



GE Industrial Systems

F60 Feeder Management Relay

UR Series Instruction Manual

F60 Revision: 3.3x

Manual P/N: 1601-0093-**E2** (GEK-106410A)

Copyright © 2003 GE Multilin



GE Multilin

215 Anderson Avenue, Markham, Ontario
Canada L6E 1B3

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

Internet: <http://www.GEindustrial.com/multilin>



Manufactured under an
ISO9000 Registered system.



ADDENDUM

This Addendum contains information that relates to the F60 Feeder Management Relay relay, version 3.3x. This addendum lists a number of information items that appear in the instruction manual GEK-106410A (revision **E2**) 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



The UCA2 specifications are not yet finalized. There will be changes to the object models described in Appendix C: UCA/MMS Protocol.

GE Multilin

215 Anderson Avenue, Markham, Ontario

Canada L6E 1B3

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

Internet: <http://www.GEindustrial.com/multilin>

TABLE OF CONTENTS

1. GETTING STARTED

1.1 IMPORTANT PROCEDURES

1.1.1	CAUTIONS AND WARNINGS	1-1
1.1.2	INSPECTION CHECKLIST	1-1

1.2 UR OVERVIEW

1.2.1	INTRODUCTION TO THE UR	1-2
1.2.2	HARDWARE ARCHITECTURE	1-3
1.2.3	SOFTWARE ARCHITECTURE	1-4
1.2.4	IMPORTANT CONCEPTS	1-4

1.3 URPC® SOFTWARE

1.3.1	PC REQUIREMENTS	1-5
1.3.2	INSTALLATION	1-5
1.3.3	CONNECTING URPC® WITH THE F60	1-6

1.4 UR HARDWARE

1.4.1	MOUNTING AND WIRING	1-8
1.4.2	COMMUNICATIONS	1-8
1.4.3	FACEPLATE DISPLAY	1-8

1.5 USING THE RELAY

1.5.1	FACEPLATE KEYPAD	1-9
1.5.2	MENU NAVIGATION	1-9
1.5.3	MENU HIERARCHY	1-9
1.5.4	RELAY ACTIVATION	1-10
1.5.5	BATTERY TAB	1-10
1.5.6	RELAY PASSWORDS	1-10
1.5.7	FLEXLOGIC™ CUSTOMIZATION	1-10
1.5.8	COMMISSIONING	1-10

2. PRODUCT DESCRIPTION

2.1 INTRODUCTION

2.1.1	OVERVIEW	2-1
2.1.2	ORDERING	2-3

2.2 SPECIFICATIONS

2.2.1	PROTECTION ELEMENTS	2-5
2.2.2	USER-PROGRAMMABLE ELEMENTS	2-8
2.2.3	MONITORING	2-9
2.2.4	METERING	2-9
2.2.5	INPUTS	2-10
2.2.6	POWER SUPPLY	2-11
2.2.7	OUTPUTS	2-11
2.2.8	COMMUNICATIONS	2-12
2.2.9	INTER-RELAY COMMUNICATIONS	2-12
2.2.10	ENVIRONMENTAL	2-13
2.2.11	TYPE TESTS	2-13
2.2.12	PRODUCTION TESTS	2-13
2.2.13	APPROVALS	2-13
2.2.14	MAINTENANCE	2-13

3. HARDWARE

3.1 DESCRIPTION

3.1.1	PANEL CUTOUT	3-1
3.1.2	MODULE WITHDRAWAL AND INSERTION	3-4
3.1.3	REAR TERMINAL LAYOUT	3-5

3.2 WIRING

3.2.1	TYPICAL WIRING	3-6
3.2.2	TYPICAL WIRING WITH HI-Z	3-7
3.2.3	DIELECTRIC STRENGTH	3-8
3.2.4	CONTROL POWER	3-9
3.2.5	CT/VT MODULES	3-10
3.2.6	CONTACT INPUTS/OUTPUTS	3-12
3.2.7	TRANSDUCER INPUTS/OUTPUTS	3-18
3.2.8	RS232 FACEPLATE PORT	3-19

TABLE OF CONTENTS

3.2.9	CPU COMMUNICATION PORTS	3-19
3.2.10	IRIG-B	3-21

3.3 DIRECT I/O COMMUNICATIONS

3.3.1	DESCRIPTION	3-22
3.3.2	FIBER: LED AND ELED TRANSMITTERS	3-24
3.3.3	FIBER-LASER TRANSMITTERS	3-24
3.3.4	G.703 INTERFACE	3-25
3.3.5	RS422 INTERFACE	3-27
3.3.6	RS422 AND FIBER INTERFACE	3-30
3.3.7	G.703 AND FIBER INTERFACE	3-30
3.3.8	IEEE C37.94 INTERFACE	3-31

4. HUMAN INTERFACES

4.1 URPC SOFTWARE INTERFACE

4.1.1	INTRODUCTION	4-1
4.1.2	CREATING A SITE LIST	4-1
4.1.3	URPC SOFTWARE OVERVIEW	4-1
4.1.4	URPC SOFTWARE MAIN WINDOW	4-3

4.2 FACEPLATE INTERFACE

4.2.1	FACEPLATE	4-4
4.2.2	LED INDICATORS	4-5
4.2.3	DISPLAY	4-8
4.2.4	KEYPAD	4-8
4.2.5	BREAKER CONTROL	4-8
4.2.6	MENUS	4-9
4.2.7	CHANGING SETTINGS	4-11

5. SETTINGS

5.1 OVERVIEW

5.1.1	SETTINGS MAIN MENU	5-1
5.1.2	INTRODUCTION TO ELEMENTS	5-3
5.1.3	INTRODUCTION TO AC SOURCES	5-5

5.2 PRODUCT SETUP

5.2.1	PASSWORD SECURITY	5-7
5.2.2	DISPLAY PROPERTIES	5-8
5.2.3	CLEAR RELAY RECORDS	5-9
5.2.4	COMMUNICATIONS	5-10
5.2.5	MODBUS USER MAP	5-16
5.2.6	REAL TIME CLOCK	5-16
5.2.7	FAULT REPORT	5-17
5.2.8	OSCILLOGRAPHY	5-18
5.2.9	DATA LOGGER	5-20
5.2.10	DEMAND	5-20
5.2.11	USER-PROGRAMMABLE LEDS	5-22
5.2.12	USER-PROGRAMMABLE SELF-TESTS	5-25
5.2.13	CONTROL PUSHBUTTONS	5-25
5.2.14	USER-PROGRAMMABLE PUSHBUTTONS	5-26
5.2.15	FLEX STATE PARAMETERS	5-28
5.2.16	USER-DEFINABLE DISPLAYS	5-28
5.2.17	DIRECT I/O	5-30
5.2.18	INSTALLATION	5-35

5.3 SYSTEM SETUP

5.3.1	AC INPUTS	5-36
5.3.2	POWER SYSTEM	5-37
5.3.3	SIGNAL SOURCES	5-38
5.3.4	LINE	5-40
5.3.5	BREAKERS	5-41
5.3.6	FLEXCURVES™	5-44

5.4 FLEXLOGIC™

5.4.1	INTRODUCTION TO FLEXLOGIC™	5-51
5.4.2	FLEXLOGIC™ RULES	5-59

TABLE OF CONTENTS

5.4.3	FLEXLOGIC™ EVALUATION.....	5-59
5.4.4	FLEXLOGIC™ EXAMPLE	5-60
5.4.5	FLEXLOGIC™ EQUATION EDITOR	5-64
5.4.6	FLEXLOGIC™ TIMERS.....	5-64
5.4.7	FLEXELEMENTS™	5-65
5.4.8	NON-VOLATILE LATCHES	5-69
5.5 GROUPED ELEMENTS		
5.5.1	OVERVIEW	5-70
5.5.2	SETTING GROUP	5-70
5.5.3	LOAD ENCROACHMENT.....	5-71
5.5.4	PHASE CURRENT	5-73
5.5.5	NEUTRAL CURRENT.....	5-83
5.5.6	GROUND CURRENT	5-90
5.5.7	NEGATIVE SEQUENCE CURRENT	5-92
5.5.8	BREAKER FAILURE.....	5-98
5.5.9	VOLTAGE ELEMENTS.....	5-107
5.5.10	SENSITIVE DIRECTIONAL POWER.....	5-114
5.6 CONTROL ELEMENTS		
5.6.1	OVERVIEW.....	5-117
5.6.2	SETTING GROUPS.....	5-117
5.6.3	SELECTOR SWITCH.....	5-118
5.6.4	UNDERFREQUENCY.....	5-123
5.6.5	OVERFREQUENCY	5-124
5.6.6	FREQUENCY RATE OF CHANGE.....	5-125
5.6.7	SYNCHROCHECK.....	5-127
5.6.8	AUTORECLOSE	5-131
5.6.9	DIGITAL ELEMENTS.....	5-137
5.6.10	DIGITAL COUNTERS.....	5-140
5.6.11	MONITORING ELEMENTS	5-142
5.6.12	COLD LOAD PICKUP	5-151
5.7 INPUTS/OUTPUTS		
5.7.1	CONTACT INPUTS.....	5-153
5.7.2	VIRTUAL INPUTS.....	5-155
5.7.3	CONTACT OUTPUTS.....	5-156
5.7.4	LATCHING OUTPUTS.....	5-156
5.7.5	VIRTUAL OUTPUTS.....	5-158
5.7.6	REMOTE DEVICES	5-159
5.7.7	REMOTE INPUTS.....	5-160
5.7.8	REMOTE OUTPUTS.....	5-161
5.7.9	RESETTING.....	5-162
5.7.10	DIRECT INPUTS/OUTPUTS	5-162
5.8 TRANSDUCER I/O		
5.8.1	DCMA INPUTS	5-166
5.8.2	RTD INPUTS.....	5-167
5.9 TESTING		
5.9.1	TEST MODE	5-168
5.9.2	FORCE CONTACT INPUTS	5-168
5.9.3	FORCE CONTACT OUTPUTS	5-169

6. ACTUAL VALUES

6.1 OVERVIEW

6.1.1	ACTUAL VALUES MAIN MENU	6-1
-------	-------------------------------	-----

6.2 STATUS

6.2.1	CONTACT INPUTS.....	6-3
6.2.2	VIRTUAL INPUTS.....	6-3
6.2.3	REMOTE INPUTS.....	6-3
6.2.4	CONTACT OUTPUTS.....	6-4
6.2.5	VIRTUAL OUTPUTS.....	6-4
6.2.6	AUTORECLOSE	6-4
6.2.7	REMOTE DEVICES	6-4
6.2.8	DIGITAL COUNTERS	6-5
6.2.9	SELECTOR SWITCHES.....	6-5
6.2.10	FLEX STATES	6-5

TABLE OF CONTENTS

6.2.11	ETHERNET	6-6
6.2.12	HI-Z STATUS	6-6
6.2.13	DIRECT INPUTS	6-6
6.2.14	DIRECT DEVICES STATUS	6-7

6.3 METERING

6.3.1	METERING CONVENTIONS	6-8
6.3.2	SOURCES	6-11
6.3.3	SENSITIVE DIRECTIONAL POWER	6-15
6.3.4	SYNCHROCHECK	6-16
6.3.5	TRACKING FREQUENCY	6-16
6.3.6	FREQUENCY RATE OF CHANGE	6-16
6.3.7	FLEXELEMENTS™	6-17
6.3.8	TRANSDUCER I/O	6-17

6.4 RECORDS

6.4.1	FAULT REPORTS	6-18
6.4.2	EVENT RECORDS	6-20
6.4.3	OSCILLOGRAPHY	6-20
6.4.4	DATA LOGGER	6-20
6.4.5	BREAKER MAINTENANCE	6-21
6.4.6	HI-Z RECORDS	6-21

6.5 PRODUCT INFORMATION

6.5.1	MODEL INFORMATION	6-22
6.5.2	FIRMWARE REVISIONS	6-22

7. COMMANDS AND TARGETS

7.1 COMMANDS

7.1.1	COMMANDS MENU	7-1
7.1.2	VIRTUAL INPUTS	7-1
7.1.3	CLEAR RECORDS	7-1
7.1.4	SET DATE AND TIME	7-2
7.1.5	RELAY MAINTENANCE	7-2

7.2 TARGETS

7.2.1	TARGETS MENU	7-3
7.2.2	TARGET MESSAGES	7-3
7.2.3	RELAY SELF-TESTS	7-3

8. THEORY OF OPERATION

8.1 HIGH-IMPEDANCE (HI-Z) FAULT DETECTION

8.1.1	DESCRIPTION	8-1
8.1.2	ENERGY ALGORITHM	8-1
8.1.3	RANDOMNESS ALGORITHM	8-2
8.1.4	EXPERT ARC DETECTOR ALGORITHM	8-2
8.1.5	SPECTRAL ANALYSIS ALGORITHM	8-2
8.1.6	LOAD EVENT DETECTOR ALGORITHM	8-2
8.1.7	LOAD ANALYSIS ALGORITHM	8-3
8.1.8	LOAD EXTRACTION ALGORITHM	8-3
8.1.9	ARC BURST PATTERN ANALYSIS ALGORITHM	8-3
8.1.10	ARCING SUSPECTED ALGORITHM	8-3
8.1.11	OVERCURRENT DISTURBANCE MONITORING	8-3
8.1.12	HI-Z EVEN HARMONIC RESTRAINT ALGORITHM	8-3
8.1.13	HI-Z VOLTAGE SUPERVISION ALGORITHM	8-4

A. FLEXANALOG PARAMETERS

A.1 PARAMETER LIST

TABLE OF CONTENTS

B. MODBUS COMMUNICATIONS

B.1 MODBUS RTU PROTOCOL

B.1.1	INTRODUCTION.....	B-1
B.1.2	PHYSICAL LAYER.....	B-1
B.1.3	DATA LINK LAYER.....	B-1
B.1.4	CRC-16 ALGORITHM.....	B-2

B.2 MODBUS FUNCTION CODES

B.2.1	SUPPORTED FUNCTION CODES	B-3
B.2.2	READ ACTUAL VALUES OR SETTINGS (FUNCTION CODE 03/04H)	B-3
B.2.3	EXECUTE OPERATION (FUNCTION CODE 05H)	B-4
B.2.4	STORE SINGLE SETTING (FUNCTION CODE 06H)	B-4
B.2.5	STORE MULTIPLE SETTINGS (FUNCTION CODE 10H)	B-5
B.2.6	EXCEPTION RESPONSES	B-5

B.3 FILE TRANSFERS

B.3.1	OBTAINING RELAY FILES VIA MODBUS	B-6
B.3.2	MODBUS PASSWORD OPERATION	B-7

B.4 MEMORY MAPPING

B.4.1	MODBUS MEMORY MAP	B-8
B.4.2	DATA FORMATS	B-48

C. UCA/MMS COMMUNICATIONS

C.1 UCA/MMS PROTOCOL

C.1.1	UCA.....	C-1
C.1.2	MMS.....	C-1
C.1.3	UCA REPORTING	C-6

D. IEC 60870-5-104 COMMUNICATIONS

D.1 IEC 60870-5-104

D.1.1	INTEROPERABILITY DOCUMENT	D-1
D.1.2	IEC 60870-5-104 POINT LIST	D-10

E. DNP COMMUNICATIONS

E.1 DNP PROTOCOL

E.1.1	DEVICE PROFILE DOCUMENT.....	E-1
E.1.2	DNP IMPLEMENTATION.....	E-4

E.2 DNP POINT LISTS

E.2.1	BINARY INPUTS.....	E-8
E.2.2	BINARY AND CONTROL RELAY OUTPUTS.....	E-13
E.2.3	COUNTERS	E-14
E.2.4	ANALOG INPUTS	E-15

F. MISCELLANEOUS

F.1 CHANGE NOTES

F.1.1	REVISION HISTORY	F-1
F.1.2	CHANGES TO F60 MANUAL	F-1

F.2 ABBREVIATIONS

F.2.1	STANDARD ABBREVIATIONS	F-4
-------	------------------------------	-----

F.3 WARRANTY

F.3.1	GE MULTILIN WARRANTY	F-6
-------	----------------------------	-----

INDEX

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.
- Check that the battery tab is intact on the power supply module (for additional details, see the Battery Tab section near the end of this chapter).
- View the rear nameplate and verify that the correct model has been ordered.

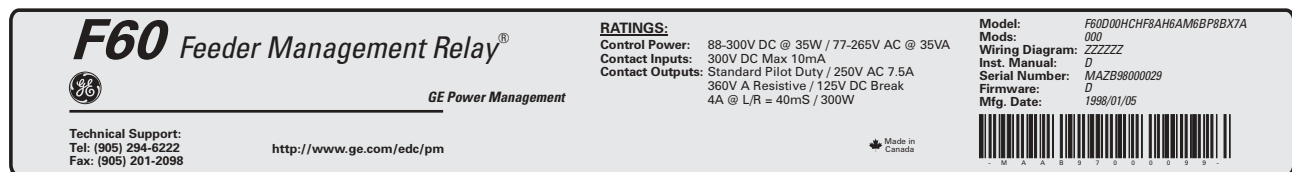


Figure 1-1: REAR NAMEPLATE (EXAMPLE)

- Ensure that the following items are included:
 - Instruction Manual
 - GE Multilin Products CD (includes the URPC software and manuals in PDF format)
 - mounting screws
 - registration card (attached as the last page of the manual)
- Fill out the registration form and mail it back to GE Multilin (include the serial number located on the rear nameplate).
- For product information, instruction manual updates, and the latest software updates, please visit the GE Multilin web-site at <http://www.GEindustrial.com/multilin>.



NOTE

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

GE MULTILIN CONTACT INFORMATION AND CALL CENTER FOR PRODUCT SUPPORT:

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

TELEPHONE: (905) 294-6222, 1-800-547-8629 (North America only)
FAX: (905) 201-2098
E-MAIL: info.pm@indsys.ge.com
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 5 milliseconds. This has been established by the Electric Power Research Institute, a collective body of many American and Canadian power utilities, in their Utilities Communications Architecture 2 (MMS/UCA2) project. In late 1998, some European utilities began to show an interest in this ongoing initiative.

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

1.2.2 HARDWARE ARCHITECTURE

1

a) UR BASIC DESIGN

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

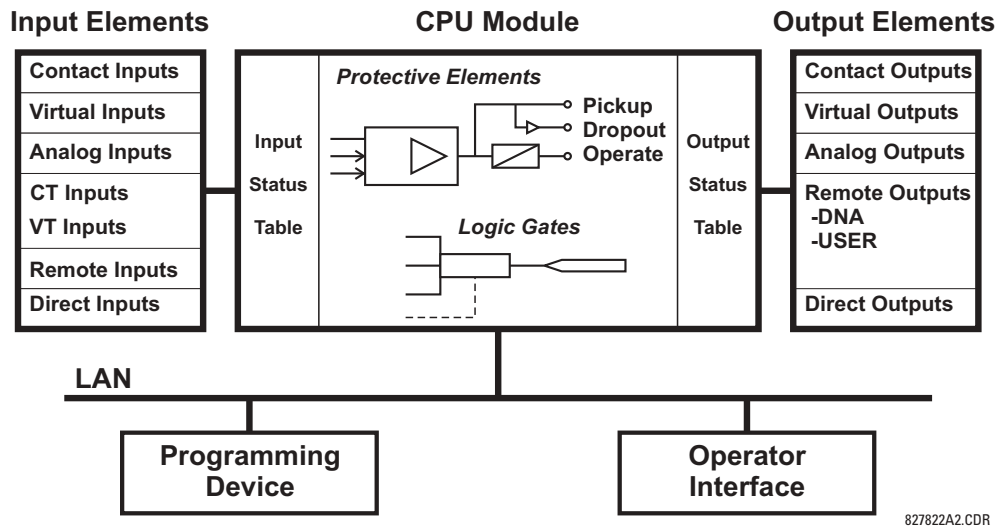


Figure 1-2: UR CONCEPT BLOCK DIAGRAM

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

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

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

b) UR SIGNAL TYPES

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

The **virtual inputs and outputs** are digital signals associated with UR 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 UR 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 supports 1 A and 5 A CTs.

The **remote inputs and outputs** provide a means of sharing digital point state information between remote UR devices. The remote outputs interface to the remote inputs of other UR devices. Remote outputs are FlexLogic™ operands inserted into UCA2 GOOSE messages and are of two assignment types: DNA standard functions and USER defined functions.

The **direct inputs and outputs** provide a means of sharing digital point states between a number of UR 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 UR chassis.

c) UR SCAN OPERATION

The UR device operates in a cyclic scan fashion. The UR 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.

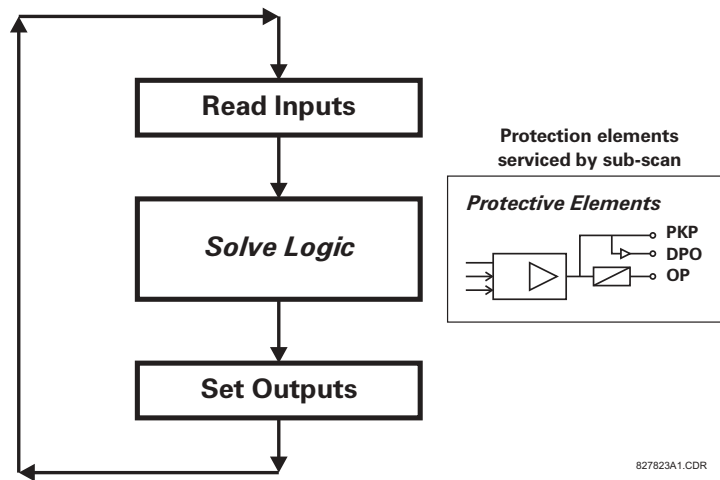


Figure 1–3: UR SCAN OPERATION

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, I/O 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 platform-based applications.

1.2.4 IMPORTANT CONCEPTS

As described above, the architecture of the UR relay is different from previous devices. In order 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 UR 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 settings 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

1

The Faceplate keypad and display or the URPC software interface can be used to communicate with the relay.

The URPC 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 URPC 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
- 64 MB of RAM (256 MB recommended)
- 40 MB of available hard drive space (100 MB recommended)
- Video capable of displaying 800 x 600 or higher in High Color mode (16-bit color)
- RS232 and/or Ethernet communications port to the relay

1.3.2 INSTALLATION

Refer to the following procedure to install the **URPC** software:

1. Insert the GE Multilin Products CD into your PC or direct your web browser to the GE Multilin website at <http://www.GEindustrial.com/multilin> (preferred method). The Products CD is essentially a snapshot of the GE Multilin website at the date printed on the CD; install from the website to ensure the most recent version of URPC.
2. If the Products CD does not start automatically, choose **Run** from the Windows® **Start** menu and type D:\SETUP.EXE.
3. Select the **Software** item from the **Resources** menu on the right of the GE Multilin welcome page.
4. Select the **F60 Feeder Management Relay** item from the list of protective relays shown.
5. The F60 Software page will be shown. Select the **URPC Software** item from the list and save the installation program to your local PC.
6. Run the installation program and follow the on-screen instructions. When the **Choose Destination Location** window appears and if the software is not to be located in the default directory, click **Browse** and type in the complete path name including the new directory name.
7. Click **Next** to continue with the installation procedure.
8. The default program group where the application will be added to is shown in the **Select Program Folder** window. If it is desired that the application be added to an already existing program group, choose the group name from the list shown.
9. Click **Next** to begin the installation process.
10. To launch the URPC application, click **Finish** in the Setup Complete window.
11. Subsequently, double click on the URPC software icon to activate the application.



Refer to Chapter 4: Human Interfaces and the URPC Help File for additional information about the URPC software interface.

1.3.3 CONNECTING URPC® WITH THE F60

This section is intended as a quick start guide to using the URPC software. Please refer to the URPC 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 URPC software (available from the GE Multilin Products CD or online from <http://www.GEindustrial.com/multilin>).
2. Select the **Online > Device Setup** menu item 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 URPC window. Click on the new site name and then select the **Online > Device Setup** menu item 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 “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.
8. Click the “Read Order Code” button to connect to the UR device and upload the order code. If an communications error occurs, ensure that the three URPC 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 URPC 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.

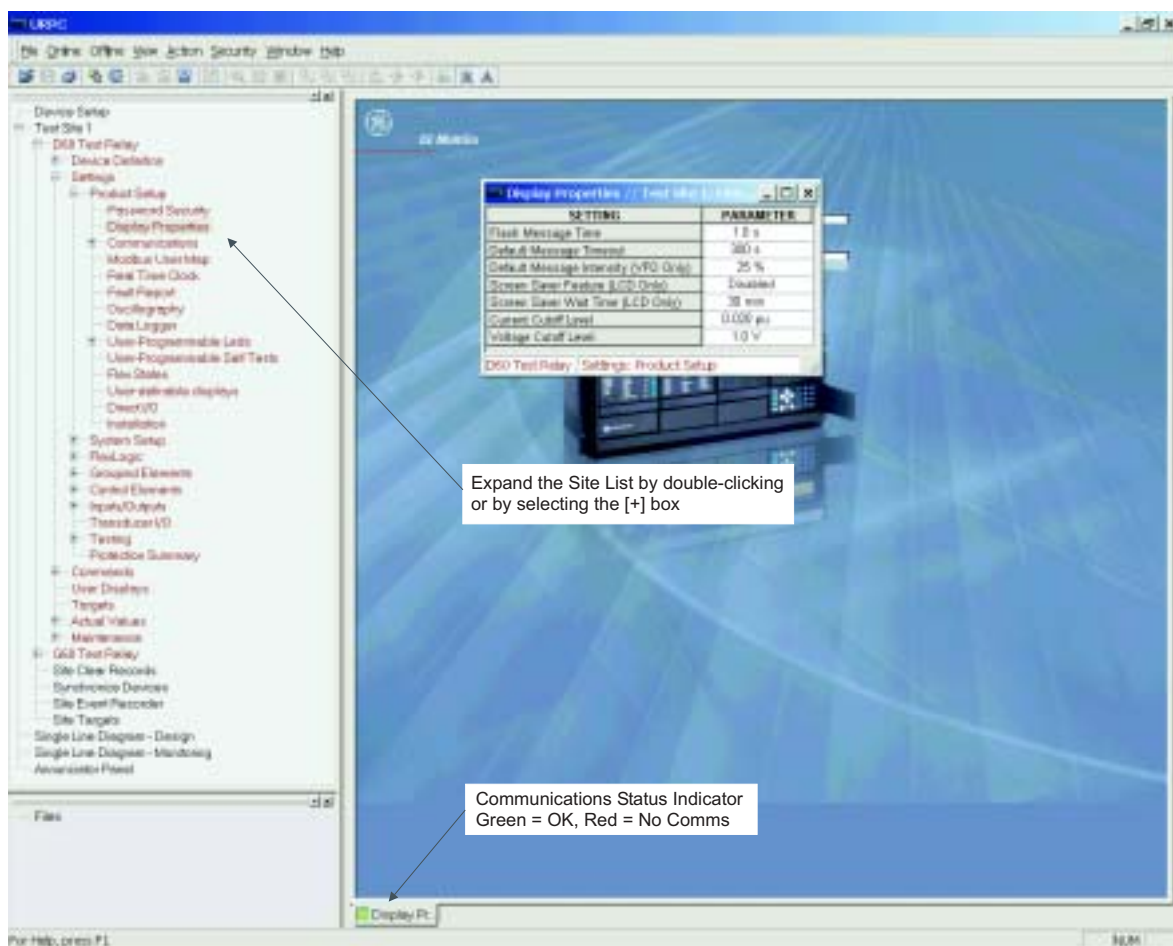
1. Install and start the latest version of the URPC software (available from the GE Multilin Products CD or online from <http://www.GEindustrial.com/multilin>).
2. Select the **Online > Device Setup** menu item to open the Device Setup window and click the “Add Site” button to define a new site.
3. Enter 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 URPC window. Click on the new site name and then select the **Online > Device Setup** menu item 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 Ethernet functionality.

- 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 UR device and upload the order code. If an communications error occurs, ensure that the URPC 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 URPC 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:



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



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

NOTE

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 URPC 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.

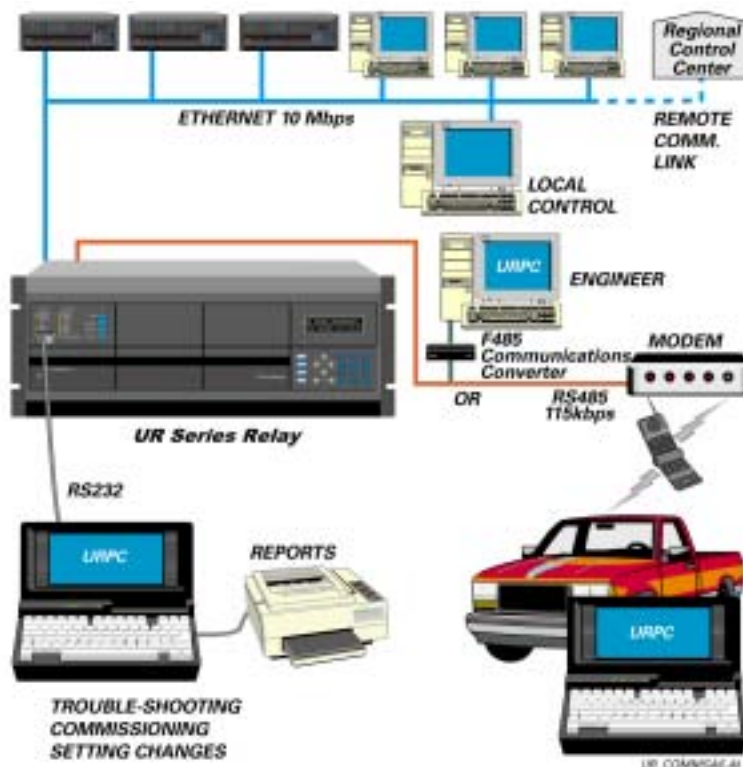


Figure 1-4: RELAY COMMUNICATIONS OPTIONS

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 \times 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

1

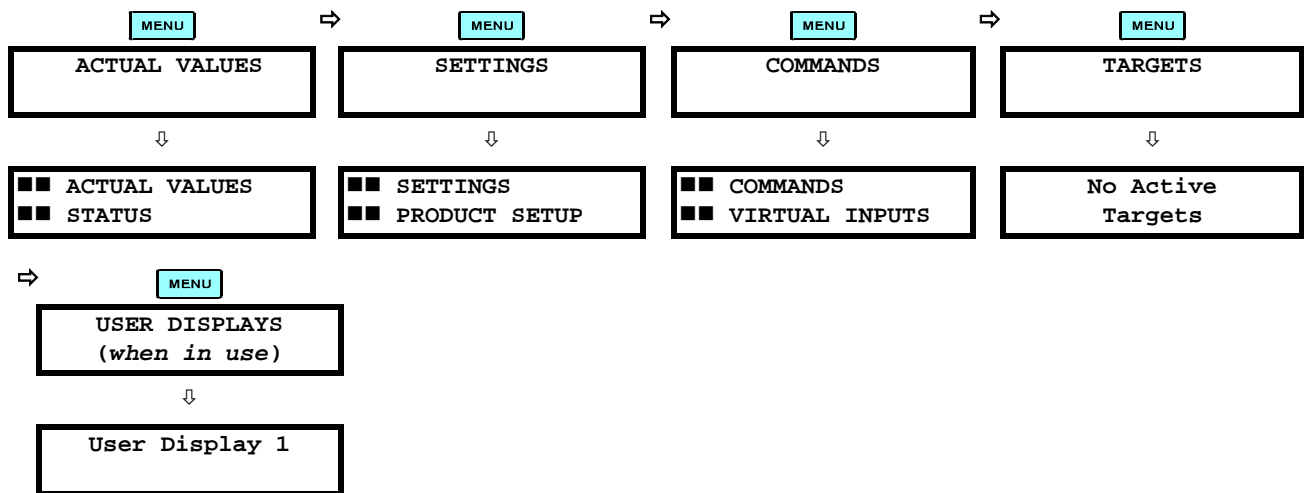
Display messages are organized into 'pages' under the following headings: Actual Values, Settings, Commands, and Targets. The **MENU** key navigates through these pages. Each heading page is broken down further into logical subgroups.

The **MESSAGE** **VALUE** 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 **ENTER** 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.

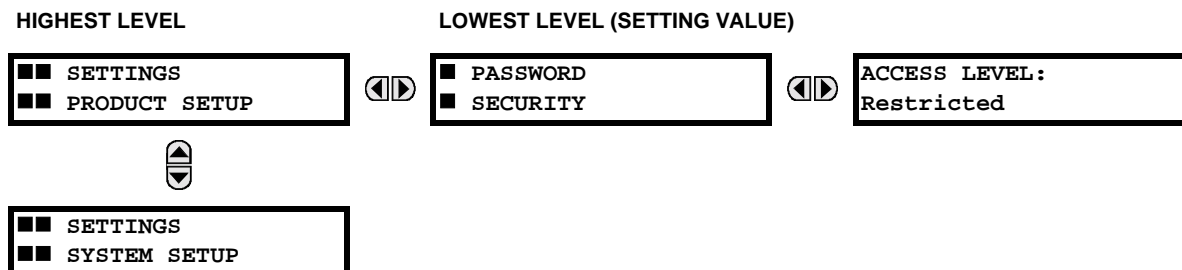
1.5.2 MENU NAVIGATION

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 **MESSAGE** and **VALUE** keys move within a group of headers, sub-headers, setting values, or actual values. Continually pressing the MESSAGE **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 . 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 URPC Help file) via the URPC software interface.

1.5.5 BATTERY TAB

The battery tab is installed in the power supply module before the F60 shipped from the factory. The battery tab prolongs battery life in the event the relay is powered down for long periods of time before installation. The battery is responsible for backing up event records, oscillography, data logger, and real-time clock information when the relay is powered off. The battery failure self-test error generated by the relay is a minor and should not affect the relay functionality. When the relay is installed and ready for commissioning, the tab should be removed. The battery tab should be re-inserted if the relay is powered off for an extended period of time. If required, contact the factory for a replacement battery or battery tab.

1.5.6 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.



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

1.5.7 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.

1.5.8 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>.

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 MMS/UCA2, Modbus®/TCP, and TFTP protocols, and allows access to the relay via any standard web browser (UR 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	DEVICE NUMBER	FUNCTION
25 (2)	Synchrocheck	51_2 (2)	Negative Sequence Time Overcurrent
27P (2)	Phase Undervoltage	52	AC Circuit Breaker
27X	Auxiliary Undervoltage	59N	Neutral Overvoltage
32	Sensitive Directional Power	59P	Phase Overvoltage
50BF / 50NBF (2)	Breaker Failure	59X	Auxiliary Overvoltage
50DD	Disturbance Detector	59_2	Negative Sequence Overvoltage
50G (2)	Ground Instantaneous Overcurrent	67N (2)	Neutral Directional Overcurrent
50N (2)	Neutral Instantaneous Overcurrent	67P (2)	Phase Directional
50P (2)	Phase Instantaneous Overcurrent	67_2 (2)	Negative Sequence Directional OC
50_2 (2)	Negative Sequence Instantaneous OC	79	Automatic Recloser
51G (2)	Ground Time Overcurrent	81O (4)	Overfrequency
51N (2)	Neutral Time Overcurrent	81U (6)	Underfrequency
51P (2)	Phase Time Overcurrent		

2

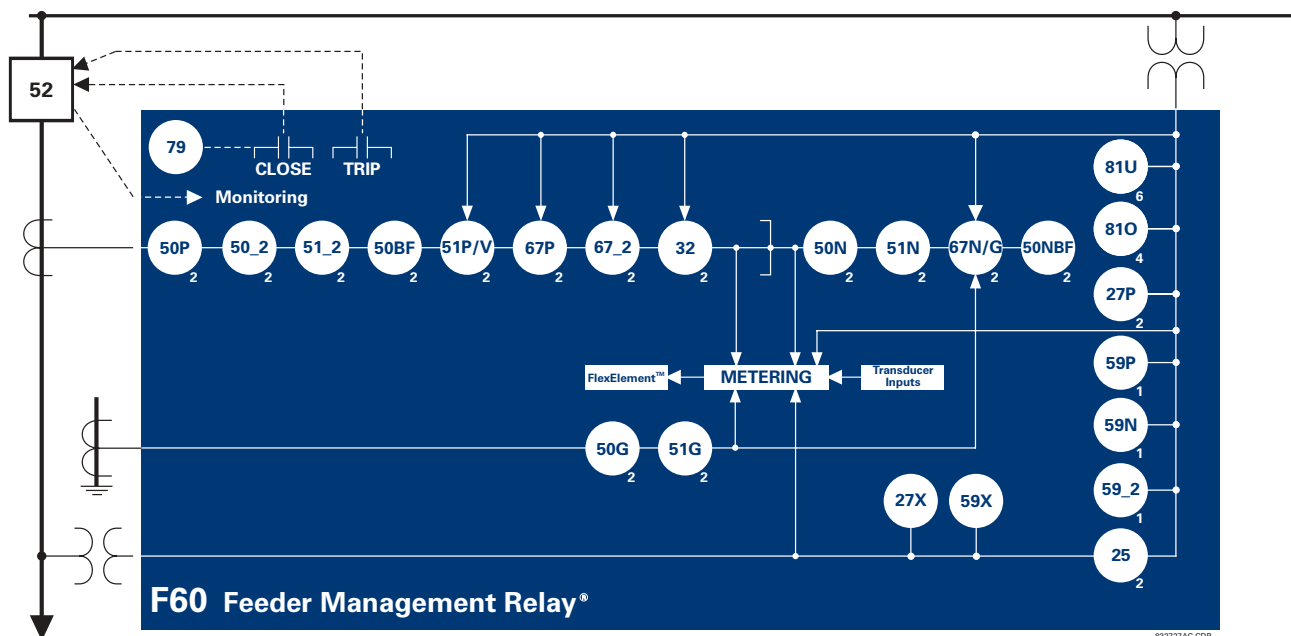


Figure 2-1: SINGLE LINE DIAGRAM

Table 2-2: OTHER DEVICE FUNCTIONS

FUNCTION	FUNCTION
Breaker Arcing Current (I^2t)	Metering: Current, Voltage, Power, Power Factor, Energy, Frequency, Harmonics, THD
Breaker Control (2)	MMS/UCA Communications
Cold Load Pickup (2)	MMS/UCA Remote I/O ("GOOSE")
Contact Inputs (up to 96)	Modbus Communications
Contact Outputs (up to 64)	Modbus User Map
Control Pushbuttons	Non-Volatile Latches
Data Logger	Non-Volatile Selector Switch
Demand	Oscillography
Digital Counters (8)	Setting Groups (6)
Digital Elements (16)	Time Synchronization over SNTP
Direct Inputs/Outputs (32)	Transducer I/O
DNP 3.0 or IEC 60870-5-104 Communications	User Definable Displays
Event Recorder	User Programmable LEDs
Fault Detector and Fault Report	User Programmable Pushbuttons
Fault Locator	User Programmable Self-Tests
FlexElements™ (8)	Virtual Inputs (32)
FlexLogic™ Equations	Virtual Outputs (64)
Hi-Z High Impedance Fault Detection	VT Fuse Failure
Load Encroachment	

The relay is available as a 19-inch rack horizontal mount unit or as a reduced size (¾) vertical mount unit, and consists of the following UR module functions: power supply, CPU, CT/VT DSP, digital input/output, transducer input/output. Each of these modules can be supplied in a number of configurations which must be specified at the time of ordering. The information required to completely specify the relay is provided in the following table (full details of available relay modules are contained in Chapter 3: Hardware).

Table 2-3: F60 ORDER CODES

	F60	- *	00	- H	* *	- F	**	- H	**	- M	**	- P	**	- U	**	- W	**	For Full Sized Horizontal Mount
	F60	- *	00	- V	* *	- F	**	- H	**	- M	**	- P	**	- U	**	- R	**	For Reduced Sized Vertical Mount
BASE UNIT	F60																	Base Unit
CPU	A																	RS485 + RS485 (ModBus RTU, DNP)
	C																	RS485 + 10BaseF (MMS/UCA2, Modbus TCP/IP, DNP)
	D																	RS485 + Redundant 10BaseF (MMS/UCA2, Modbus TCP/IP, DNP)
SOFTWARE	00																	No Software Options
MOUNT/ FACEPLATE				H	C													Horizontal (19" rack)
				H	P													Horizontal (19" rack) with User-Programmable Pushbuttons
				V	F													Vertical (3/4 rack)
POWER SUPPLY					H													125 / 250 V AC/DC
					L													24 to 48 V (DC only)
CT/VT DSP						8A												Standard 4CT/4VT
						8B												Sensitive Ground 4CT/4VT
						8C												Standard 8CT
						8D												Sensitive Ground 8CT
									8Z									Hi-Z 4CT (required for use of the Hi-Z element)
DIGITAL I/O								XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	No Module
						4A		4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4 Solid-State (No Monitoring) MOSFET Outputs
						4B		4B	4B	4B	4B	4B	4B	4B	4B	4B	4B	4 Solid-State (Voltage w/ opt Current) MOSFET Outputs
						4C		4C	4C	4C	4C	4C	4C	4C	4C	4C	4C	4 Solid-State (Current w/ opt Voltage) MOSFET Outputs
						4L		4L	4L	4L	4L	4L	4L	4L	4L	4L	4L	14 Form-A (No Monitoring) Latchable Outputs
						6A		6A	6A	6A	6A	6A	6A	6A	6A	6A	6A	2 Form-A (Volt w/ opt Curr) & 2 Form-C outputs, 8 Digital Inputs
						6B		6B	6B	6B	6B	6B	6B	6B	6B	6B	6B	2 Form-A (Volt w/ opt Curr) & 4 Form-C Outputs, 4 Digital Inputs
						6C		6C	6C	6C	6C	6C	6C	6C	6C	6C	6C	8 Form-C Outputs
						6D		6D	6D	6D	6D	6D	6D	6D	6D	6D	6D	16 Digital Inputs
						6E		6E	6E	6E	6E	6E	6E	6E	6E	6E	6E	4 Form-C Outputs, 8 Digital Inputs
						6F		6F	6F	6F	6F	6F	6F	6F	6F	6F	6F	8 Fast Form-C Outputs
						6G		6G	6G	6G	6G	6G	6G	6G	6G	6G	6G	4 Form-A (Voltage w/ opt Current) Outputs, 8 Digital Inputs
						6H		6H	6H	6H	6H	6H	6H	6H	6H	6H	6H	6 Form-A (Voltage w/ opt Current) Outputs, 4 Digital Inputs
						6K		6K	6K	6K	6K	6K	6K	6K	6K	6K	6K	4 Form-C & 4 Fast Form-C Outputs
						6L		6L	6L	6L	6L	6L	6L	6L	6L	6L	6L	2 Form-A (Curr w/ opt Volt) & 2 Form-C Outputs, 8 Digital Inputs
						6M		6M	6M	6M	6M	6M	6M	6M	6M	6M	6M	2 Form-A (Curr w/ opt Volt) & 4 Form-C Outputs, 4 Digital Inputs
						6N		6N	6N	6N	6N	6N	6N	6N	6N	6N	6N	4 Form-A (Current w/ opt Voltage) Outputs, 8 Digital Inputs
						6P		6P	6P	6P	6P	6P	6P	6P	6P	6P	6P	6 Form-A (Current w/ opt Voltage) Outputs, 4 Digital Inputs
						6R		6R	6R	6R	6R	6R	6R	6R	6R	6R	6R	2 Form-A (No Monitoring) & 2 Form-C Outputs, 8 Digital Inputs
						6S		6S	6S	6S	6S	6S	6S	6S	6S	6S	6S	2 Form-A (No Monitoring) & 4 Form-C Outputs, 4 Digital Inputs
						6T		6T	6T	6T	6T	6T	6T	6T	6T	6T	6T	4 Form-A (No Monitoring) Outputs, 8 Digital Inputs
						6U		6U	6U	6U	6U	6U	6U	6U	6U	6U	6U	6 Form-A (No Monitoring) Outputs, 4 Digital Inputs
TRANSUCER I/O (maximum of 4 per unit)						5C		5C	5C	5C	5C	5C	5C	5C	5C	5C	5C	8 RTD Inputs
						5E		5E	5E	5E	5E	5E	5E	5E	5E	5E	5E	4 RTD Inputs, 4 dcmA Inputs
						5F		5F	5F	5F	5F	5F	5F	5F	5F	5F	5F	8 dcmA Inputs
INTER-RELAY COMMUNICATIONS																		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
																		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
																		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 Channel	
																	74 Channel 1 - RS422; 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	

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

Table 2–4: ORDER CODES FOR UR REPLACEMENT MODULES

	UR - ** -	
POWER SUPPLY	1H	125 / 250 V AC/DC
	1L	24 to 48 V (DC only)
CPU	9A	RS485 + RS485 (ModBus RTU, DNP 3.0)
	9C	RS485 + 10BaseF (MMS/UCA2, ModBus TCP/IP, DNP 3.0)
	9D	RS485 + Redundant 10BaseF (MMS/UCA2, ModBus TCP/IP, DNP 3.0)
FACEPLATE	3C	Horizontal Faceplate with Display & Keypad
	3F	Vertical Faceplate with Display & Keypad
DIGITAL I/O	4A	4 Solid-State (No Monitoring) MOSFET Outputs
	4B	4 Solid-State (Voltage w/ opt Current) MOSFET Outputs
	4C	4 Solid-State (Current w/ opt Voltage) MOSFET Outputs
	4L	14 Form-A (No Monitoring) Latchable Outputs
	6A	2 Form-A (Voltage w/ opt Current) & 2 Form-C Outputs, 8 Digital Inputs
	6B	2 Form-A (Voltage w/ opt Current) & 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 w/ opt Current) Outputs, 8 Digital Inputs
	6H	6 Form-A (Voltage w/ opt Current) Outputs, 4 Digital Inputs
	6K	4 Form-C & 4 Fast Form-C Outputs
	6L	2 Form-A (Current w/ opt Voltage) & 2 Form-C Outputs, 8 Digital Inputs
	6M	2 Form-A (Current w/ opt Voltage) & 4 Form-C Outputs, 4 Digital Inputs
	6N	4 Form-A (Current w/ opt Voltage) Outputs, 8 Digital Inputs
	6P	6 Form-A (Current w/ opt Voltage) Outputs, 4 Digital Inputs
	6R	2 Form-A (No Monitoring) & 2 Form-C Outputs, 8 Digital Inputs
	6S	2 Form-A (No Monitoring) & 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 DSP	8A	Standard 4CT/4VT
	8B	Sensitive Ground 4CT/4VT
	8C	Standard 8CT
	8D	Sensitive Ground 8CT
	8Z	HI-Z 4CT
L60 INTER-RELAY COMMUNICATIONS	7U	110/125 V, 20 mA Input/Output Channel Interface
	7V	48/60 V, 20 mA Input/Output Channel Interface
	7Y	125 V Input, 5V Output, 20 mA Channel Interface
	7Z	5 V Input, 5V Output, 20 mA Channel Interface
UR INTER-RELAY COMMUNICATIONS	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 LED (L90 only)
	7F	Channel 1: G.703; Channel 2: 1300 nm, multi-mode LED (L90 only)
	7G	Channel 1: G.703; Channel 2: 1300 nm, single-mode ELED (L90 only)
	7Q	Channel 1: G.703; Channel 2: 820 nm, single-mode LASER (L90 only)
	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
	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 Channel
	74	Channel 1 - RS422; Channel 2 - 1550 nm, single-mode, LASER
	75	Channel 1 - G.703, Channel 2 - 1550 nm, single -mode, LASER (L90 only)
	76	IEEE C37.94, 820 nm, multi-mode, LED, 1 Channel
	77	IEEE C37.94, 820 nm, multi-mode, LED, 2 Channels
TRANSDUCER I/O	5C	8 RTD Inputs
	5E	4 dcmA Inputs, 4 RTD Inputs
	5F	8 dcmA Inputs

SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE

2.2.1 PROTECTION ELEMENTS



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

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 ² t; FlexCurves™ (programmable); Definite Time (0.01 s base curve)
Curve multiplier:	Time Dial = 0.00 to 600.00 in steps of 0.01
Reset type:	Instantaneous/Timed (per IEEE)
Timing accuracy:	Operate at > 1.03 × actual Pickup ±3.5% of operate time or ±½ cycle (whichever is greater)

PHASE/NEUTRAL/GROUND IOC

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

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

NEGATIVE SEQUENCE IOC

Pickup level:	0.000 to 30.000 pu in steps of 0.001
Dropout level:	97 to 98% of Pickup
Level accuracy:	
0.1 to 2.0 × CT rating:	±0.5% of reading or ±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:	$3 \times (I_0 - K \times I_1)$, $K = 0.0625$; IG
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:	0.05 to 30.00 pu in steps of 0.01
Dropout level:	97 to 98%
Operation time:	< 16 ms at $3 \times$ Pickup at 60 Hz

NEGATIVE SEQUENCE DIRECTIONAL OC

Directionality:	Co-existing forward and reverse
Polarizing:	Voltage
Polarizing voltage:	V ₂
Operating current:	I ₂
Level sensing:	
Zero-sequence:	$ I_0 - K \times I_1 $, $K = 0.0625$
Negative-sequence:	$ I_2 - K \times I_1 $, $K = 0.125$
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 $3 \times$ 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 $1.10 \times$ Pickup at 60 Hz
Timing accuracy:	±3% or ±4 ms (whichever is greater)

NEUTRAL OVERVOLTAGE

Pickup level:	0.000 to 1.250 pu in steps of 0.001
Dropout level:	97 to 98% of Pickup
Level accuracy:	±0.5% of reading from 10 to 208 V
Pickup delay:	0.00 to 600.00 s in steps of 0.01
Reset delay:	0.00 to 600.00 s in steps of 0.01
Timing accuracy:	±3% or ±4 ms (whichever is greater)
Operate time:	< 30 ms at $1.10 \times$ Pickup at 60 Hz

AUXILIARY OVERVOLTAGE

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

NEGATIVE SEQUENCE OVERVOLTAGE

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

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 ±1% of rated (whichever is greater)
above 2 × CT rating:	±1.5% of reading

SYNCHROCHECK

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

AUTORECLOSURE

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

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
Compensation 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:	3
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

Upper Position Limit:	1 to 7 in steps of 1
Selecting mode:	Time-out or Acknowledge
Time-out timer:	3.0 to 60.0 s in steps of 0.1
Control inputs:	Step-up and 3-bit
Power-up mode:	Restore from non-volatile memory or synchronize to a 3-bit control input

2.2.3 MONITORING

OSCILLOGRAPHY

Maximum records:	64
Sampling rate:	64 samples per power cycle
Triggers:	Any element pickup, dropout or operate Digital input change of state Digital output change of state FlexLogic™ equation
Data:	AC input channels Element state Digital input state Digital output state
Data storage:	In non-volatile memory

EVENT RECORDER

Capacity:	1024 events
Time-tag:	to 1 microsecond
Triggers:	Any element pickup, dropout or operate Digital input change of state Digital output change of state Self-test events
Data storage:	In non-volatile memory

DATA LOGGER

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

FAULT LOCATOR

Method:	Single-ended
Maximum accuracy if:	Fault resistance is zero or fault currents from all line terminals are in phase
Relay accuracy:	±1.5% (V > 10 V, I > 0.1 pu)
Worst-case accuracy:	
VT _{%error} +	(user data)
CT _{%error} +	(user data)
Z _{Line} _{%error} +	(user data)
METHOD _{%error} +	(Chapter 6)
RELAY ACCURACY _{%error} +	(1.5%)

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
Recognition time:	< 1 ms
Debounce timer:	0.0 to 16.0 ms in steps of 0.5

DCMA INPUTS

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

RTD INPUTS

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

IRIG-B INPUT

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

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:	8
Default states on loss of comms.:	On, Off, Latest/Off, Latest/On
Ring configuration:	Yes, No
Data rate:	64 or 128 kbps
CRC:	32-bit
CRC alarm:	
Responding to:	Rate of messages failing the CRC
Monitoring message count:	10 to 10000 in steps of 1
Alarm threshold:	1 to 1000 in steps of 1
Unreturned message alarm:	
Responding to:	Rate of unreturned messages in the ring configuration
Monitoring message count:	10 to 10000 in steps of 1
Alarm threshold:	1 to 1000 in steps of 1

2.2.6 POWER SUPPLY

LOW RANGE

Nominal DC voltage: 24 to 48 V at 3 A

Min/max DC voltage: 20 / 60 V

NOTE: Low range is DC only.

