...............Voltage Transformer Fuse Failure
VTLOS............Voltage Transformer Loss Of Signal

WDG...............Winding
WH..................Watt-hour
w/ opt ....With Option
WRT................With Respect To

X ....Reactance
XDUCER.........Transducer
XFMR..............Transformer

Z......................Impedance, Zone

F

F.3.1 GE MULTILIN WARRANTY

GE MULTILIN RELAY WARRANTY

General Electric Multilin Inc. (GE Multilin) warrants each relay it manufactures to be free from defects in material and workmanship under normal use and service for a period of 24 months from date of shipment from factory.

In the event of a failure covered by warranty, GE Multilin will undertake to repair or replace the relay providing the warrantor determined that it is defective and it is returned with all transportation charges prepaid to an authorized service centre or the factory. Repairs or replacement under warranty will be made without charge.

Warranty shall not apply to any relay which has been subject to misuse, negligence, accident, incorrect installation or use not in accordance with instructions nor any unit that has been altered outside a GE Multilin authorized factory outlet.

GE Multilin is not liable for special, indirect or consequential damages or for loss of profit or for expenses sustained as a result of a relay malfunction, incorrect application or adjustment.

For complete text of Warranty (including limitations and disclaimers), refer to GE Multilin Standard Conditions of Sale.

Numerics

A

B

C

D

E

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H

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K

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M

N

O

P

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S

T

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