HIGH RANGE

Nominal DC voltage: 125 to 250 V at 0.7 A

Min/max DC voltage: 88 / 300 V

Nominal AC voltage: 100 to 240 V at 50/60 Hz, 0.7 A

Min/max AC voltage: 88 / 265 V at 48 to 62 Hz

ALL RANGESVolt withstand: $2 \times$ Highest Nominal Voltage for 10 ms

Voltage loss hold-up: 50 ms duration at nominal

Power consumption: Typical = 35 VA; Max. = 75 VA

INTERNAL FUSE**RATINGS**

Low range power supply: 7.5 A / 600 V

High range power supply: 5 A / 600 V

INTERRUPTING CAPACITY

AC: 100 000 A RMS symmetrical

DC: 10 000 A

2.2.7 OUTPUTS

FORM-A RELAY

Make and carry for 0.2 s: 30 A as per ANSI C37.90

Carry continuous: 6 A

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

Operate time: < 4 ms

Contact material: Silver alloy

LATCHING RELAY

Make and carry for 0.2 s: 30 A as per ANSI C37.90

Carry continuous: 6 A

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

Operate time: < 4 ms

Contact material: Silver alloy

Control: separate operate and reset inputs

Control mode: operate-dominant or reset-dominant

FORM-A VOLTAGE MONITOR

Applicable voltage: approx. 15 to 250 V DC

Trickle current: approx. 1 to 2.5 mA

FORM-A CURRENT MONITOR

Threshold current: approx. 80 to 100 mA

FORM-C AND CRITICAL FAILURE RELAY

Make and carry for 0.2 s: 10 A

Carry continuous: 6 A

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

Operate time: < 8 ms

Contact material: Silver alloy

FAST FORM-C RELAY

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

Minimum load impedance:

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

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

Operate time: < 0.6 ms

INTERNAL LIMITING RESISTOR:

Power: 2 watts

Resistance: 100 ohms

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

Capacity: 100 mA DC at 48 V DC

Isolation: ± 300 Vpk**REMOTE OUTPUTS (MMS GOOSE)**

Standard output points: 32

User output points: 32

DIRECT OUTPUTS

Output points: 32

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

ETHERNET PORT

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

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

Power budget: 10 dB

Max optical Ip power: -7.6 dBm

Typical distance: 1.65 km

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



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



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



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

OPERATING TEMPERATURES

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

OTHER

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

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



Type test report available upon request.

NOTE

2.2.12 PRODUCTION TESTS

THERMAL

Products go through a 12 h burn-in process at 60°C

2.2.13 APPROVALS

APPROVALS

UL Listed for the USA and Canada
 Manufactured under an ISO9000 registered system.

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

2.2.14 MAINTENANCE

MAINTENANCE

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

3.1.1 PANEL CUTOUT

The relay is available as a 19-inch rack horizontal mount unit or as a reduced size ($\frac{3}{4}$) 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.

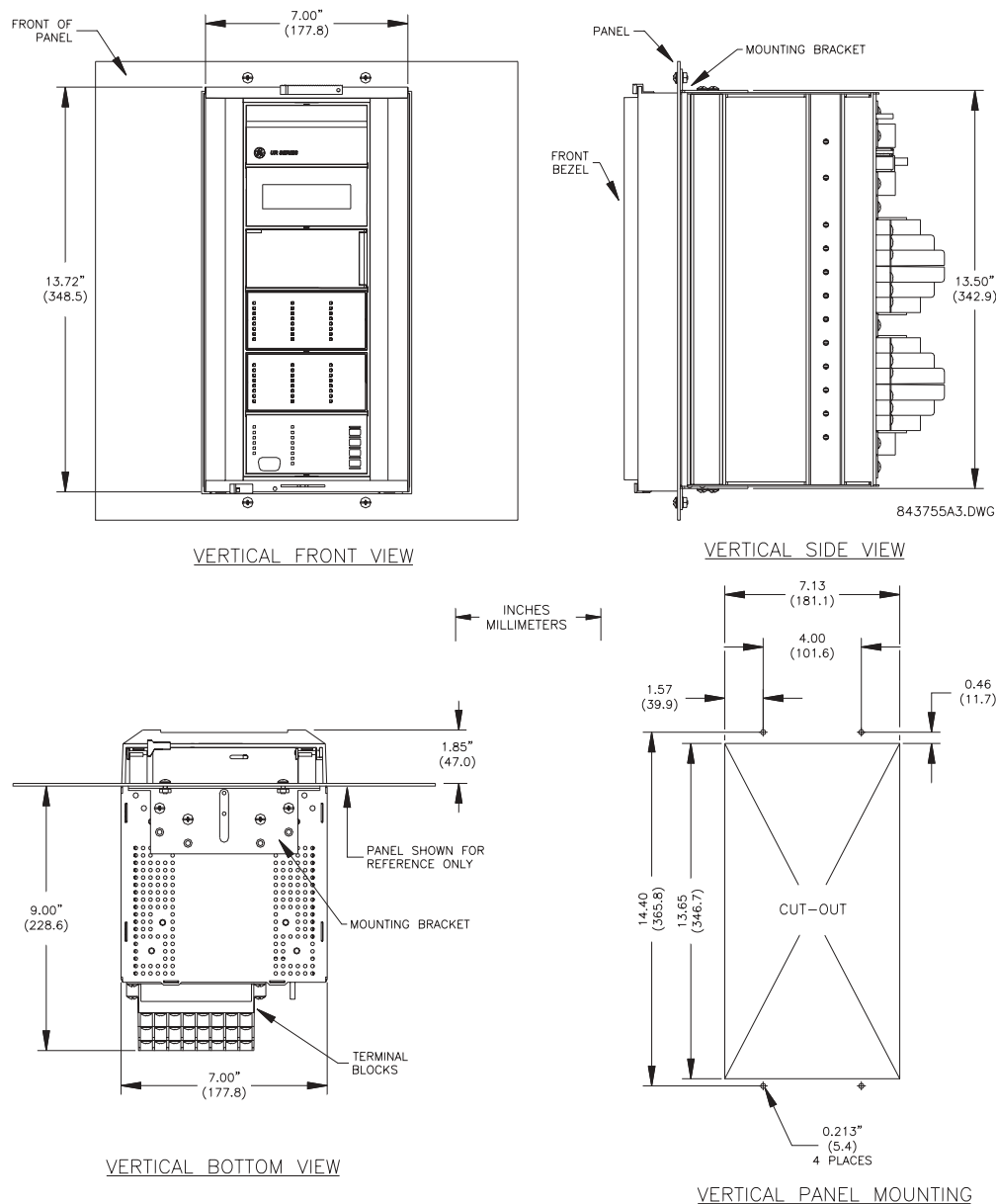


Figure 3-1: F60 VERTICAL MOUNTING AND DIMENSIONS

3

STEP 1 – CREATE THE HOLES AND CUT-OUT INTO THE PANEL AS PER DRAWING 843753.

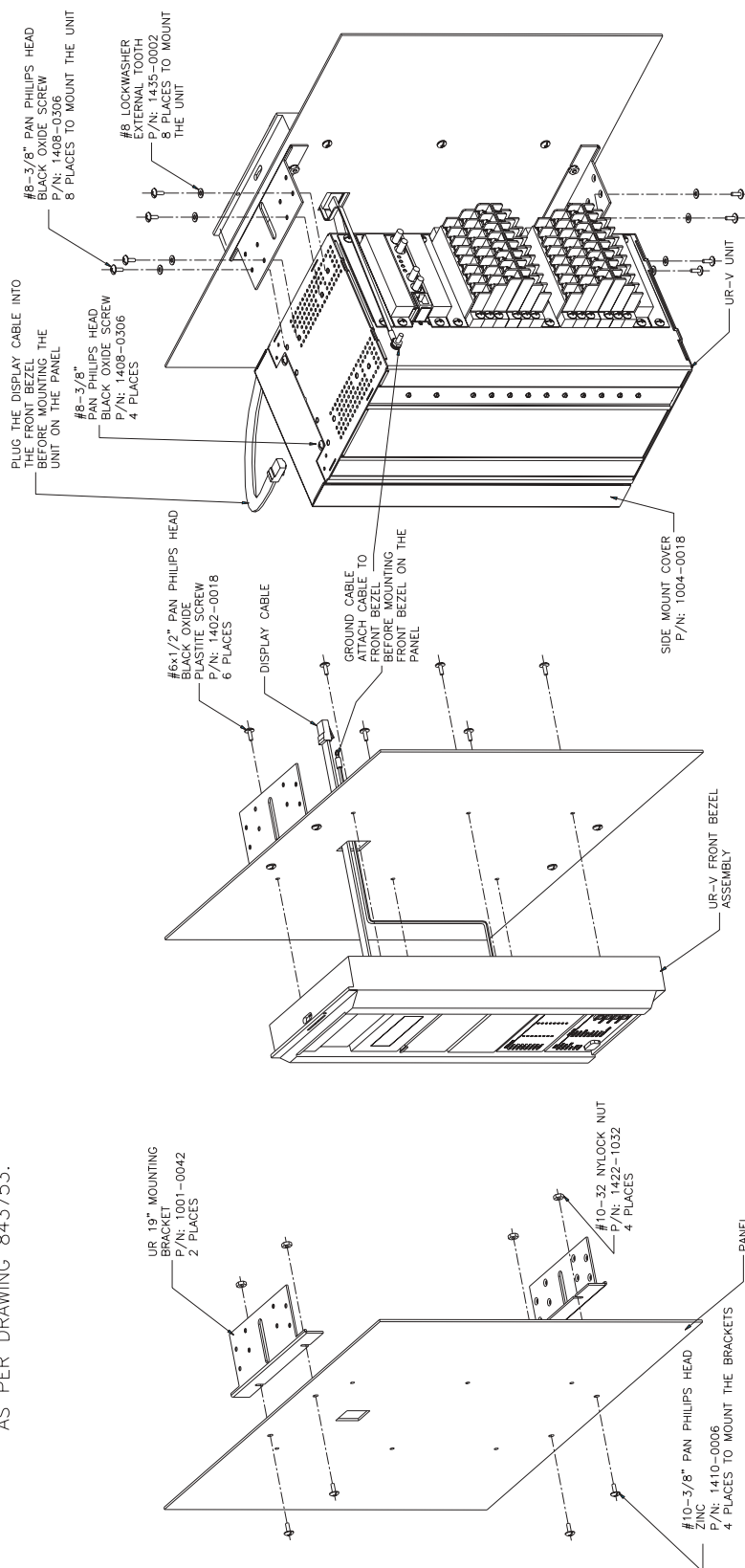


Figure 3-2: F60 VERTICAL SIDE MOUNTING INSTALLATION

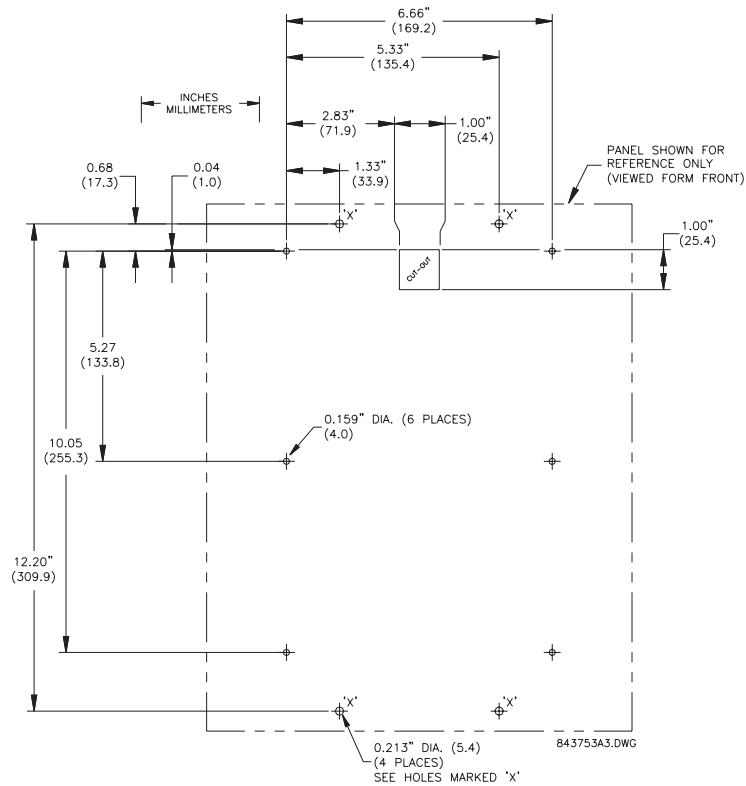


Figure 3-3: F60 VERTICAL SIDE MOUNTING REAR DIMENSIONS

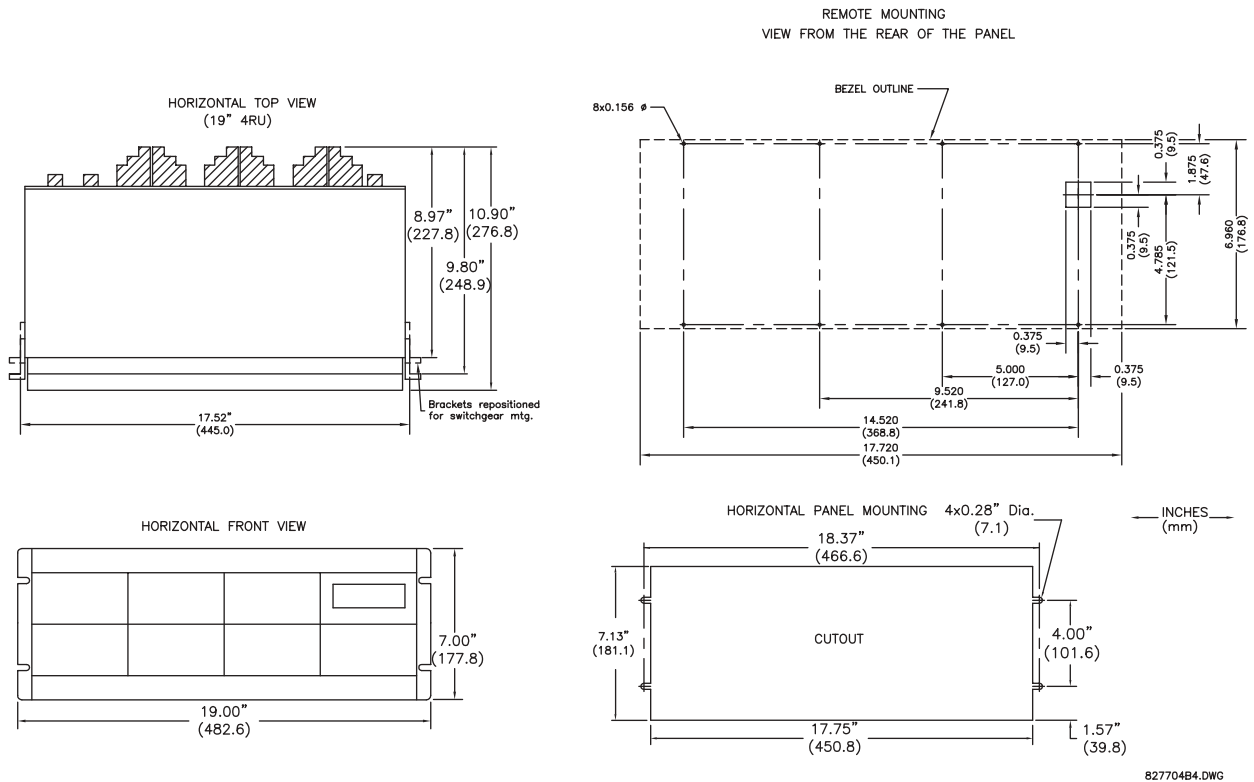


Figure 3-4: F60 HORIZONTAL MOUNTING AND DIMENSIONS

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.

3



Figure 3-5: UR MODULE WITHDRAWAL/INSERTION

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.

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



NOTE

Type 9C and 9D CPU modules are equipped with 10Base-T and 10Base-F Ethernet connectors for communications. These connectors must be individually disconnected from the module before it can be removed from the chassis.

3.1.3 REAR TERMINAL LAYOUT

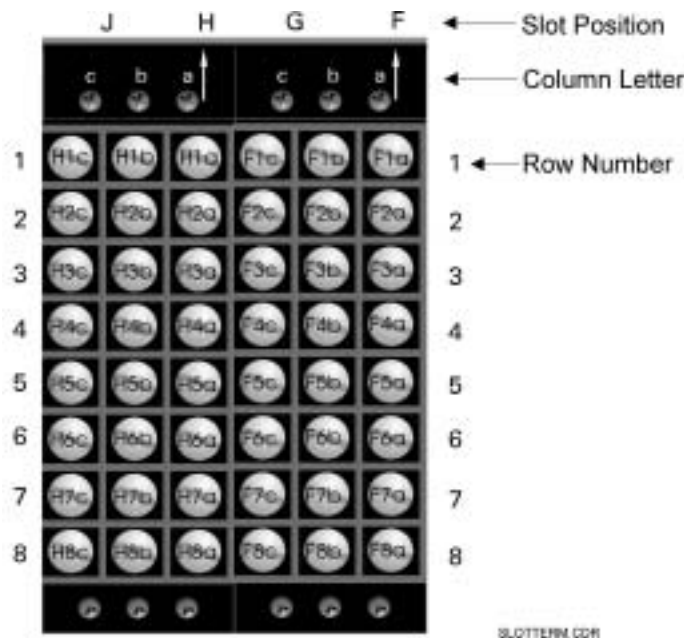


832704AG.CDR

Figure 3-6: REAR TERMINAL VIEW

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

The relay follows a convention with respect to terminal number assignments which are three characters long assigned in order by module slot position, row number, and column letter. Two-slot wide modules take their slot designation from the first slot position (nearest to CPU module) which is indicated by an arrow marker on the terminal block. See the following figure for an example of rear terminal assignments.



SLOTTERM.CDR

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

3.2.1 TYPICAL WIRING

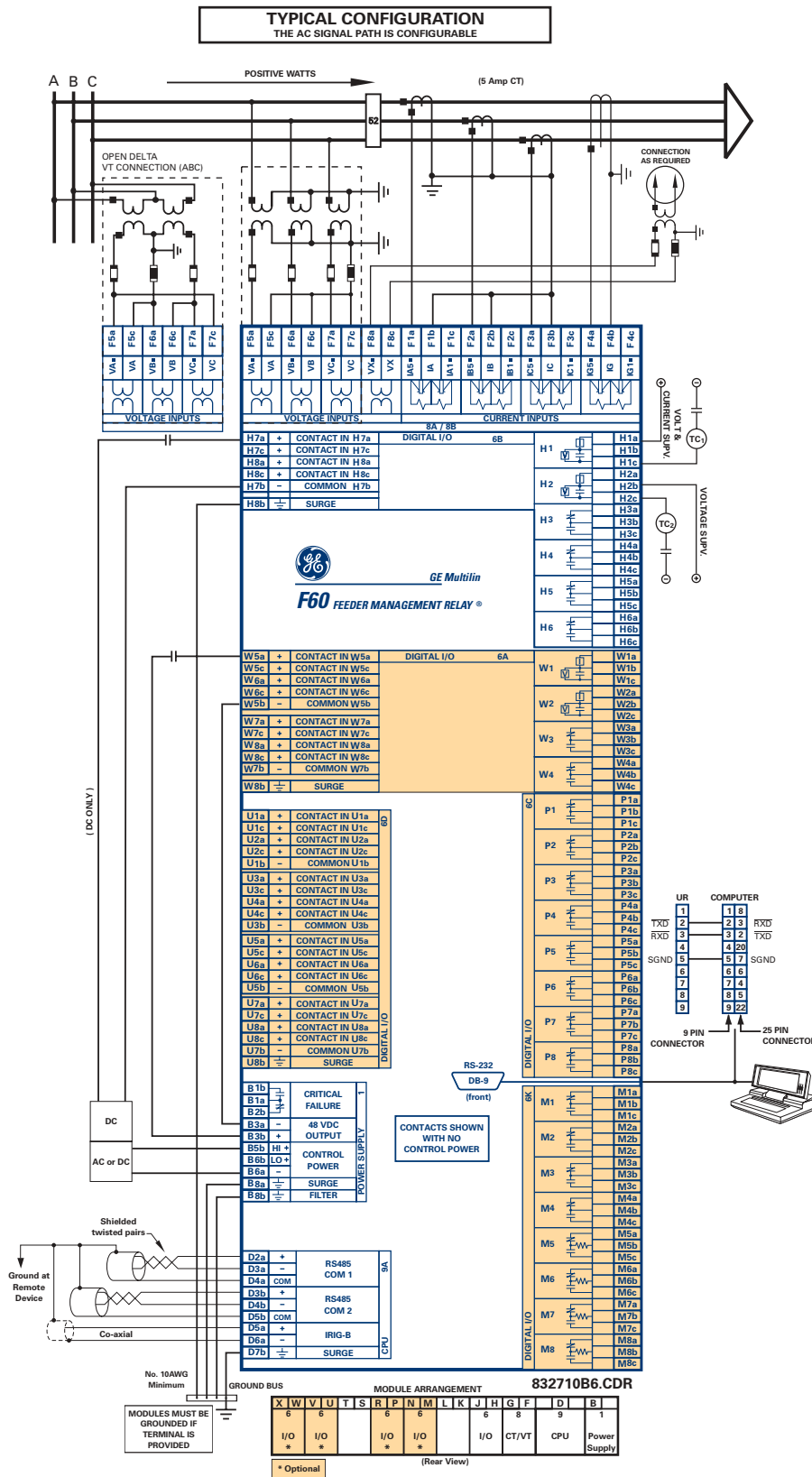


Figure 3-8: TYPICAL WIRING DIAGRAM

This diagram is based on the following order code: F60-A00-HCH-F8A-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 own relay correctly based on your own relay configuration and order code.



3.2.2 TYPICAL WIRING WITH HI-Z

FEEDER RELAY WITH HI-Z ELEMENT

TYPICAL CONFIGURATION
THE AC SIGNAL PATH IS CONFIGURABLE

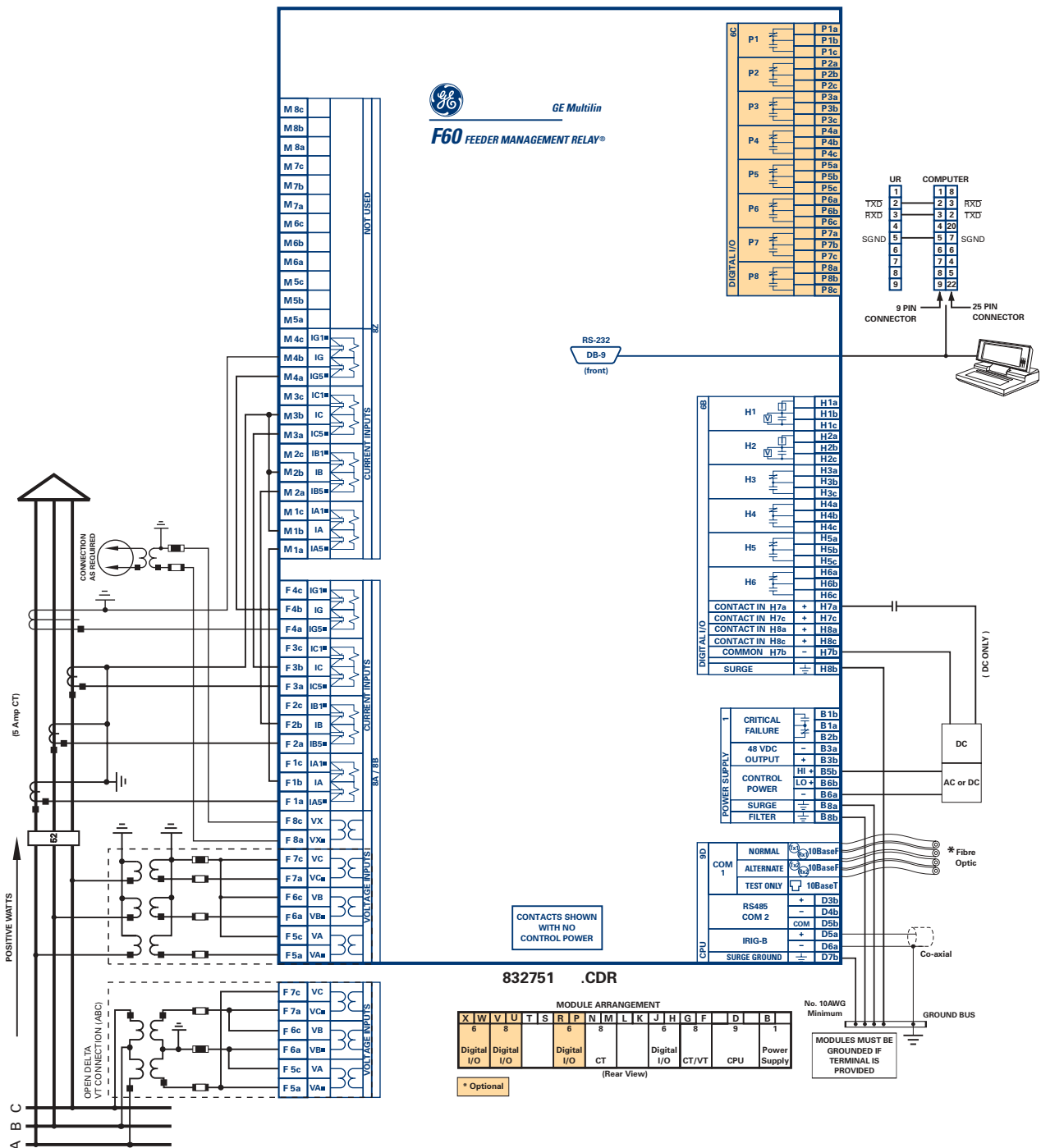


Figure 3–9: TYPICAL WIRING DIAGRAM WITH HI-Z

3.2.3 DIELECTRIC STRENGTH

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

Table 3–1: DIELECTRIC STRENGTH OF UR 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
1	Power Supply	48 V DC (+) and (–)	Chassis	2000 V AC for 1 minute ¹
1	Power Supply	Relay Terminals	Chassis	2000 V AC for 1 minute ¹
2	Reserved for Future	N/A	N/A	N/A
3	Reserved for Future	N/A	N/A	N/A
4	Reserved for Future	N/A	N/A	N/A
5	Analog I/O	All except 8b	Chassis	< 50 V DC
6	Digital I/O	All (See Precaution 2)	Chassis	2000 V AC for 1 minute
8	CT/VT	All	Chassis	2000 V AC for 1 minute
9	CPU	All except 7b	Chassis	< 50 VDC

¹ See TEST PRECAUTION 1 below.

Filter networks and transient protection clamps are used in module hardware to prevent damage caused by high peak voltage transients, radio frequency interference (RFI) and electromagnetic interference (EMI). These protective components **can be damaged** by application of the ANSI/IEEE C37.90 specified test voltage for a period longer than the specified one minute. For testing of dielectric strength where the test interval may exceed one minute, always observe the following precautions:

1. The connection from ground to the Filter Ground (Terminal 8b) and Surge Ground (Terminal 8a) must be removed before testing.
2. Some versions of the digital I/O module have a Surge Ground connection on Terminal 8b. On these module types, this connection must be removed before testing.

3.2.4 CONTROL POWER



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



The 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 with either of two possible voltage ranges. Each range has a dedicated input connection for proper operation. The ranges are as shown below (see the Technical Specifications section for details):

- LO range: 24 to 48 V (DC only) nominal
- HI range: 125 to 250 V nominal

The power supply module provides power to the relay and supplies power for dry contact input connections.

The power supply module provides 48 V DC power for dry contact input connections and a critical failure relay (see the Typical Wiring Diagram earlier). The critical failure relay is a Form-C that will be energized once control power is applied and the relay has successfully booted up with no critical self-test failures. If on-going self-test diagnostic checks detect a critical failure (see the Self-Test Errors Table in Chapter 7) or control power is lost, the relay will de-energize.

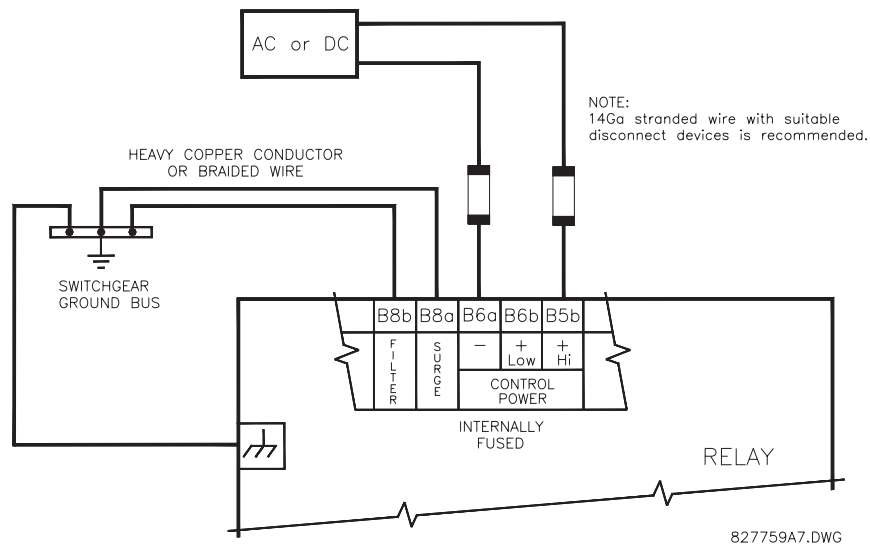


Figure 3-10: CONTROL POWER CONNECTION

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



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 8A) or with a sensitive ground input (Type 8B) which is 10 times more sensitive (see the Technical Specifications section for more 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.

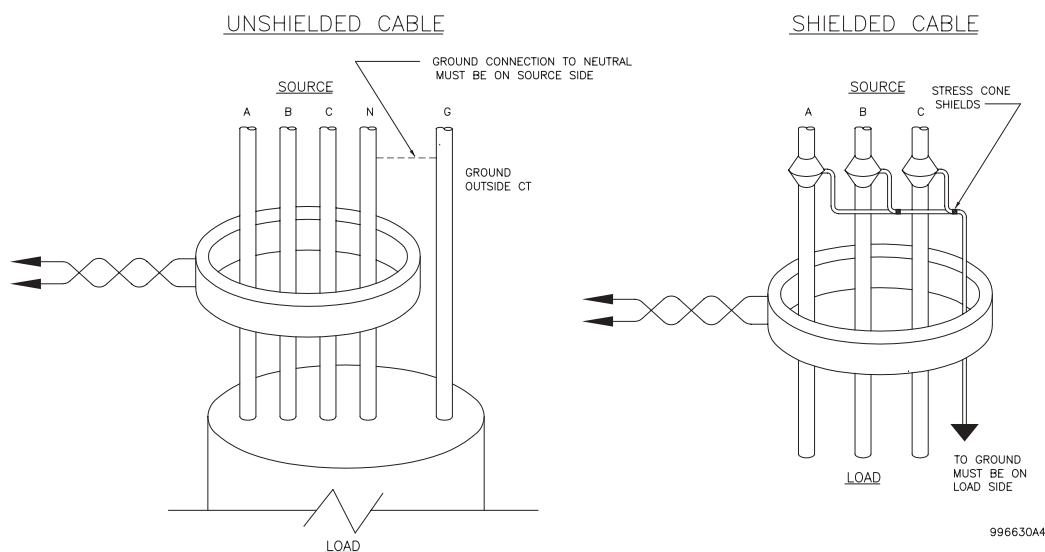


Figure 3-11: ZERO-SEQUENCE CORE BALANCE CT INSTALLATION

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.

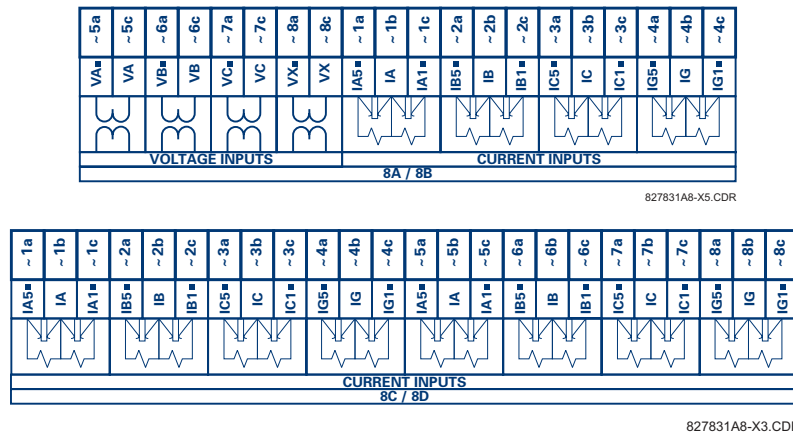


Figure 3-12: CT/VT MODULE WIRING

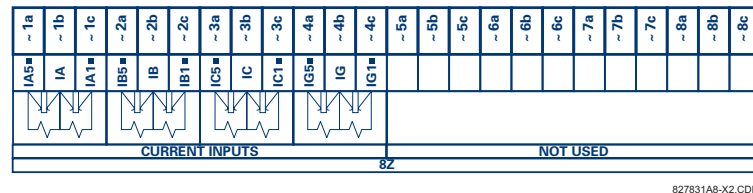


Figure 3-13: CT HI-Z MODULE WIRING



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



A feeder relay with the Hi-Z element typically includes two CT/VT modules: one Type 8A or 8B 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).

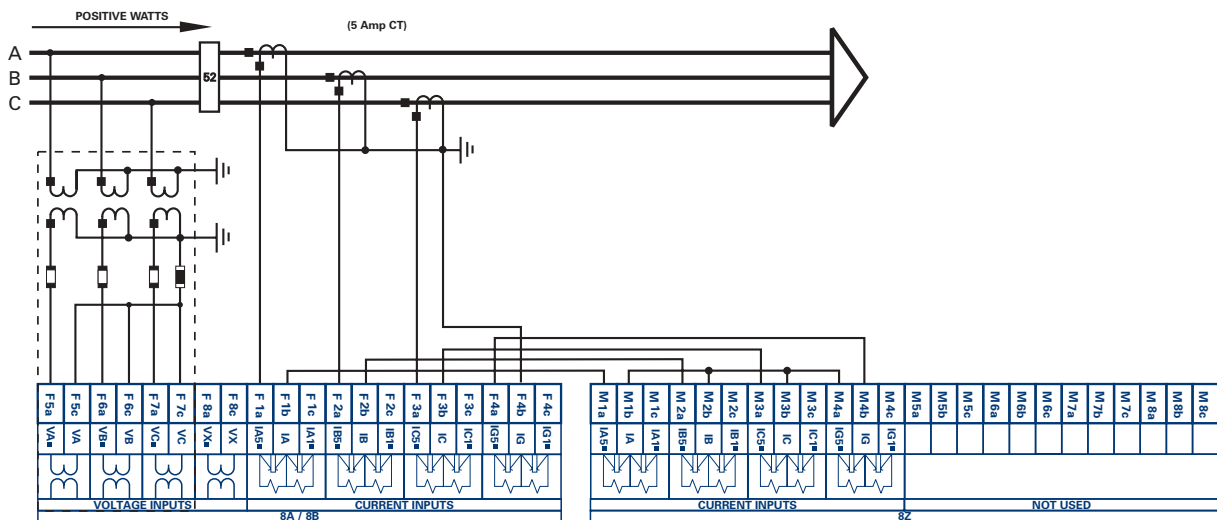


Figure 3-14: TYPICAL 8Z MODULE WIRING WITH PHASE CTs

3.2.6 CONTACT INPUTS/OUTPUTS

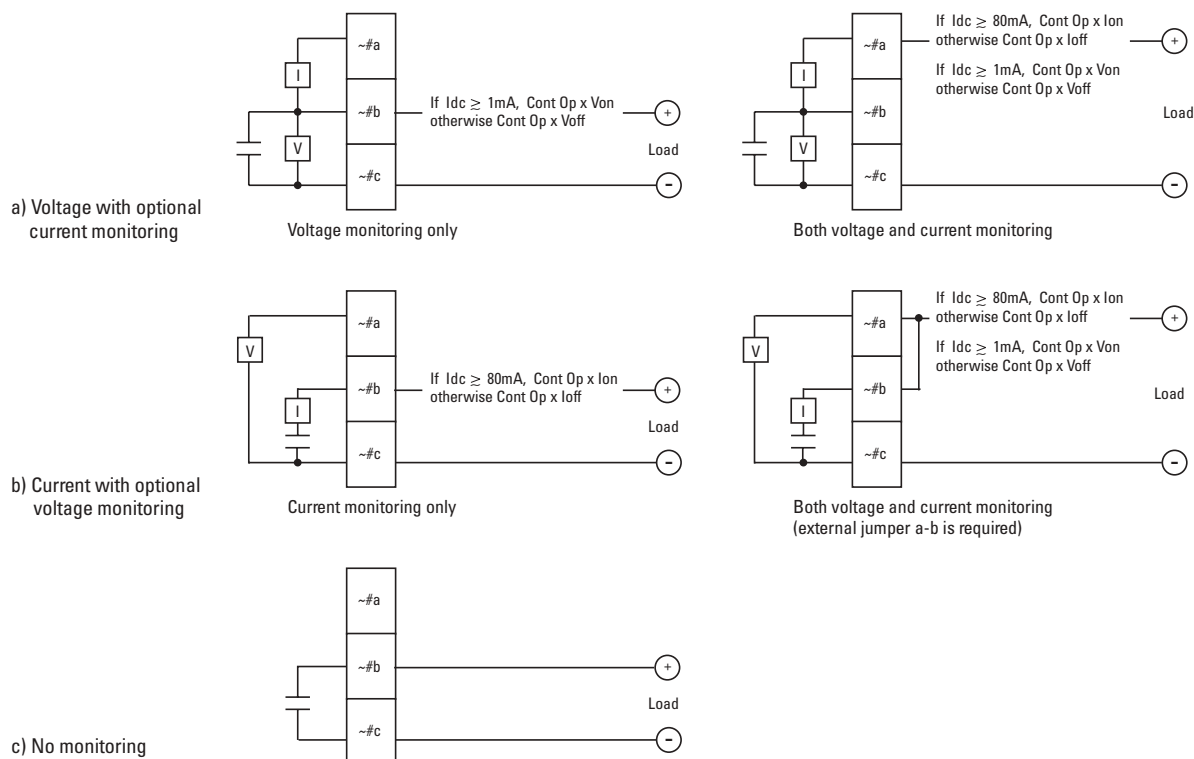
Every digital input/output module has 24 terminal connections. They are arranged as 3 terminals per row, with 8 rows in total. A given row of three terminals may be used for the outputs of one relay. For example, for Form-C relay outputs, the terminals connect to the normally open (NO), normally closed (NC), and common contacts of the relay. For a Form-A output, there are options of using current or voltage detection for feature supervision, depending on the module ordered. The terminal configuration for contact inputs is different for the two applications. When a Digital I/O module is ordered with contact inputs, they are arranged in groups of four and use two rows of three terminals. Ideally, each input would be totally isolated from any other input. However, this would require that every input have two dedicated terminals and limit the available number of contacts based on the available number of terminals. So, although each input is individually optically isolated, each group of four inputs uses a single common as a reasonable compromise. This allows each group of four outputs to be supplied by wet contacts from different voltage sources (if required) or a mix of wet and dry contacts.

The tables and diagrams on the following pages illustrate the module types (6A, etc.) and contact arrangements that may be ordered for the relay. Since an entire row is used for a single contact output, the name is assigned using the module slot position and row number. However, since there are two contact inputs per row, these names are assigned by module slot position, row number, and column position.

UR RELAY FORM-A OUTPUT CONTACTS:

Some Form-A 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



827821A4.CDR

Figure 3-15: FORM-A 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 contacts can be applied for Breaker Trip Circuit Integrity Monitoring.



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!



USE OF FORM-A OUTPUTS IN HIGH IMPEDANCE CIRCUITS

For Form-A 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.



Wherever a tilde “~” symbol appears, substitute with the Slot Position of the module; wherever a number sign “#” appears, substitute the contact number



When current monitoring is used to seal-in the Form-A 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 I/O MODULE ASSIGNMENTS

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

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

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

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

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

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

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

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

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

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

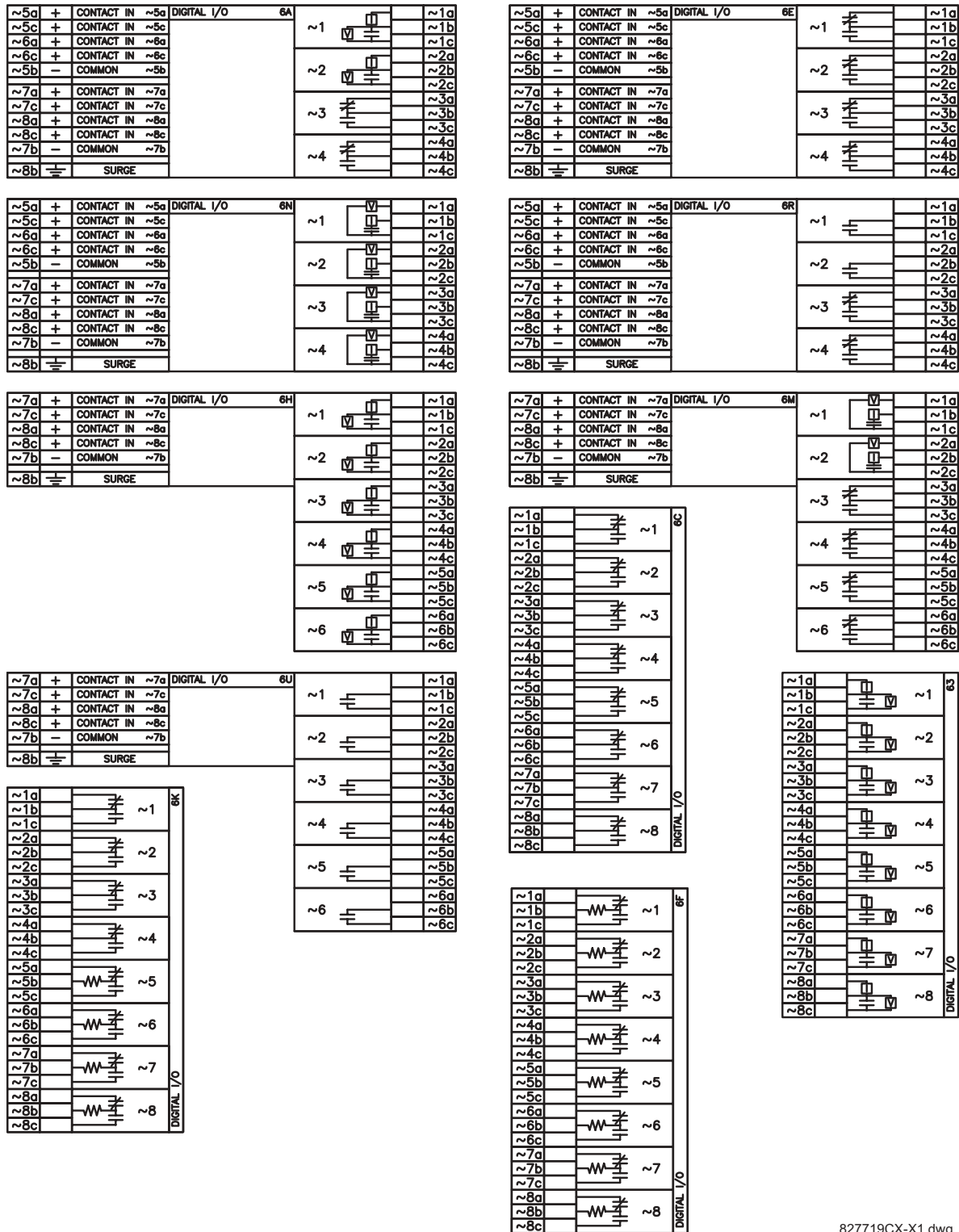
~6U I/O MODULE	
TERMINAL ASSIGNMENT	OUTPUT OR INPUT
~1	Form-A
~2	Form-A
~3	Form-A
~4	Form-A
~5	Form-A
~6	Form-A
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs

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

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

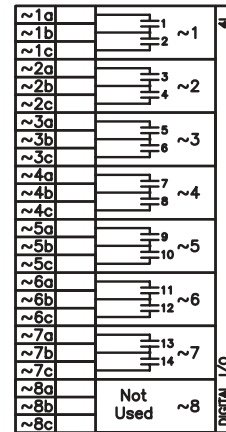
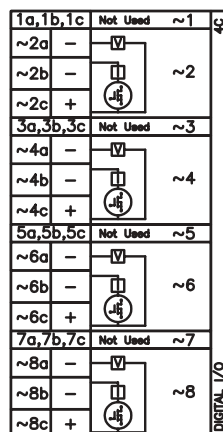
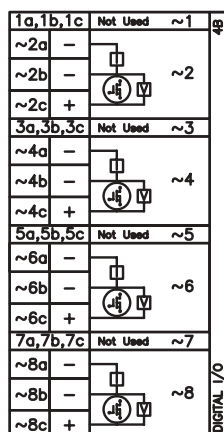
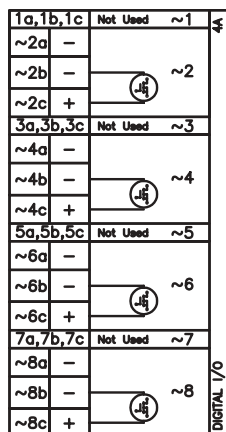
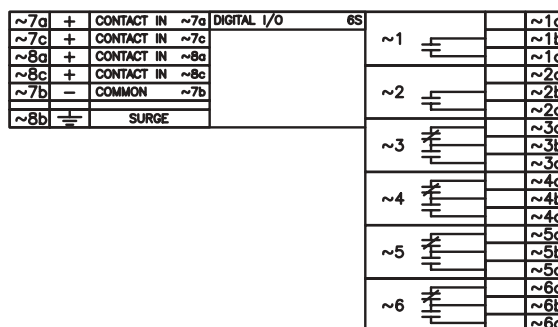
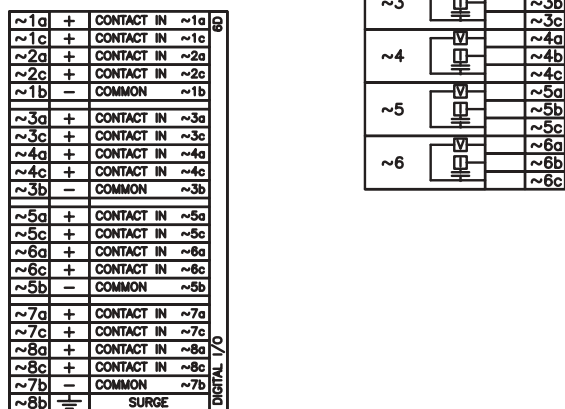
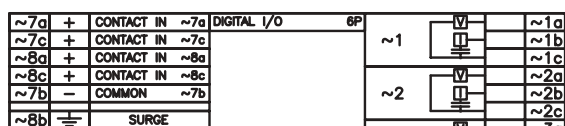
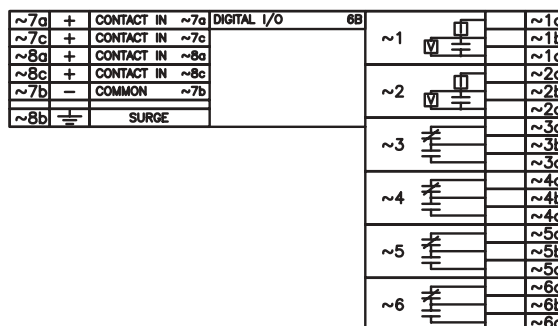
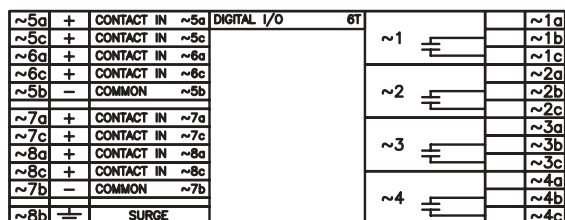
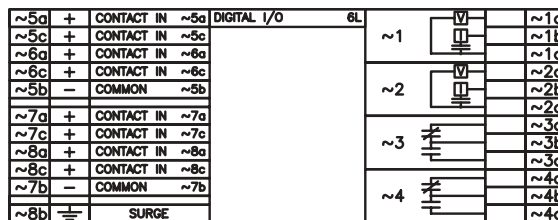
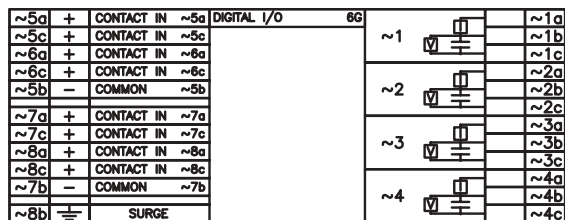
~4C I/O MODULE	
TERMINAL ASSIGNMENT	OUTPUT
~1	Not Used
~2	Solid-State
~3	Not Used
~4	Solid-State
~5	Not Used
~6	Solid-State
~7	Not Used
~8	Solid-State


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



827719CX-X1.dwg

Figure 3-16: DIGITAL I/O MODULE WIRING (1 of 2)



 - MOSFET Solid State Contact

82719CX-X2.dwg

Figure 3-17: DIGITAL I/O MODULE WIRING (2 of 2)



CORRECT POLARITY MUST BE OBSERVED FOR ALL CONTACT INPUT CONNECTIONS OR EQUIPMENT DAMAGE MAY RESULT.

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.

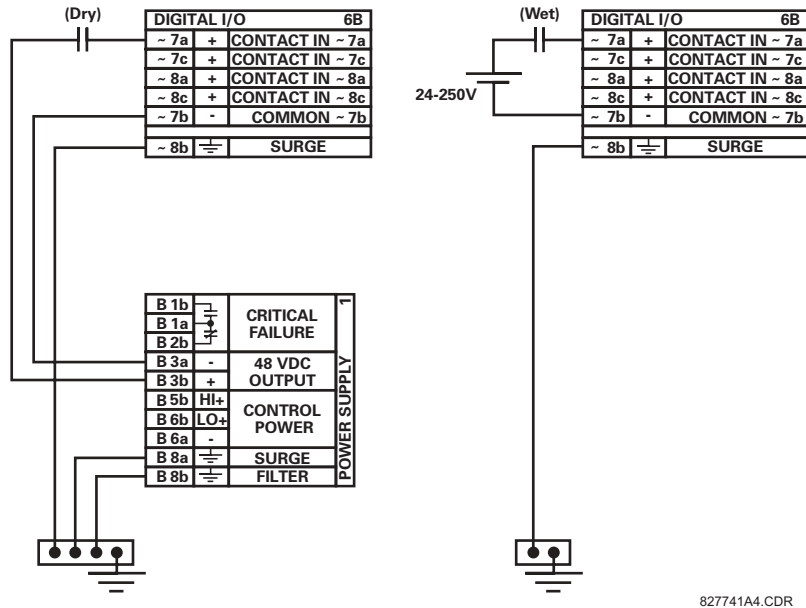


Figure 3-18: DRY AND WET CONTACT INPUT CONNECTIONS



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

NOTE

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



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

NOTE

3.2.7 TRANSDUCER INPUTS/OUTPUTS

Transducer input/output 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.

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 figure below illustrates the transducer module types (5C, 5E, and 5F) and channel arrangements that may be ordered for the relay.



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

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

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

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

827831A8-X1.CDR

Figure 3-19: TRANSDUCER I/O 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 URPC 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 that the baud rate for this port is fixed at **19200 bps**.

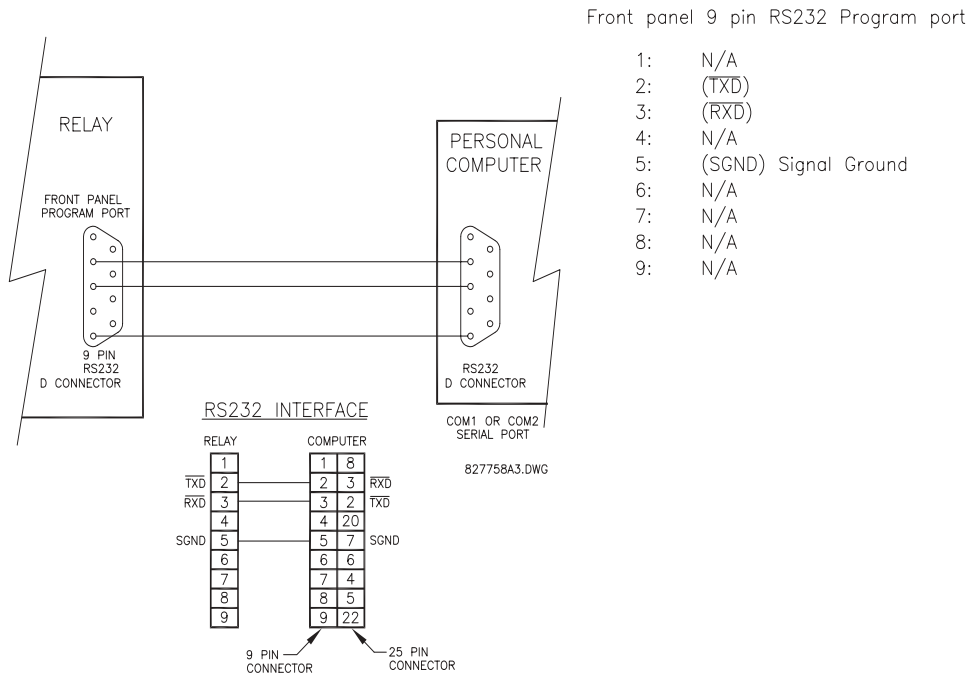


Figure 3-20: RS232 FACEPLATE PORT CONNECTION

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.

CPU TYPE	COM1	COM2
9A	RS485	RS485
9C	10BASE-F	RS485
9D	Redundant 10Base-F	RS485

D2a	+	RS485 COM 1	9A
D3a	—		
D4a	COM		
D3b	+	RS485 COM 2	CPU
D4b	—		
D5b	COM		
D5a	+	IRIG-B	
D6a	—		
D7b	⏏		

<div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div></div></div><div><div><div><div></div><div></div></div><div><div></div><div></div></div></div><div></div></div></div></div></div>
--

(Tx) (Rx)	10BaseF	NORMAL	COM 1
(Tx) (Rx)	10BaseF	ALTERNATE	
	10BaseT	TEST ONLY	
D3b	+	RS485 COM 2	CPU
D4b	-		
D5b	COM		
D5a	+	IRIG-B	
D6a	-		
D7b	⏏		
		SURGE GROUND	

827831A8-X6.CDR

Figure 3-21: CPU MODULE COMMUNICATIONS WIRING

b) RS485 PORTS

RS485 data transmission and reception are accomplished over a single twisted pair with transmit and receive data alternating over the same two wires. Through the use of these 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.

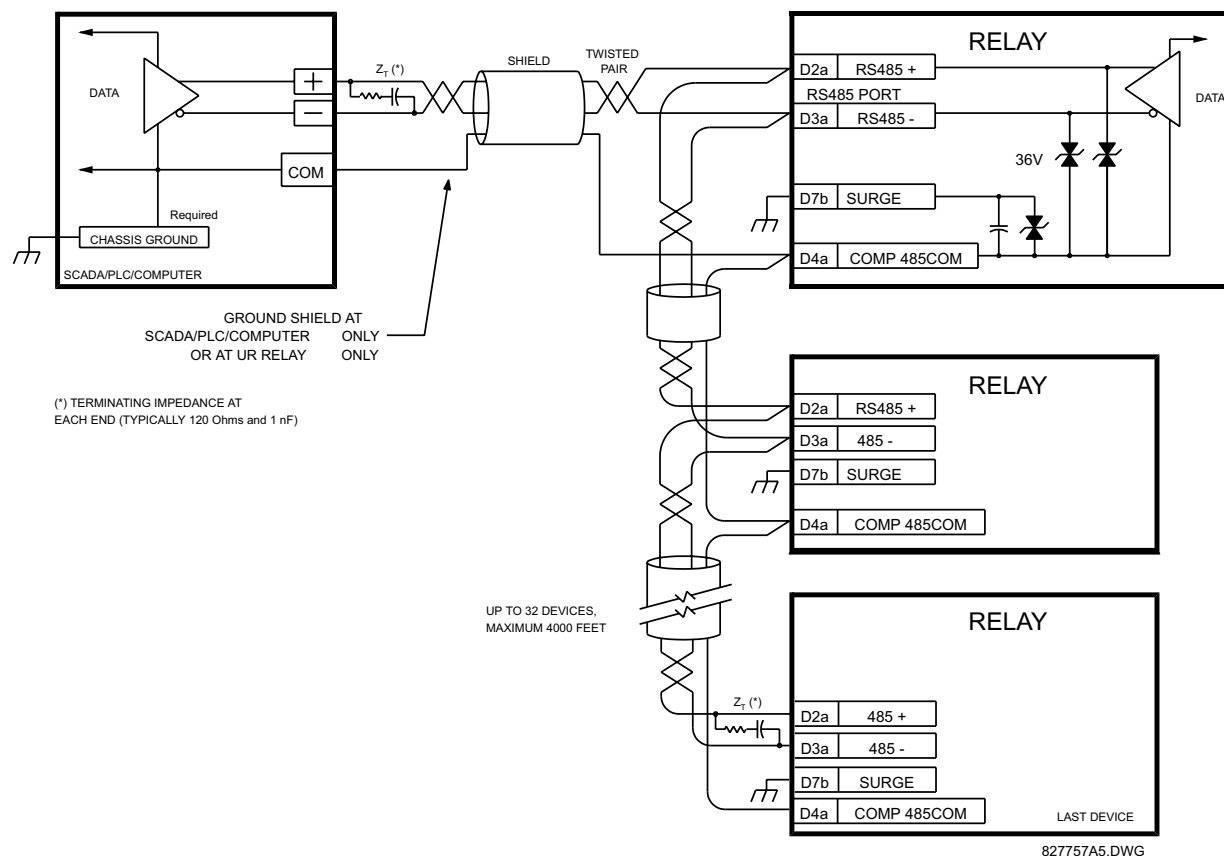


Figure 3–22: RS485 SERIAL CONNECTION

c) 10BASE-F FIBER OPTIC PORT



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



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

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

The optical fiber sizes supported include 50/125 μm , 62.5/125 μm and 100/140 μm . The fiber optic port is designed such that the response times will not vary for any core that is 100 μm or less in diameter. For optical power budgeting, splices are required every 1 km for the transmitter/receiver pair (the ST type connector contributes for a connector loss of 0.2 dB). When splicing optical fibers, the diameter and numerical aperture of each fiber must be the same. In order to engage or disengage the ST type connector, only a quarter turn of the coupling is required.

3.2.10 IRIG-B

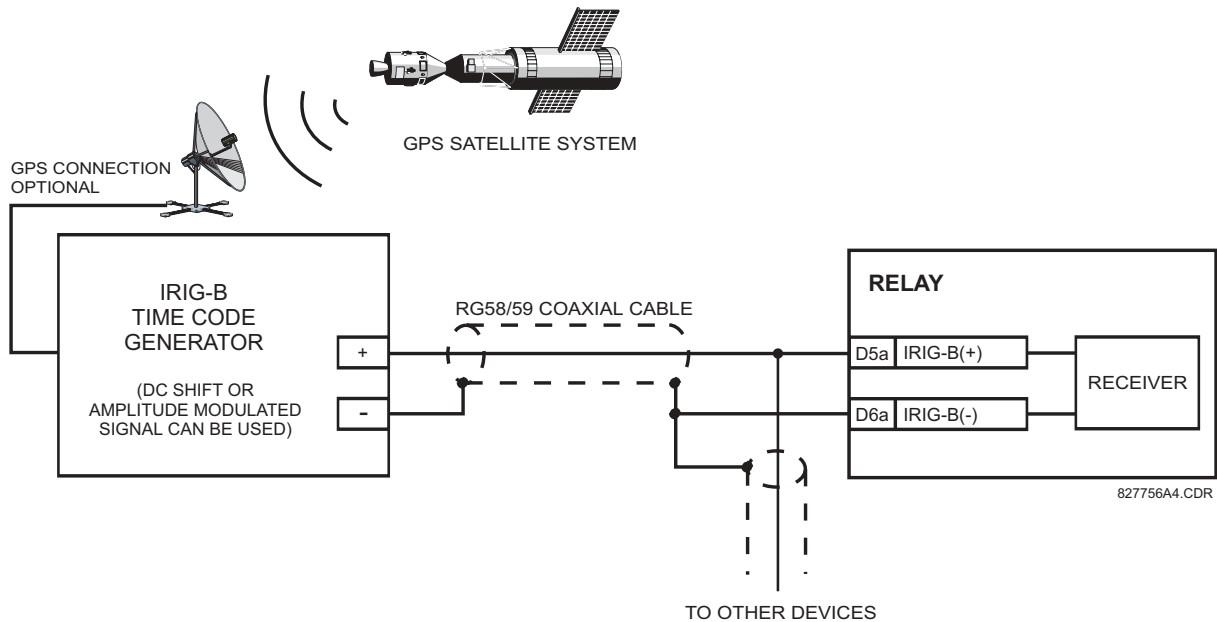


Figure 3–23: IRIG-B CONNECTION

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.

3.3.1 DESCRIPTION

The F60 Direct I/O 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 I/O feature uses the communications channel(s) provided by these modules to exchange digital state information between relays. This feature is available on all UR relays models except for the L60 and L90 Line relays.

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 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. The maximum number of UR relays that can be connected in a single ring is eight.

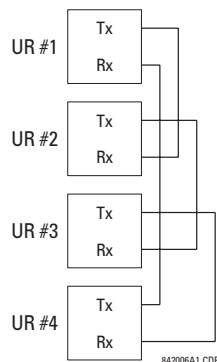


Figure 3–24: DIRECT I/O SINGLE CHANNEL CONNECTION

The following diagram shows the interconnection for dual-channel Type 7 communications modules. 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 as follows: UR1-Tx1 to UR2-Rx1, UR2-Tx1 to UR3-Rx1, UR3-Tx1 to UR4-Rx1, and UR4-Tx1 to UR1-Rx1 for the first ring; and UR1-Tx2 to UR2-Rx2, UR2-Tx2 to UR3-Rx2, UR3-Tx2 to UR4-Rx2, and UR4-Tx2 to UR1-Rx2 for the second ring.

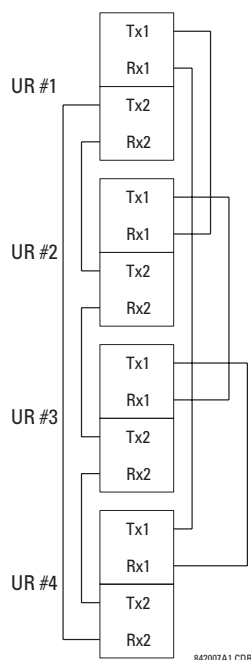


Figure 3–25: DIRECT I/O DUAL CHANNEL CONNECTION

The following diagram shows the interconnection 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 I/O 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.

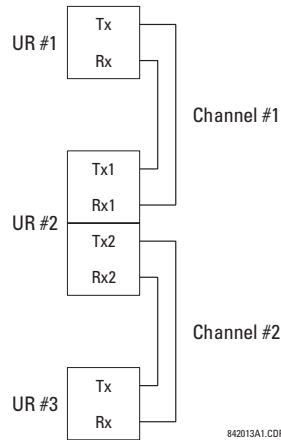


Figure 3–26: DIRECT I/O SINGLE/DUAL CHANNEL COMBINATION CONNECTION

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 TYPE	SPECIFICATION
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
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
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 Channel
74	Channel 1 - RS422; Channel 2 - 1550 nm, single-mode, LASER
76	IEEE C37.94, 820 nm, multi-mode, LED, 1 Channel
77	IEEE C37.94, 820 nm, multi-mode, LED, 2 Channels



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

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.

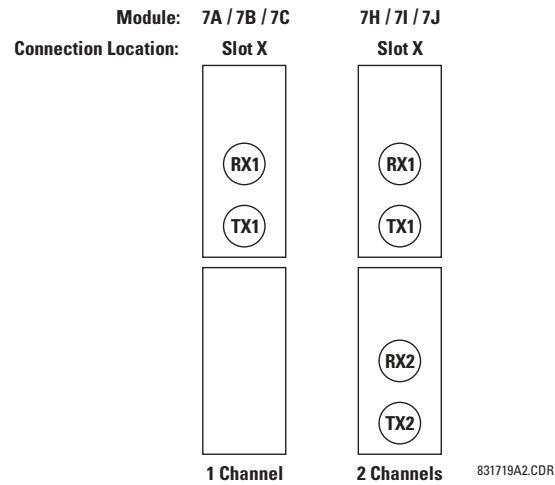


Figure 3–27: LED AND ELED FIBER MODULES

3.3.3 FIBER-LASER TRANSMITTERS

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

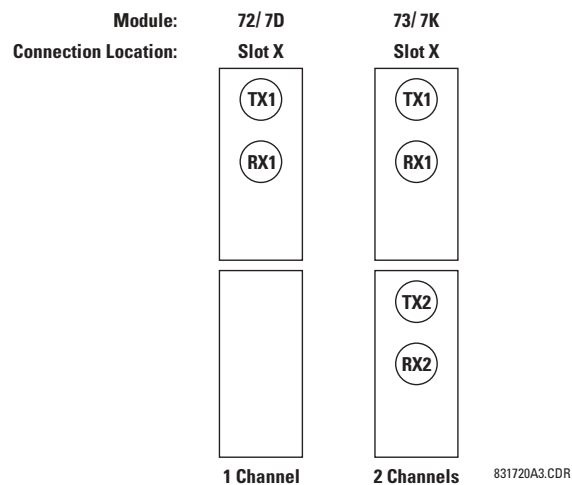


Figure 3–28: LASER FIBER MODULES



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.

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



X1a	Shld.	G.703 CHANNEL 1	7R
X1b	Tx -		
X2a	Rx -		
X2b	Tx +		
X3a	Rx +		
X3b		SURGE	
X6a	Shld.	G.703 CHANNEL 2	
X6b	Tx -		
X7a	Rx -		
X7b	Tx +		
X8a	Rx +		
X8b		SURGE	

Figure 3–29: G.703 INTERFACE CONFIGURATION

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

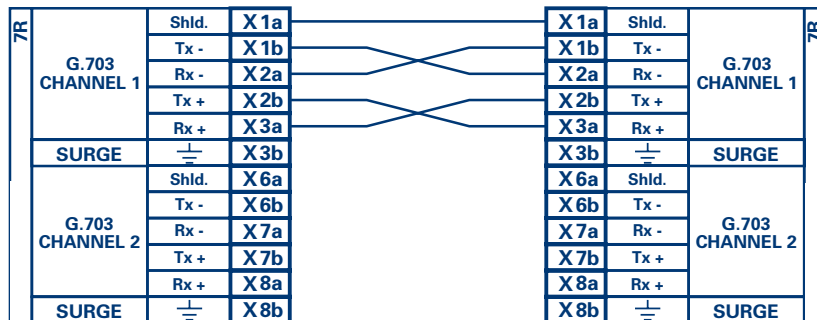


Figure 3–30: TYPICAL PIN INTERCONNECTION BETWEEN TWO G.703 INTERFACES



Pin nomenclature may differ from one manufacturer to another. Therefore, it is not uncommon to see 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/insertor clips located at the top and at the bottom of each module must be in the disengaged position as

the module is smoothly inserted into the slot. Once the clips have cleared the raised edge of the chassis, engage the clips simultaneously. When the clips have locked into position, the module will be fully inserted.

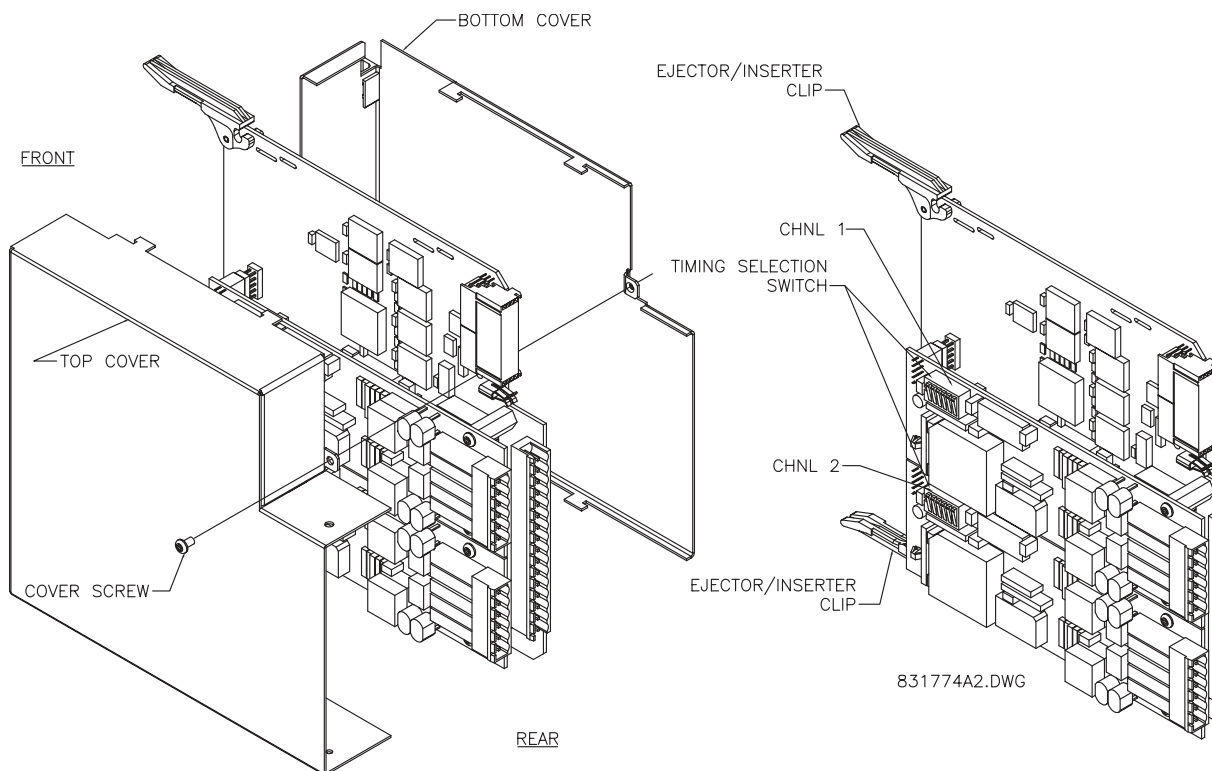


Figure 3-31: G.703 TIMING SELECTION SWITCH SETTING

Table 3-4: 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)

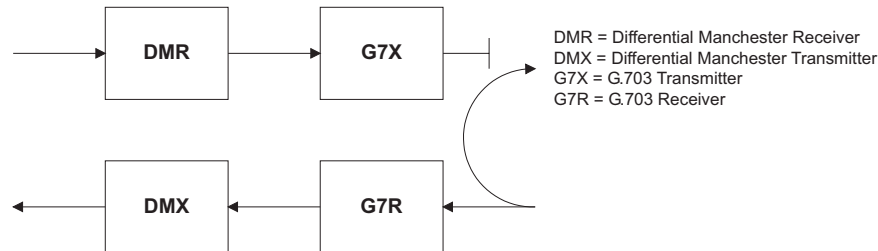
If Octet Timing is enabled (ON), this 8 kHz signal will be asserted during the violation of Bit 8 (LSB) necessary for connecting to higher order systems. When L90's are connected back to back, Octet Timing should be disabled (OFF).

d) TIMING MODES (SWITCHES S5 AND S6)

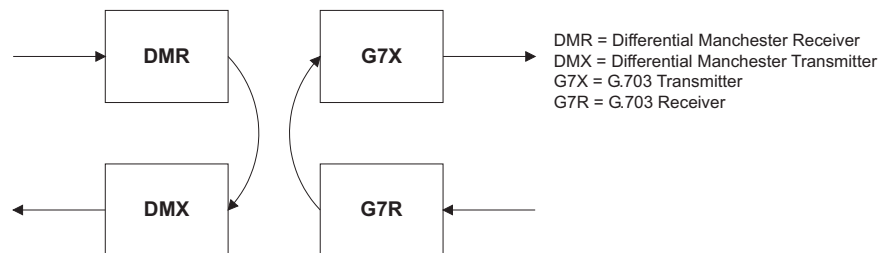
- **Internal Timing Mode:** The system clock generated internally. Therefore, the G.703 timing selection should be in the Internal Timing Mode for back-to-back (UR-to-UR) connections. For Back to Back Connections, set for Octet Timing (S1 = OFF) and Timing Mode = Internal Timing (S5 = ON and S6 = OFF).
- **Loop Timing Mode:** The system clock is derived from the received line signal. Therefore, the G.703 timing selection should be in Loop Timing Mode for connections to higher order systems. For connection to a higher order system (UR-to-multiplexer, factory defaults), set to Octet Timing (S1 = ON) and set Timing Mode = Loop Timing (S5 = OFF and S6 = OFF).

e) TEST MODES (SWITCHES S5 AND S6)**MINIMUM REMOTE LOOPBACK MODE:**

In Minimum Remote Loopback mode, the multiplexer is enabled to return the data from the external interface without any processing to assist in diagnosing G.703 Line Side problems irrespective of clock rate. Data enters from the G.703 inputs, passes through the data stabilization latch which also restores the proper signal polarity, passes through the multiplexer and then returns to the transmitter. The Differential Received Data is processed and passed to the G.703 Transmitter module after which point the data is discarded. The G.703 Receiver module is fully functional and continues to process data and passes it to the Differential Manchester Transmitter module. Since timing is returned as it is received, the timing source is expected to be from the G.703 line side of the interface.

**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**

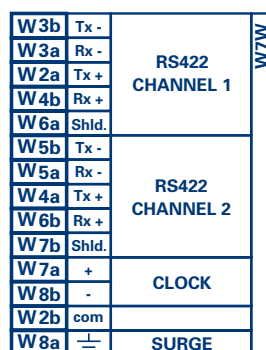
The following figure shows the RS422 2-Terminal interface configuration at 64K baud. AWG 22 twisted shielded pair is recommended for external connections. This interface module is protected by surge suppression devices which optically isolated.

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.

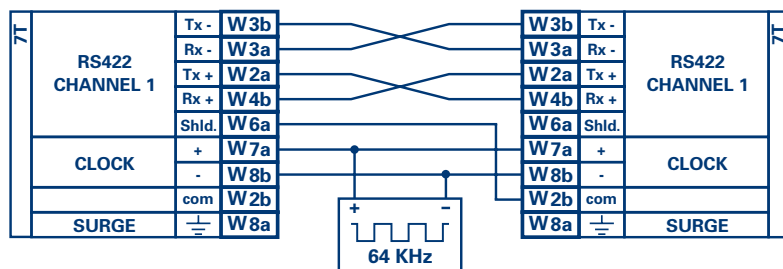
The clock terminating impedance should match the impedance of the line.



RS422.CDR
p/o 827831A6.CDR

Figure 3–32: RS422 INTERFACE CONFIGURATION

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

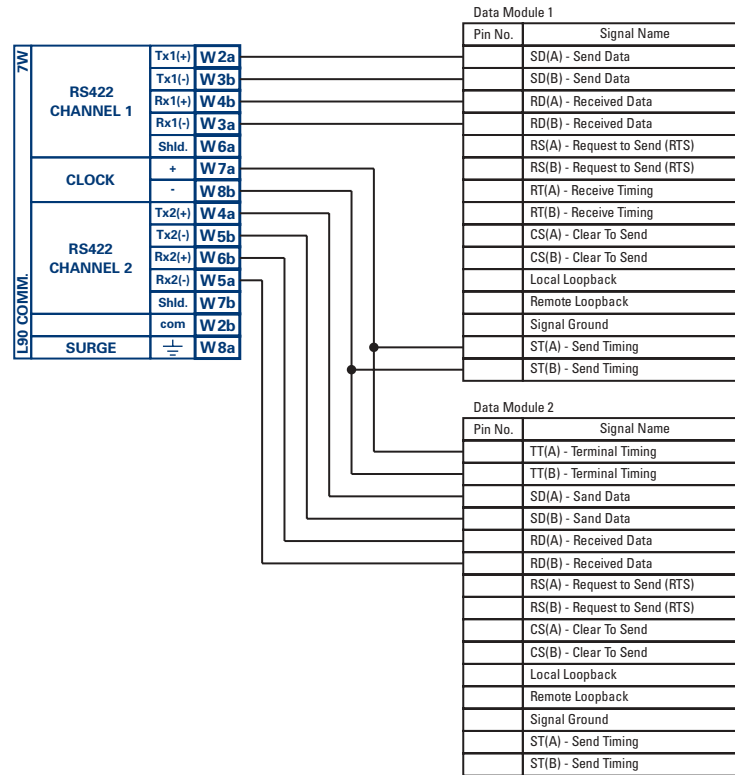


831728A3.CDR

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

b) TWO CHANNEL APPLICATIONS VIA MULTIPLEXERS

The RS422 Interface may be used for '1 channel' or '2 channel' applications over SONET/SDH and/or Multiplexed systems. When used in 1 channel applications, the RS422 interface links to higher order systems in a typical fashion observing Tx, Rx, and Send Timing connections. However, when used in 2 channel applications, certain criteria have to be followed due to the fact that there is 1 clock input for the two RS422 channels. The system will function correctly if the following connections are observed and your Data Module has a feature called Terminal Timing. Terminal Timing is a common feature to most Synchronous Data Units that allows the module to accept timing from an external source. Using the Terminal Timing feature, 2 channel applications can be achieved if these connections are followed: The Send Timing outputs from the Multiplexer - Data Module 1, will connect to the Clock inputs of the UR-RS422 interface in the usual fashion. In addition, the Send Timing outputs of Data Module 1 will also be paralleled to the Terminal Timing inputs of Data Module 2. By using this configuration the timing for both Data Modules and both UR-RS422 channels will be derived from a single clock source. As a result, data sampling for both of the UR-RS422 channels will be synchronized via the Send Timing leads on Data Module 1 as shown in the following figure. If the Terminal Timing feature is not available or this type of connection is not desired, the G.703 interface is a viable option that does not impose timing restrictions.



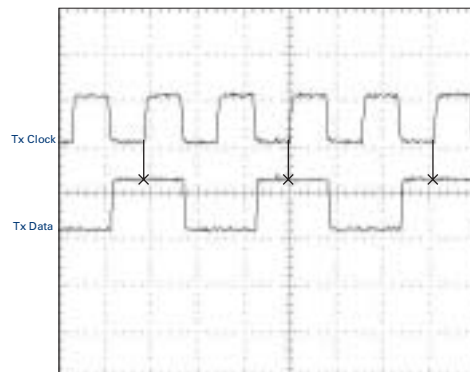
831022A2.CDR

Figure 3–34: 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 3–35: CLOCK AND DATA TRANSITIONS**

d) RECEIVE TIMING

The RS422 Interface utilizes NRZI-MARK Modulation Code and; therefore, does not rely on an Rx Clock to recapture data. NRZI-MARK is an edge-type, invertible, self-clocking code.

To recover the Rx Clock from the data-stream, an integrated DPLL (Digital Phase Lock Loop) circuit is utilized. The DPLL is driven by an internal clock, which is over-sampled 16X, and uses this clock along with the data-stream to generate a data clock that can be used as the SCC (Serial Communication Controller) receive clock.

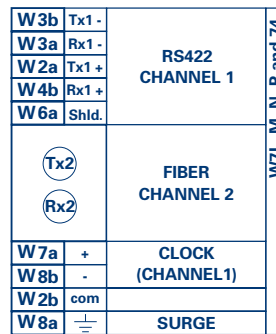
3.3.6 RS422 AND FIBER INTERFACE

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

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



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



L907LMNP.CDR
P/O 827831A6.CDR

Figure 3–36: RS422 AND FIBER INTERFACE CONNECTION

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

3.3.7 G.703 AND FIBER INTERFACE

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



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

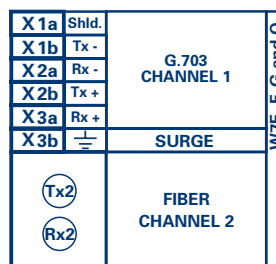


Figure 3–37: G.703 AND FIBER INTERFACE CONNECTION

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 multiplexer and/or an IEEE C37.94 compliant interface converter for use with Direct I/O applications on firmware revision 3.3x. The IEEE C37.94 Standard defines a point to point optical link for synchronous data between a multiplexer and a teleprotection device. This data is typically 64 kbps but the standard provides for speeds up to $64n$ kbps, where $n = 1, 2, \dots, 12$. The UR series C37.94 communication module is 64 kbps only with n fixed at 1. The frame is a valid International Telecommunications Union (ITU-T) recommendation 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

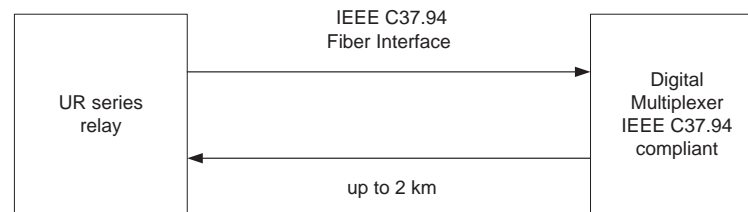
Fiber optic cable length: up to 2 km

Fiber optic connector: Type ST

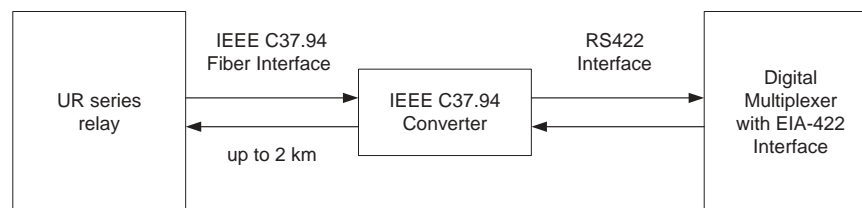
Wavelength: 830 \pm 40 nm

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 an 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 the control switches is shown below.



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

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

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

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

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

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

2. Remove the module cover screw.
3. Remove the top cover by sliding it towards the rear and then lift it upwards.
4. Set the Timing Selection Switches (Channel 1, Channel 2) to the desired timing modes (see description above).
5. Replace the top cover and the cover screw.
6. Re-insert the C37.94 module Take care to ensure that the **correct** module type is inserted into the **correct** slot position. The ejector/inserters located at the top and at the bottom of each module must be in the disengaged position as the module is smoothly inserted into the slot. Once the clips have cleared the raised edge of the chassis, engage the clips simultaneously. When the clips have locked into position, the module will be fully inserted.

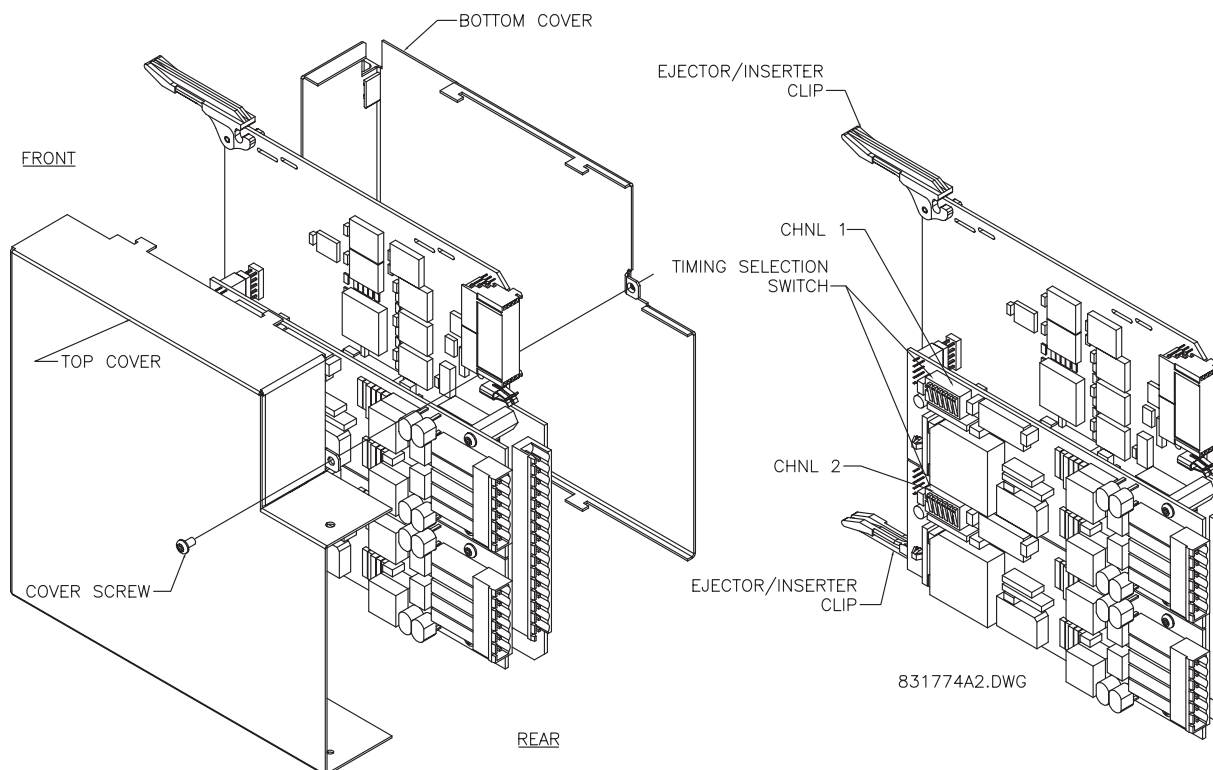


Figure 3–38: C37.94 TIMING SELECTION SWITCH SETTING

4.1.1 INTRODUCTION

The URPC 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).

URPC 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 URPC software, provided with every F60 relay, can be run from any computer supporting Microsoft Windows® 95, 98, or NT. This chapter provides a summary of the basic URPC software interface features. The URPC Help File provides details for getting started and using the URPC software interface.

4.1.2 CREATING A SITE LIST

To start using the URPC software, a site definition and device definition must first be created. See the URPC Help File or refer to the Connecting URPC with the F60 section in Chapter 1 for details.

4.1.3 URPC SOFTWARE OVERVIEW**a) ENGAGING A DEVICE**

The URPC 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 URPC 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 URPC 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 UR device can be upgraded, locally or remotely, via the URPC[®] software. The corresponding instructions are provided by the URPC[®] Help program under the topic “Upgrading Firmware”.



Modbus addresses assigned to firmware modules, features, settings, and corresponding data items (i.e. default values, min/max 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 URPC SOFTWARE MAIN WINDOW

The URPC software main window supports the following primary display components:

- Title bar which shows the pathname of the active data view
- Main window menu bar
- Main window tool bar
- Site List control bar window
- Settings List control bar window
- Device data view window(s), with common tool bar
- Settings File data view window(s), with common tool bar
- Workspace area with data view tabs
- Status bar

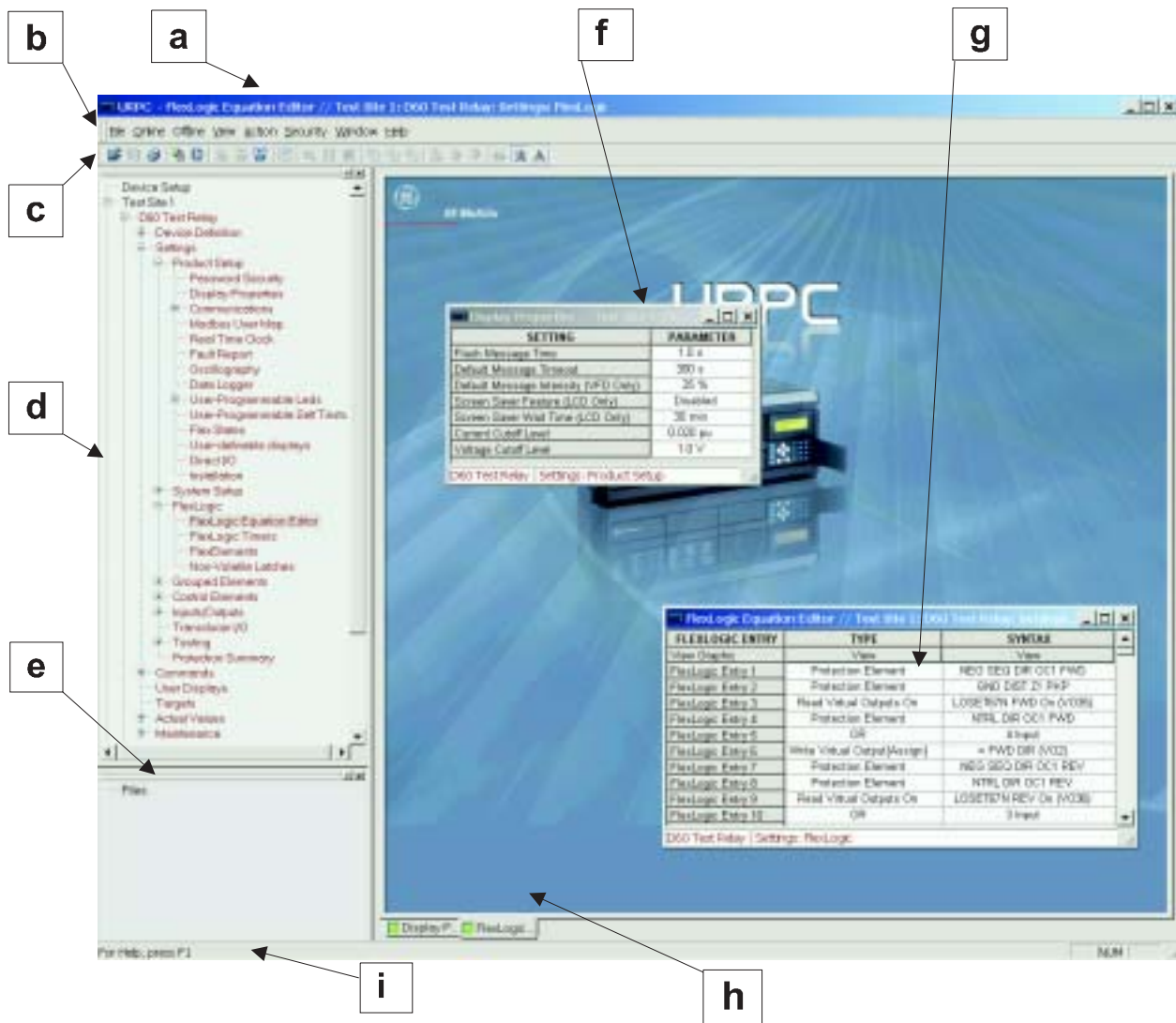


Figure 4-1: URPC SOFTWARE MAIN WINDOW

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 URPC software. The UR 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.

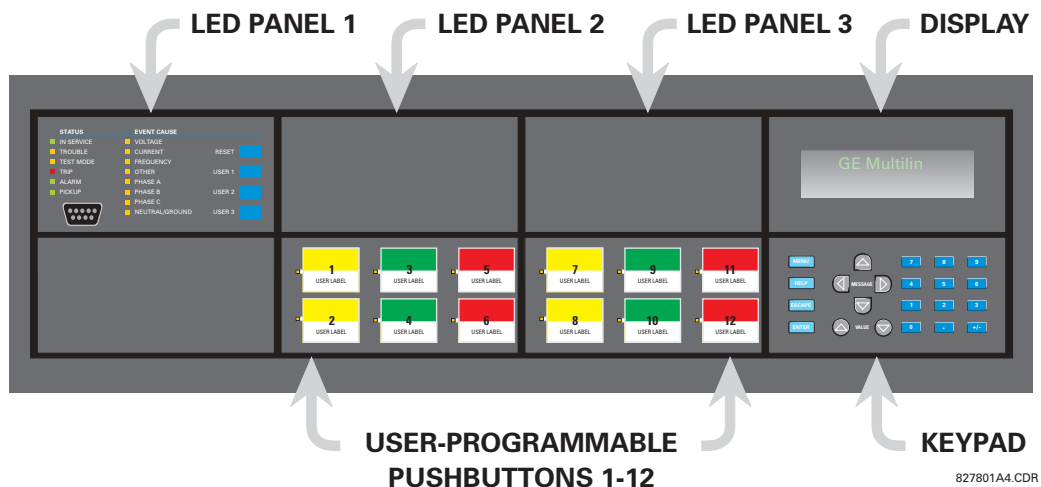


Figure 4-2: UR HORIZONTAL FACEPLATE PANELS

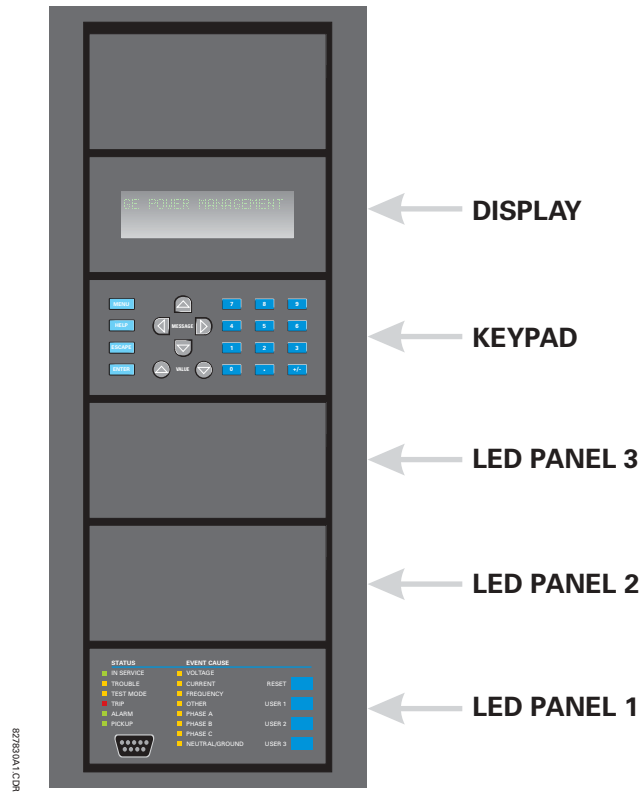


Figure 4-3: UR VERTICAL FACEPLATE PANELS

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.

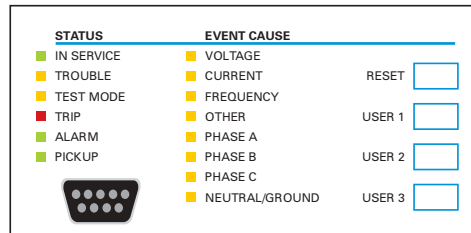


Figure 4–4: LED PANEL 1

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.

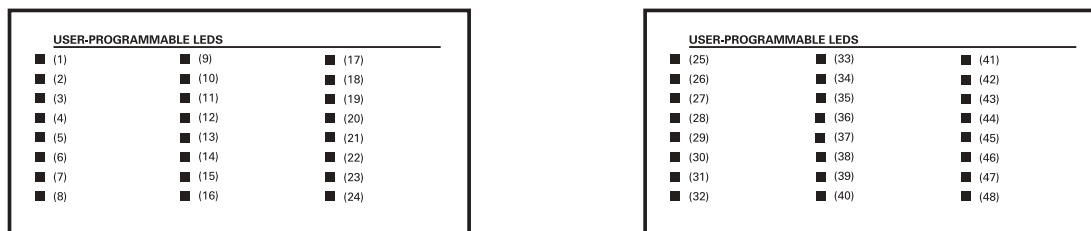


Figure 4-5: LED PANELS 2 AND 3 (INDEX TEMPLATE)

c) DEFAULT LABELS FOR LED PANEL 2

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

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.



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 LED panels 2 and 3 as explained in the next section.

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:

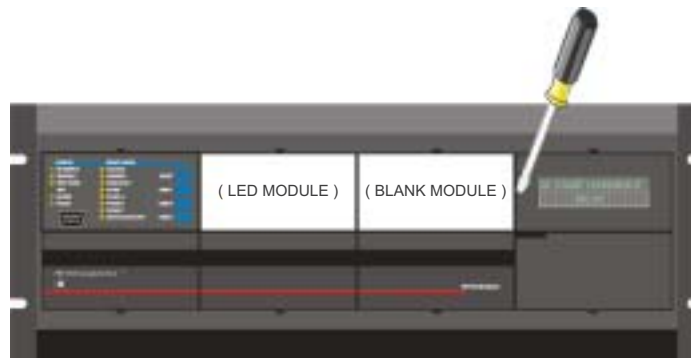
<http://www.GEindustrial.com/multilin/support/ur/>

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 UR display module:

- Black and white or color printer (color preferred)
 - Microsoft Word 97 or later software
 - 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.

4.2.3 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.

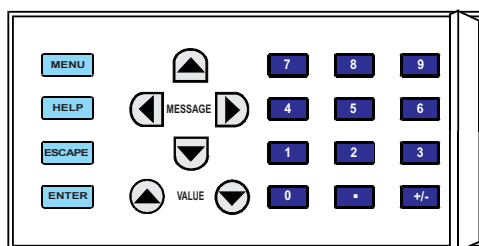


Figure 4–6: KEYPAD

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.

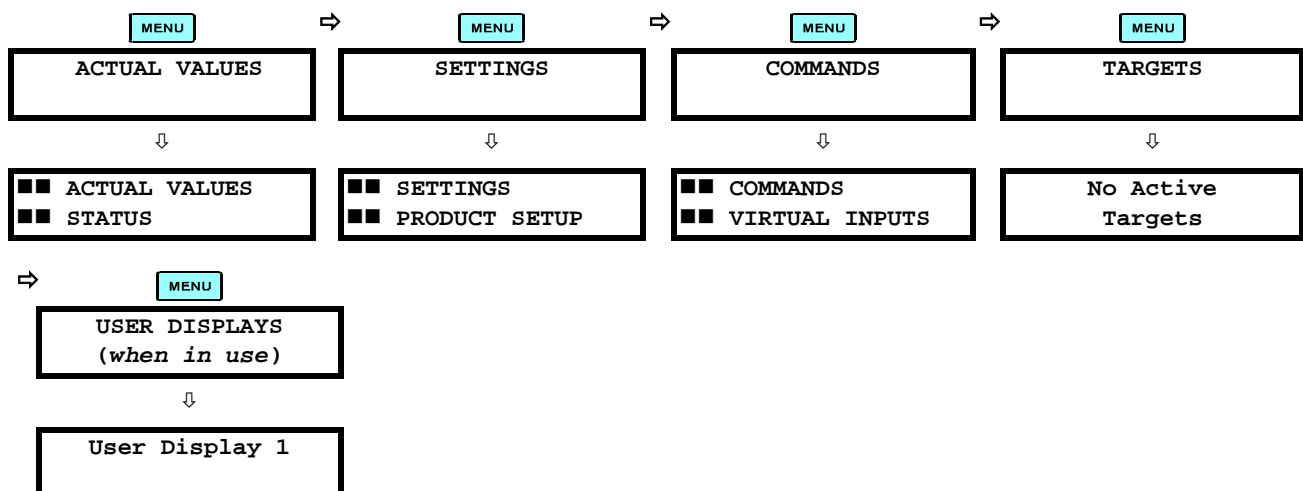
e) CONTROL OF ONE BREAKER

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

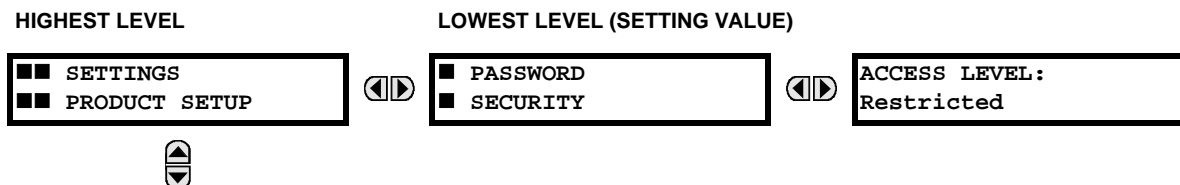
a) NAVIGATION

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.

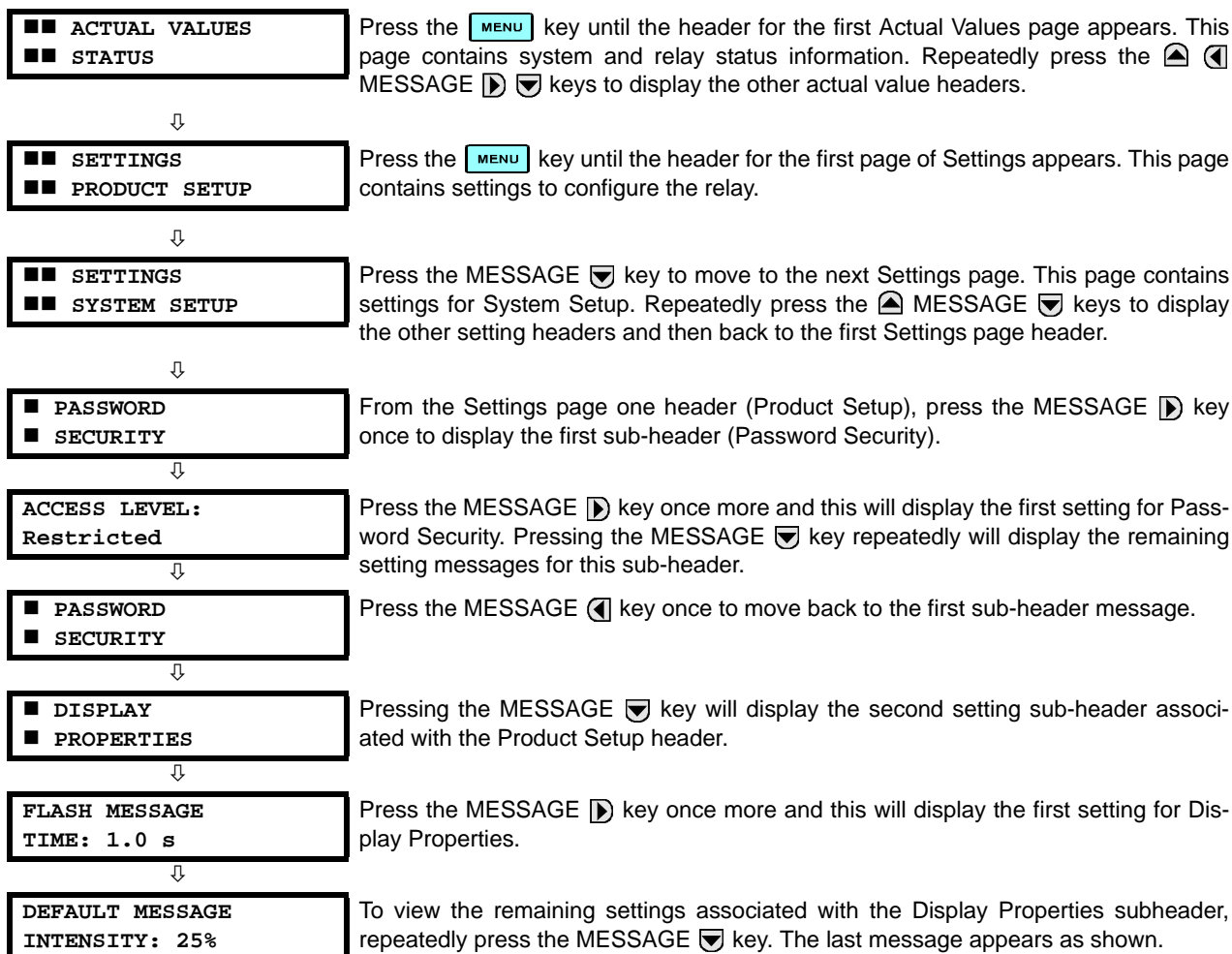


b) HIERARCHY

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.



c) EXAMPLE MENU NAVIGATION









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**  **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  to store the text.
5. If you have any problem, press  to view context sensitive help. Flash messages will sequentially appear for several seconds each. For the case of a text setting message, pressing  displays how to edit and store new values.





d) ACTIVATING THE RELAY

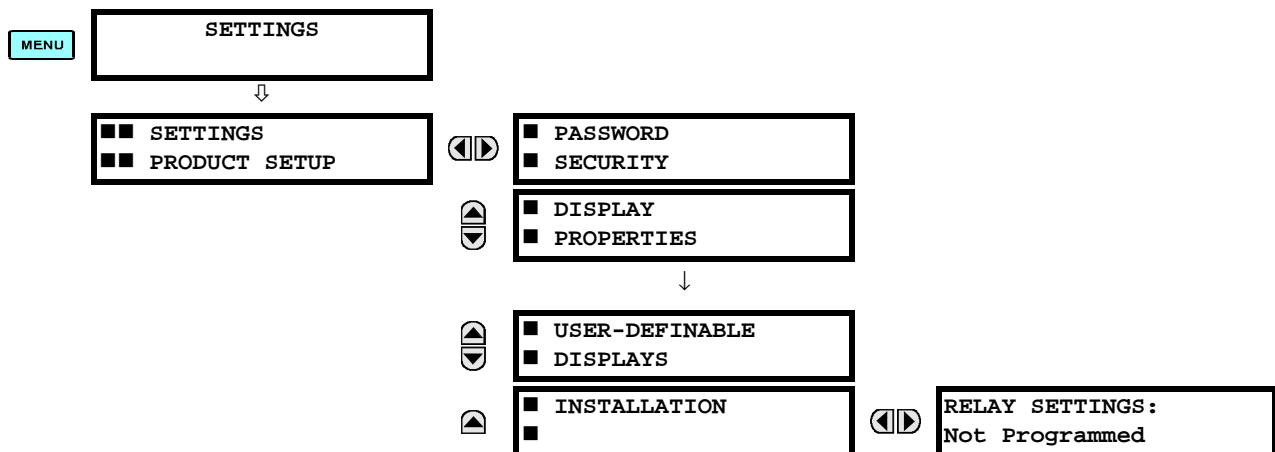
4


RELAY SETTINGS:
Not Programmed

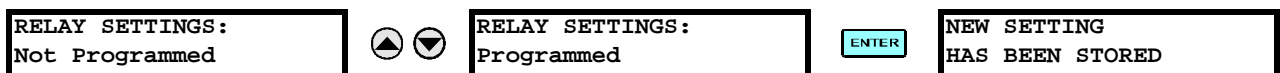
When the relay is powered up, the Trouble LED will be on, the In Service LED off, and this message displayed, indicating the relay is in the "Not Programmed" state and is safeguarding (output relays blocked) against the installation of a relay whose settings have not been entered. This message remains until the relay is explicitly put in the "Programmed" state.

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

1. Press the  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  key.

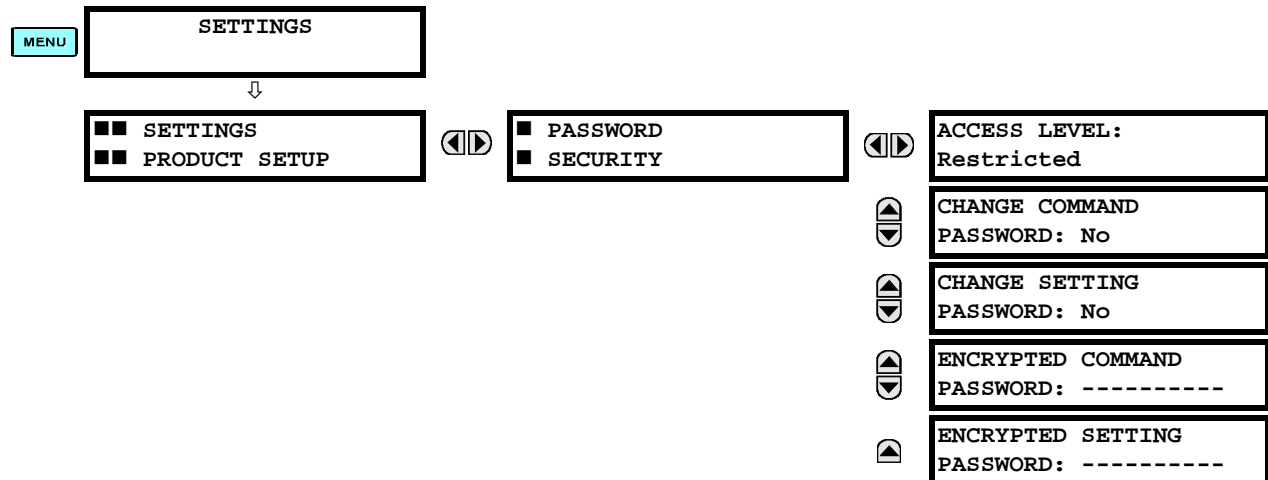


7. When the "NEW SETTING HAS BEEN STORED" message appears, the relay will be in "Programmed" state and the In Service LED will turn on.

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.

5.1.1 SETTINGS MAIN MENU

<div> <div>■ ■ SETTINGS</div> <div>■ ■ PRODUCT SETUP</div> </div> <div>▼</div>	◀▶	<div> <div>■ PASSWORD</div> <div>■ SECURITY</div> </div>	See page 5-7.
	▲▼	<div> <div>■ DISPLAY</div> <div>■ PROPERTIES</div> </div>	See page 5-8.
	▲▼	<div> <div>■ CLEAR RELAY</div> <div>■ RECORDS</div> </div>	See page 5-9.
	▲▼	<div> <div>■ COMMUNICATIONS</div> <div>■</div> </div>	See page 5-10.
	▲▼	<div> <div>■ MODBUS USER MAP</div> <div>■</div> </div>	See page 5-16.
	▲▼	<div> <div>■ REAL TIME</div> <div>■ CLOCK</div> </div>	See page 5-16.
	▲▼	<div> <div>■ FAULT REPORT</div> <div>■</div> </div>	See page 5-17.
	▲▼	<div> <div>■ OSCILLOGRAPHY</div> <div>■</div> </div>	See page 5-18.
	▲▼	<div> <div>■ DATA LOGGER</div> <div>■</div> </div>	See page 5-20.
	▲▼	<div> <div>■ DEMAND</div> <div>■</div> </div>	See page 5-20.
	▲▼	<div> <div>■ USER-PROGRAMMABLE</div> <div>■ LEDS</div> </div>	See page 5-22.
	▲▼	<div> <div>■ USER-PROGRAMMABLE</div> <div>■ SELF TESTS</div> </div>	See page 5-25.
	▲▼	<div> <div>■ CONTROL</div> <div>■ PUSHBUTTONS</div> </div>	See page 5-25.
	▲▼	<div> <div>■ USER-PROGRAMMABLE</div> <div>■ PUSHBUTTONS</div> </div>	See page 5-26.
	▲▼	<div> <div>■ FLEX STATE</div> <div>■ PARAMETERS</div> </div>	See page 5-28.
	▲▼	<div> <div>■ USER-DEFINABLE</div> <div>■ DISPLAYS</div> </div>	See page 5-28.
	▲▼	<div> <div>■ DIRECT I/O</div> <div>■</div> </div>	See page 5-30.
	▲	<div> <div>■ INSTALLATION</div> <div>■</div> </div>	See page 5-35.
<div> <div>■ ■ SETTINGS</div> <div>■ ■ SYSTEM SETUP</div> </div> <div>▼</div>	◀▶	<div> <div>■ AC INPUTS</div> <div>■</div> </div>	See page 5-36.
	▲▼	<div> <div>■ POWER SYSTEM</div> <div>■</div> </div>	See page 5-37.
	▲▼	<div> <div>■ SIGNAL SOURCES</div> <div>■</div> </div>	See page 5-38.

	▲	■ LINE	See page 5-40.
	▲	■ BREAKERS	See page 5-41.
	▲	■ FLEXCURVES	See page 5-44.
▲			
■ ■ SETTINGS	◀▶	■ FLEXLOGIC	See page 5-64.
■ ■ FLEXLOGIC			
▼	▲	■ FLEXLOGIC	See page 5-64.
	▲	■ TIMERS	
	▲	■ FLEXELEMENTS	See page 5-65.
	▲	■ NON-VOLATILE	See page 5-69.
	▲	■ LATCHES	
▲			
■ ■ SETTINGS	◀▶	■ SETTING GROUP 1	See page 5-70.
■ ■ GROUPED ELEMENTS		■ SETTING GROUP 2	
▼			
		↓	
	▲	■ SETTING GROUP 6	
▲			
■ ■ SETTINGS	◀▶	■ SETTING GROUPS	See page 5-117.
■ ■ CONTROL ELEMENTS			
▼	▲	■ SELECTOR SWITCH	See page 5-118.
	▲	■ UNDERFREQUENCY	See page 5-123.
	▲	■ OVERFREQUENCY	See page 5-124.
	▲	■ FREQUENCY RATE	See page 5-125.
	▲	■ OF CHANGE	
	▲	■ SYNCHROCHECK	See page 5-127.
	▲	■ AUTORECLOSE	See page 5-131.
	▲	■ DIGITAL ELEMENTS	See page 5-137.
	▲	■ DIGITAL COUNTERS	See page 5-140.
	▲	■ MONITORING	See page 5-142.
	▲	■ ELEMENTS	

<div>▲</div> <div>■ ■ SETTINGS</div> <div>■ ■ INPUTS / OUTPUTS</div> <div>▼</div>	▲	<div>■ COLD LOAD PICKUP</div> <div>■</div>	See page 5-151.
	◀▶	<div>■ CONTACT INPUTS</div> <div>■</div>	See page 5-153.
	▲▼	<div>■ VIRTUAL INPUTS</div> <div>■</div>	See page 5-155.
	▲▼	<div>■ CONTACT OUTPUTS</div> <div>■</div>	See page 5-156.
	▲▼	<div>■ LATCHING OUTPUTS</div> <div>■</div>	See page 5-156.
	▲▼	<div>■ VIRTUAL OUTPUTS</div> <div>■</div>	See page 5-158.
	▲▼	<div>■ REMOTE DEVICES</div> <div>■</div>	See page 5-159.
	▲▼	<div>■ REMOTE INPUTS</div> <div>■</div>	See page 5-160.
	▲▼	<div>■ REMOTE OUTPUTS</div> <div>■ DNA BIT PAIRS</div>	See page 5-161.
	▲▼	<div>■ REMOTE OUTPUTS</div> <div>■ UserSt BIT PAIRS</div>	See page 5-162.
	▲▼	<div>■ RESETTING</div> <div>■</div>	See page 5-162.
	▲▼	<div>■ DIRECT INPUTS</div> <div>■</div>	See page 5-162.
	▲	<div>■ DIRECT OUTPUTS</div> <div>■</div>	See page 5-162.
	▲		
<div>▲</div> <div>■ ■ SETTINGS</div> <div>■ ■ TRANSDUCER I/O</div> <div>▼</div>	◀▶	<div>■ DCMA INPUTS</div> <div>■</div>	See page 5-166.
	▲	<div>■ RTD INPUTS</div> <div>■</div>	See page 5-167.
	◀▶	<div>TEST MODE</div> <div>FUNCTION:</div>	See page 5-168.
	▲▼	<div>■ FORCE CONTACT</div> <div>■ INPUTS</div>	See page 5-169.
	▲	<div>■ FORCE CONTACT</div> <div>■ OUTPUTS</div>	See page 5-169.

5.1.2 INTRODUCTION TO ELEMENTS

In the design of UR relays, the term “element” is used to describe a feature that is based around a comparator. The comparator is provided with an input (or set of inputs) that is tested against a programmed setting (or group of settings) to determine if the input is within the defined range that will set the output to logic 1, also referred to as “setting the flag”. A single comparator may make multiple tests and provide multiple outputs; for example, the time overcurrent comparator sets a

Pickup flag when the current input is above the setting and sets an Operate flag when the input current has been at a level above the pickup setting for the time specified by the time-current curve settings. All comparators, except the Digital Element which uses a logic state as the input, use analog parameter actual values as the input.

Elements are arranged into two classes, GROUPED and CONTROL. Each element classed as a GROUPED element is provided with six alternate sets of settings, in setting groups numbered 1 through 6. The performance of a GROUPED element is defined by the setting group that is active at a given time. The performance of a CONTROL element is independent of the selected active setting group.

The main characteristics of an element are shown on the element logic diagram. This includes the input(s), settings, fixed logic, and the output operands generated (abbreviations used on scheme logic diagrams are defined in Appendix F).

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

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

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

Some 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 3I₀ residual currents may be required for the circuit relaying and metering functions. For a three-winding transformer application, it may be required to calculate watts and vars for each of three windings, using voltage from different sets of VTs. These requirements can be satisfied with a single UR, equipped with sufficient CT and VT input channels, by selecting the parameter to measure. A mechanism is provided to specify the AC parameter (or group of parameters) used as the input to protection/control comparators and some metering elements.

Selection of the parameter(s) to measure is partially performed by the design of a measuring element or protection/control comparator by identifying the type of parameter (fundamental frequency phasor, harmonic phasor, symmetrical component, total waveform RMS magnitude, phase-phase or phase-ground voltage, etc.) to measure. The user completes the process by selecting the instrument transformer input channels to use and some of the parameters calculated from these channels. The input parameters available include the summation of currents from multiple input channels. For the summed currents of phase, 3I₀, and ground current, current from CTs with different ratios are adjusted to a single ratio before summation.

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

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

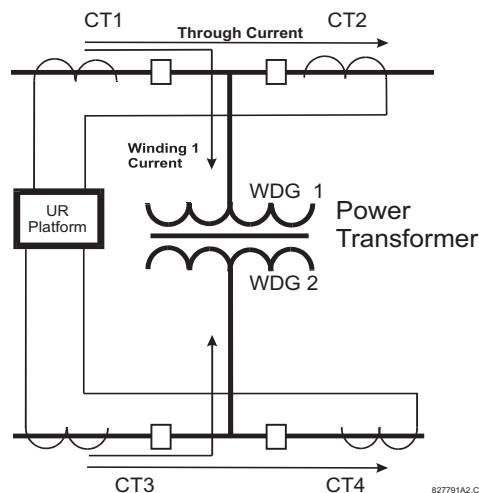


Figure 5–1: BREAKER-AND-A-HALF SCHEME

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

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

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

The internal grouping of current and voltage signals forms an internal source. This source can be given a specific name through the settings, and becomes available to protection and metering elements in the UR platform. Individual names can be given to each source to help identify them more clearly for later use. For example, in the scheme shown in the above diagram, the configures one Source to be the sum of CT1 and CT2 and can name this Source as “Wdg 1 Current”.

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

b) CT/VT MODULE CONFIGURATION

CT and VT input channels are contained in CT/VT modules. The type of input channel can be phase/neutral/other voltage, phase/ground current, or sensitive ground current. The CT/VT modules calculate total waveform RMS levels, fundamental frequency phasors, symmetrical components and harmonics for voltage or current, as allowed by the hardware in each channel. These modules may calculate other parameters as directed by the CPU module.

A CT/VT module contains up to eight input channels, numbered 1 through 8. The channel numbering corresponds to the module terminal numbering 1 through 8 and is arranged as follows: Channels 1, 2, 3 and 4 are always provided as a group, hereafter called a “bank,” and all four are either current or voltage, as are Channels 5, 6, 7 and 8. Channels 1, 2, 3 and 5, 6, 7 are arranged as phase A, B and C respectively. Channels 4 and 8 are either another current or voltage.

Banks are ordered sequentially from the block of lower-numbered channels to the block of higher-numbered channels, and from the CT/VT module with the lowest slot position letter to the module with the highest slot position letter, as follows:

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

The UR platform allows for a maximum of three sets of three-phase voltages and six sets of three-phase currents. The result of these restrictions leads to the maximum number of CT/VT modules in a chassis to three. The maximum number of Sources is six. A summary of CT/VT module configurations is shown below.

ITEM	MAXIMUM NUMBER
CT/VT Module	3
CT Bank (3 phase channels, 1 ground channel)	6
VT Bank (3 phase channels, 1 auxiliary channel)	3

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**. Operations under password supervision are:

- **COMMAND:** operating the breakers via faceplate keypad, changing the state of virtual inputs, clearing the event records, clearing the oscillography records, clearing fault reports, changing the date and time, clearing the breaker arcing amps, clearing energy records, clearing the data logger
- **SETTING:** changing any setting, test mode operation

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

Programming a password code is required to enable each access level. A password consists of 1 to 10 numerical characters. When a **CHANGE ... PASSWORD** setting is set to "Yes", the following message sequence is invoked:

1. ENTER NEW PASSWORD: _____
2. VERIFY NEW PASSWORD: _____
3. NEW PASSWORD HAS BEEN STORED

To gain write access to a "Restricted" setting, set **ACCESS LEVEL** to "Setting" and then change the setting, or attempt to change the setting and follow the prompt to enter the programmed password. If the password is correctly entered, access will be allowed. If no keys are pressed for longer than 30 minutes or control power is cycled, accessibility will automatically revert to the "Restricted" level.

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

The 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 UNAUTHORISED ACCESS operand is reset with the **COMMANDS** ⇒ **CLEAR RECORDS** ⇒ **RESET UNAUTHORISED 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.



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



When URPC 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 URPC. To re-establish the Password Security feature, all URPC windows must be closed for at least 30 minutes.

5.2.2 DISPLAY PROPERTIES

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ DISPLAY PROPERTIES

■ DISPLAY	◀▶	FLASH MESSAGE	Range: 0.5 to 10.0 s in steps of 0.1
■ PROPERTIES		TIME: 1.0 s	
MESSAGE	▲▼	DEFAULT MESSAGE	Range: 10 to 900 s in steps of 1
		TIMEOUT: 300 s	
MESSAGE	▲▼	DEFAULT MESSAGE	Range: 25%, 50%, 75%, 100%
		INTENSITY: 25 %	Visible only if a VFD is installed
MESSAGE	▲▼	SCREEN SAVER	Range: Disabled, Enabled
		FEATURE: Disabled	Visible only if an LCD is installed
MESSAGE	▲▼	SCREEN SAVER	Range: 1 to 65535 min. in steps of 1
		WAIT TIME: 30 min	Visible only if an LCD is installed
MESSAGE	▲▼	CURRENT CUT-OFF	Range: 0.002 to 0.020 pu in steps of 0.001
		LEVEL: 0.020 pu	
MESSAGE	▲▼	VOLTAGE CUT-OFF	Range: 0.1 to 1.0 V secondary in steps of 0.1
		LEVEL: 1.0 V	

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

- **FLASH MESSAGE TIME:** Flash messages are status, warning, error, or information messages displayed for several seconds in response to certain key presses during setting programming. These messages override any normal messages. The duration of a flash message on the display can be changed to accommodate different reading rates.
- **DEFAULT MESSAGE TIMEOUT:** If the keypad is inactive for a period of time, the relay automatically reverts to a default message. The inactivity time is modified via this setting to ensure messages remain on the screen long enough during programming or reading of actual values.
- **DEFAULT MESSAGE INTENSITY:** To extend phosphor life in the vacuum fluorescent display, the brightness can be attenuated during default message display. During keypad interrogation, the display always operates at full brightness.
- **SCREEN SAVER FEATURE and SCREEN SAVER WAIT TIME:** These settings are only visible if the 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 substituted with zero. This applies to phase and ground current phasors as well as true RMS values and symmetrical components. The cut-off operation applies to quantities used for metering, protection, and control, as well as those used by communications protocols. Note that the cut-off level for the sensitive ground input is 10 times lower than the **CURRENT CUT-OFF LEVEL** setting value. Raw current samples available via oscillography are not subject to cut-off.
- **VOLTAGE CUT-OFF LEVEL:** This setting modifies the voltage cut-off threshold. Very low secondary voltage measurements (at the fractional volt level) can be affected by noise. Some customers prefer these low voltages to be displayed as zero, while others prefer the voltage to be displayed even when the value reflects noise rather than the actual signal. The 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.



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

5.2.3 CLEAR RELAY RECORDS

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ ⬇️ CLEAR RELAY RECORDS

<div> <div> <div>■</div> <div>CLEAR RELAY</div> </div> <div> <div>■</div> <div>RECORDS</div> </div> </div>	<div> <div>◀▶</div> </div>	<div> <div>CLEAR FAULT REPORTS:</div> <div>Off</div> </div>	<div>Range: FlexLogic™ operand</div>
<div>MESSAGE</div>	<div> <div>▲▼</div> </div>	<div> <div>CLEAR EVENT RECORDS:</div> <div>Off</div> </div>	<div>Range: FlexLogic™ operand</div>
<div>MESSAG</div>	<div> <div>▲▼</div> </div>	<div> <div>CLEAR OSCILLOGRAPHY?</div> <div>No</div> </div>	<div>Range: FlexLogic™ operand</div>
<div>MESSAG</div>	<div> <div>▲▼</div> </div>	<div> <div>CLEAR DATA LOGGER:</div> <div>Off</div> </div>	<div>Range: FlexLogic™ operand</div>
<div>MESSAG</div>	<div> <div>▲▼</div> </div>	<div> <div>CLEAR ARC AMPS 1:</div> <div>Off</div> </div>	<div>Range: FlexLogic™ operand</div>
<div>MESSAG</div>	<div> <div>▲▼</div> </div>	<div> <div>CLEAR ARC AMPS 2:</div> <div>Off</div> </div>	<div>Range: FlexLogic™ operand</div>
<div>MESSAG</div>	<div> <div>▲▼</div> </div>	<div> <div>CLEAR DEMAND:</div> <div>Off</div> </div>	<div>Range: FlexLogic™ operand</div>
<div>MESSAG</div>	<div> <div>▲▼</div> </div>	<div> <div>CLEAR ENERGY:</div> <div>Off</div> </div>	<div>Range: FlexLogic™ operand</div>
<div>MESSAG</div>	<div> <div>▲▼</div> </div>	<div> <div>CLEAR HIZ RECORDS:</div> <div>Off</div> </div>	<div>Range: FlexLogic™ operand</div>
<div>MESSAG</div>	<div> <div>▲▼</div> </div>	<div> <div>RESET UNAUTH ACCESS:</div> <div>Off</div> </div>	<div>Range: FlexLogic™ operand</div>
<div>MESSAG</div>	<div> <div>▲</div> </div>	<div> <div>CLEAR DIR I/O STATS:</div> <div>Off</div> </div>	<div> <div>Range: FlexLogic™ operand.</div> <div>Valid only for units with Direct I/O module.</div> </div>

The F60 allows selected records to be cleared from user-programmable conditions with FlexLogic™ operands. Setting user-programmable pushbuttons to clear specific records are typical applications for these commands. The F60 responds to rising edges of the configured FlexLogic™ operands. As such, the operand 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.

APPLICATION EXAMPLE:

User-Programmable Pushbutton 1 is to be used to clear demand records. The following settings should be applied.

Assign the Clear Demand function to Pushbutton 1 by making the following change in the **SETTINGS** ⇒ **PRODUCT SETUP** ⇒ **CLEAR RELAY RECORDS** menu:

CLEAR DEMAND: "PUSHBUTTON 1 ON"

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

PUSHBUTTON 1 FUNCTION: "Self-reset"

PUSHBTN 1 DROP-OUT TIME: "0.20 s"

5.2.4 COMMUNICATIONS

a) MAIN MENU

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS

■ COMMUNICATIONS	◀▶	■ SERIAL PORTS	See below.
MESSAGE	▲▼	■ NETWORK	See page 5-11.
MESSAGE	▲▼	■ MODBUS PROTOCOL	See page 5-11.
MESSAGE	▲▼	■ DNP PROTOCOL	See page 5-12.
MESSAGE	▲▼	■ UCA/MMS PROTOCOL	See page 5-14.
MESSAGE	▲▼	■ WEB SERVER ■ HTTP PROTOCOL	See page 5-14.
MESSAGE	▲▼	■ TFTP PROTOCOL	See page 5-14.
MESSAGE	▲▼	■ IEC 60870-5-104 ■ PROTOCOL	See page 5-15.
MESSAGE	▲	■ SNTP PROTOCOL	See page 5-16.

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 9A is ordered.
MESSAGE	▲▼	RS485 COM1 PARITY: None	Range: None, Odd, Even Only active if CPU Type 9A is ordered
MESSAGE	▲▼	RS485 COM1 RESPONSE MIN TIME: 0 ms	Range: 0 to 1000 ms in steps of 10 Only active if CPU 9A 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 has fixed parameters of 19200 baud and no parity. The rear COM1 port type will depend on the CPU ordered: it may be either an Ethernet or an 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 personal computer running URPC. This software is used for downloading or uploading setting files, viewing measured parameters, and upgrading the relay firmware to the latest version. A maximum of 32 relays can be daisy-chained and connected to a DCS, PLC or PC using the RS485 ports.



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

c) NETWORK

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ NETWORK

<div> <div>■ NETWORK</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> </div>	<div> <div>◀▶</div> <div>IP ADDRESS: 0.0.0.0</div> </div>	Range: Standard IP address format Only active if CPU Type 9C or 9D is ordered.
	<div> <div>▲▼</div> <div>SUBNET IP MASK: 0.0.0.0</div> </div>	Range: Standard IP address format Only active if CPU Type 9C or 9D is ordered.
	<div> <div>▲▼</div> <div>GATEWAY IP ADDRESS: 0.0.0.0</div> </div>	Range: Standard IP address format Only active if CPU Type 9C or 9D is ordered.
	<div> <div>▲▼</div> <div> <div>■ OSI NETWORK</div> <div>■ ADDRESS (NSAP)</div> </div> </div>	Range: Press the MESSAGE ⇒ key to enter the OSI NETWORK ADDRESS . Only active if CPU Type 9C or 9D is ordered.
	<div> <div>▲▼</div> <div>ETHERNET OPERATION MODE: Half-Duplex</div> </div>	Range: Half-Duplex, Full-Duplex Only active if CPU Type 9C or 9D is ordered.
	<div> <div>▲▼</div> <div>ETHERNET PRI LINK MONITOR: Disabled</div> </div>	Range: Disabled, Enabled Only active if CPU Type 9C or 9D is ordered.
<div> <div>▲</div> <div>ETHERNET SEC LINK MONITOR: Disabled</div> </div>	Range: Disabled, Enabled Only active if CPU Type 9D is ordered.	

These messages appear only if the F60 is ordered with an Ethernet card. The **ETHERNET PRI LINK MONITOR** and **ETHERNET SEC LINK MONITOR** settings allow internal self-test targets to be triggered when either the Primary or Secondary ethernet link status indicates a connection loss. When both channels are healthy, the primary Ethernet link will be the active link. In the event of a communication failure on the primary Ethernet link, the secondary link becomes the active link until the primary link failure has been rectified.

The IP addresses are used with DNP/Network, Modbus/TCP, MMS/UCIA2, IEC 60870-5-104, TFTP, and HTTP protocols. The NSAP address is used with the MMS/UCIA2 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 URs behind a router). By setting a different **TCP/UDP PORT NUMBER** for a given protocol on each UR, the router can map the URs to the same external IP address. The client software (URPC, for example) must be configured to use the correct port number if these settings are used.



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



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

d) MODBUS PROTOCOL

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ MODBUS PROTOCOL

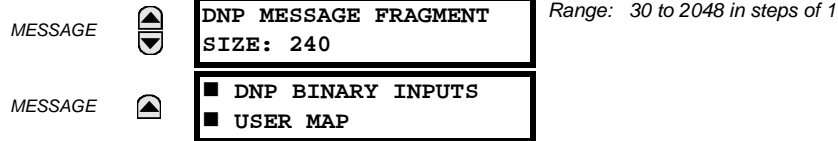
<div> <div>■ MODBUS PROTOCOL</div> <div>MESSAGE</div> </div>	<div> <div>◀▶</div> <div>MODBUS SLAVE ADDRESS: 254</div> </div>	Range: 1 to 254 in steps of 1
	<div> <div>▲</div> <div>MODBUS TCP PORT NUMBER: 502</div> </div>	Range: 1 to 65535 in steps of 1

The serial communication ports utilize the Modbus protocol, unless configured for DNP operation (see the DNP Protocol description below). This allows the URPC 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.

e) DNP PROTOCOL

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ DNP PROTOCOL

■ DNP PROTOCOL			DNP PORT:	NONE	Range: NONE, COM1 - RS485, COM2 - RS485, FRONT PANEL - RS232, NETWORK
	MESSAGE		DNP ADDRESS:	255	Range: 0 to 65519 in steps of 1
	MESSAGE		■ DNP NETWORK		Range: Press the MESSAGE ⇒ key to enter the DNP NETWORK CLIENT ADDRESSES
			■ CLIENT ADDRESSES		
	MESSAGE		DNP TCP/UDP PORT	NUMBER: 20000	Range: 1 to 65535 in steps of 1
	MESSAGE		DNP UNSOL RESPONSE	FUNCTION: Disabled	Range: Enabled, Disabled
	MESSAGE		DNP UNSOL RESPONSE	TIMEOUT: 5 s	Range: 0 to 60 s in steps of 1
	MESSAGE		DNP UNSOL RESPONSE	MAX RETRIES: 10	Range: 1 to 255 in steps of 1
	MESSAGE		DNP UNSOL RESPONSE	DEST ADDRESS: 1	Range: 0 to 65519 in steps of 1
	MESSAGE		USER MAP FOR DNP	ANALOGS: Disabled	Range: Enabled, Disabled
	MESSAGE		NUMBER OF SOURCES	IN ANALOG LIST: 1	Range: 1 to 2 in steps of 1
	MESSAGE		DNP CURRENT SCALE	FACTOR: 1	Range: 0.01, 0.1, 1, 10, 100, 1000
	MESSAGE		DNP VOLTAGE SCALE	FACTOR: 1	Range: 0.01, 0.1, 1, 10, 100, 1000
	MESSAGE		DNP POWER SCALE	FACTOR: 1	Range: 0.01, 0.1, 1, 10, 100, 1000
	MESSAGE		DNP ENERGY SCALE	FACTOR: 1	Range: 0.01, 0.1, 1, 10, 100, 1000
	MESSAGE		DNP OTHER SCALE	FACTOR: 1	Range: 0.01, 0.1, 1, 10, 100, 1000
	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



The F60 supports the Distributed Network Protocol (DNP) version 3.0. The F60 can be used as a DNP slave device connected to a single DNP master (usually an RTU or a SCADA master station). Since the F60 maintains one set of DNP data change buffers and connection information, only one DNP master should actively communicate with the F60 at one time. The **DNP PORT** setting selects the communications port assigned to the DNP protocol; only a single port can be assigned. Once DNP is assigned to a serial port, the Modbus protocol is disabled on that port. Note that COM1 can be used only in non-ethernet UR relays. When this setting is set to “Network”, the DNP protocol can be used over either TCP/IP or UDP/IP. Refer to Appendix E for more information on the DNP protocol. The **DNP ADDRESS** setting is the DNP slave address. This number identifies the F60 on a DNP communications link. Each DNP slave should be assigned a unique address. The **DNP NETWORK CLIENT ADDRESS** setting can force the F60 to respond to a maximum of five specific DNP masters.

The **DNP UNSOL RESPONSE FUNCTION** should be “Disabled” for RS485 applications since there is no collision avoidance mechanism. The **DNP UNSOL RESPONSE TIMEOUT** sets the time the 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 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 **USER MAP FOR DNP ANALOGS** setting allows the large pre-defined Analog Inputs points list to be replaced by the much smaller Modbus User Map. This can be useful for users wishing to read only selected Analog Input points from the F60. See Appendix E for more information.

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

The **DNP SCALE FACTOR** settings are numbers used to scale Analog Input point values. These settings group the 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.

The **DNP BINARY INPUTS USER MAP** setting allows for the creation of a custom DNP Binary Inputs points list. The default DNP Binary Inputs list on the F60 contains 928 points representing various binary states (contact inputs and outputs, virtual inputs and outputs, protection element states, etc.). If not all of these points are required in the DNP master, a custom Binary Inputs points list can be created by selecting up to 58 blocks of 16 points. Each block represents 16 Binary Input points. Block 1 represents Binary Input points 0 to 15, block 2 represents Binary Input points 16 to 31, block 3 represents Binary Input points 32 to 47, etc. The minimum number of Binary Input points that can be selected is 16 (1 block). If all of the **BIN INPUT BLOCK X** settings are set to “Not Used”, the standard list of 928 points will be in effect. The F60 will form the Binary Inputs points list from the **BIN INPUT BLOCK X** settings up to the first occurrence of a setting value of “Not Used”.



When using the User Maps for DNP data points (Analog Inputs and/or Binary Inputs) for relays with ethernet installed, check the “DNP Points Lists” F60 web page to ensure the desired points lists are created. This web page can be viewed using 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.

f) UCA/MMS PROTOCOL

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ UCA/MMS PROTOCOL

<div> <div>■ UCA/MMS PROTOCOL</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> </div>	<div> <div>◀▶</div> <div> <div>DEFAULT GOOSE UPDATE TIME: 60 s</div> </div> </div>	Range: 1 to 60 s in steps of 1. See UserSt Bit Pairs in the Remote Outputs section of this Chapter.
	<div> <div>▲▼</div> <div> <div>UCA LOGICAL DEVICE:</div> <div>UCADevice</div> </div> </div>	Range: Up to 16 alphanumeric characters representing the name of the UCA logical device.
	<div> <div>▲▼</div> <div> <div>UCA/MMS TCP PORT NUMBER:</div> <div>102</div> </div> </div>	Range: 1 to 65535 in steps of 1
	<div> <div>▲▼</div> <div> <div>GOOSE FUNCTION:</div> <div>Enabled</div> </div> </div>	Range: Disabled, Enabled
	<div> <div>▲</div> <div> <div>GLOBE.ST.LocRemDS:</div> <div>Off</div> </div> </div>	Range: FlexLogic™ operand

The F60 supports the Manufacturing Message Specification (MMS) protocol as specified by the Utility Communication Architecture (UCA). UCA/MMS is supported over two protocol stacks: TCP/IP over ethernet and TP4/CLNP (OSI) over ethernet. The F60 operates as a UCA/MMS server. The Remote Inputs/Outputs section in this chapter describe the peer-to-peer GOOSE message scheme.

The **UCA LOGICAL DEVICE** setting represents the MMS domain name (UCA logical device) where all UCA objects are located. The **GOOSE FUNCTION** setting allows for the blocking of GOOSE messages from the F60. This can be used during testing or to prevent the relay from sending GOOSE messages during normal operation. The **GLOBE.ST.LocRemDS** setting selects a FlexLogic™ operand to provide the state of the UCA GLOBE.ST.LocRemDS data item. Refer to Appendix C: UCA/MMS Communications for additional details on the F60 UCA/MMS support.

g) WEB SERVER HTTP PROTOCOL

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ WEB SERVER HTTP PROTOCOL

<div> <div>■ WEB SERVER</div> <div>■ HTTP PROTOCOL</div> </div>	<div> <div>◀▶</div> <div> <div>HTTP TCP PORT NUMBER:</div> <div>80</div> </div> </div>	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.

h) TFTP PROTOCOL

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ TFTP PROTOCOL

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

The Trivial File Transfer Protocol (TFTP) can be used to transfer files from the UR over a network. The 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.).

i) IEC 60870-5-104 PROTOCOL

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

<div> <div>IEC 60870-5-104</div> <div>PROTOCOL</div> </div>		<div>IEC 60870-5-104</div> <div>FUNCTION: Disabled</div>	Range: Enabled, Disabled
MESSAGE		<div>IEC TCP PORT</div> <div>NUMBER: 2404</div>	Range: 1 to 65535 in steps of 1
MESSAGE		<div>IEC COMMON ADDRESS</div> <div>OF ASDU: 0</div>	Range: 0 to 65535 in steps of 1
MESSAGE		<div>IEC CYCLIC DATA</div> <div>PERIOD: 60 s</div>	Range: 1 to 65535 s in steps of 1
MESSAGE		<div>NUMBER OF SOURCES</div> <div>IN MMENC1 LIST: 1</div>	Range: 1 to 2 in steps of 1
MESSAGE		<div>IEC CURRENT DEFAULT</div> <div>THRESHOLD: 30000</div>	Range: 0 to 65535 in steps of 1
MESSAGE		<div>IEC VOLTAGE DEFAULT</div> <div>THRESHOLD: 30000</div>	Range: 0 to 65535 in steps of 1
MESSAGE		<div>IEC POWER DEFAULT</div> <div>THRESHOLD: 30000</div>	Range: 0 to 65535 in steps of 1
MESSAGE		<div>IEC ENERGY DEFAULT</div> <div>THRESHOLD: 30000</div>	Range: 0 to 65535 in steps of 1
MESSAGE		<div>IEC OTHER DEFAULT</div> <div>THRESHOLD: 30000</div>	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 single master (usually either an RTU or a SCADA master station). Since the F60 maintains one set of IEC 60870-5-104 data change buffers, only one master should actively communicate with the F60 at one time. For situations where a second master is active in a “hot standby” configuration, the UR supports a second IEC 60870-5-104 connection providing the standby master sends only IEC 60870-5-104 Test Frame Activation messages for as long as the primary master is active.

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

The **IEC ----- DEFAULT THRESHOLD** settings are the values used by the UR to determine when to trigger spontaneous responses containing M_ME_NC_1 analog data. These settings group the UR analog data into types: current, voltage, power, energy, and other. Each setting represents the default threshold value for all M_ME_NC_1 analog points of that type. For example, in order to trigger spontaneous responses from the UR when any current values change by 15 A, the **IEC CURRENT DEFAULT THRESHOLD** setting should be set to 15. Note that these settings are the default values of the dead-bands. P_ME_NC_1 (Parameter of measured value, short floating point value) points can be used to change threshold values, from the default, for each individual M_ME_NC_1 analog point. Whenever power is removed and re-applied to the UR, the default thresholds will be in effect.



NOTE

The IEC 60870-5-104 and DNP protocols can not be used at the same time. When the IEC 60870-5-104 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).

j) SNTP PROTOCOL

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ SNTP PROTOCOL

<input checked="" type="checkbox"/> TFTP PROTOCOL <input type="checkbox"/>	◀▶	SNTP FUNCTION: Disabled	Range: Enabled, Disabled
	MESSAGE ▲	SNTP SERVER IP ADDR: 0.0.0.0	Range: 1 to 65535 in steps of 1
	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 one minute 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 does not support the multicast or anycast SNTP functionality.

5.2.5 MODBUS USER MAP

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ MODBUS USER MAP

<input checked="" type="checkbox"/> MODBUS USER MAP <input type="checkbox"/>	◀▶	ADDRESS 1: 0	Range: 0 to 65535 in steps of 1
		VALUE: 0	
↓			
MESSAGE ▲		ADDRESS 256: 0	Range: 0 to 65535 in steps of 1
		VALUE: 0	

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



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

5.2.6 REAL TIME CLOCK

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ REAL TIME CLOCK

<input checked="" type="checkbox"/> REAL TIME <input checked="" type="checkbox"/> CLOCK	◀▶	IRIG-B SIGNAL TYPE: None	Range: None, DC Shift, Amplitude Modulated
--	----	-----------------------------	--

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

5.2.7 FAULT REPORT

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ ⚙ FAULT REPORT

■ FAULT REPORT	◀▶	FAULT REPORT SOURCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE ▲		FAULT REPORT TRIG: Off	Range: FlexLogic™ operand

The fault report stores data, in non-volatile memory, pertinent to an event when triggered. The captured data includes:

- Name of the relay, programmed by the user
- Date and time of trigger
- Name of trigger (specific operand)
- Active setting group
- Pre-fault current and voltage phasors (one-quarter cycle before the trigger)
- Fault current and voltage phasors (three-quarter cycle after the trigger)
- Target Messages that are set at the time of triggering
- Events (9 before trigger and 7 after trigger)

The captured data also includes the fault type and the distance to the fault location, as well as the reclose shot number.

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.

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 ten files. An eleventh trigger overwrites the oldest file. The operand selected as the fault report trigger automatically triggers an oscillography record which can also be triggered independently.

URPC 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 SOURCE** setting selects the Source for input currents and voltages and disturbance detection. The **FAULT 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.

See also **SETTINGS** ⚙ **SYSTEM SETUP** ⇒ ⚙ **LINE** menu for specifying line characteristics and the **ACTUAL VALUES** ⚙ **RECORDS** ⇒ **FAULT REPORTS** menu.

5.2.8 OSCILLOGRAPHY

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ OSCILLOGRAPHY

■ OSCILLOGRAPHY

◀▶

NUMBER OF RECORDS:
15

Range: 1 to 64 in steps of 1

▲▼

TRIGGER MODE:
Automatic Overwrite

Range: Automatic Overwrite, Protected

▲▼

TRIGGER POSITION:
50%

Range: 0 to 100 in steps of 1

▲▼

TRIGGER SOURCE:
Off

Range: FlexLogic™ operand

▲▼

AC INPUT WAVEFORMS:
16 samples/cycle

Range: Off, 8, 16, 32, 64 samples/cycle

▲▼

■ DIGITAL CHANNELS

Range: 2 to 63 channels

◀▶

DIGITAL CHANNEL 1:
Off

Range: FlexLogic™ operand

▲

DIGITAL CHANNEL 63:
Off

Range: FlexLogic™ operand

▲

■ ANALOG CHANNELS

Range: 1 to 16 channels

◀▶

ANALOG CHANNEL 1:
Off

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

▲

ANALOG CHANNEL 16:
Off

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

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	266.0
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”.

The **TRIGGER POSITION** is programmable as a percent of the total buffer size (e.g. 10%, 50%, 75%, etc.). A trigger position of 25% consists of 25% pre- and 75% post-trigger data.

The **TRIGGER SOURCE** is always captured in oscillography and may be any FlexLogic™ parameter (element state, contact input, virtual output, etc.). The relay sampling rate is 64 samples per cycle.

The **AC INPUT WAVEFORMS** setting determines the sampling rate at which AC input signals (i.e. current and voltage) are stored. Reducing the sampling rate allows longer records to be stored. This setting has no effect on the internal sampling rate of the relay which is always 64 samples per cycle, i.e. it has no effect on the fundamental calculations of the device.

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.



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

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



When the NUMBER OF RECORDS setting is altered, all oscillography records will be CLEARED.

5.2.9 DATA LOGGER

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ DATA LOGGER

■ DATA LOGGER	◀▶	DATA LOGGER RATE: 1 min	Range: 1 sec; 1 min, 5 min, 10 min, 15 min, 20 min, 30 min, 60 min
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 the URPC software and displayed with 'parameters' on the vertical axis and 'time' on the horizontal axis. All data is stored in non-volatile memory, meaning that the information is retained when power to the relay is lost.

For a fixed sampling rate, the data logger can be configured with a few channels over a long period or a larger number of channels for a shorter period. The relay automatically partitions the available memory between the channels in use.



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

- **DATA LOGGER RATE:** This setting selects the time interval at which the actual value data will be recorded.
- **DATA LOGGER CHNL 1 (16):** This setting selects the metering actual value that is to be recorded in Channel 1(16) of the data log. The parameters available in a given relay are dependent on: the type of relay, the type and number of CT/VT hardware modules installed, and the type and number of Analog Input hardware modules installed. Upon startup, the relay will automatically prepare the parameter list. A list of all possible analog metering actual value parameters is shown in Appendix A: Flexanalog Parameters. The parameter index number shown in any of the tables is used to expedite the selection of the parameter on the relay display. It can be quite time-consuming to scan through the list of parameters via the relay keypad/display – entering this number via the relay keypad will cause the corresponding parameter to be displayed.
- **DATA LOGGER CONFIG:** This display presents the total amount of time the Data Logger can record the channels not selected to "Off" without over-writing old data.

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:

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

d = demand value after applying input quantity for time t (in minutes)
 D = input quantity (constant)
 $k = 2.3 / \text{thermal 90\% response time.}$

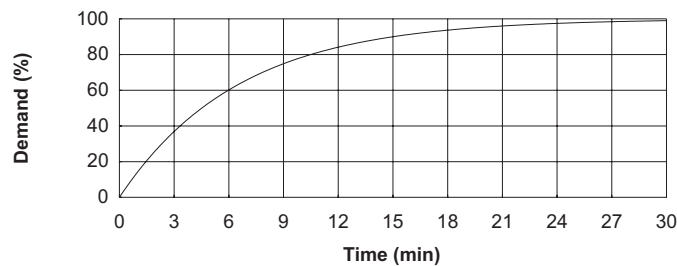


Figure 5-2: THERMAL DEMAND CHARACTERISTIC

See the 90% thermal response time characteristic of 15 minutes in the figure above. 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.

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.



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 μ s.

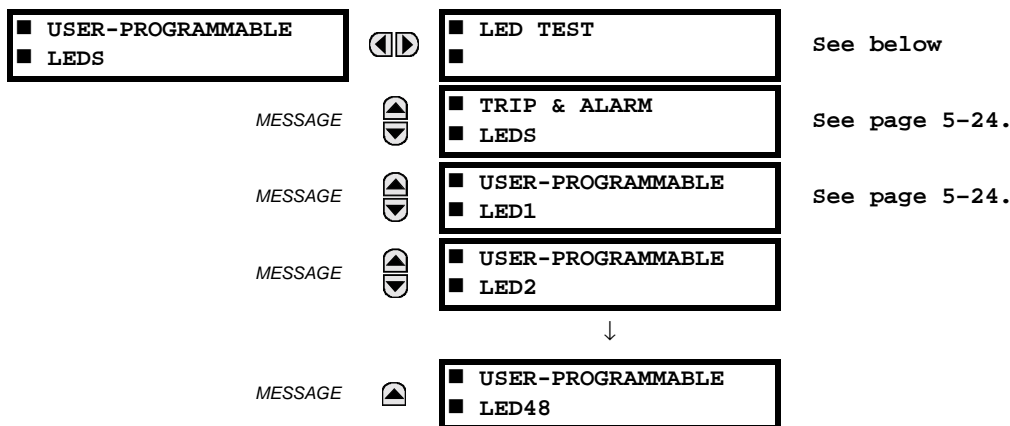
CALCULATION METHOD 3: ROLLING DEMAND

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

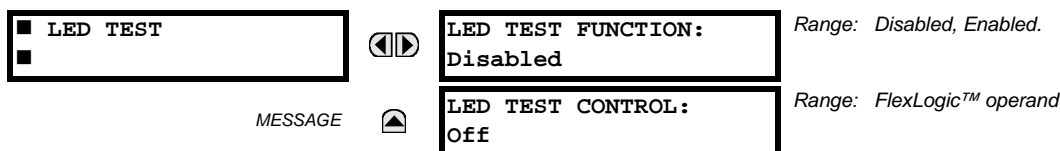
a) MAIN MENU

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ USER-PROGRAMMABLE LEDs



b) LED TEST

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



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

The test consists of three stages.

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.

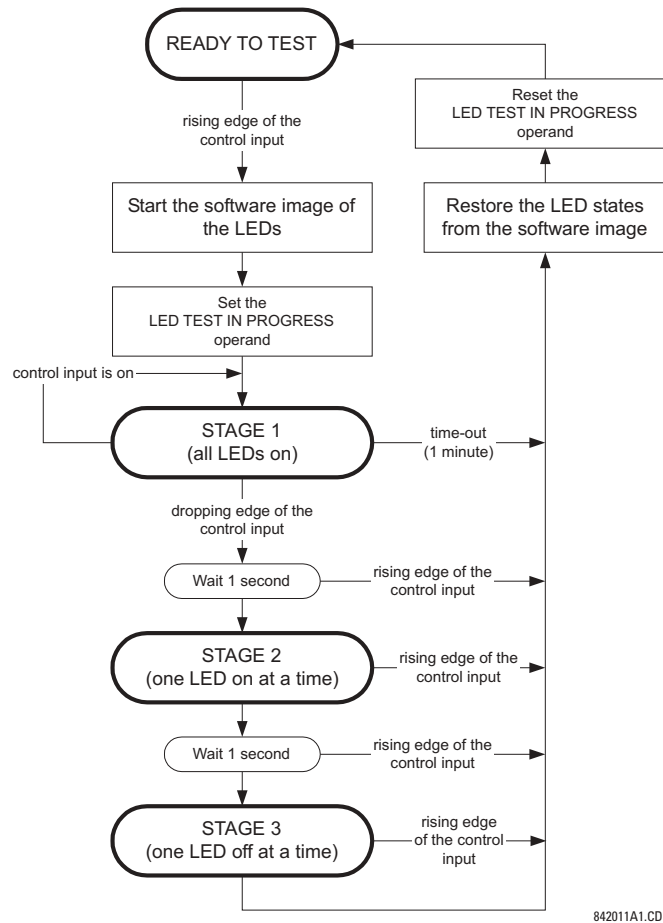


Figure 5–3: LED TEST SEQUENCE

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

<div> <div>TRIP & ALARM</div> <div>LEDS</div> </div> <div>MESSAGE</div>	<div>◀▶</div>	<div>TRIP LED INPUT:</div> <div>Disabled</div>	Range: Disabled, Enabled
	<div>▲</div>	<div>ALARM LED INPUT:</div> <div>Off</div>	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)

<div> <div>USER-PROGRAMMABLE</div> <div>LED 1</div> </div> <div>MESSAGE</div>	<div>◀▶</div>	<div>LED 1 OPERAND:</div> <div>Off</div>	Range: FlexLogic™ operand
	<div>▲</div>	<div>LED 1 TYPE:</div> <div>Self-Reset</div>	Range: Self-Reset, Latched

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

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

Refer to the LED Indicators section in Chapter 4 for the locations of these indexed LEDs. This menu selects the operands to control these LEDs. Support for applying user-customized labels to these LEDs is provided. If the **LED X TYPE** setting is “Self-Reset” (default setting), the LED illumination will track the state of the selected LED operand. If the **LED X TYPE** setting is ‘Latched’, the LED, once lit, remains so until reset by the faceplate RESET button, from a remote device via a communications channel, or from any programmed operand, even if the LED operand state de-asserts.

Table 5–2: RECOMMENDED SETTINGS FOR LED PANEL 2 LABELS

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

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

5.2.12 USER-PROGRAMMABLE SELF-TESTS

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ ⬇ USER-PROGRAMMABLE SELF TESTS

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

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(3)

Diagram illustrating the relationship between a MESSAGE and a CONTROL:

- MESSAGE** (Left Box):
 - CONTROL
 - PUSHBUTTON 1
- CONTROL** (Right Box):
 - CONTROL PUSHBUTTON 1
 - FUNCTION: Disabled

Connections:

- A double-headed arrow connects the MESSAGE box and the CONTROL box.
- A single-headed arrow points from the MESSAGE box to the CONTROL box.

Labels:

- MESSAGE** (Label for the left box)
- CONTROL** (Label for the right box)

Range: Disabled, Enabled

The three standard pushbuttons located on the top left panel of the faceplate are user-programmable and can be used for various applications such as performing an LED test, switching setting groups, and invoking and scrolling through 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 is shown below.

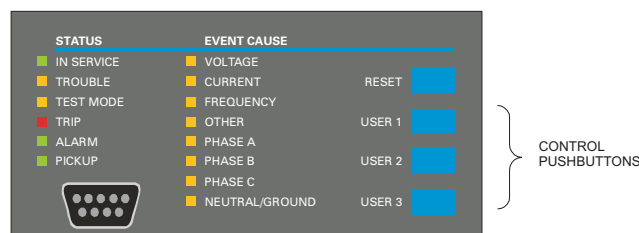


Figure 5-4: CONTROL PUSHBUTTONS

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

Each control pushbutton asserts its own FlexLogic™ operand, CONTROL PUSHBTN 1(3) 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 used setting) when a control pushbutton is pressed; no event is logged when the pushbutton is released. The faceplate keys (including control keys) cannot be operated simultaneously – a given key must be released before the next one can be pressed.

The control pushbuttons become user-programmable only if the Breaker Control feature is not configured for manual control via the User 1 through User 3 pushbuttons as shown below. Typically, if configured for manual control, the Breaker Control feature will use the larger, optional user-programmable pushbuttons, making the control pushbuttons available for any other user application.

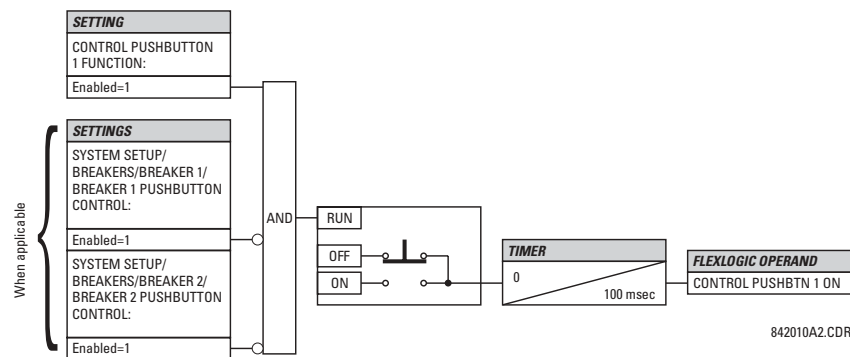


Figure 5-5: CONTROL PUSHBUTTON LOGIC

5.2.14 USER-PROGRAMMABLE PUSHBUTTONS

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ USER-PROGRAMMABLE PUSHBUTTONS ⇒ USER PUSHBUTTON 1(12)

USER PUSHBUTTON 1	PUSHBUTTON 1	Range: Self-Reset, Latched, Disabled
	FUNCTION: 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 www.GEindustrial.com/multilin.



Figure 5-6: USER-PROGRAMMABLE PUSHBUTTONS

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

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

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

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

If set to "Latched", the control logic alternates the state of the corresponding FlexLogic™ operand between "On" and "Off" on each push of the button. When operating in "Latched" mode, FlexLogic™ operand states are stored in non-volatile memory. Should power be lost, the correct pushbutton state is retained upon subsequent power up of the relay.
- PUSHBTN 1 ID TEXT:** This setting specifies the top 20-character line of the user-programmable message and is intended to provide ID information of the pushbutton. Refer to the User-Definable Displays section for instructions on how to enter alphanumeric characters from the keypad.
- PUSHBTN 1 ON TEXT:** This setting specifies the bottom 20-character line of the user-programmable message and is displayed when the pushbutton is in the "on" position. Refer to the User-Definable Displays section for instructions on entering alphanumeric characters from the keypad.
- PUSHBTN 1 OFF TEXT:** This setting specifies the bottom 20-character line of the user-programmable message and is displayed when the pushbutton is activated from the On to the Off position and the **PUSHBUTTON 1 FUNCTION** is "Latched". This message is not displayed when the **PUSHBUTTON 1 FUNCTION** is "Self-reset" as the pushbutton operand status is implied to be "Off" upon its release. All user text messaging durations for the pushbuttons are configured with the **PRODUCT SETUP** ⇒ **DISPLAY PROPERTIES** ⇒ **FLASH MESSAGE TIME** setting.
- PUSHBTN 1 DROP-OUT TIME:** This setting specifies a drop-out time delay for a pushbutton in the self-reset mode. A typical applications for this setting is providing a select-before-operate functionality. The selecting pushbutton should have the drop-out time set to a desired value. The operating pushbutton should be logically ANDed with the selecting pushbutton in FlexLogic™. The selecting pushbutton LED remains on for the duration of the drop-out time, signaling the time window for the intended operation.

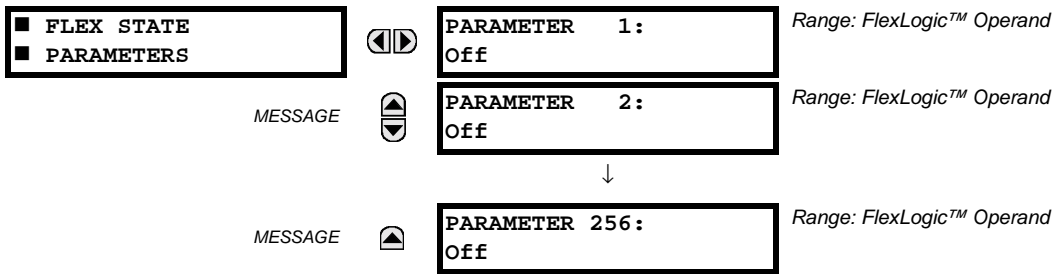
For example, consider a relay with the following settings: **PUSHBTN 1 ID TEXT:** "AUTORECLOSER", **PUSHBTN 1 ON TEXT:** "DISABLED - CALL 2199", and **PUSHBTN 1 OFF TEXT:** "ENABLED". When Pushbutton 1 changes its state to the "On" position, the following **AUTOCLOSER DISABLED – Call 2199** message is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



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 URPC with the **Maintenance > Enable Pushbutton** command.

5.2.15 FLEX STATE PARAMETERS

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ FLEX STATE PARAMETERS



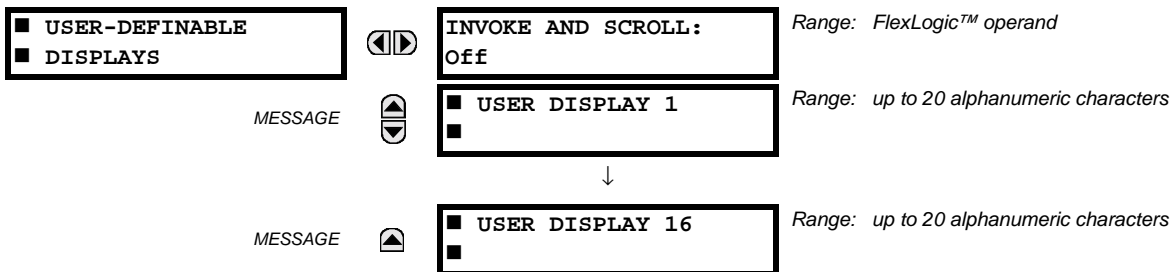
This feature provides a mechanism where any of 256 selected FlexLogic™ operand states can be used for efficient monitoring. The feature allows user-customized access to the FlexLogic™ operand states in the relay. The state bits are packed so that 16 states may be read out in a single Modbus register.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

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



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.

The **INVOKE AND SCROLL** input is active since the last activity for the time specified by the **DEFAULT MESSAGE TIMEOUT** setting. When this time expires, the feature resets and the next activity of the input invokes the first 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 URPC 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 (URPC usage conveniently facilitates this conversion).

Use the **MENU** key to go to the User Displays menu **to view** the user-defined content. The current user displays will show in sequence, changing every 4 seconds. While viewing a User Display, press the **ENTER** key and then select the ‘Yes’ option **to remove** the display from the user display list. Use the **MENU** key again **to exit** the User Displays menu.

An example User Display setup and result is shown below:

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

a) MAIN MENU

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ DIRECT I/O

<div> <div>■ DIRECT I/O</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> </div>	<div> <div>◀▶</div> <div>▲▼</div> <div>▲▼</div> <div>▲▼</div> <div>▲▼</div> <div>▲▼</div> <div>▲▼</div> <div>▲</div> </div>	<div>DIRECT OUTPUT DEVICE ID: 1</div>	Range: 1 to 8
		<div>DIRECT I/O CH1 RING CONFIGURATION: Yes</div>	Range: Yes, No
		<div>DIRECT I/O CH2 RING CONFIGURATION: Yes</div>	Range: Yes, No
		<div>DIRECT I/O DATA RATE: 64 kbps</div>	Range: 64 kbps, 128 kbps
		<div>DIRECT I/O CHANNEL CROSSOVER: Disabled</div>	Range: Disabled, Enabled
		<div>■ CRC ALARM CH1</div>	See page 5-34.
		<div>■ CRC ALARM CH2</div>	See page 5-34.
		<div>■ UNRETURNED ■ MESSAGES ALARM CH1</div>	See page 5-35.
		<div>■ UNRETURNED ■ MESSAGES ALARM CH2</div>	See page 5-35.

Direct I/Os are intended for exchange of status information (inputs and outputs) between UR relays connected directly via Type-7 UR digital communications cards. The mechanism is very similar to UCA GOOSE, 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 GOOSE message timing. Integrity messages (with no state changes) are sent at least every 500 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 I/O Ring Break). This FlexLogic™ operand indicates that Direct Output messages sent from a UR are not being received back by the UR.
2. **DIRECT DEVICE X OFF** (Direct Device Offline). This FlexLogic™ operand indicates that Direct Output messages from at least one Direct Device are not being received.

Direct I/O settings are similar to Remote I/O settings. The equivalent of the Remote Device name strings for Direct I/O, is the Direct Output Device ID.

The **DIRECT OUTPUT DEVICE ID** identifies this UR in all Direct Output messages. All UR IEDs in a ring should have unique numbers assigned. The IED ID is used to identify the sender of the Direct I/O message.

If the Direct I/O 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 I/O 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 capabilities of the communications channel. Back-to-back connections of the local relays may be set to 128 kbps. All IEDs communicating over Direct I/Os must be set to the same data rate. UR IEDs equipped with dual-channel communications cards apply the same data rate to both channels. Delivery time for Direct I/O 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".

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 IEDs into one Direct I/O network regardless of the physical media of the two communication channels.

The following application examples illustrate the basic concepts for Direct I/O configuration. Please refer to the Inputs/Outputs section later in this chapter for information on configuring FlexLogic™ operands (flags, bits) to be exchanged.

EXAMPLE 1: EXTENDING THE I/O CAPABILITIES OF A UR 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 chassis. The problem is solved by adding an extra UR IED, such as the C30, to satisfy the additional I/Os and programmable logic requirements. The two IEDs are connected via single-channel digital communication cards as shown in the figure below.

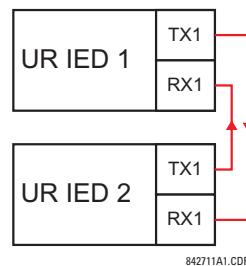


Figure 5–7: INPUT/OUTPUT EXTENSION VIA DIRECT I/Os

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

- UR IED 1: **DIRECT OUTPUT DEVICE ID:** "1"
 DIRECT I/O RING CONFIGURATION: "Yes"
 DIRECT I/O DATA RATE: "128 kbps"
- UR IED 2: **DIRECT OUTPUT DEVICE ID:** "2"
 DIRECT I/O RING CONFIGURATION: "Yes"
 DIRECT I/O DATA RATE: "128 kbps"

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

EXAMPLE 2: INTERLOCKING BUSBAR PROTECTION

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

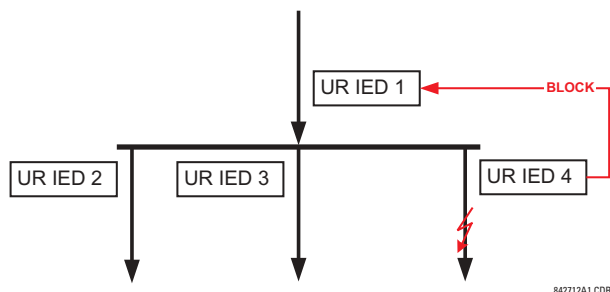


Figure 5-8: SAMPLE INTERLOCKING BUSBAR PROTECTION SCHEME

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

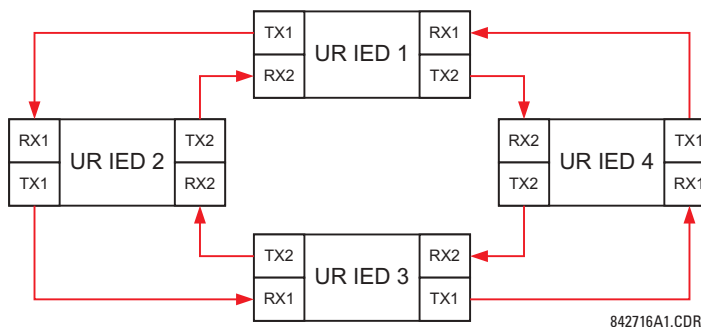


Figure 5-9: INTERLOCKING BUS PROTECTION SCHEME VIA DIRECT I/O

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

UR IED 1:	DIRECT OUTPUT DEVICE ID: "1"	UR IED 2:	DIRECT OUTPUT DEVICE ID: "2"
	DIRECT I/O RING CONFIGURATION: "Yes"		DIRECT I/O RING CONFIGURATION: "Yes"
UR IED 3:	DIRECT OUTPUT DEVICE ID: "3"	UR IED 4:	DIRECT OUTPUT DEVICE ID: "4"
	DIRECT I/O RING CONFIGURATION: "Yes"		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 I/O feature would be primarily used to address these concerns.

EXAMPLE 3: PILOT-AIDED SCHEMES

Consider the three-terminal line protection application shown below:

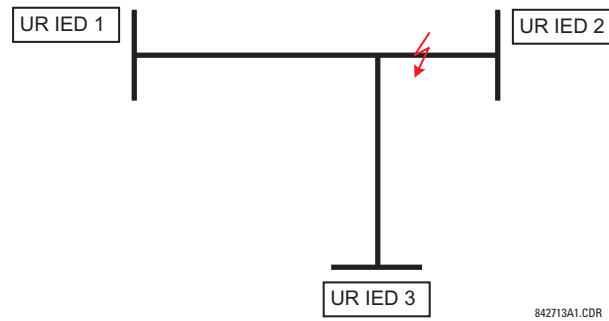


Figure 5-10: THREE-TERMINAL LINE APPLICATION

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):

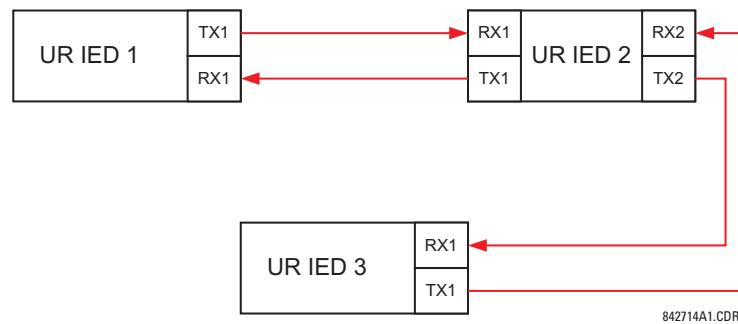


Figure 5-11: SINGLE-CHANNEL OPEN LOOP CONFIGURATION

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

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

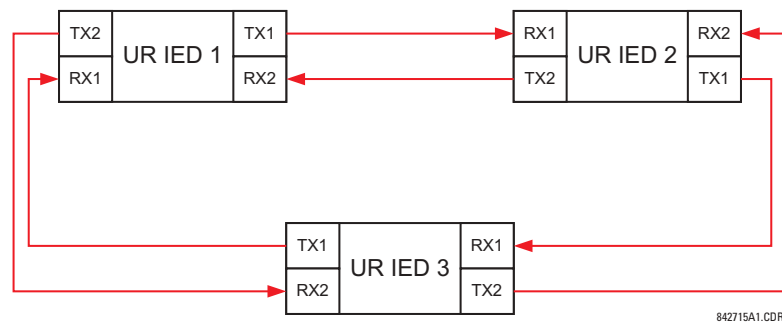


Figure 5-12: DUAL-CHANNEL CLOSED LOOP (DUAL-RING) CONFIGURATION

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

UR IED 1:	DIRECT OUTPUT DEVICE ID: "1"	UR IED 2:	DIRECT OUTPUT DEVICE ID: "2"
	DIRECT I/O RING CONFIGURATION: "Yes"		DIRECT I/O RING CONFIGURATION: "Yes"
UR IED 3:	DIRECT OUTPUT DEVICE ID: "3"		
	DIRECT I/O RING CONFIGURATION: "Yes"		

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

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

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

b) CRC ALARM CH1(2)

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

<div style="border: 1px solid black; padding: 2px;"> <input checked="" type="checkbox"/> CRC ALARM CH1 </div>	◀▶	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 I/O 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 Flex-Logic™ 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 I/O messages that failed the CRC check is available as the **ACTUAL VALUES ⇒ STATUS ⇒ DIRECT INPUTS ⇒ CRC FAIL COUNT CH1(2)** actual value.

Message Count and Length of the Monitoring Window:

To monitor communications integrity, the relay sends 2 messages per second (at 64 kbps) or 4 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 80 minutes at 64 kbps and 40 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 $10 \times 60 \times 2 = 1200$.

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 I/O 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)

<div>■ UNRETURNED</div> <div>■ MESSAGES ALARM CH1</div>	◀▶	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 I/O 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 Flex-Logic™ 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 Direct I/O messages is available as the **ACTUAL VALUES ⇒ STATUS ⇒ DIRECT INPUTS ⇒ UNRETURNED MSG COUNT CH1(2)** actual value.

5

5.2.18 INSTALLATION

PATH: SETTINGS ⇒ PRODUCT SETUP ⇒ INSTALLATION

<div>■ INSTALLATION</div> <div>■</div>	◀▶	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 UCA2/MMS protocol.

5.3.1 AC INPUTS

a) CURRENT BANKS

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

<div>■ CURRENT BANK F1</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div>	<div>◀▶</div>	<div>PHASE CT F1</div> <div>PRIMARY: 1 A</div>	Range: 1 to 65000 A in steps of 1
	<div>▲▼</div>	<div>PHASE CT F1</div> <div>SECONDARY: 1 A</div>	Range: 1 A, 5 A
	<div>▲▼</div>	<div>GROUND CT F1</div> <div>PRIMARY: 1 A</div>	Range: 1 to 65000 A in steps of 1
	<div>▲</div>	<div>GROUND CT F1</div> <div>SECONDARY: 1 A</div>	Range: 1 A, 5 A



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.

5

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

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

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

F1: CT bank with 500:1 ratio; F5: CT bank with 1000: ratio

The following rule applies:

$$\text{SRC 1} = \text{F1} + \text{F5} \quad (\text{EQ 5.1})$$

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

<input checked="" type="checkbox"/> 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 1.00



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.



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. $14400 / 120$.

5.3.2 POWER SYSTEM

PATH: SETTINGS ⇒ SYSTEM SETUP ⇒ POWER SYSTEM

<input checked="" type="checkbox"/> POWER SYSTEM	◀▶	NOMINAL FREQUENCY: 60 Hz	Range: 25 to 60 Hz in steps of 1
MESSAGE	▲▼	PHASE ROTATION: ABC	Range: ABC, ACB
MESSAGE	▲▼	FREQUENCY AND PHASE REFERENCE: SRC 1	Range: SRC 1, SRC 2
MESSAGE	▲▼	FREQUENCY TRACKING: Enabled	Range: Disabled, Enabled

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

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

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

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

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

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

The phase angle referencing is done via a phase locked loop, which can synchronize independent UR 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 relays provided the relays have an IRIG-B connection.



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

5.3.3 SIGNAL SOURCES

5

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

<div> <div>■</div> <div>SOURCE 1</div> </div>	<div>◀▶</div>	<div>SOURCE 1 NAME:</div> <div>SRC 1</div>	Range: up to 6 alphanumeric characters
MESSAGE	▲▼	<div>SOURCE 1 PHASE CT:</div> <div>None</div>	Range: None, F1, F5, F1+F5,... up to a combination of any 5 CTs. Only Phase CT inputs are displayed.
MESSAGE	▲▼	<div>SOURCE 1 GROUND CT:</div> <div>None</div>	Range: None, F1, F5, F1+F5,... up to a combination of any 5 CTs. Only Ground CT inputs are displayed.
MESSAGE	▲▼	<div>SOURCE 1 PHASE VT:</div> <div>None</div>	Range: None, F1, F5 Only phase voltage inputs will be displayed.
MESSAGE	▲	<div>SOURCE 1 AUX VT:</div> <div>None</div>	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 five (5) CTs. The first channel displayed is the CT to which all others will be referred. For example, the selection "F1+F5" indicates the sum of each phase from channels "F1" and "F5", scaled to whichever CT has the higher ratio. Selecting "None" hides the associated actual values.

The approach used to configure the AC Sources consists of several steps; first step is to specify the information about each CT and VT input. For CT inputs, this is the nominal primary and secondary current. For VTs, this is the connection type, ratio and nominal secondary voltage. Once the inputs have been specified, the configuration for each Source is entered, including specifying which CTs will be summed together.

User Selection of AC Parameters for Comparator Elements:

CT/VT modules automatically calculate all current and voltage parameters from the available inputs. Users must select the specific input parameters to be measured by every element in the relevant settings menu. The internal design of the element specifies which type of parameter to use and provides a setting for Source selection. In elements where the parameter may be either fundamental or RMS magnitude, such as phase time overcurrent, two settings are provided. One setting specifies the Source, the second setting selects between fundamental phasor and RMS.

AC Input Actual Values:

The calculated parameters associated with the configured voltage and current inputs are displayed in the current and voltage sections of Actual Values. Only the phasor quantities associated with the actual AC physical input channels will be displayed here. All parameters contained within a configured Source are displayed in the Sources section of 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:

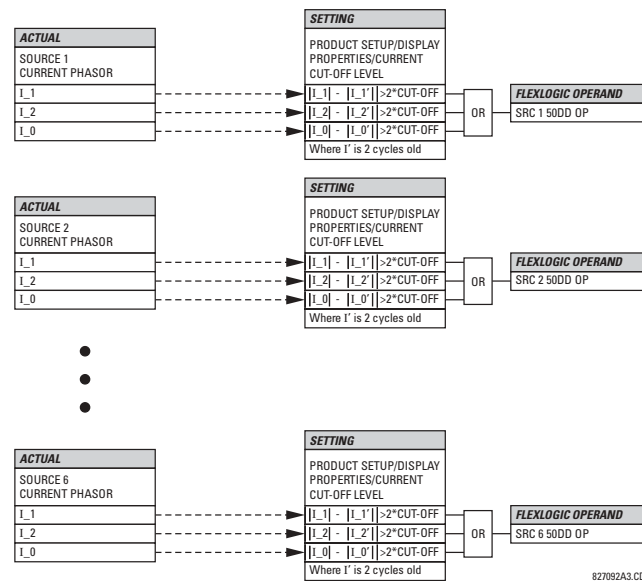


Figure 5-13: DISTURBANCE DETECTOR LOGIC DIAGRAM

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 LINE

PATH: SETTINGS ⇒ ⚙ SYSTEM SETUP ⇒ ⚙ LINE

<div>■ LINE</div>	<div>⏪ ⏩</div>	<div>POS SEQ IMPEDANCE MAGNITUDE: 3.00 Ω</div>	Range: 0.01 to 250.00 Ω in steps of 0.01
MESSAGE	<div>⬆ ⬇ ⬆</div>	<div>POS SEQ IMPEDANCE ANGLE: 75°</div>	Range: 25 to 90° in steps of 1
MESSAGE	<div>⬆ ⬇ ⬆</div>	<div>ZERO SEQ IMPEDANCE MAGNITUDE: 9.00 Ω</div>	Range: 0.01 to 650.00 Ω in steps of 0.01
MESSAGE	<div>⬆ ⬇ ⬆</div>	<div>ZERO SEQ IMPEDANCE ANGLE: 75°</div>	Range: 25 to 90° in steps of 1
MESSAGE	<div>⬆ ⬇ ⬆</div>	<div>LINE LENGTH UNITS: km</div>	Range: km, miles
MESSAGE	<div>⬆ ⬇ ⬆</div>	<div>LINE LENGTH (km): 100.0</div>	Range: 0.0 to 2000.0 in steps of 0.1

These settings specify the characteristics of the line. The line impedance value should be entered as secondary ohms.

This data is used for fault location calculations. See the **SETTINGS ⇒ PRODUCT SETUP ⇒ ⚙ FAULT REPORT** menu for assigning the Source and Trigger for fault calculations.

5.3.5 BREAKERS

PATH: SETTINGS ⇒ SYSTEM SETUP ⇒ BREAKERS ⇒ BREAKER 1(2)

<div>■ BREAKER 1</div>		<div>◀▶</div>	<div>BREAKER 1</div> <div>FUNCTION: Disabled</div>	Range: Disabled, Enabled
MESSAGE	<div>▲▼</div>	<div>▲▼</div>	<div>BREAKER1 PUSH BUTTON</div> <div>CONTROL: Disabled</div>	Range: Disabled, Enabled
MESSAGE	<div>▲▼</div>	<div>▲▼</div>	<div>BREAKER 1 NAME:</div> <div>Bkr 1</div>	Range: up to 6 alphanumeric characters
MESSAGE	<div>▲▼</div>	<div>▲▼</div>	<div>BREAKER 1 MODE:</div> <div>3-Pole</div>	Range: 3-Pole, 1-Pole
MESSAGE	<div>▲▼</div>	<div>▲▼</div>	<div>BREAKER 1 OPEN:</div> <div>Off</div>	Range: FlexLogic™ operand
MESSAGE	<div>▲▼</div>	<div>▲▼</div>	<div>BREAKER 1 CLOSE:</div> <div>Off</div>	Range: FlexLogic™ operand
MESSAGE	<div>▲▼</div>	<div>▲▼</div>	<div>BREAKER 1 φA/3-POLE:</div> <div>Off</div>	Range: FlexLogic™ operand
MESSAGE	<div>▲▼</div>	<div>▲▼</div>	<div>BREAKER 1 φB:</div> <div>Off</div>	Range: FlexLogic™ operand
MESSAGE	<div>▲▼</div>	<div>▲▼</div>	<div>BREAKER 1 φC:</div> <div>Off</div>	Range: FlexLogic™ operand
MESSAGE	<div>▲▼</div>	<div>▲▼</div>	<div>BREAKER 1 EXT ALARM:</div> <div>Off</div>	Range: FlexLogic™ operand
MESSAGE	<div>▲▼</div>	<div>▲▼</div>	<div>BREAKER 1 ALARM</div> <div>DELAY: 0.000 s</div>	Range: 0.000 to 1 000 000.000 s in steps of 0.001
MESSAGE	<div>▲▼</div>	<div>▲▼</div>	<div>MANUAL CLOSE RECAL</div> <div>TIME: 0.000 s</div>	Range: 0.000 to 1 000 000.000 s in steps of 0.001
MESSAGE	<div>▲▼</div>	<div>▲▼</div>	<div>BREAKER 1 OUT OF SV:</div> <div>Off</div>	Range: FlexLogic™ operand
MESSAGE	<div>▲▼</div>	<div>▲▼</div>	<div>UCA XCBR1 PwrSupSt0:</div> <div>Off</div>	Range: FlexLogic™ operand
MESSAGE	<div>▲▼</div>	<div>▲▼</div>	<div>UCA XCBR1 PresSt:</div> <div>Off</div>	Range: FlexLogic™ operand
MESSAGE	<div>▲▼</div>	<div>▲▼</div>	<div>UCA XCBR1 TrpCoil:</div> <div>Off</div>	Range: FlexLogic™ operand
▼				
<div>■ BREAKER 2</div>		<div>◀▶</div>	As for Breaker 1 above	
▼				
<div>■ UCA XCBR SBO TIMER</div>		<div>◀▶</div>	<div>BKR XCBR SBO TIMEOUT:</div> <div>30 s</div>	Range: 1 to 60 s in steps of 1

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 No. 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 No. 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) Φ A/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 Φ B** and **BREAKER 1 Φ C** select operands to track phases B and C, respectively.
- **BREAKER 1(2) Φ B:** 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) Φ C:** 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 No. 1 is out-of-service.
- **UCA XCBR1(2) PwrSupSt0:** Selects a FlexLogic™ operand to provide a value for the UCA XCBR1(2) PwrSupSt bit 0 data item.
- **UCA XCBR1(2) PresSt:** Selects a FlexLogic™ operand to provide a value for the UCA XCBR1(2) PresSt data item.
- **UCA XCBR1(2) TrpCoil:** Selects a FlexLogic™ operand to provide a value for the UCA XCBR1(2) TrpCoil data item.
- **BKR XCBR SBO TIMEOUT:** The Select-Before-Operate timer specifies an interval from the receipt of the UCA Breaker Control Select signal until the automatic de-selection of the breaker, so that the breaker does not remain selected indefinitely. This setting applies only to UCA SBO operation.

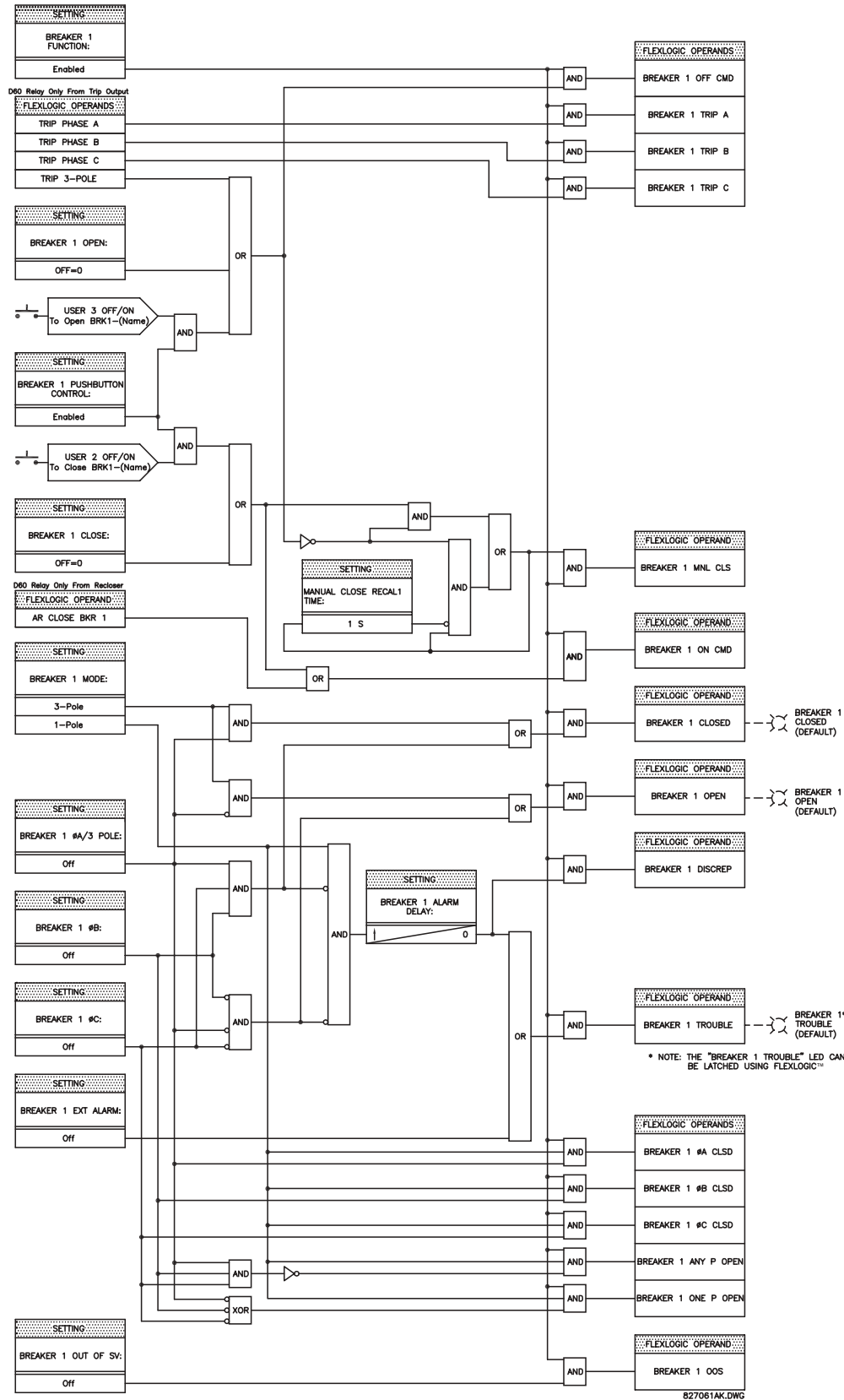


Figure 5-14: DUAL BREAKER CONTROL SCHEME LOGIC

5.3.6 FLEXCURVES™

a) SETTINGS

PATH: SETTINGS ⇒ SYSTEM SETUP ⇒ FLEXCURVES ⇒ FLEXCURVE A(D)

FLEXCURVE A



FLEXCURVE A TIME AT

0.00 xPKP: 0 ms

Range: 0 to 65535 ms in steps of 1

FlexCurves™ A through D have settings for entering times to Reset/Operate at the following pickup levels: 0.00 to 0.98 / 1.03 to 20.00. This data is converted into 2 continuous curves by linear interpolation between data points. To enter a custom FlexCurve™, enter the Reset/Operate time (using the ▲ VALUE ▼ keys) for each selected pickup point (using the ▲ MESSAGE ▼ keys) for the desired protection curve (A, B, C, or D).

Table 5–3: FLEXCURVE™ TABLE

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



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 URPC

URPC 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 URPC** 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 URPC setting is set to "Recloser Curve" and the Initialize FlexCurve button is clicked.

Multiplier: Scales (multiplies) the curve operating times

Addr: Adds the time specified in this field (in ms) to each curve operating time value.

Minimum Response Time (MRT): If enabled, the MRT setting defines the shortest operating time even if the curve suggests a shorter time at higher current multiples. A composite operating characteristic is effectively defined. For current multiples lower than the intersection point, the curve dictates the operating time; otherwise, the MRT does. An information message appears when attempting to apply an MRT shorter than the minimum curve time.

High Current Time: Allows the user to set a pickup multiple from which point onwards the operating time is fixed. This is normally only required at higher current levels. The **HCT Ratio** defines the high current pickup multiple; the **HCT** defines the operating time.

842721A1.CDR

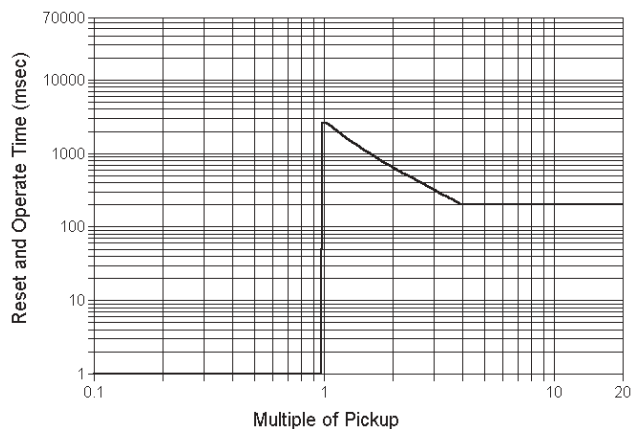
Figure 5–15: RECLOSER CURVE INITIALIZATION



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

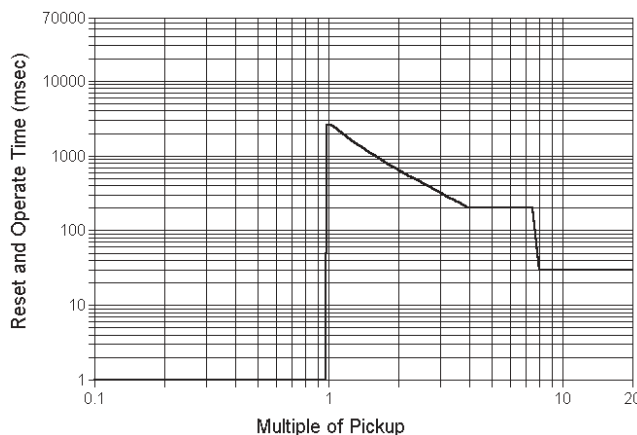
A composite curve can be created from the GE_111 standard with MRT = 200 ms and HCT initially disabled and then enabled at 8 times pickup with an operating time of 30 ms. At approximately 4 times pickup, the curve operating time is equal to the MRT and from then onwards the operating time remains at 200 ms (see below).



842719A1.CDR

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.

5

842729A1.CDR

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 URPC 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.

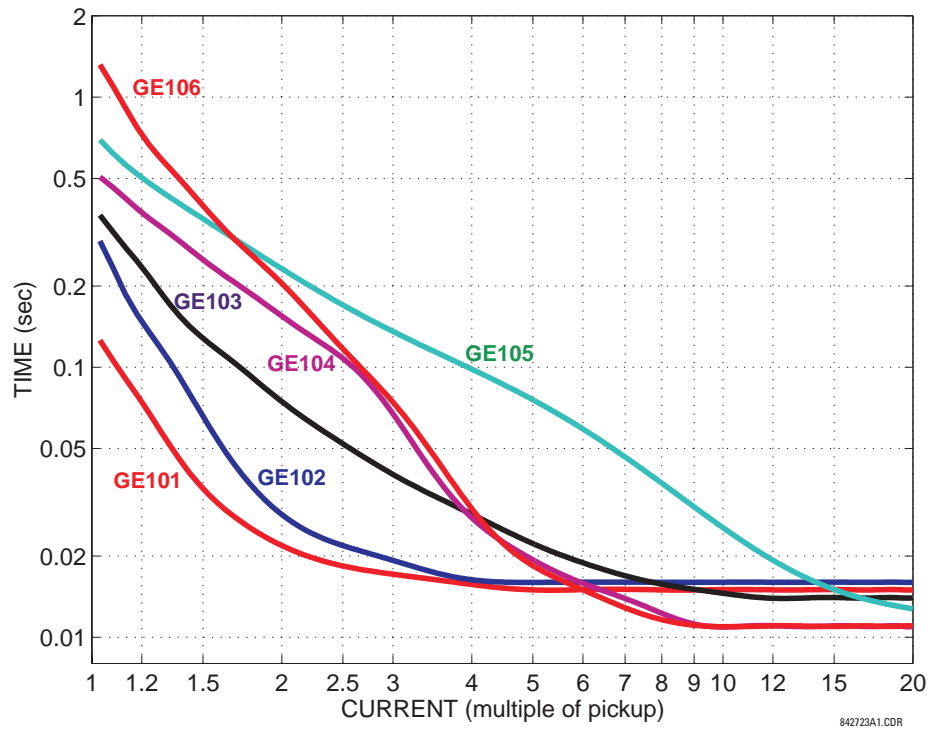


Figure 5-18: RECLOSER CURVES GE101 TO GE106

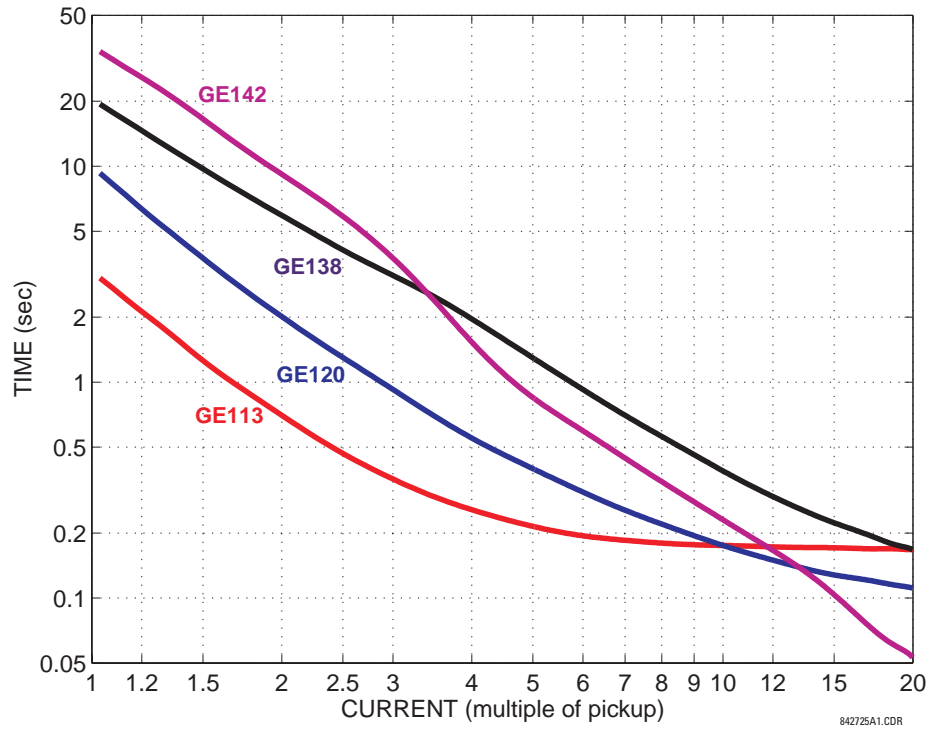


Figure 5-19: RECLOSER CURVES GE113, GE120, GE138 AND GE142

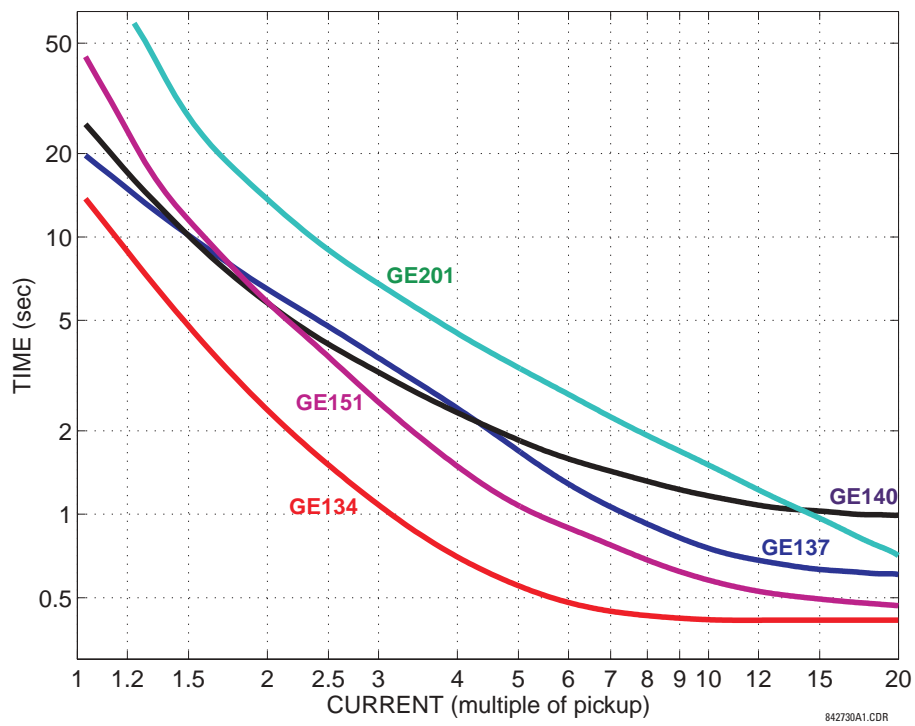


Figure 5-20: RECLOSER CURVES GE134, GE137, GE140, GE151 AND GE201

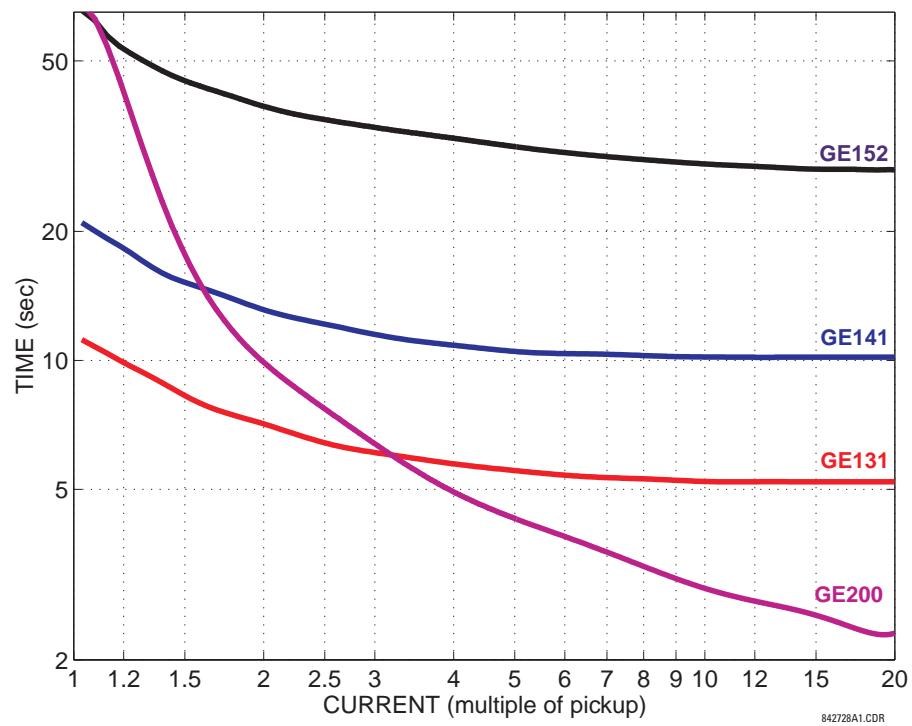


Figure 5-21: RECLOSER CURVES GE131, GE141, GE152, AND GE200

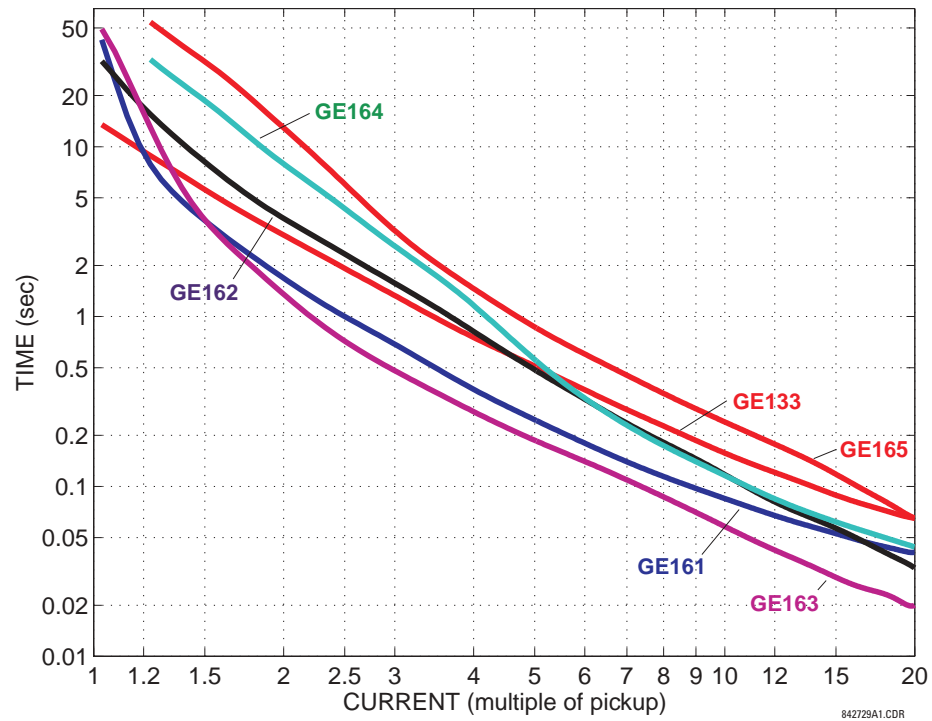


Figure 5-22: RECLOSER CURVES GE133, GE161, GE162, GE163, GE164 AND GE165

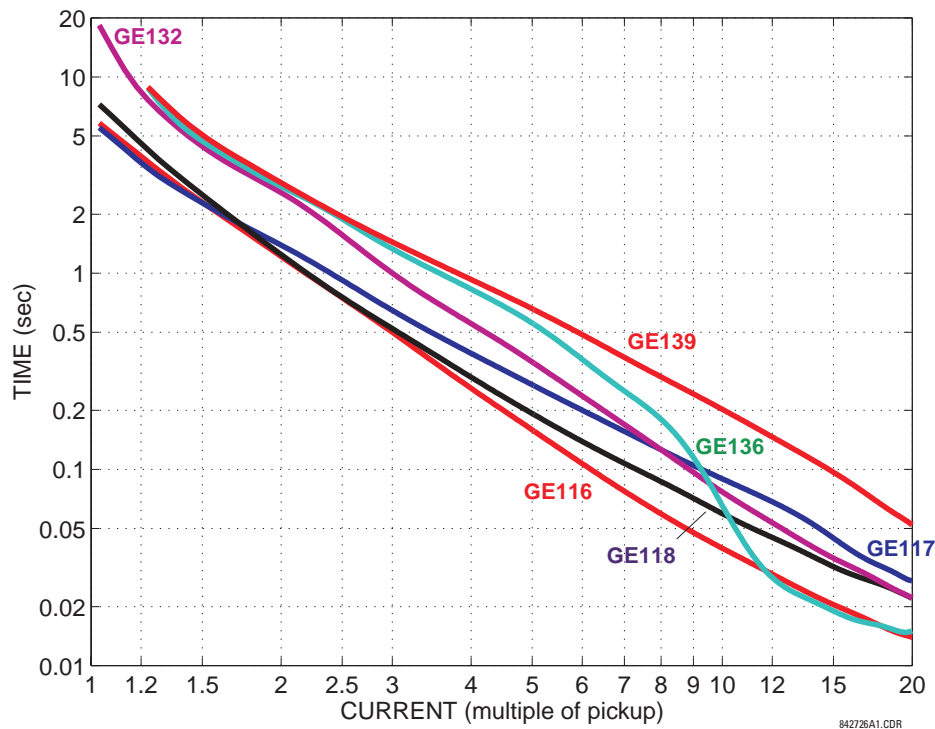


Figure 5-23: RECLOSER CURVES GE116, GE117, GE118, GE132, GE136, AND GE139

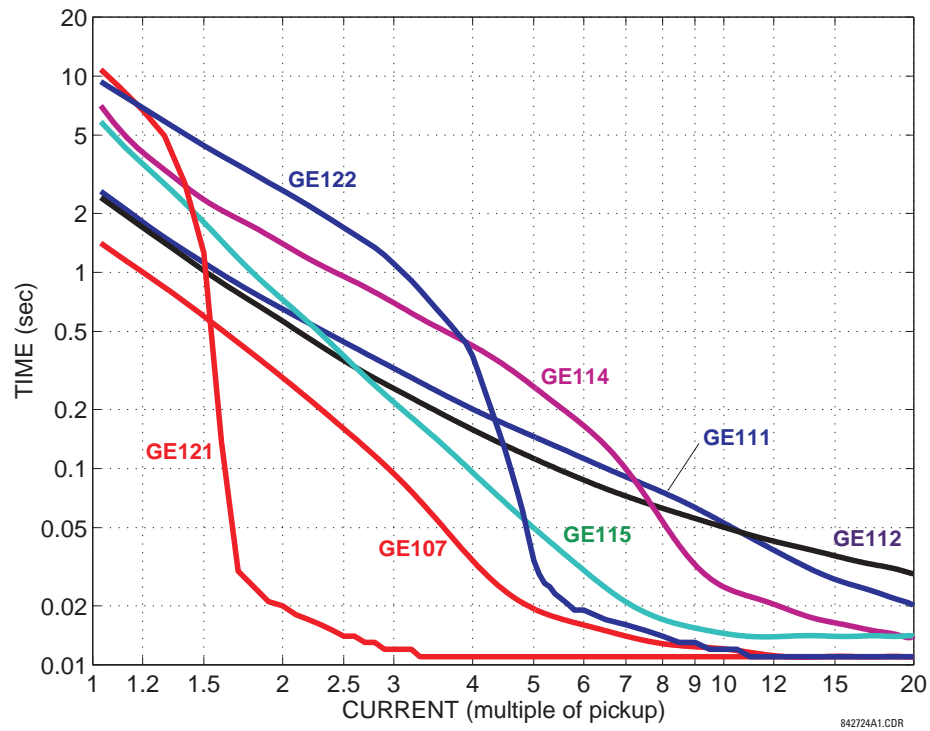


Figure 5-24: RECLOSER CURVES GE107, GE111, GE112, GE114, GE115, GE121, AND GE122

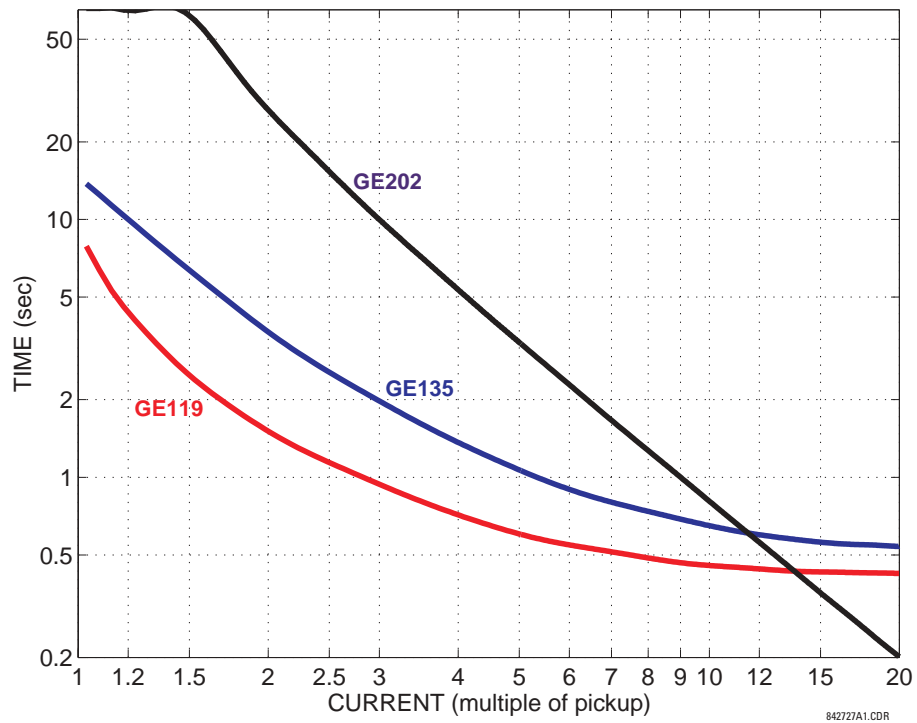


Figure 5-25: RECLOSER CURVES GE119, GE135, AND GE202

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 relay involved in this process are shown below.

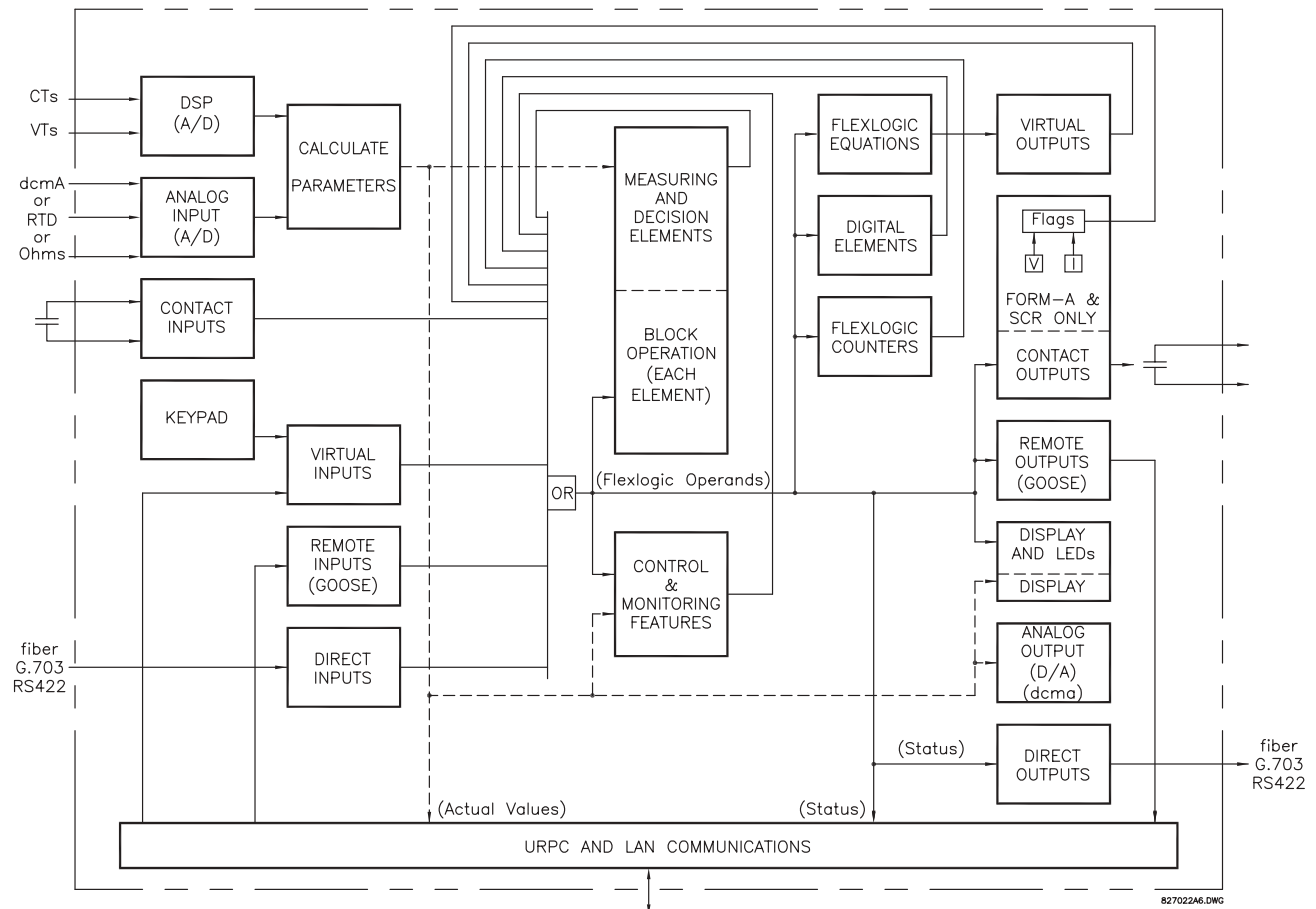


Figure 5-26: UR ARCHITECTURE OVERVIEW

The states of all digital signals used in the UR 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 5–4: UR FLEXLOGIC™ OPERAND TYPES

OPERAND TYPE	STATE	EXAMPLE FORMAT	CHARACTERISTICS [INPUT IS '1' (= ON) IF...]
Contact Input	On	Cont Ip On	Voltage is presently applied to the input (external contact closed).
	Off	Cont Ip Off	Voltage is presently not applied to the input (external contact open).
Contact Output (type Form-A contact only)	Voltage On	Cont Op 1 VOn	Voltage exists across the contact.
	Voltage Off	Cont Op 1 VOff	Voltage does not exist across the contact.
	Current On	Cont Op 1 IOn	Current is flowing through the contact.
	Current Off	Cont Op 1 IOff	Current is not flowing through the contact.
Direct Input	On	DIRECT INPUT 1 On	The direct input is presently in the ON state.
Element (Analog)	Pickup	PHASE TOC1 PKP	The tested parameter is presently above the pickup setting of an element which responds to rising values or below the pickup setting of an element which responds to falling values.
	Dropout	PHASE TOC1 DPO	This operand is the logical inverse of the above PKP operand.
	Operate	PHASE TOC1 OP	The tested parameter has been above/below the pickup setting of the element for the programmed delay time, or has been at logic 1 and is now at logic 0 but the reset timer has not finished timing.
	Block	PH DIR1 BLK	The output of the comparator is set to the block function.
Element (Digital)	Pickup	Dig Element 1 PKP	The input operand is at logic 1.
	Dropout	Dig Element 1 DPO	This operand is the logical inverse of the above PKP operand.
	Operate	Dig Element 1 OP	The input operand has been at logic 1 for the programmed pickup delay time, or has been at logic 1 for this period and is now at logic 0 but the reset timer has not finished timing.
Element (Digital Counter)	Higher than	Counter 1 HI	The number of pulses counted is above the set number.
	Equal to	Counter 1 EQL	The number of pulses counted is equal to the set number.
	Lower than	Counter 1 LO	The number of pulses counted is below the set number.
Fixed	On	On	Logic 1
	Off	Off	Logic 0
Remote Input	On	REMOTE INPUT 1 On	The remote input is presently in the ON state.
Virtual Input	On	Virt Ip 1 On	The virtual input is presently in the ON state.
Virtual Output	On	Virt Op 1 On	The virtual output is presently in the set state (i.e. evaluation of the equation which produces this virtual output results in a "1").

The operands available for this relay are listed alphabetically by types in the following table.

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

OPERAND TYPE	OPERAND SYNTAX	OPERAND DESCRIPTION
CONTROL PUSHBUTTONS	CONTROL PUSHBTN n ON	Control Pushbutton n ($n = 1$ to 3) is being pressed.
DIRECT DEVICES	DIRECT DEVICE 1 On ↓ DIRECT DEVICE 8 On DIRECT DEVICE 1 Off ↓ DIRECT DEVICE 8 Off	Flag is set, logic=1 ↓ Flag is set, logic=1 Flag is set, logic=1 ↓ Flag is set, logic=1
DIRECT I/O 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 I/O messages on Channel 1(2) exceeded the user-specified level (ring configurations only). The rate of returned Direct I/O messages exceeded the user-specified level on Channel 1 or 2 (ring configurations only).
ELEMENT: Autoreclose (per CT bank)	AR 1 ENABLED AR 1 RIP AR 1 LO AR 1 BLK FROM MAN CL AR 1 CLOSE AR 1 SHOT CNT=0 ↓ AR 1 SHOT CNT=4 AR 1 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 OV	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 UV	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 1 is operated Breaker Arcing 2 is 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 BKR FAIL 2	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 Same set of operands as shown for BKR FAIL 1
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 2	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 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

Table 5–5: F60 FLEXLOGIC™ OPERANDS (Sheet 2 of 6)

OPERAND TYPE	OPERAND SYNTAX	OPERAND DESCRIPTION
ELEMENT: Digital Counter	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 Element	Dig Element 1 PKP Dig Element 1 OP Dig Element 1 DPO ↓ Dig Element 16 PKP Dig Element 16 OP Dig Element 16 DPO	Digital Element 1 is picked up Digital Element 1 is operated Digital Element 1 is dropped out ↓ Digital Element 16 is picked up Digital Element 16 is operated Digital Element 16 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 ↓ DIR POWER 2	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 Same set of operands as DIR POWER 1
ELEMENT: Disturbance Detector	SRCx 50DD OP	Source x Disturbance Detector is operated
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 IOC	GROUND IOC1 PKP GROUND IOC1 OP GROUND IOC1 DPO ↓ GROUND IOC2	Ground Instantaneous Overcurrent 1 has picked up Ground Instantaneous Overcurrent 1 has operated Ground Instantaneous Overcurrent 1 has dropped out Same set of operands as shown for GROUND IOC 1
ELEMENT: Ground TOC	GROUND TOC1 PKP GROUND TOC1 OP GROUND TOC1 DPO ↓ GROUND TOC2	Ground Time Overcurrent 1 has picked up Ground Time Overcurrent 1 has operated Ground Time Overcurrent 1 has dropped out Same set of operands as shown for GROUND TOC1
ELEMENT 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

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

OPERAND TYPE	OPERAND SYNTAX	OPERAND DESCRIPTION
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 OC	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 IOC	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 OV	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
	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
ELEMENT: Negative Sequence TOC	NEG SEQ TOC2	Same set of operands as shown for NEG SEQ TOC1
	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
ELEMENT: Neutral IOC	NEUTRAL IOC2	Same set of operands as shown for NEUTRAL IOC1
	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 OV	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 TOC	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: Neutral Directional	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
ELEMENT: Overfrequency	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 Directional	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

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

OPERAND TYPE	OPERAND SYNTAX	OPERAND DESCRIPTION
ELEMENT: Phase OV	PHASE OV1 PKP	At least one phase of OV1 has picked up
	PHASE OV1 OP	At least one phase of OV1 has operated
	PHASE OV1 DPO	At least one phase of OV1 has dropped out
	PHASE OV1 PKP A	Phase A of OV1 has picked up
	PHASE OV1 PKP B	Phase B of OV1 has picked up
	PHASE OV1 PKP C	Phase C of OV1 has picked up
	PHASE OV1 OP A	Phase A of OV1 has operated
	PHASE OV1 OP B	Phase B of OV1 has operated
	PHASE OV1 OP C	Phase C of OV1 has operated
	PHASE OV1 DPO A	Phase A of OV1 has dropped out
	PHASE OV1 DPO B	Phase B of OV1 has dropped out
	PHASE OV1 DPO C	Phase C of OV1 has dropped out
ELEMENT: Phase TOC	PHASE TOC1 PKP	At least one phase of PHASE TOC1 has picked up
	PHASE TOC1 OP	At least one phase of PHASE TOC1 has operated
	PHASE TOC1 DPO	At least one phase of PHASE TOC1 has dropped out
	PHASE TOC1 PKP A	Phase A of PHASE TOC1 has picked up
	PHASE TOC1 PKP B	Phase B of PHASE TOC1 has picked up
	PHASE TOC1 PKP C	Phase C of PHASE TOC1 has picked up
	PHASE TOC1 OP A	Phase A of PHASE TOC1 has operated
	PHASE TOC1 OP B	Phase B of PHASE TOC1 has operated
	PHASE TOC1 OP C	Phase C of PHASE TOC1 has operated
	PHASE TOC1 DPO A	Phase A of PHASE TOC1 has dropped out
	PHASE TOC1 DPO B	Phase B of PHASE TOC1 has dropped out
	PHASE TOC1 DPO C	Phase C of PHASE TOC1 has dropped out
ELEMENT: Phase UV	PHASE TOC2	Same set of operands as shown for PHASE TOC1
	PHASE UV1 PKP	At least one phase of UV1 has picked up
	PHASE UV1 OP	At least one phase of UV1 has operated
	PHASE UV1 DPO	At least one phase of UV1 has dropped out
	PHASE UV1 PKP A	Phase A of UV1 has picked up
	PHASE UV1 PKP B	Phase B of UV1 has picked up
	PHASE UV1 PKP C	Phase C of UV1 has picked up
	PHASE UV1 OP A	Phase A of UV1 has operated
	PHASE UV1 OP B	Phase B of UV1 has operated
	PHASE UV1 OP C	Phase C of UV1 has operated
	PHASE UV1 DPO A	Phase A of UV1 has dropped out
	PHASE UV1 DPO B	Phase B of UV1 has dropped out
	PHASE UV1 DPO C	Phase C of UV1 has dropped out
ELEMENT: Selector Switch	PHASE UV2	Same set of operands as shown for PHASE UV1
	SELECTOR 1 POS Y	Selector Switch 1 is in Position Y (mutually exclusive operands).
	SELECTOR 1 BIT 0	First bit of the 3-bit word encoding position of Selector 1.
	SELECTOR 1 BIT 1	Second bit of the 3-bit word encoding position of Selector 1.
	SELECTOR 1 BIT 2	Third bit of the 3-bit word encoding position of Selector 1.
	SELECTOR 1 STP ALARM	Position of Selector 1 has been pre-selected with the stepping up control input but not acknowledged.
	SELECTOR 1 BIT ALARM	Position of Selector 1 has been pre-selected with the 3-bit control input but not acknowledged.
	SELECTOR 1 ALARM	Position of Selector 1 has been pre-selected but not acknowledged.
	SELECTOR 1 PWR ALARM	Position of Selector Switch 1 is undetermined when the relay powers up and synchronizes to the 3-bit input.
	SELECTOR 2	Same set of operands as shown above for SELECTOR 1
ELEMENT: Setting Group	SETTING GROUP ACT 1	Setting Group 1 is active
	SETTING GROUP ACT 6	Setting Group 6 is active
ELEMENT: Synchrocheck		
	SYNC 1 DEAD S OP	Synchrocheck 1 dead source has operated
	SYNC 1 DEAD S DPO	Synchrocheck 1 dead source has dropped out
	SYNC 1 SYNC OP	Synchrocheck 1 in synchronization has operated
	SYNC 1 SYNC DPO	Synchrocheck 1 in synchronization has dropped out
	SYNC 1 CLS OP	Synchrocheck 1 close has operated
	SYNC 1 CLS DPO	Synchrocheck 1 close has dropped out
	SYNC 1 V1 ABOVE MIN	Synchrocheck 1 V1 is above the minimum live voltage
	SYNC 1 V1 BELOW MAX	Synchrocheck 1 V1 is below the maximum dead voltage
	SYNC 1 V2 ABOVE MIN	Synchrocheck 1 V2 is above the minimum live voltage
	SYNC 1 V2 BELOW MAX	Synchrocheck 1 V2 is below the maximum dead voltage
	SYNC 2	Same set of operands as shown for SYNC 1
ELEMENT: Underfrequency		
	UNDERFREQ 1 PKP	Underfrequency 1 has picked up
	UNDERFREQ 1 OP	Underfrequency 1 has operated
	UNDERFREQ 1 DPO	Underfrequency 1 has dropped out
	UNDERFREQ 2 to 6	Same set of operands as shown for UNDERFREQ 1 above

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

OPERAND TYPE	OPERAND SYNTAX	OPERAND DESCRIPTION
ELEMENT: VTFF	SRCx VT FF OP SRCx VT FF DPO SRCx VT FF 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 above 25% or V1 below 70% of nominal)
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 ↓ Cont Op 1 IOff Cont Op 2 IOff	(will not appear unless ordered) (will not appear unless ordered) ↓ (will not appear unless ordered) (will not appear unless ordered)
INPUTS/OUTPUTS: Contact Outputs, Voltage (from detector on Form-A output only)	Cont Op 1 VOn Cont Op 2 VOn ↓ Cont Op 1 VOff Cont Op 2 VOff	(will not appear unless ordered) (will not appear unless ordered) ↓ (will not appear unless ordered) (will not appear unless ordered)
INPUTS/OUTPUTS Direct Inputs	DIRECT INPUT 1 On ↓ DIRECT INPUT 32 On	Flag is set, logic=1 ↓ Flag is set, logic=1
INPUTS/OUTPUTS: Remote Inputs	REMOTE INPUT 1 On ↓ REMOTE INPUT 32 On	Flag is set, logic=1 ↓ Flag is set, logic=1
INPUTS/OUTPUTS: Virtual Inputs	Virt Ip 1 On ↓ Virt Ip 32 On	Flag is set, logic=1 ↓ Flag is set, logic=1
INPUTS/OUTPUTS: Virtual Outputs	Virt Op 1 On ↓ Virt Op 64 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

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

OPERAND TYPE	OPERAND SYNTAX	OPERAND DESCRIPTION
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. See description in Chapter 7: Commands and Targets. See description in Chapter 7: Commands and Targets. See description in Chapter 7: Commands and Targets. See description in Chapter 7: Commands and Targets. See description in Chapter 7: Commands and Targets. See description in Chapter 7: Commands and Targets. See description in Chapter 7: Commands and Targets. See description in Chapter 7: Commands and Targets. See description in Chapter 7: Commands and Targets. See description in Chapter 7: Commands and Targets. See description in Chapter 7: Commands and Targets. See description in Chapter 7: Commands and Targets. See description in Chapter 7: Commands and Targets. See description in Chapter 7: Commands and Targets. See description in Chapter 7: Commands and Targets. See description in Chapter 7: Commands and Targets. See description in Chapter 7: Commands and Targets. 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 5–6: FLEXLOGIC™ GATE CHARACTERISTICS

GATES	NUMBER OF INPUTS	OUTPUT IS '1' (= ON) IF...
NOT	1	input is '0'
OR	2 to 16	any input is '1'
AND	2 to 16	all inputs are '1'
NOR	2 to 16	all inputs are '0'
NAND	2 to 16	any input is '0'
XOR	2	only one input is '1'

Table 5–7: FLEXLOGIC™ OPERATORS

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

5.4.2 FLEXLOGIC™ RULES

When forming a FlexLogic™ equation, the sequence in the linear array of parameters must follow these general rules:

1. Operands must precede the operator which uses the operands as inputs.
2. Operators have only one output. The output of an operator must be used to create a virtual output if it is to be used as an input to two or more operators.
3. Assigning the output of an operator to a Virtual Output terminates the equation.
4. A timer operator (e.g. "TIMER 1") or virtual output assignment (e.g. "= Virt Op 1") may only be used once. If this rule is broken, a syntax error will be declared.

5.4.3 FLEXLOGIC™ EVALUATION

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



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 64) can only be properly assigned once.

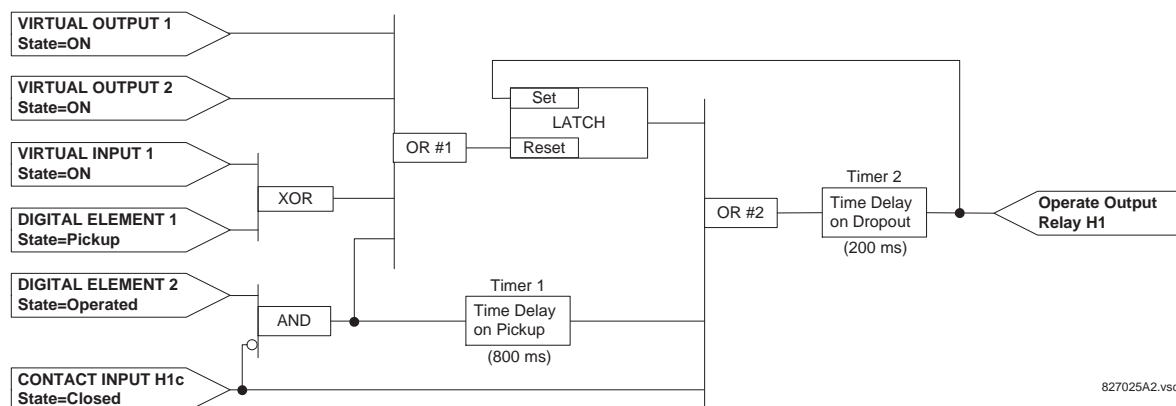


Figure 5-27: EXAMPLE LOGIC SCHEME

5

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.

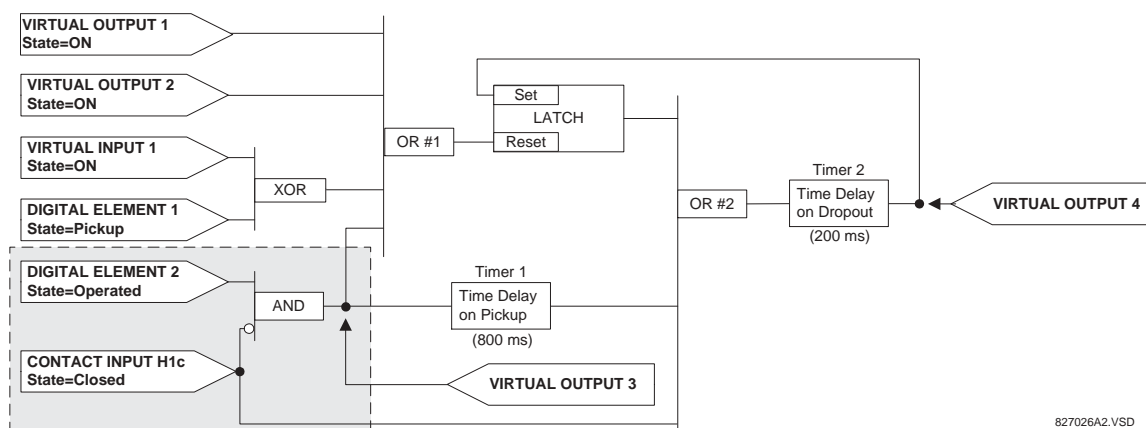


Figure 5-28: LOGIC EXAMPLE WITH VIRTUAL OUTPUTS

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.

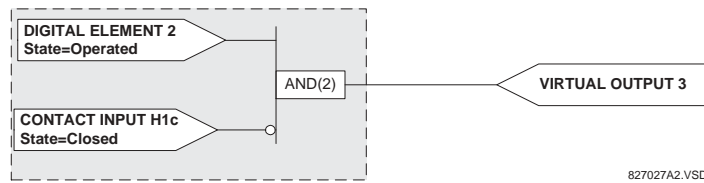


Figure 5–29: LOGIC FOR VIRTUAL OUTPUT 3

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.

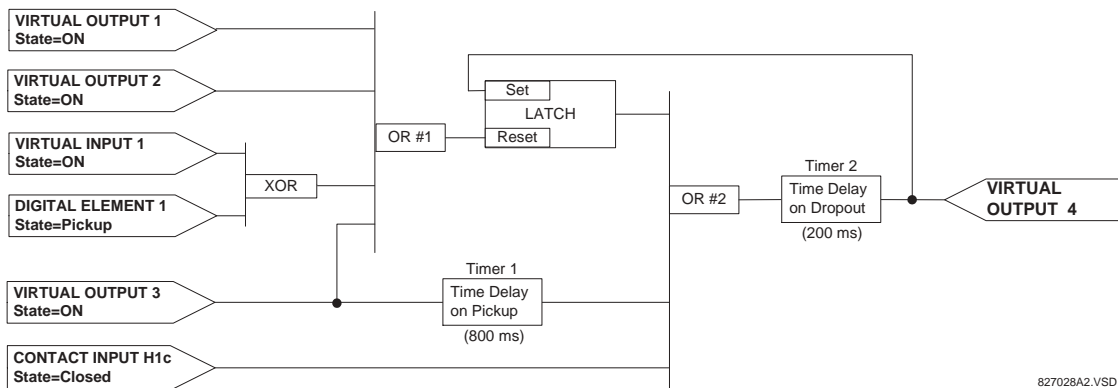


Figure 5–30: LOGIC FOR VIRTUAL OUTPUT 4

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.

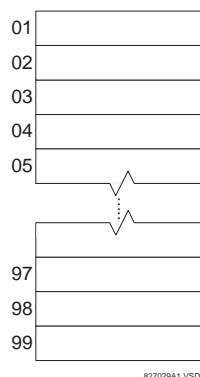


Figure 5–31: FLEXLOGIC™ WORKSHEET

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.

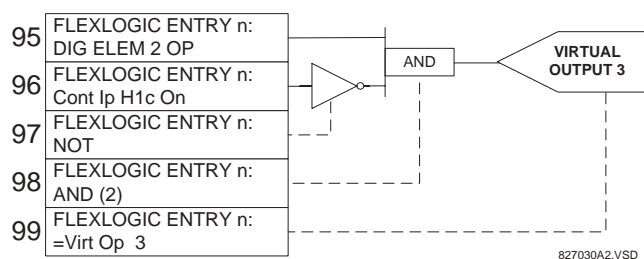


Figure 5–32: FLEXLOGIC™ EQUATION FOR VIRTUAL OUTPUT 3

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".

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 Hlc 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.

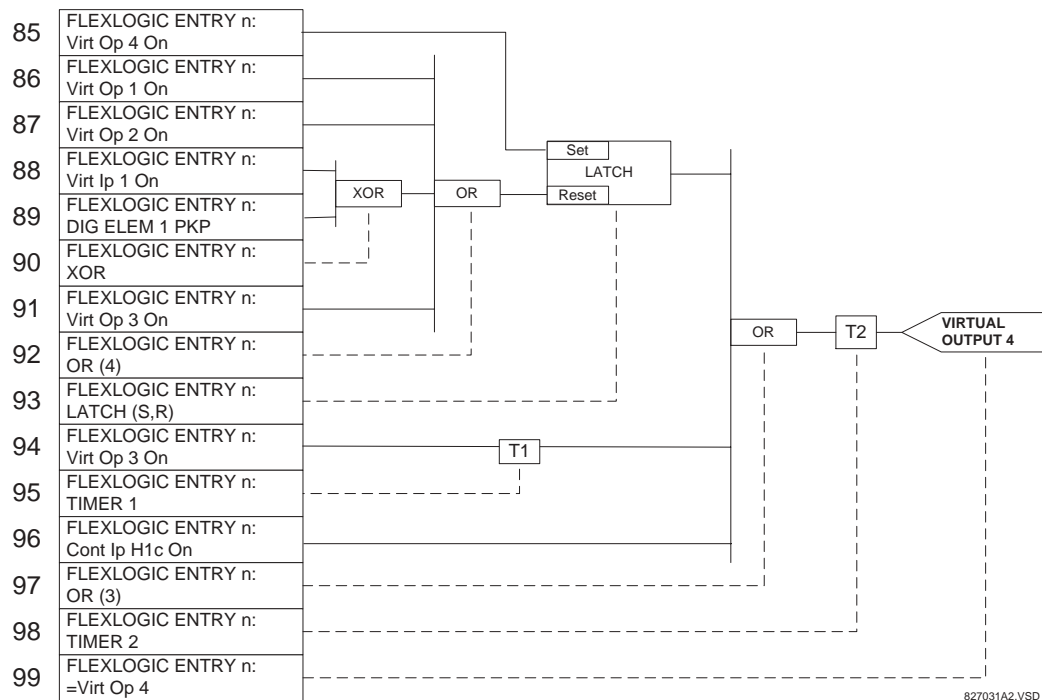


Figure 5–33: FLEXLOGIC™ EQUATION FOR VIRTUAL OUTPUT 4

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

```

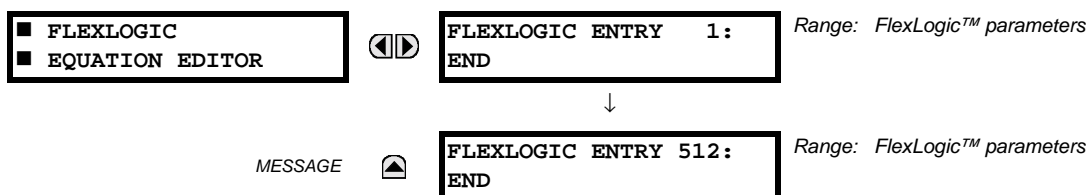
In the expression above, the Virtual Output 4 input to the 4-input OR is listed before it is created. This is typical of a form of feedback, in this case, used to create a seal-in effect with the latch, and is correct.

- The logic should always be tested after it is loaded into the relay, in the same fashion as has been used in the past. Testing can be simplified by placing an "END" operator within the overall set of FlexLogic™ equations. The equations will then only be evaluated up to the first "END" operator.

The "On" and "Off" operands can be placed in an equation to establish a known set of conditions for test purposes, and the "INSERT" and "DELETE" commands can be used to modify equations.

5.4.5 FLEXLOGIC™ EQUATION EDITOR

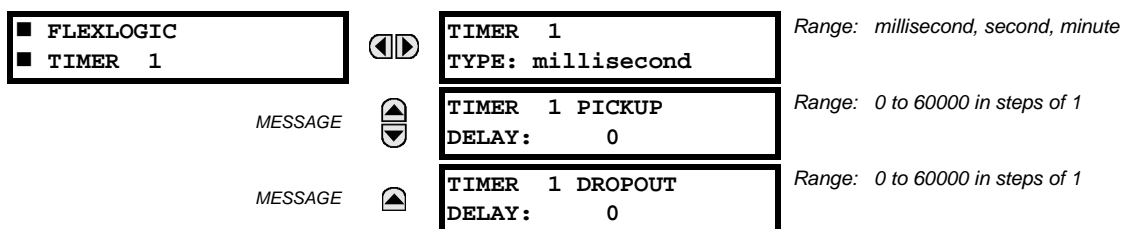
PATH: SETTINGS ⇒ FLEXLOGIC ⇒ FLEXLOGIC EQUATION EDITOR



There are 512 FlexLogic™ entries available, numbered from 1 to 512, with default 'END' entry settings. If a "Disabled" Element is selected as a FlexLogic™ entry, the associated state flag will never be set to '1'. The '+/-' key may be used when editing FlexLogic™ equations from the keypad to quickly scan through the major parameter types.

5.4.6 FLEXLOGIC™ TIMERS

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



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

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

5.4.7 FLEXELEMENTS™

PATH: SETTING ⇒ FLEXLOGIC ⇒ FLEXELEMENTS ⇒ FLEXELEMENT 1(8)

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

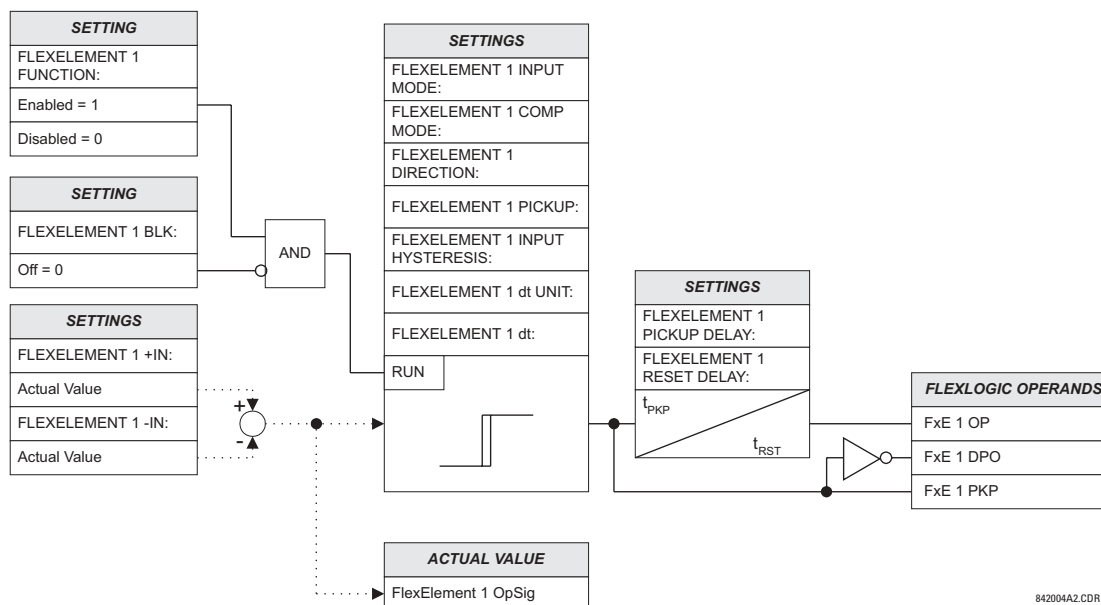


Figure 5-34: FLEXELEMENT™ SCHEME LOGIC

5

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

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

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

The element responds directly to its operating signal – as defined by the **FLEXELEMENT 1 +IN**, **FLEXELEMENT 1 -IN** and **FLEXELEMENT 1 INPUT MODE** settings – if the **FLEXELEMENT 1 COMP MODE** setting is set to “Threshold”. The element responds to the rate of change of its operating signal if the **FLEXELEMENT 1 COMP MODE** setting is set to “Delta”. In this case the **FLEXELEMENT 1 dt UNIT** and **FLEXELEMENT 1 dt** settings specify how the rate of change is derived.

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

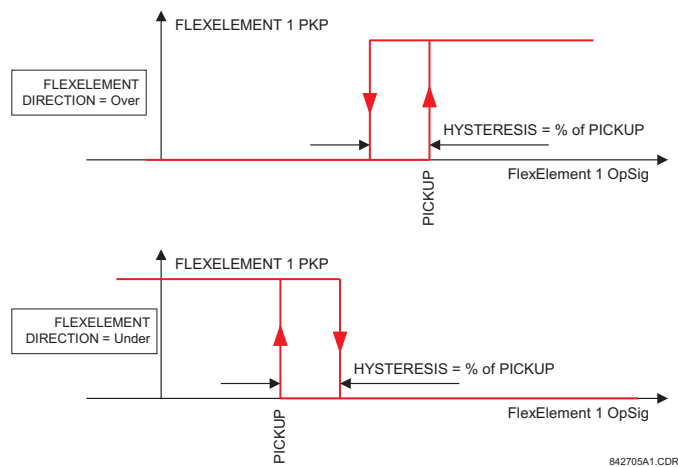


Figure 5-35: FLEXELEMENT™ DIRECTION, PICKUP, AND HYSTERESIS

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

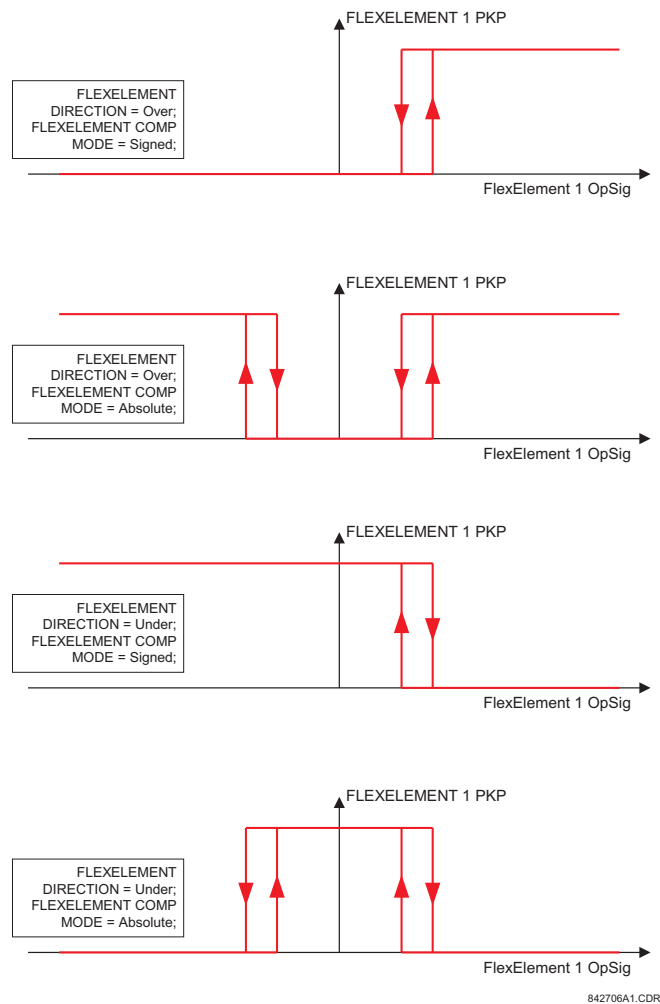


Figure 5-36: FLEXELEMENT™ INPUT MODE SETTING

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

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

Table 5–8: FLEXELEMENT™ BASE UNITS

BREAKER ARCING AMPS (Brk X Arc Amp A, B, and C)	BASE = $2000 \text{ kA}^2 \times \text{cycle}$
dcmA	BASE = maximum value of the DCMA INPUT MAX setting for the two transducers configured under the +IN and –IN inputs.
FREQUENCY	$f_{\text{BASE}} = 1 \text{ Hz}$
PHASE ANGLE	$\phi_{\text{BASE}} = 360 \text{ degrees}$ (see the UR angle referencing convention)
POWER FACTOR	$\text{PF}_{\text{BASE}} = 1.00$
RTDs	BASE = 100°C
SENSITIVE DIR POWER (Sns Dir Power)	$P_{\text{BASE}} = \text{maximum value of } 3 \times V_{\text{BASE}} \times I_{\text{BASE}} \text{ for the +IN and –IN inputs of the sources configured for the Sensitive Power Directional element(s).}$
SOURCE CURRENT	$I_{\text{BASE}} = \text{maximum nominal primary RMS value of the +IN and –IN inputs}$
SOURCE ENERGY (Positive and Negative Watthours, Positive and Negative Varhours)	$E_{\text{BASE}} = 10000 \text{ MWh or MVAh, respectively}$
SOURCE POWER	$P_{\text{BASE}} = \text{maximum value of } V_{\text{BASE}} \times I_{\text{BASE}} \text{ for the +IN and –IN inputs}$
SOURCE THD & HARMONICS	BASE = 100% of fundamental frequency component
SOURCE VOLTAGE	$V_{\text{BASE}} = \text{maximum nominal primary RMS value of the +IN and –IN inputs}$
SYNCHROCHECK (Max Delta Volts)	$V_{\text{BASE}} = \text{maximum primary RMS value of all the sources related to the +IN and –IN inputs}$

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

LATCH 1 TYPE:

Reset Dominant

LATCH 1 SET:

Off

LATCH 1 RESET:

Off

LATCH 1

TARGET: Self-reset

LATCH 1

EVENTS: Disabled

Range: Self-Reset, Latched, Disabled

Range: Reset Dominant, Set Dominant

Range: FlexLogic™ operand

Range: FlexLogic™ operand

Range: Self-reset, Latched, 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.

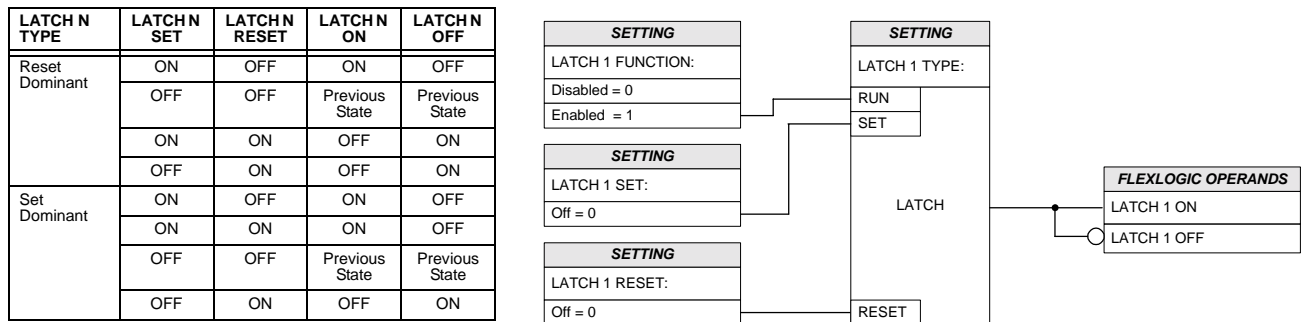


Figure 5–37: NON-VOLATILE LATCH OPERATION TABLE (N=1 TO 16) AND LOGIC

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 5-71.
MESSAGE	▲▼	■ PHASE CURRENT	See page 5-78.
MESSAGE	▲▼	■ NEUTRAL CURRENT	See page 5-84.
MESSAGE	▲▼	■ GROUND CURRENT	See page 5-90.
MESSAGE	▲▼	■ NEGATIVE SEQUENCE ■ CURRENT	See page 5-93.
MESSAGE	▲▼	■ BREAKER FAILURE	See page 5-98.
MESSAGE	▲▼	■ VOLTAGE ELEMENTS	See page 5-107.
MESSAGE	▲	■ SENSITIVE ■ DIRECTIONAL POWER	See page 5-114.

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

5.5.3 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.

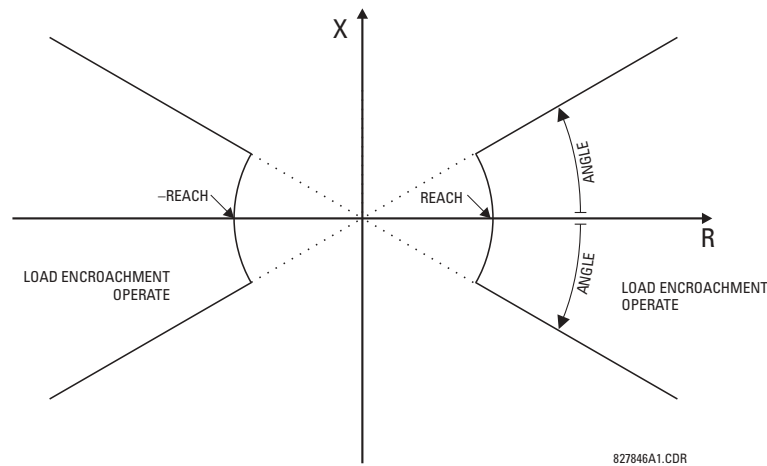


Figure 5-38: LOAD ENCROACHMENT CHARACTERISTIC

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.

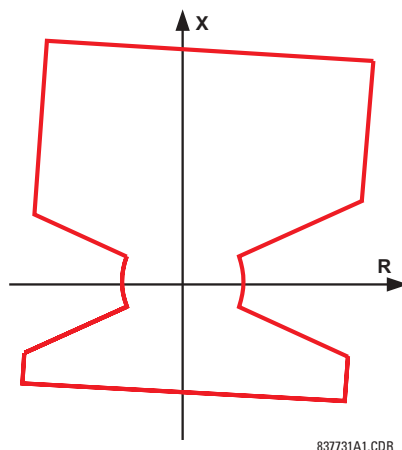


Figure 5-39: LOAD ENCROACHMENT APPLIED TO DISTANCE ELEMENT

- **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 X1** ⇒ **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.

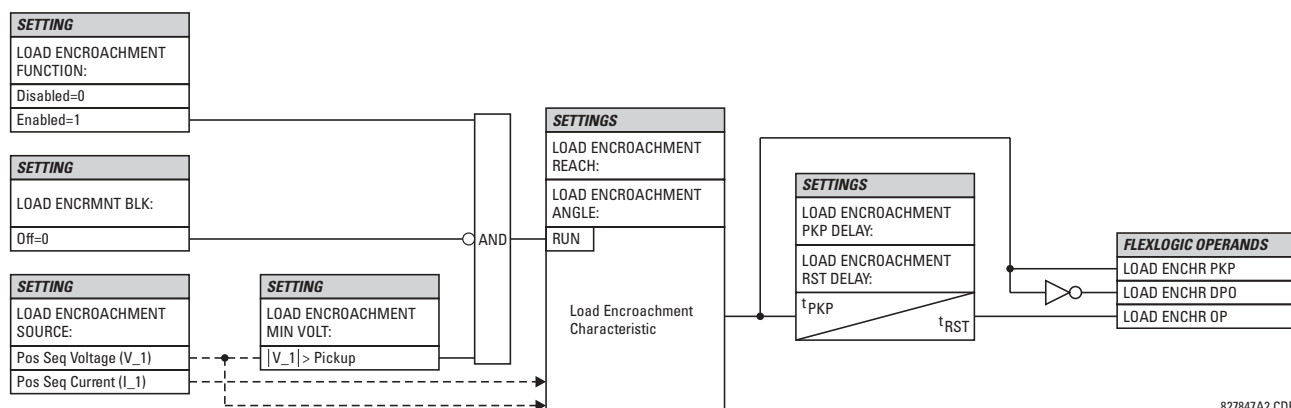


Figure 5-40: LOAD ENCROACHMENT SCHEME LOGIC

827847A2.CDR

5.5.4 PHASE CURRENT

a) MAIN MENU

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

■ PHASE CURRENT	◀▶	■ PHASE TOC1	See page 5-78.
MESSAGE	▲▼	■ PHASE TOC2	See page 5-78.
MESSAGE	▲▼	■ PHASE IOC1	See page 5-80.
MESSAGE	▲▼	■ PHASE IOC2	See page 5-80.
MESSAGE	▲▼	■ PHASE ■ DIRECTIONAL 1	See page 5-81.
MESSAGE	▲	■ PHASE ■ DIRECTIONAL 2	See page 5-81.

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

b) INVERSE TOC CHARACTERISTICS

The inverse time overcurrent curves used by the TOC (time overcurrent) Current 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 5-9: 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. With this setting, the energy capacity variable is decremented according to the equation provided.



NOTE

Graphs of standard time-current curves on 11" × 17" log-log graph paper are available upon request from the GE Multilin literature department. The original files are also available in PDF format on the UR Software Installation CD and the GE Multilin website at <http://www.GEindustrial.com/multilin>.

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:

$$T = TDM \times \left[\frac{A}{\left(\frac{I}{I_{pickup}} \right)^p - 1} + B \right], \quad T_{RESET} = TDM \times \left[\frac{t_r}{\left(\frac{I}{I_{pickup}} \right)^2 - 1} \right] \quad (\text{EQ 5.2})$$

where: T = operate time (in seconds), TDM = Multiplier setting, I = input current, I_{pickup} = Pickup Current setting
 A, B, p = constants, T_{RESET} = reset time in seconds (assuming energy capacity is 100% and RESET is "Timed"),
 t_r = characteristic constant

Table 5–10: IEEE INVERSE TIME CURVE CONSTANTS

IEEE CURVE SHAPE	A	B	P	T _R
IEEE Extremely Inverse	28.2	0.1217	2.0000	29.1
IEEE Very Inverse	19.61	0.491	2.0000	21.6
IEEE Moderately Inverse	0.0515	0.1140	0.02000	4.85

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

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

IEC CURVES

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

$$T = TDM \times \left[\frac{K}{(I/I_{pickup})^E - 1} \right], T_{RESET} = TDM \times \left[\frac{t_r}{(I/I_{pickup})^2 - 1} \right] \quad (\text{EQ 5.3})$$

where: T = operate time (in seconds), TDM = Multiplier setting, I = input current, I_{pickup} = Pickup Current setting, K , E = constants, t_r = characteristic constant, and T_{RESET} = reset time in seconds (assuming energy capacity is 100% and RESET is "Timed")

Table 5-12: IEC (BS) INVERSE TIME CURVE CONSTANTS

IEC (BS) CURVE SHAPE	K	E	T _R
IEC Curve A (BS142)	0.140	0.020	9.7
IEC Curve B (BS142)	13.500	1.000	43.2
IEC Curve C (BS142)	80.000	2.000	58.2
IEC Short Inverse	0.050	0.040	0.500

Table 5-13: IEC CURVE TRIP TIMES (IN SECONDS)

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

IAC CURVES:

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

$$T = TDM \times \left(A + \frac{B}{(I/I_{pkp}) - C} + \frac{D}{((I/I_{pkp}) - C)^2} + \frac{E}{((I/I_{pkp}) - C)^3} \right), T_{RESET} = TDM \times \left[\frac{t_r}{(I/I_{pkp})^2 - 1} \right] \quad (\text{EQ 5.4})$$

where: T = operate time (in seconds), TDM = Multiplier setting, I = Input current, I_{pkp} = Pickup Current setting, A to E = constants, t_r = characteristic constant, and T_{RESET} = reset time in seconds (assuming energy capacity is 100% and RESET is "Timed")

Table 5-14: GE TYPE IAC INVERSE TIME CURVE CONSTANTS

IAC CURVE SHAPE	A	B	C	D	E	T _R
IAC Extreme Inverse	0.0040	0.6379	0.6200	1.7872	0.2461	6.008
IAC Very Inverse	0.0900	0.7955	0.1000	-1.2885	7.9586	4.678
IAC Inverse	0.2078	0.8630	0.8000	-0.4180	0.1947	0.990
IAC Short Inverse	0.0428	0.0609	0.6200	-0.0010	0.0221	0.222

Table 5-15: IAC CURVE TRIP TIMES

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

I²t CURVES:

The curves for the I²t are derived from the formulae:

$$T = \text{TDM} \times \left[\frac{100}{\left(\frac{I}{I_{pickup}} \right)^2} \right], T_{RESET} = \text{TDM} \times \left[\frac{100}{\left(\frac{I}{I_{pickup}} \right)^{-2}} \right] \quad (\text{EQ 5.5})$$

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

Table 5–16: I²T CURVE TRIP TIMES

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

FLEXCURVES™:

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

$$T = \text{TDM} \times \left[\text{FlexCurve Time at } \left(\frac{I}{I_{pickup}} \right) \right] \quad \text{when } \left(\frac{I}{I_{pickup}} \right) \geq 1.00 \quad (\text{EQ 5.6})$$

$$T_{RESET} = \text{TDM} \times \left[\text{FlexCurve Time at } \left(\frac{I}{I_{pickup}} \right) \right] \quad \text{when } \left(\frac{I}{I_{pickup}} \right) \leq 0.98 \quad (\text{EQ 5.7})$$

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

DEFINITE TIME CURVE:

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

$$T = \text{TDM} \text{ in seconds, when } I > I_{pickup} \quad (\text{EQ 5.8})$$

$$T_{RESET} = -\text{TDM} \text{ in seconds} \quad (\text{EQ 5.9})$$

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 TOC1(2) (PHASE TIME OVERCURRENT: ANSI 51P)

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

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

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.

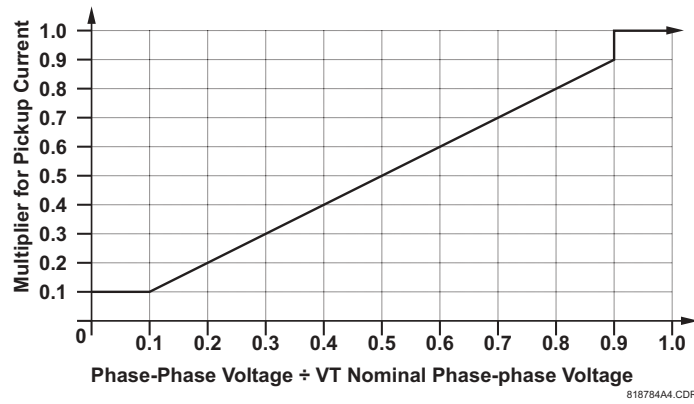


Figure 5-41: PHASE TOC VOLTAGE RESTRAINT CHARACTERISTIC

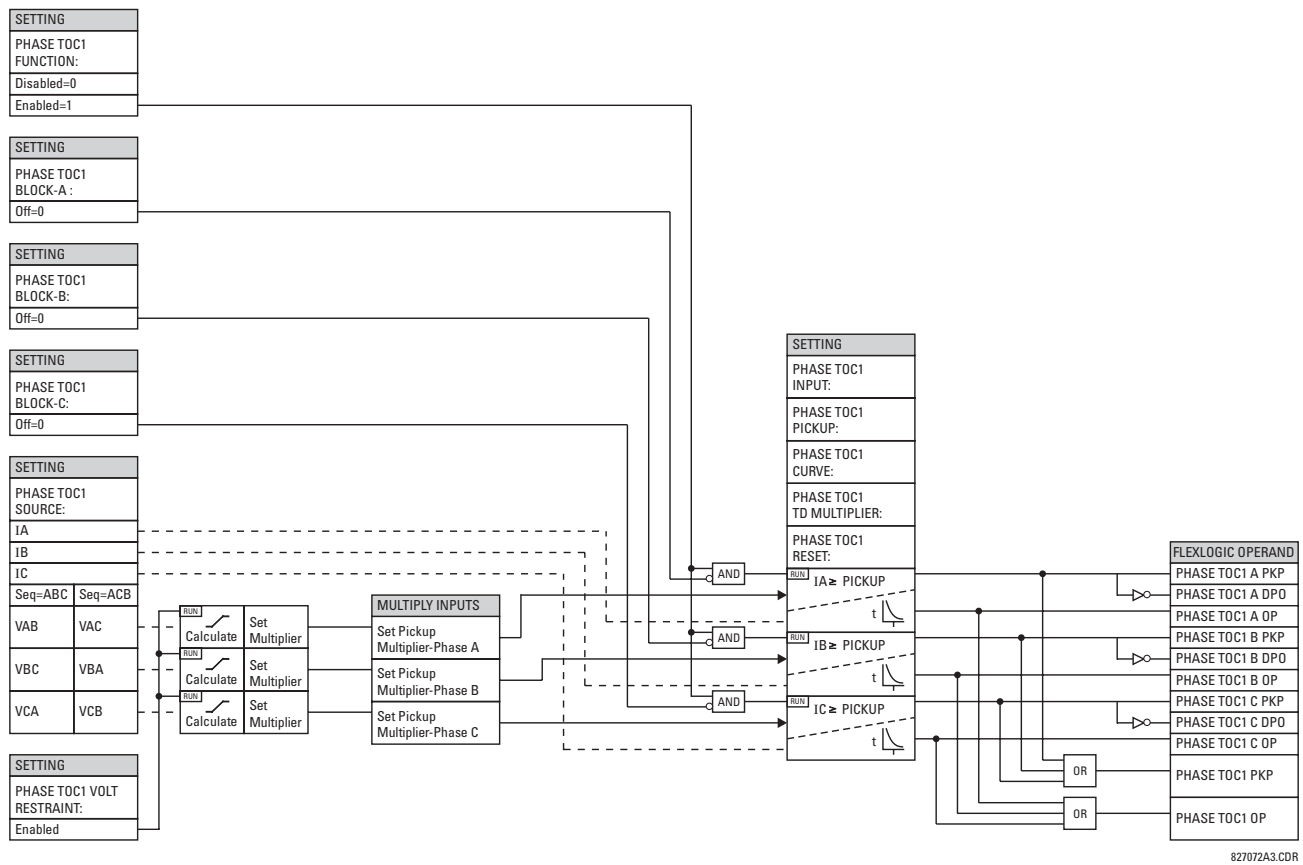


Figure 5-42: PHASE TOC1 SCHEME LOGIC

d) PHASE IOC1(2) (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 in steps of 0.01
MESSAGE		PHASE IOC1 RESET DELAY: 0.00 s	Range: 0.00 to 600.00 in steps of 0.01
MESSAGE		PHASE IOC1 BLOCK A: Off	Range: FlexLogic™ operand
MESSAGE		PHASE IOC1 BLOCK B: Off	Range: FlexLogic™ operand
MESSAGE		PHASE IOC1 BLOCK C: Off	Range: FlexLogic™ operand
MESSAGE		PHASE IOC1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE		PHASE IOC1 EVENTS: Disabled	Range: Disabled, Enabled

The phase instantaneous overcurrent element may be used as an instantaneous element with no intentional delay or as a Definite Time element. The input current is the fundamental phasor magnitude.

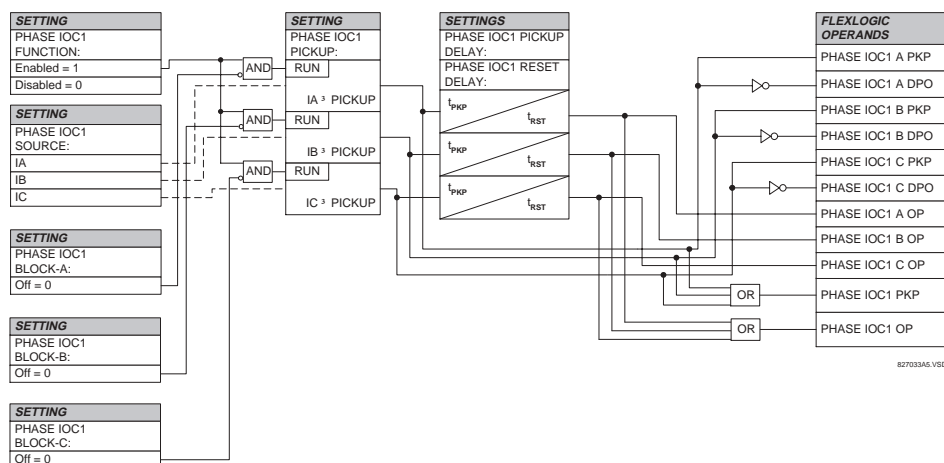


Figure 5-43: PHASE IOC1 SCHEME LOGIC

e) PHASE DIRECTIONAL 1(2) (PHASE DIRECTIONAL OVERCURRENT: ANSI 67P)

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

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

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.

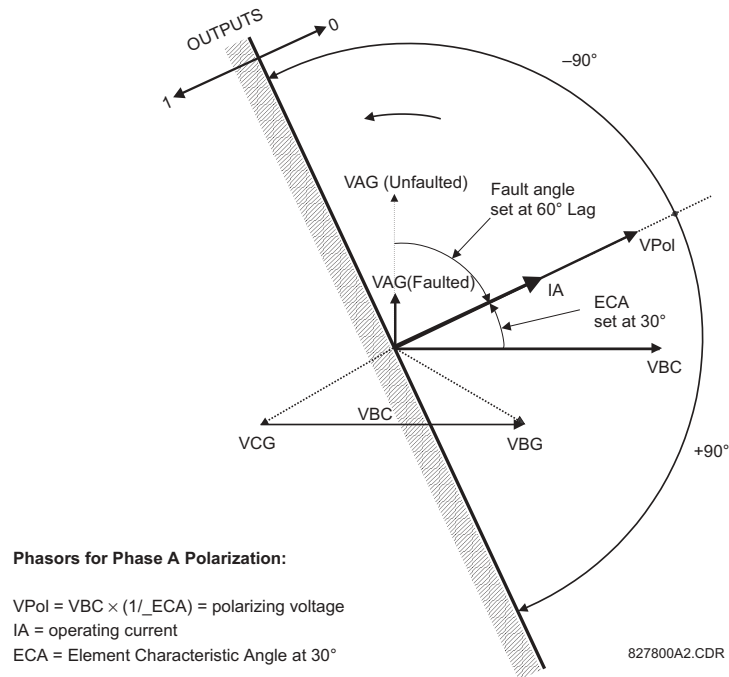


Figure 5-44: PHASE A DIRECTIONAL POLARIZATION

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 $\times (1\angle ECA)$	Angle of VCB $\times (1\angle ECA)$
B	Angle of IB	Angle of VCA $\times (1\angle ECA)$	Angle of VAC $\times 1\angle ECA)$
C	Angle of IC	Angle of VAB $\times (1\angle ECA)$	Angle of VBA $\times (1\angle ECA)$

MODE OF OPERATION:

- When the function is "Disabled", or the operating current is below $5\% \times CT$ Nominal, the element output is "0".
- When the function is "Enabled", the operating current is above $5\% \times CT$ 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 $\pm 90^\circ$.
 - 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 set to "No", the directional element allows tripping of Phase OC 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 UR 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 "0.05 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.



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 msec – 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 msec 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 msec – may be needed.

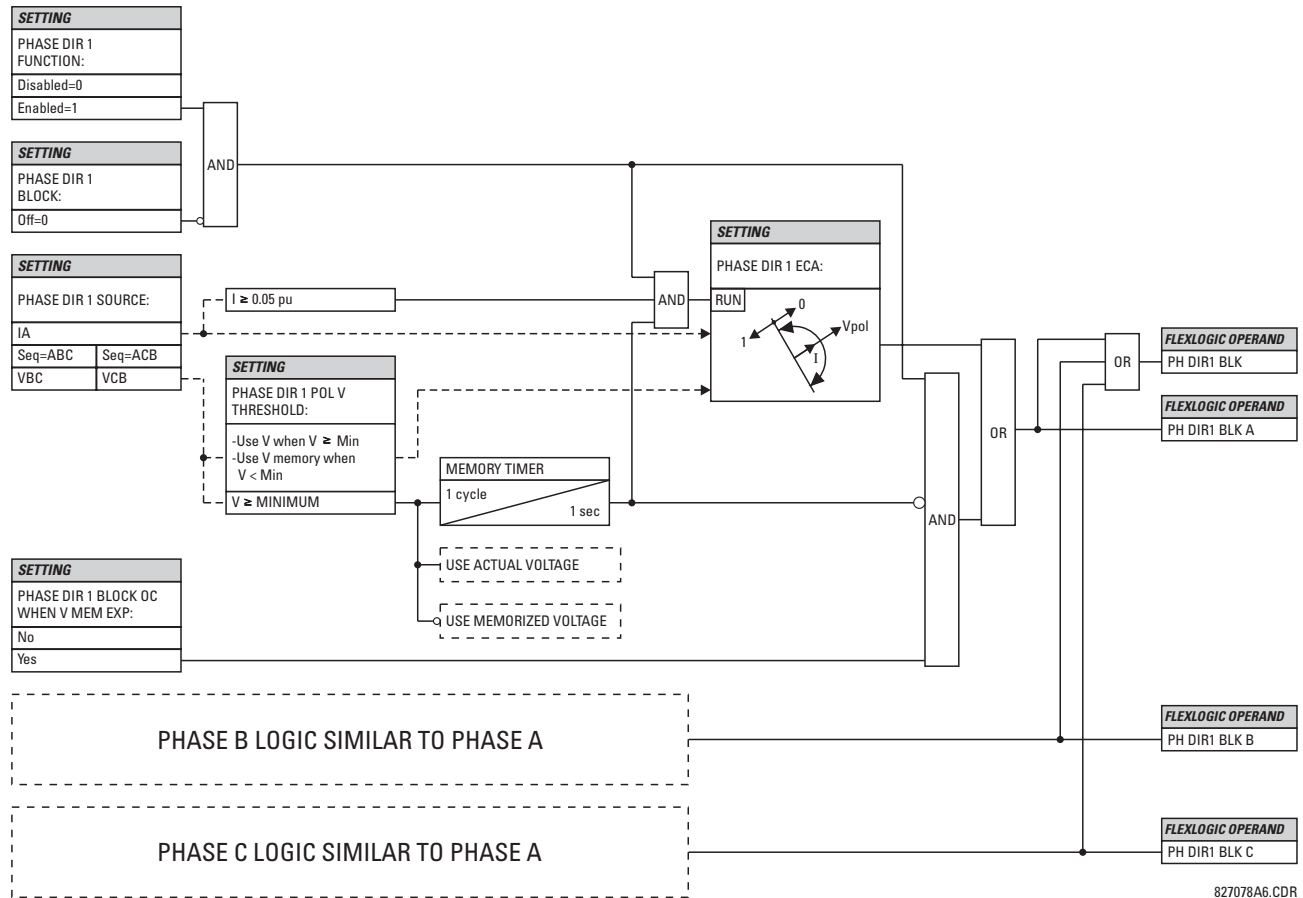
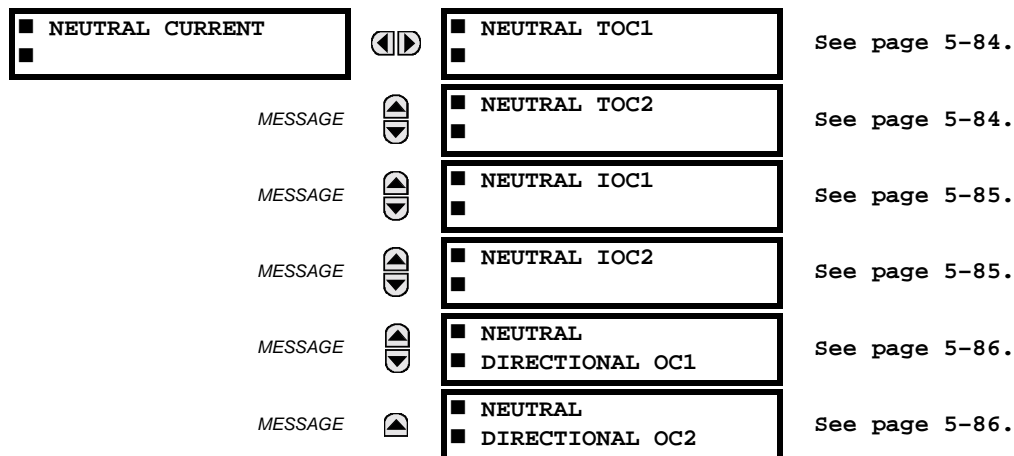


Figure 5–45: PHASE DIRECTIONAL SCHEME LOGIC

5.5.5 NEUTRAL CURRENT

a) MAIN MENU

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



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 TOC1(2) (NEUTRAL TIME OVERCURRENT: ANSI 51N)

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

■ 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 $3I_0$ from the phase currents and may be programmed as fundamental phasor magnitude or total waveform RMS magnitude as required by the application.

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

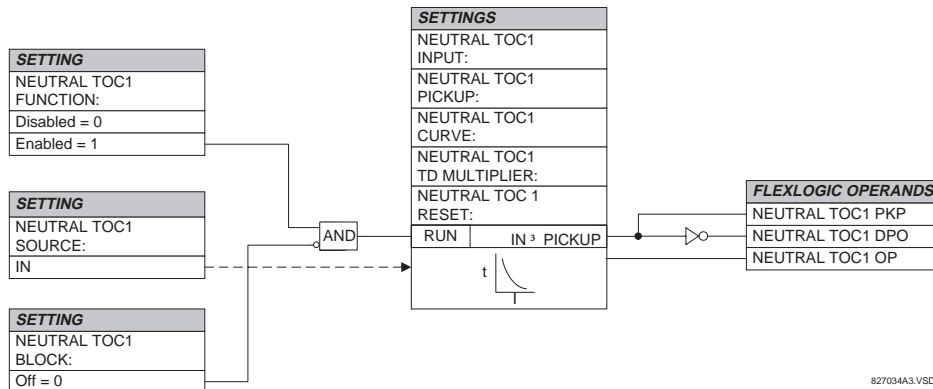


Figure 5-46: NEUTRAL TOC1 SCHEME LOGIC



Once picked up, the NEUTRAL TOCx PKP output operand remains picked up until the thermal memory of the element resets completely. The PKP operand will not reset immediately after the operating current drops below the pickup threshold unless NEUTRL TOCx RESET is set to "Instantaneous".

c) NEUTRAL IOC1(2) (NEUTRAL INSTANTANEOUS OVERCURRENT: ANSI 50N)

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

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

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

$$I_{op} = 3 \times (|I_0| - K \cdot |I_1|) \quad \text{where } K = 1/16 \quad (\text{EQ 5.10})$$

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

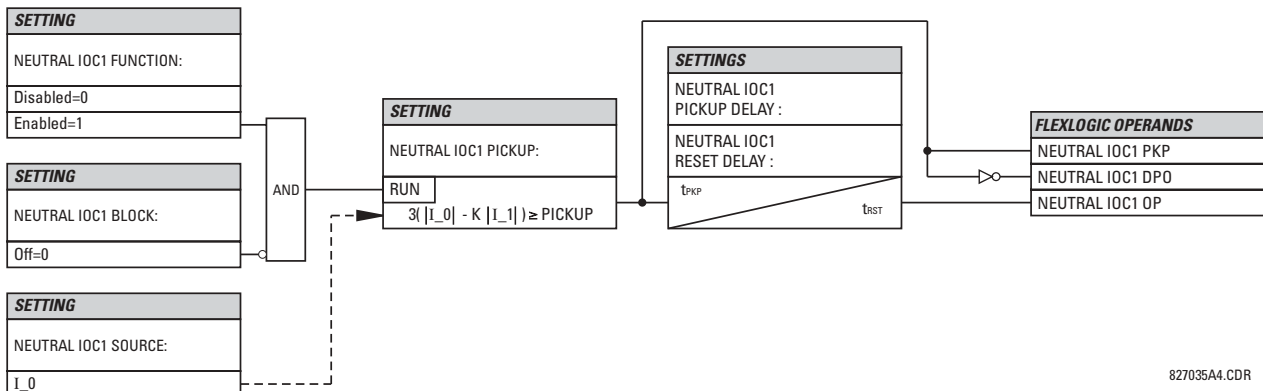


Figure 5-47: NEUTRAL IOC1 SCHEME LOGIC

d) NEUTRAL DIRECTIONAL OC1(2) (NEUTRAL DIRECTIONAL OVERCURRENT: ANSI 67N)

PATH: SETTINGS ⇒ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ NEUTRAL CURRENT ⇒ NEUTRAL DIRECTIONAL OC1

■ 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 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 3I₀, the element applies a “positive-sequence restraint” 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.

$$I_{op} = 3 \times (|I_0| - K \times |I_1|) \quad \text{where } K = 1/16 \quad (\text{EQ 5.11})$$

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: $I_{op} = 0.9375 \times I_{injected}$; 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 5–17: QUANTITIES FOR "CALCULATED V0" CONFIGURATION

DIRECTIONAL UNIT				OVERCURRENT UNIT
POLARIZING MODE	DIRECTION	COMPARED PHASORS		
Voltage	Forward	$-V_0 + Z_offset \times I_0$	$I_0 \times 1\angle ECA$	$I_{op} = 3 \times (I_0 - K \times I_1)$ if $ I_1 > 0.8$ pu $I_{op} = 3 \times (I_0)$ if $ I_1 \leq 0.8$ pu
	Reverse	$-V_0 + Z_offset \times I_0$	$-I_0 \times 1\angle ECA$	
Current	Forward	IG	I_0	
	Reverse	IG	$-I_0$	
Dual	Forward	$-V_0 + Z_offset \times I_0$	$I_0 \times 1\angle ECA$	
		or		
		IG	I_0	
	Reverse	$-V_0 + Z_offset \times I_0$	$-I_0 \times 1\angle ECA$	
		or		
		IG	$-I_0$	

Table 5–18: QUANTITIES FOR "MEASURED IG" CONFIGURATION

DIRECTIONAL UNIT				OVERCURRENT UNIT
POLARIZING MODE	DIRECTION	COMPARED PHASORS		
Voltage	Forward	$-V_0 + Z_offset \times IG/3$	$IG \times 1 \angle ECA$	$I_{op} = IG $
	Reverse	$-V_0 + Z_offset \times IG/3$	$-IG \times 1 \angle ECA$	

where: $V_0 = \frac{1}{3}(V_{AG} + V_{BG} + V_{CG})$ = zero sequence voltage ,

$I_0 = \frac{1}{3}I_N = \frac{1}{3}(I_A + I_B + I_C)$ = 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 \pm angular limit with the ECA for operation)

REV LA = 80° (Reverse Limit Angle = the \pm 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.

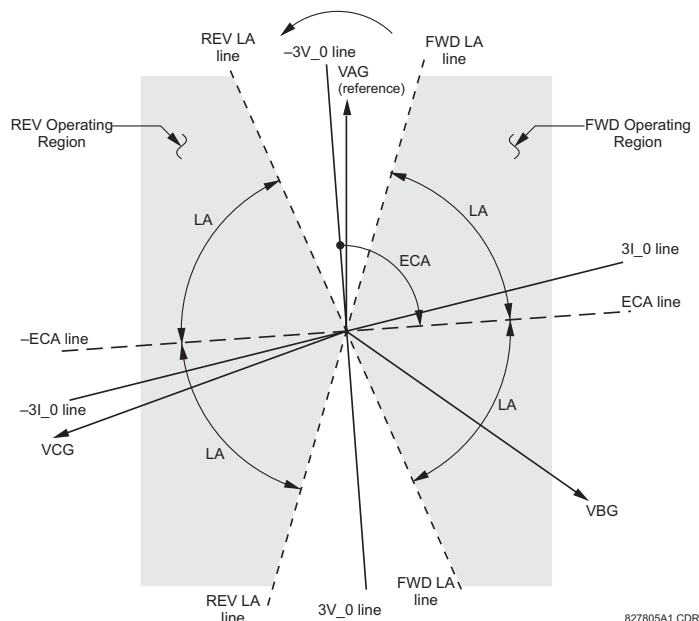


Figure 5-48: NEUTRAL DIRECTIONAL VOLTAGE-POLARIZED CHARACTERISTICS

- 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 V_x , both from the **NEUTRAL DIR OC1 SOURCE**.

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

The zero-sequence (V_0) or auxiliary voltage (V_x), accordingly, must be higher than 1 V secondary to be validated for use as a polarizing signal. If the polarizing signal is invalid, neither forward nor reverse indication is given.
 - If “Current” polarizing is selected, the element uses the ground current angle connected externally and configured under **NEUTRAL OC1 SOURCE** for polarization. The Ground CT must be connected between the ground and neutral point of an adequate local source of ground current. The ground current must be 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 V_0 ”) or supplied externally as an auxiliary voltage (“Measured V_X ”).
 - **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 $3I_0$ ” 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**. Naturally, it is not possible to use the ground current as an operating

and polarizing signal simultaneously. Therefore, "Voltage" is the only applicable selection for the polarizing mode under the "Measured IG" selection of this setting.

- **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. See the Chapter 9 for information on how to calculate this setting. 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. See Chapter 8 for additional details. 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.

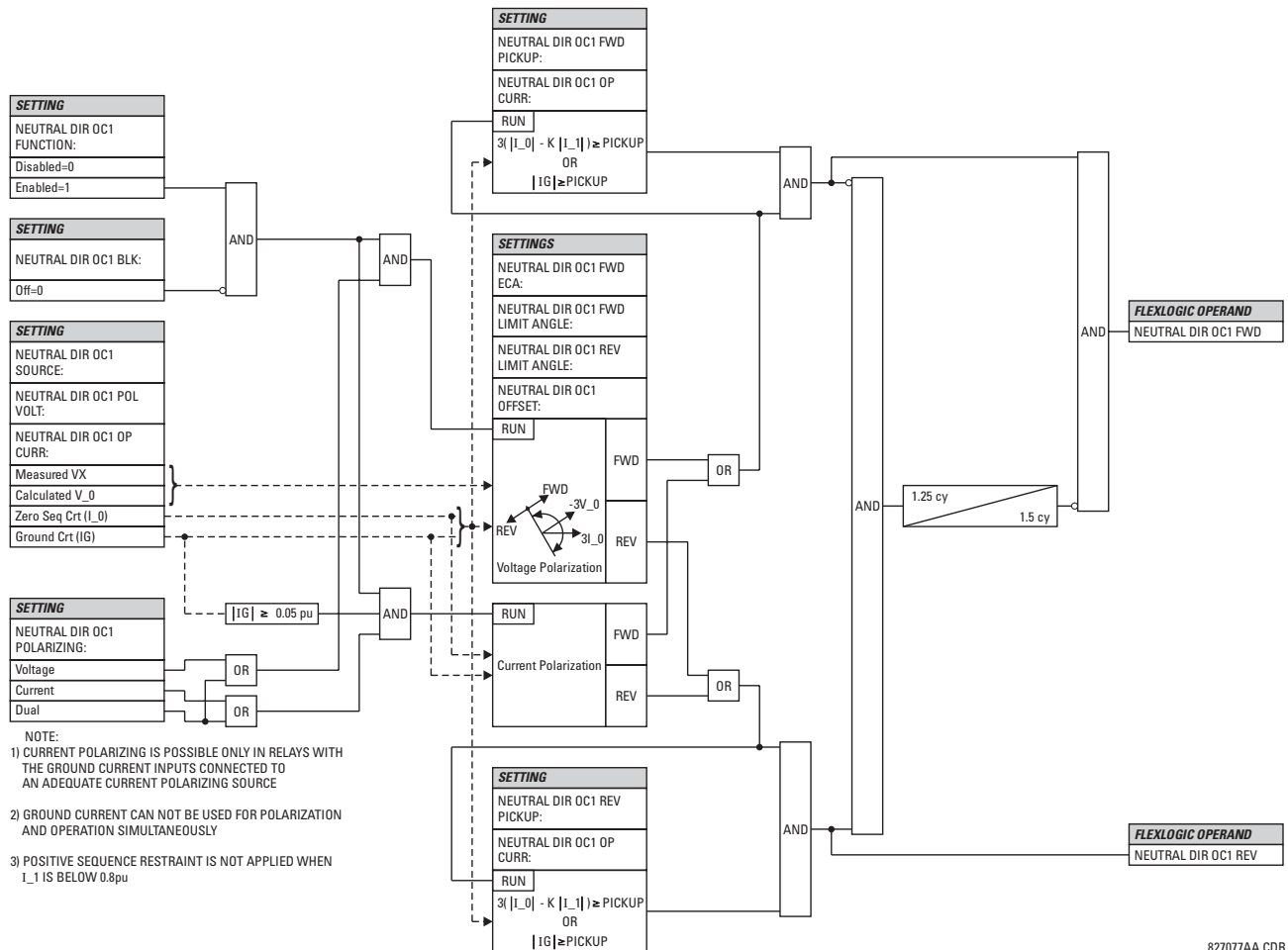


Figure 5-49: NEUTRAL DIRECTIONAL OC1 SCHEME LOGIC

5.5.6 GROUND CURRENT

a) GROUND TOC1(2) (GROUND TIME OVERCURRENT: ANSI 51G)

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

■ 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 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 TOC 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.



NOTE

Once picked up, the GROUND TOCx PKP output operand remains picked up until the thermal memory of the element resets completely. The PKP operand will not reset immediately after the operating current drops below the pickup threshold unless GROUND TOCx RESET is set to "Instantaneous".

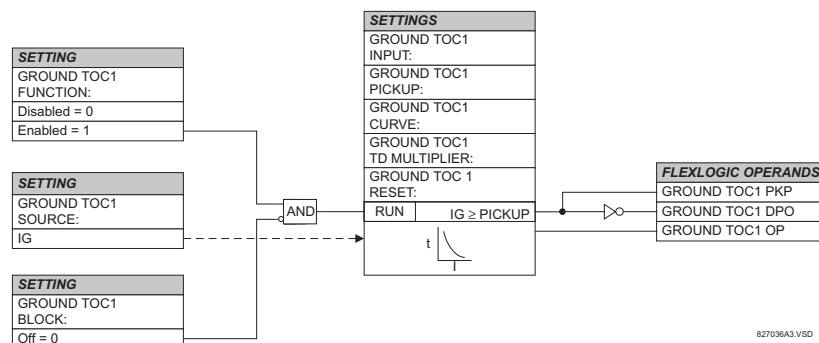


Figure 5-50: GROUND TOC1 SCHEME LOGIC

b) GROUND IOC1(2) (GROUND INSTANTANEOUS OVERCURRENT: ANSI 50G)

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

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

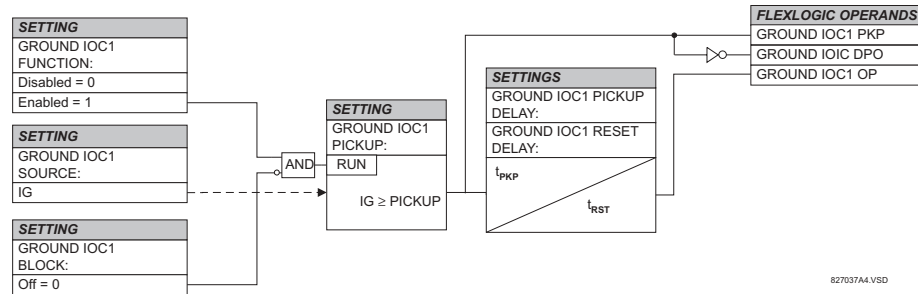


Figure 5-51: GROUND IOC1 SCHEME LOGIC



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

<div> <div>■ NEGATIVE SEQUENCE</div> <div>■ CURRENT</div> </div>		⏪ ⏩	<div>■ NEG SEQ TOC1</div> <div>■</div>	See page 5-93.
	MESSAGE	⬆ ⬇ ⬆	<div>■ NEG SEQ TOC2</div> <div>■</div>	See page 5-93.
	MESSAGE	⬆ ⬇ ⬆	<div>■ NEG SEQ IOC1</div> <div>■</div>	See page 5-94.
	MESSAGE	⬆ ⬇ ⬆	<div>■ NEG SEQ IOC2</div> <div>■</div>	See page 5-94.
	MESSAGE	⬆ ⬇ ⬆	<div>■ NEG SEQ DIR OC2</div> <div>■</div>	See page 5-95.
	MESSAGE	⬆ ⬇ ⬆	<div>■ NEG SEQ DIR OC2</div> <div>■</div>	See page 5-95.

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) NEG SEQ TOC1(2) (NEGATIVE SEQUENCE TIME OVERCURRENT: ANSI 51_2)

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

■ 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 TOC 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.



Once picked up, the NEG SEQ TOCx PKP output operand remains picked up until the thermal memory of the element resets completely. The PKP operand will not reset immediately after the operating current drops below the pickup threshold unless NEG SEQ TOCx RESET is set to "Instantaneous".

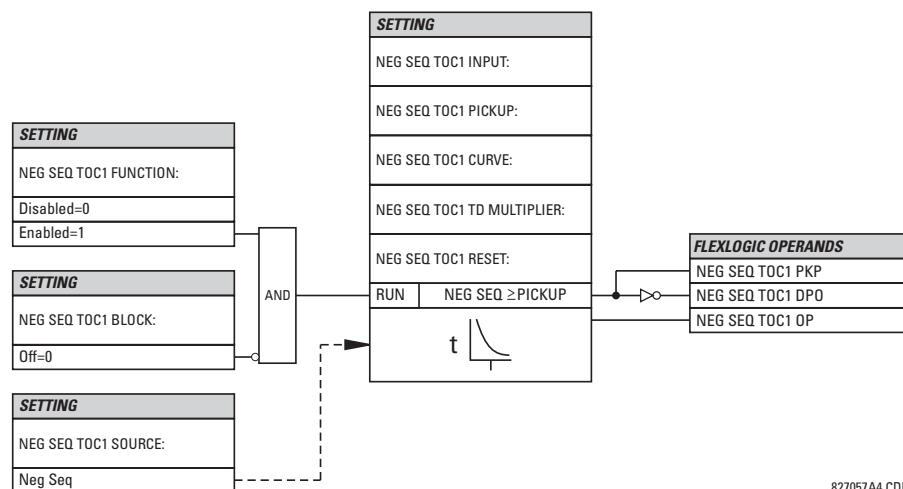


Figure 5-52: NEGATIVE SEQUENCE TOC1 SCHEME LOGIC

c) NEG SEQ IOC1(2) (NEGATIVE SEQUENCE INSTANTANEOUS O/C: ANSI 50_2)

PATH: SETTINGS ↓ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ ↓ NEGATIVE SEQUENCE CURRENT ⇒ ↓ NEG SEQ OC1

■ 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

5

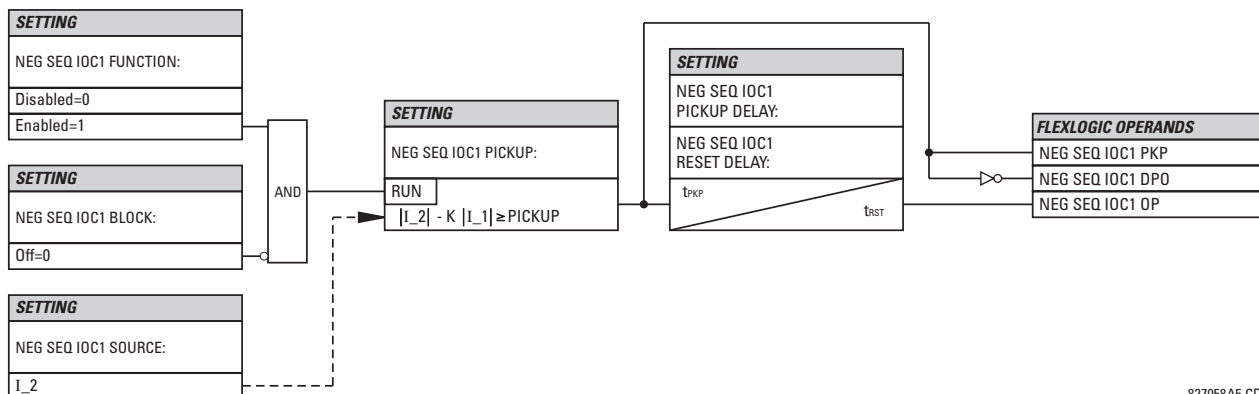
The Negative Sequence Instantaneous Overcurrent element may be used as an instantaneous function with no intentional delay or as a Definite Time function. The element responds to the negative-sequence current fundamental frequency phasor magnitude (calculated from the phase currents) and applies a “positive-sequence” 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:

$$I_{op} = |I_2| - K \cdot |I_1| \quad \text{where } K = 1/8 \quad (\text{EQ 5.12})$$

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: $I_{op} = I_{injected}$).



827058A5.CDR

Figure 5-53: NEGATIVE SEQUENCE IOC1 SCHEME LOGIC

d) NEG SEQ DIR OC1(2) (NEGATIVE SEQUENCE DIRECTIONAL O/C: ANSI 67_2)

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

<div> <div>■</div> <div>NEG SEQ DIR OC1</div> </div>		<div> <div>◀▶</div> <div>NEG SEQ DIR OC1</div> <div>FUNCTION: Disabled</div> </div>	Range: Disabled, Enabled
MESSAGE	<div> <div>▲▼</div> <div>NEG SEQ DIR OC1</div> <div>SOURCE: SRC 1</div> </div>		Range: SRC 1, SRC 2
MESSAGE	<div> <div>▲▼</div> <div>NEG SEQ DIR OC1</div> <div>OFFSET: 0.00 Ω</div> </div>		Range: 0.00 to 250.00 Ω in steps of 0.01
MESSAGE	<div> <div>▲▼</div> <div>NEG SEQ DIR OC1</div> <div>TYPE: Neg Sequence</div> </div>		Range: Neg Sequence, Zero Sequence
MESSAGE	<div> <div>▲▼</div> <div>NEG SEQ DIR OC1 FWD</div> <div>ECA: 75° Lag</div> </div>		Range: 0 to 90° Lag in steps of 1
MESSAGE	<div> <div>▲▼</div> <div>NEG SEQ DIR OC1 FWD</div> <div>LIMIT ANGLE: 90°</div> </div>		Range: 40 to 90° in steps of 1
MESSAGE	<div> <div>▲▼</div> <div>NEG SEQ DIR OC1 FWD</div> <div>PICKUP: 0.05 pu</div> </div>		Range: 0.05 to 30.00 pu in steps of 0.01
MESSAGE	<div> <div>▲▼</div> <div>NEG SEQ DIR OC1 REV</div> <div>LIMIT ANGLE: 90°</div> </div>		Range: 40 to 90° in steps of 1
MESSAGE	<div> <div>▲▼</div> <div>NEG SEQ DIR OC1 REV</div> <div>PICKUP: 0.05 pu</div> </div>		Range: 0.05 to 30.00 pu in steps of 0.01
MESSAGE	<div> <div>▲▼</div> <div>NEG SEQ DIR OC1 BLK:</div> <div>Off</div> </div>		Range: FlexLogic™ operand
MESSAGE	<div> <div>▲▼</div> <div>NEG SEQ DIR OC1</div> <div>TARGET: Self-reset</div> </div>		Range: Self-reset, Latched, Disabled
MESSAGE	<div> <div>▲</div> <div>NEG SEQ DIR OC1</div> <div>EVENTS: Disabled</div> </div>		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 (over-current 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 portion (12.5% for negative-sequence and 6.25% for zero-sequence) of the positive-sequence current magnitude is subtracted from the negative- or zero-sequence current magnitude, respectively, when forming the element operating quantity.

$$I_{op} = |I_{-2}| - K \times |I_{-1}|, \text{ where } K = 1/8 \quad \text{or} \quad I_{op} = |I_{-0}| - K \times |I_{-1}|, \text{ where } K = 1/16 \quad (\text{EQ 5.13})$$

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: $I_{op} = 0.2917 \times I_{injected}$ (negative-sequence mode); $I_{op} = 0.3125 \times I_{injected}$ (zero-sequence mode)

- 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 \times I_{-1} $	Forward	$-V_{-2} + Z_{offset} \times I_{-2}$	$I_{-2} \times 1 \angle ECA$
		Reverse	$-V_{-2} + Z_{offset} \times I_{-2}$	$-(I_{-2} \times 1 \angle ECA)$
Zero-Sequence	$I_{op} = I_{-0} - K \times I_{-1} $	Forward	$-V_{-2} + Z_{offset} \times I_{-2}$	$I_{-2} \times 1 \angle ECA$
		Reverse	$-V_{-2} + Z_{offset} \times I_{-2}$	$-(I_{-2} \times 1 \angle ECA)$

The negative-sequence voltage must be higher than 1 V secondary in order 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.

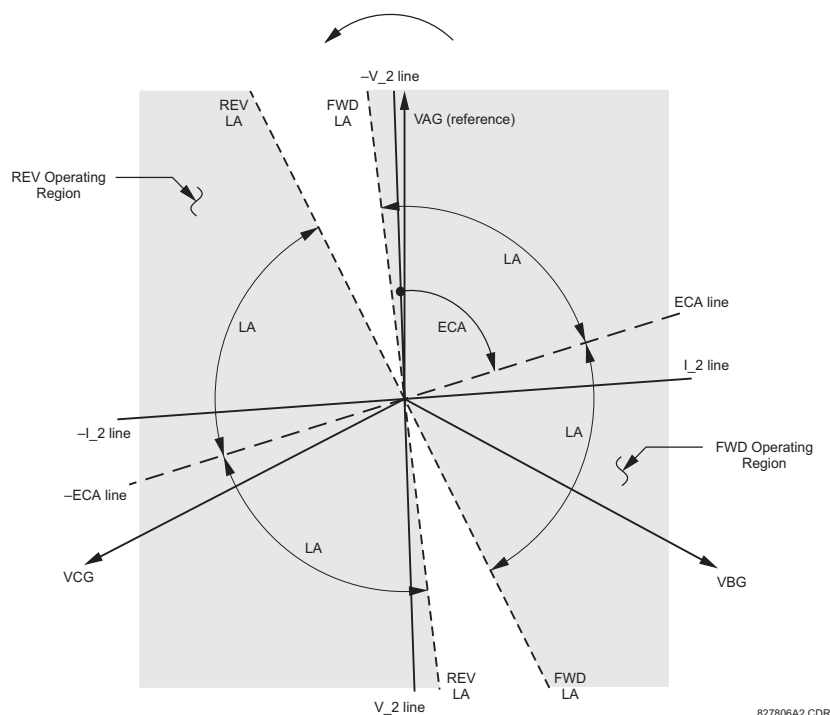


Figure 5-54: NEG SEQ DIRECTIONAL CHARACTERISTICS

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 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 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.

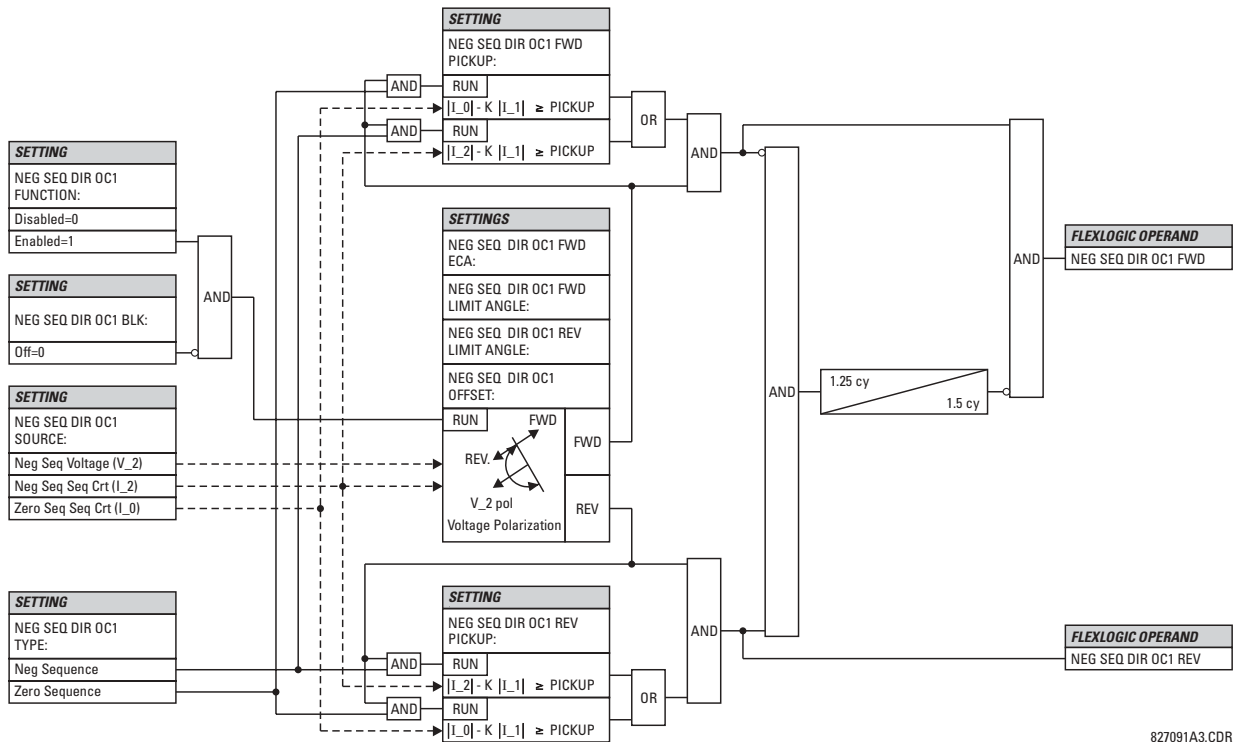












































Figure 5-55: NEG SEQ DIRECTIONAL OC1 SCHEME LOGIC

827091A3.CDR

5.5.8 BREAKER FAILURE

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

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

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

There are 2 identical Breaker Failure menus available, numbered 1 and 2.

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

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

INITIATION STAGE:

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

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

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

DETERMINATION OF A BREAKER FAILURE CONDITION:

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

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

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

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

Timer 3 logic (Slow Path) is supervised by a breaker auxiliary contact and a control switch contact used to indicate that the breaker is in/out of service, disabling this path when the breaker is out of service for maintenance. There is no current level check in this logic as it is intended to detect low magnitude faults and it is therefore the slowest to operate.

OUTPUT:

The outputs from the schemes are:

- FlexLogic™ operands that report on the operation of portions of the scheme
- FlexLogic™ operand used to re-trip the protected breaker
- FlexLogic™ operands that initiate tripping required to clear the faulted zone. The trip output can be sealed-in for an adjustable period.
- Target message indicating a failed breaker has been declared
- Illumination of the faceplate Trip LED (and the Phase A, B or C LED, if applicable)

MAIN PATH SEQUENCE:

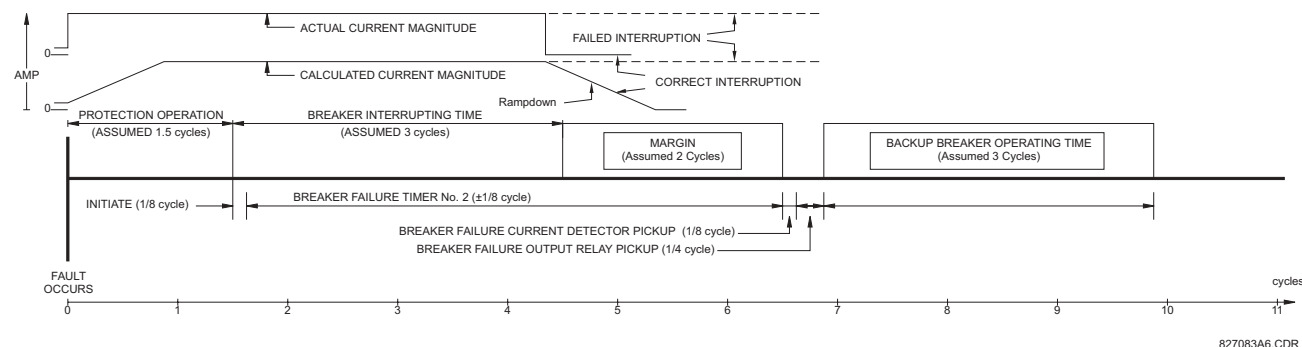


Figure 5-56: BREAKER FAILURE MAIN PATH SEQUENCE

827083A6.CDR

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 ϕ A/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 ϕ A/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 ϕ B / BF1 BKR POS 1 ϕ C:** These settings select the FlexLogic™ operand to represents the protected breaker early-type auxiliary switch contact on poles B or C, accordingly. This contact is normally a non-multiplied Form-A contact. The contact may even be adjusted to have the shortest possible operating time. *This setting is valid only for 1-pole breaker failure schemes.*
- **BF1 BKR POS2 ϕ B:** Selects the FlexLogic™ operand that represents the protected breaker normal-type auxiliary switch contact on pole B (52/a). This may be a multiplied contact. *This setting is valid only for 1-pole breaker failure schemes.*
- **BF1 BKR POS2 ϕ C:** This setting selects the FlexLogic™ operand that represents the protected breaker normal-type auxiliary switch contact on pole C (52/a). This may be a multiplied contact. For single-pole operation, the scheme has the same overall general concept except that it provides re-tripping of each single pole of the protected breaker. The approach shown in the following single pole tripping diagram uses the initiating information to determine which pole is supposed to trip. The logic is segregated on a per-pole basis. The overcurrent detectors have ganged settings. *This setting is valid only for 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 "BF1 TRIP OP".

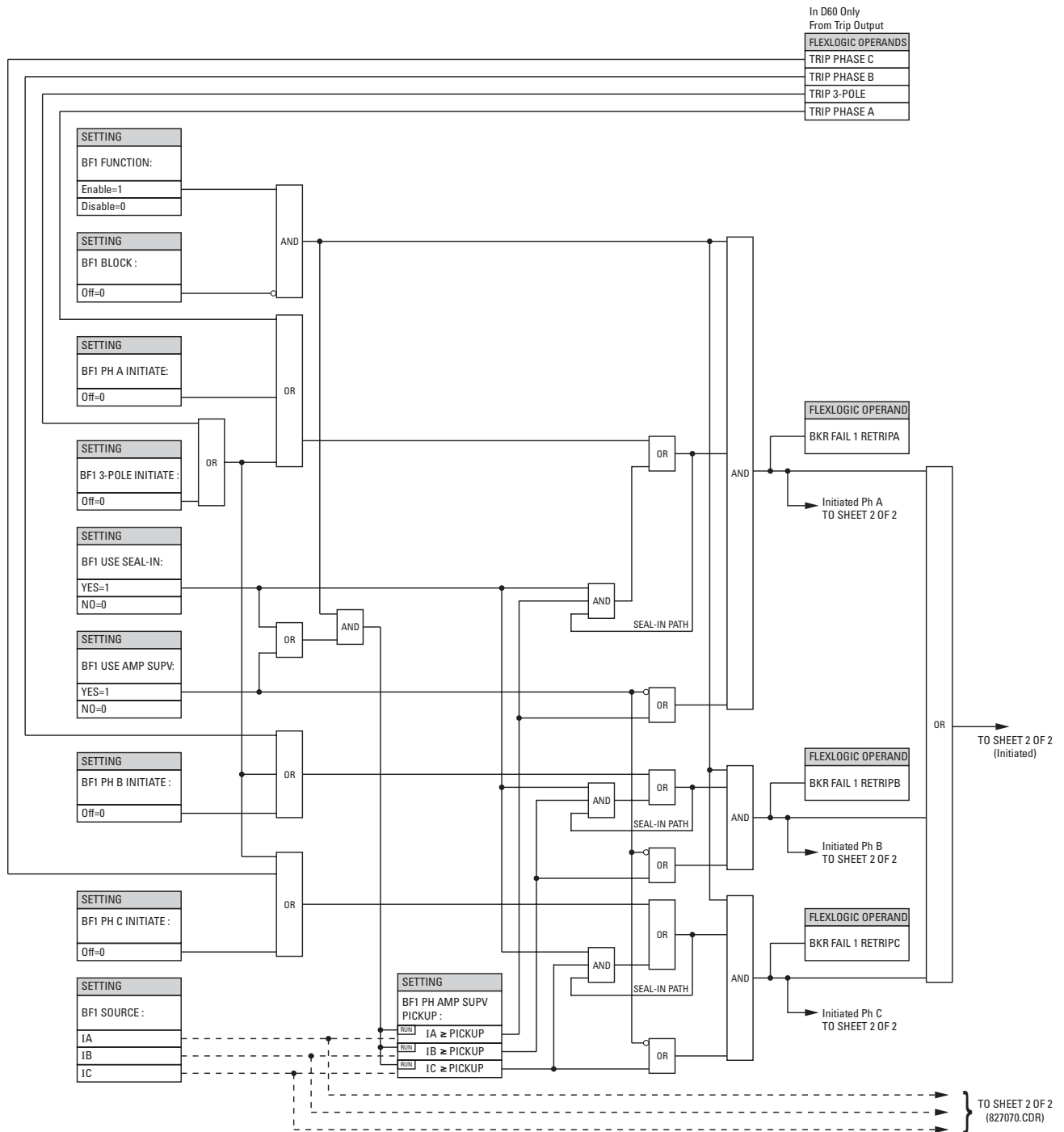
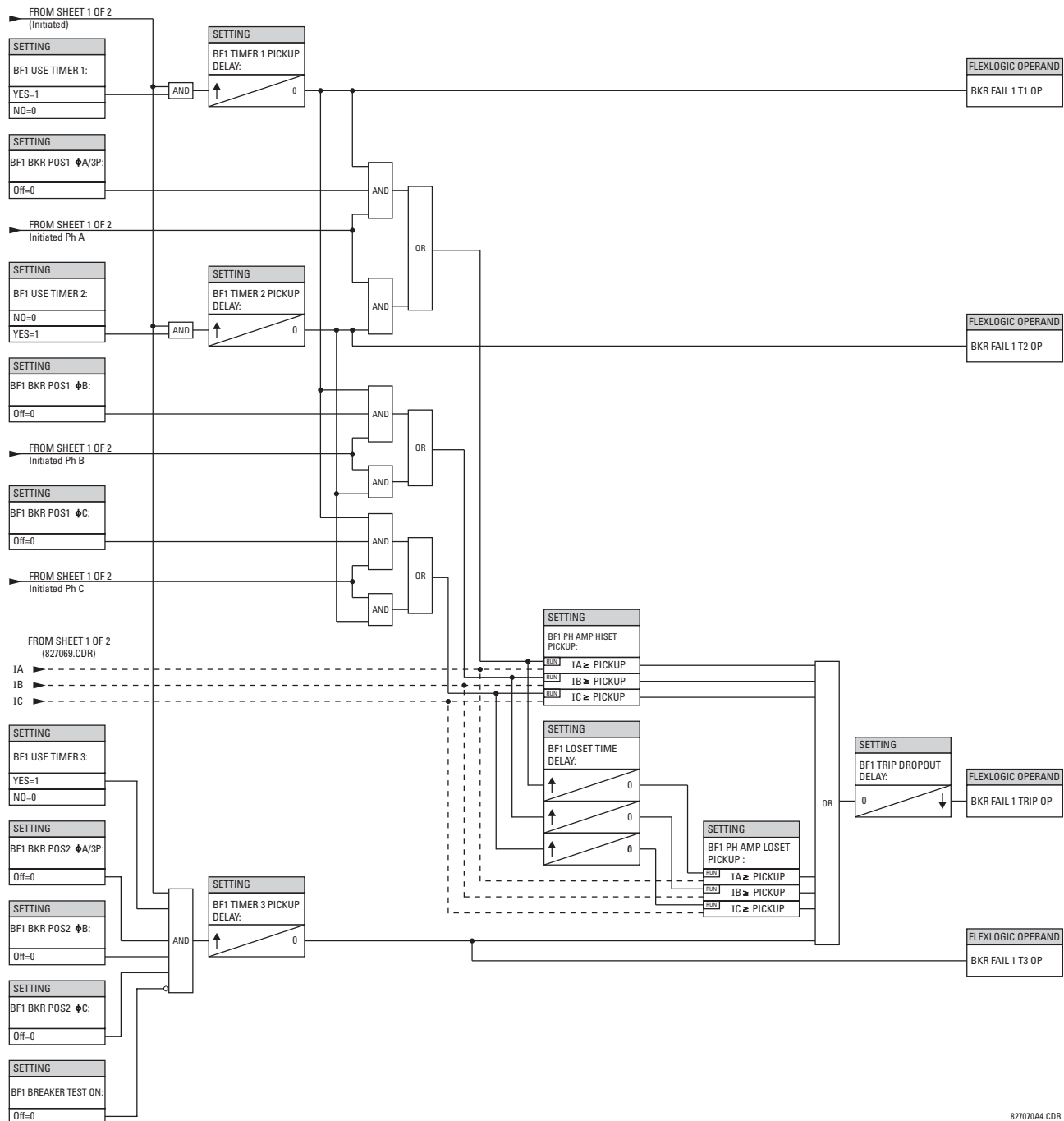


Figure 5–57: BREAKER FAILURE 1-POLE [INITIATE] (Sheet 1 of 2)

5



827070A4.CDR

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

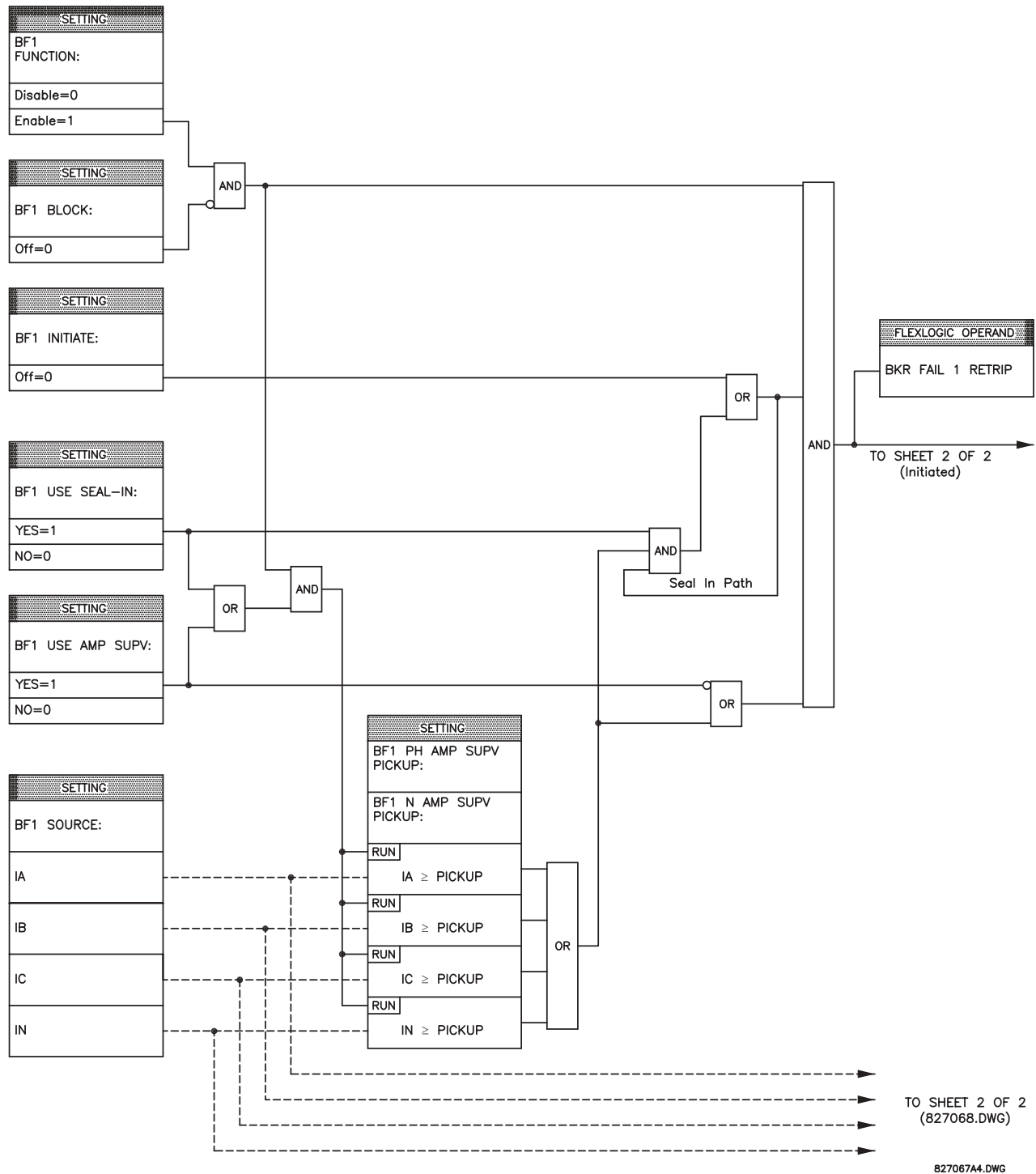


Figure 5–59: BREAKER FAILURE 3-POLE [INITIATE] (Sheet 1 of 2)

5

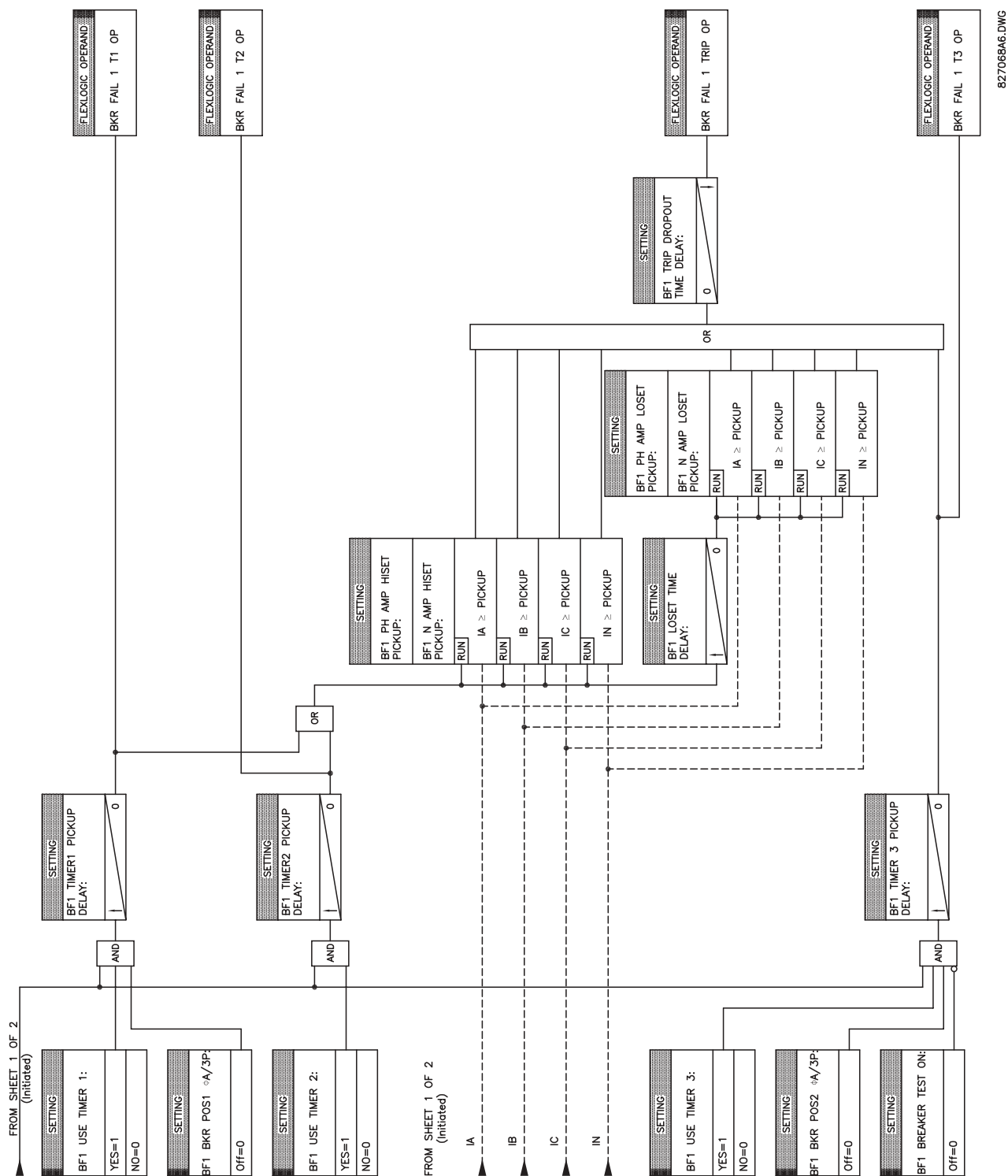


Figure 5–60: BREAKER FAILURE 3-POLE [TIMERS] (Sheet 2 of 2)

5.5.9 VOLTAGE ELEMENTS

a) MAIN MENU

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

■ VOLTAGE ELEMENTS	◀▶	■ PHASE	See page 5-108.
■		■ UNDERVOLTAGE1	
MESSAGE	▲▼	■ PHASE	See page 5-108.
		■ UNDERVOLTAGE2	
MESSAGE	▲▼	■ PHASE	See page 5-109.
		■ OVERVOLTAGE1	
MESSAGE	▲▼	■ NEUTRAL OV1	See page 5-110.
		■	
MESSAGE	▲▼	■ NEG SEQ OV	See page 5-111.
		■	
MESSAGE	▲▼	■ AUXILIARY UV1	See page 5-112.
		■	
MESSAGE	▲	■ AUXILIARY OV1	See page 5-113.
		■	

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



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

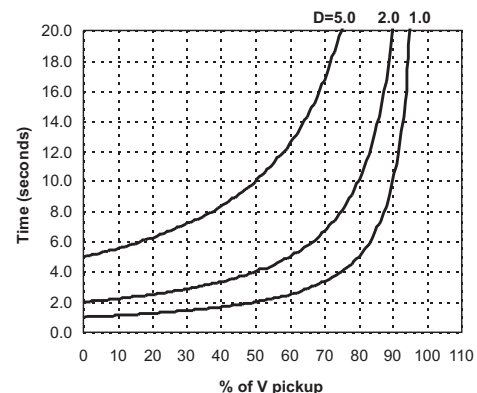


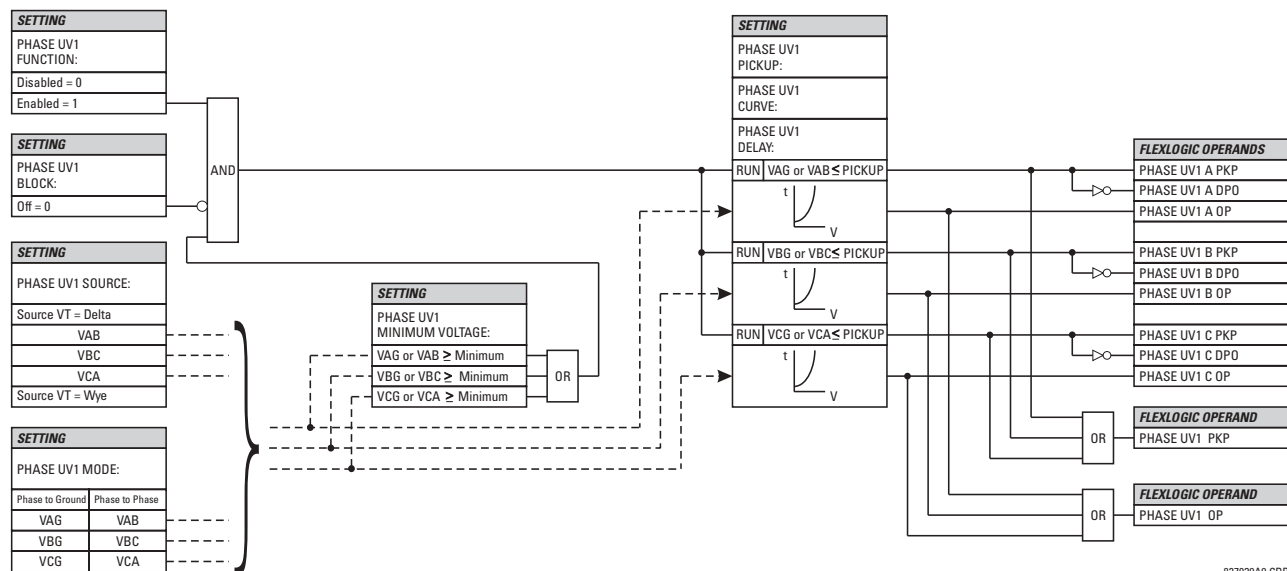
Figure 5-61: INVERSE TIME UNDERVOLTAGE CURVES

b) PHASE UV1(2) (PHASE UNDERVOLTAGE: ANSI 27P)

PATH: SETTINGS ⇒ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ VOLTAGE ELEMENTS ⇒ PHASE UNDERVOLTAGE1

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

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



827039A9.CDR

Figure 5-62: PHASE UNDERVOLTAGE1 SCHEME LOGIC

c) PHASE OVERVOLTAGE1 (PHASE OVERVOLTAGE: ANSI 59P)

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

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

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 on the logic diagram.

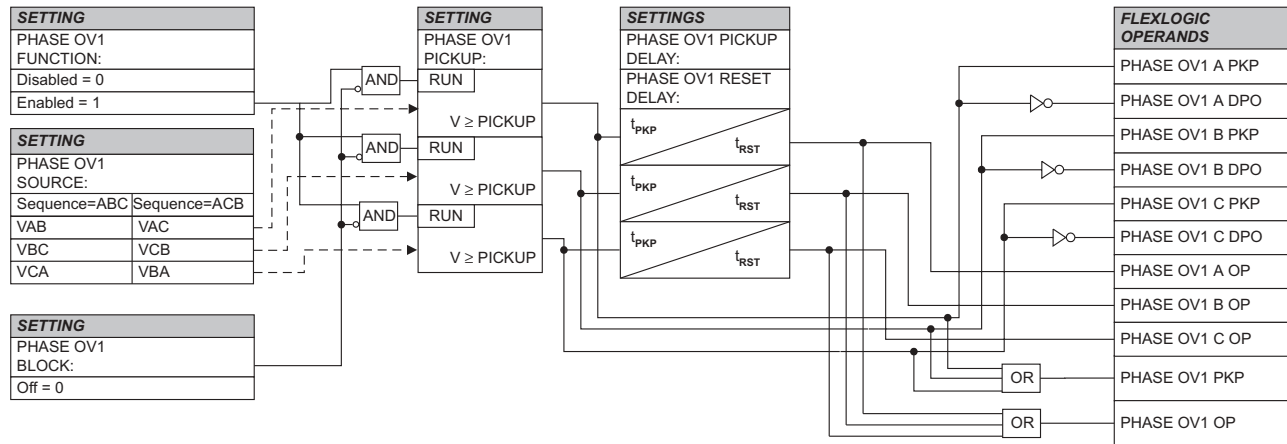


Figure 5-63: PHASE OV SCHEME LOGIC

d) NEUTRAL OV1 (NEUTRAL OVERVOLTAGE: ANSI 59N)

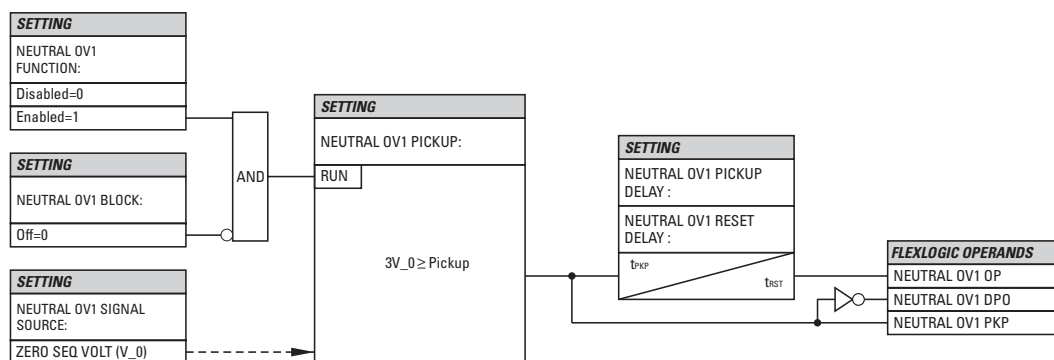
PATH: SETTINGS ⇒ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ VOLTAGE ELEMENTS ⇒ NEUTRAL OV1

<div>■ NEUTRAL OV1</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div>	<div>⏮</div> <div>⏭</div> <div>⏮</div> <div>⏭</div> <div>⏮</div> <div>⏭</div> <div>⏮</div>	NEUTRAL OV1	Range: Disabled, Enabled
		FUNCTION: Disabled	
		NEUTRAL OV1 SIGNAL	Range: SRC 1, SRC 2
		SOURCE: SRC 1	
		NEUTRAL OV1 PICKUP:	Range: 0.000 to 1.250 pu in steps of 0.001
		0.300 pu	
		NEUTRAL OV1 PICKUP:	Range: 0.00 to 600.00 s in steps of 0.01
	<div>⏮</div> <div>⏭</div> <div>⏮</div> <div>⏭</div> <div>⏮</div>	DELAY: 1.00 s	
		NEUTRAL OV1 RESET:	Range: 0.00 to 600.00 s in steps of 0.01
		DELAY: 1.00 s	
		NEUTRAL OV1 BLOCK:	Range: FlexLogic™ operand
		Off	
	<div>⏮</div> <div>⏭</div>	NEUTRAL OV1 TARGET:	Range: Self-reset, Latched, Disabled
		Self-reset	
	<div>⏮</div>	NEUTRAL OV1 EVENTS:	Range: Disabled, Enabled
		Disabled	

5

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

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



827848A1.CDR

Figure 5-64: NEUTRAL OVERVOLTAGE1 SCHEME LOGIC

e) NEG SEQ OV (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.

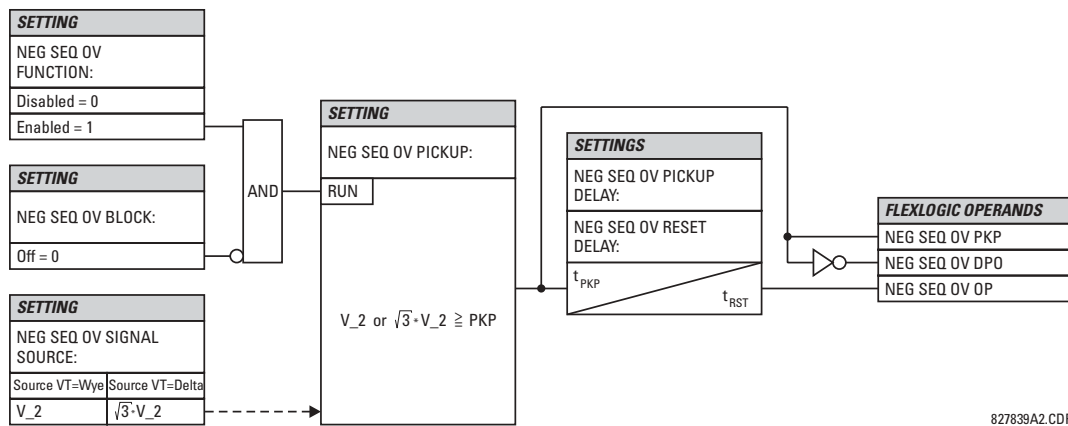


Figure 5-65: NEG SEQ OV SCHEME LOGIC

f) AUXILIARY UV1 (AUXILIARY UNDERVOLTAGE: ANSI 27X)

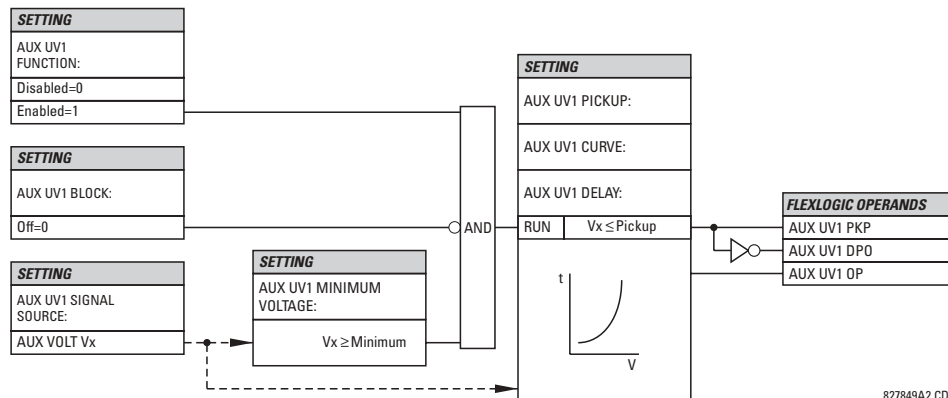
PATH: SETTINGS ⇒ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ VOLTAGE ELEMENTS ⇒ AUXILIARY UV1

<div>■ AUXILIARY UV1</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div>	<div>⏮</div> <div>⏭</div> <div>⏭</div> <div>⏭</div> <div>⏭</div> <div>⏭</div> <div>⏭</div> <div>⏭</div>	<div>AUX UV1</div> <div>FUNCTION: Disabled</div>	Range: Disabled, Enabled
		<div>AUX UV1 SIGNAL</div> <div>SOURCE: SRC 1</div>	Range: SRC 1, SRC 2
		<div>AUX UV1 PICKUP:</div> <div>0.700 pu</div>	Range: 0.000 to 3.000 pu in steps of 0.001
		<div>AUX UV1 CURVE:</div> <div>Definite Time</div>	Range: Definite Time, Inverse Time
		<div>AUX UV1 DELAY:</div> <div>1.00 s</div>	Range: 0.00 to 600.00 s in steps of 0.01
		<div>AUX UV1 MINIMUM:</div> <div>VOLTAGE: 0.100 pu</div>	Range: 0.000 to 3.000 pu in steps of 0.001
		<div>AUX UV1 BLOCK:</div> <div>Off</div>	Range: FlexLogic™ operand
		<div>AUX UV1</div> <div>TARGET: Self-reset</div>	Range: Self-reset, Latched, Disabled
		<div>AUX UV1</div> <div>EVENTS: Disabled</div>	Range: Disabled, Enabled

This element is intended for monitoring undervoltage conditions of the auxiliary voltage. The **AUX UV1 PICKUP** selects the voltage level at which the time undervoltage element starts timing. The nominal secondary voltage of the auxiliary voltage channel entered under **SETTINGS ⇒ SYSTEM SETUP ⇒ AC INPUTS ⇒ VOLTAGE BANK X5 ⇒ AUXILIARY VT X5 SECONDARY** is the p.u. base used when setting the pickup level.

The **AUX UV1 DELAY** setting selects the minimum operating time of the auxiliary undervoltage element. Both **AUX UV1 PICKUP** and **AUX UV1 DELAY** settings establish the operating curve of the undervoltage element. The auxiliary undervoltage element can be programmed to use either Definite Time Delay or Inverse Time Delay characteristics. The operating characteristics and equations for both Definite and Inverse Time Delay are as for the Phase Undervoltage element.

The element resets instantaneously. The minimum voltage setting selects the operating voltage below which the element is blocked.



827849A2.CDR

Figure 5-66: AUXILIARY UNDERVOLTAGE SCHEME LOGIC

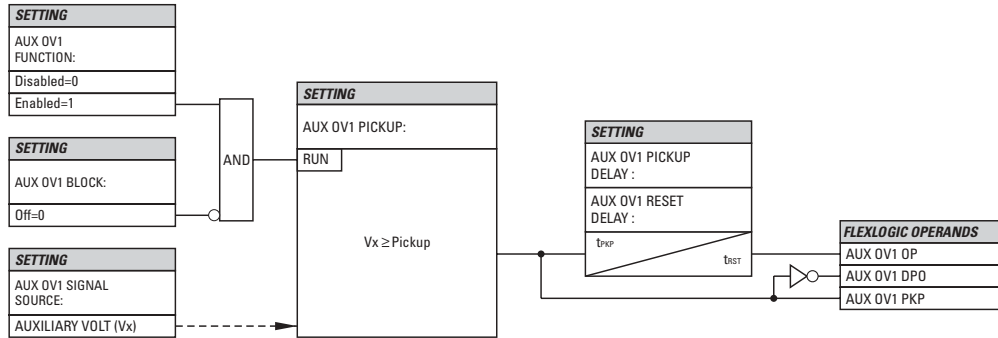
g) AUXILIARY OV1 (AUXILIARY OVERVOLTAGE: ANSI 59X)

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

<div> <div>■ AUXILIARY OV1</div> <div> <div>MESSAGE</div> <div>▲▼</div> </div> </div>		<div> <div>◀▶</div> <div>AUX OV1</div> <div>FUNCTION: Disabled</div> </div>	Range: Disabled, Enabled
<div> <div>MESSAGE</div> <div>▲▼</div> </div>		<div> <div>▲▼</div> <div>AUX OV1 SIGNAL</div> <div>SOURCE: SRC 1</div> </div>	Range: SRC 1, SRC 2
<div> <div>MESSAGE</div> <div>▲▼</div> </div>		<div> <div>▲▼</div> <div>AUX OV1 PICKUP:</div> <div>0.300 pu</div> </div>	Range: 0.000 to 3.000 pu in steps of 0.001
<div> <div>MESSAGE</div> <div>▲▼</div> </div>		<div> <div>▲▼</div> <div>AUX OV1 PICKUP</div> <div>DELAY: 1.00 s</div> </div>	Range: 0.00 to 600.00 s in steps of 0.01
<div> <div>MESSAGE</div> <div>▲▼</div> </div>		<div> <div>▲▼</div> <div>AUX OV1 RESET</div> <div>DELAY: 1.00 s</div> </div>	Range: 0.00 to 600.00 s in steps of 0.01
<div> <div>MESSAGE</div> <div>▲▼</div> </div>		<div> <div>▲▼</div> <div>AUX OV1 BLOCK:</div> <div>Off</div> </div>	Range: FlexLogic™ operand
<div> <div>MESSAGE</div> <div>▲▼</div> </div>		<div> <div>▲▼</div> <div>AUX OV1</div> <div>TARGET: Self-reset</div> </div>	Range: Self-reset, Latched, Disabled
<div> <div>MESSAGE</div> <div>▲</div> </div>		<div> <div>▲</div> <div>AUX OV1</div> <div>EVENTS: Disabled</div> </div>	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 (3V₀) 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.

5



827836A2.CDR

Figure 5-67: AUXILIARY OVERVOLTAGE SCHEME LOGIC

5.5.10 SENSITIVE DIRECTIONAL POWER

PATH: SETTINGS ⇒ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ SENSITIVE DIRECTIONAL... ⇒ DIRECTIONAL POWER 1(2)

<div> <div>■ DIRECTIONAL</div> <div>■ POWER 1</div> </div>		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:

$$P \cos \theta + Q \sin \theta > SMIN \quad (\text{EQ 5.14})$$

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 POWER 1(2)**. The element has two independent (as to the pickup and delay settings) stages for alarm and trip, respectively.

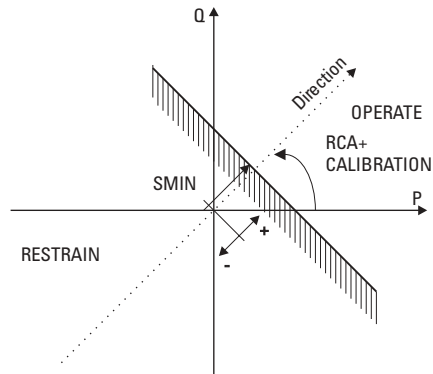


Figure 5-68: DIRECTIONAL POWER CHARACTERISTIC

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.

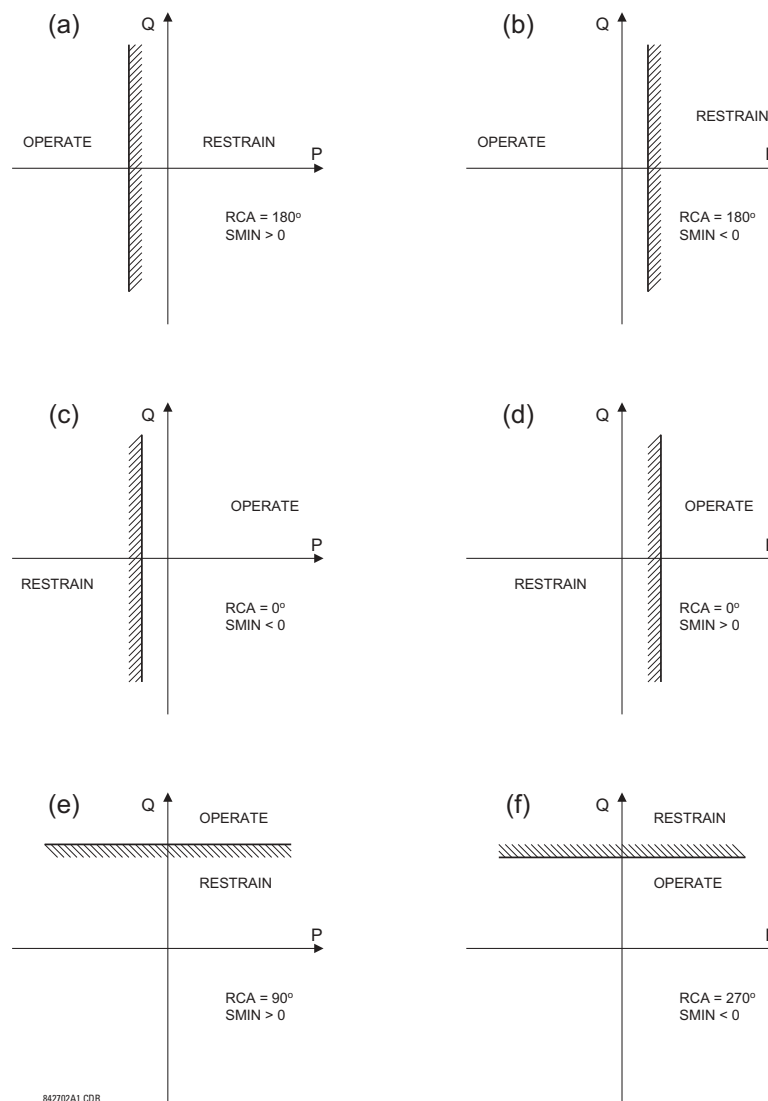


Figure 5-69: DIRECTIONAL POWER ELEMENT SAMPLE APPLICATIONS

- **DIR POWER 1(2) RCA:** Specifies the relay characteristic angle (RCA) for the directional power function. Application of this setting is threefold:
 1. It allows the element to respond to active or reactive power in any direction (active overpower, active 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.

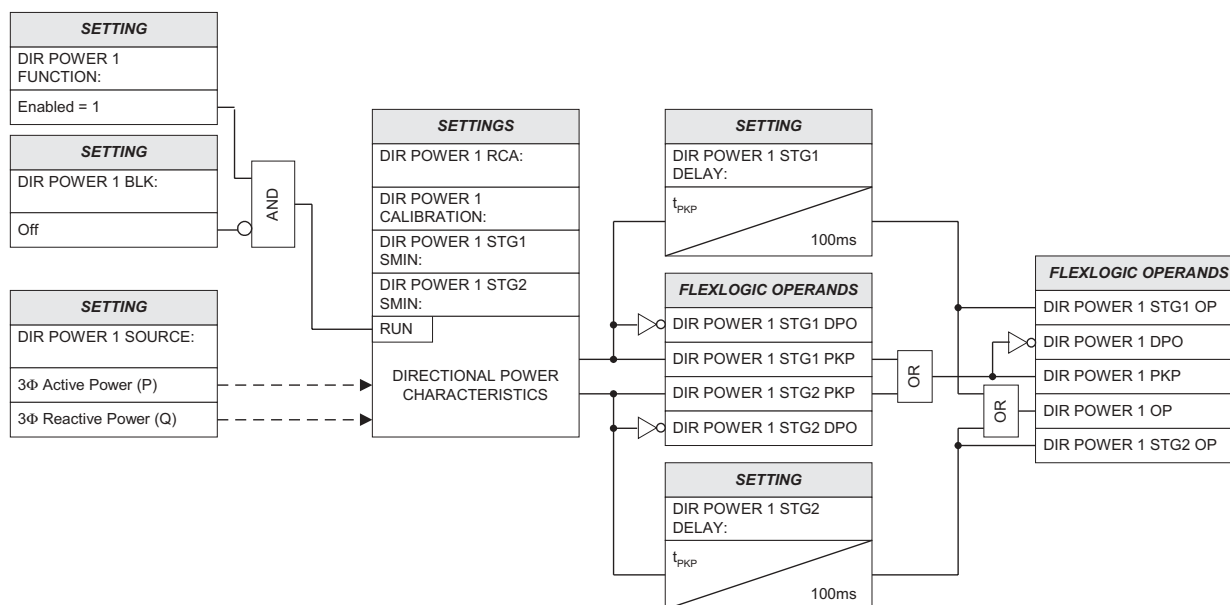
The element responds to the sum of the **DIR POWER X RCA** and **DIR POWER X CALIBRATION** settings.

- **DIR POWER 1(2) STG1 SMIN:** This setting specifies the minimum power as defined along the RCA angle for the stage 1 of the element. The positive values imply a shift towards the operate region along the RCA line. The negative values imply a shift towards the restrain region along the RCA line. Refer to the Directional Power Sample Applications figure for an illustration. Together with the RCA, this setting enables a wide range of operating characteristics. This setting applies to three-phase power and is entered in pu. The base quantity is $3 \times \text{VT pu base} \times \text{CT pu base}$.

For example, a setting of 2% for a 200 MW machine, is $0.02 \times 200 \text{ MW} = 4 \text{ MW}$. 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 $4 \text{ MW} / 239 \text{ MVA} = 0.0167 \text{ pu} \approx 0.017 \text{ pu}$. 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 the Stage 1 of the element. For reverse power or low forward power applications for a synchronous machine, Stage 1 is typically applied for alarming and Stage 2 for tripping.



842003A2.CDR

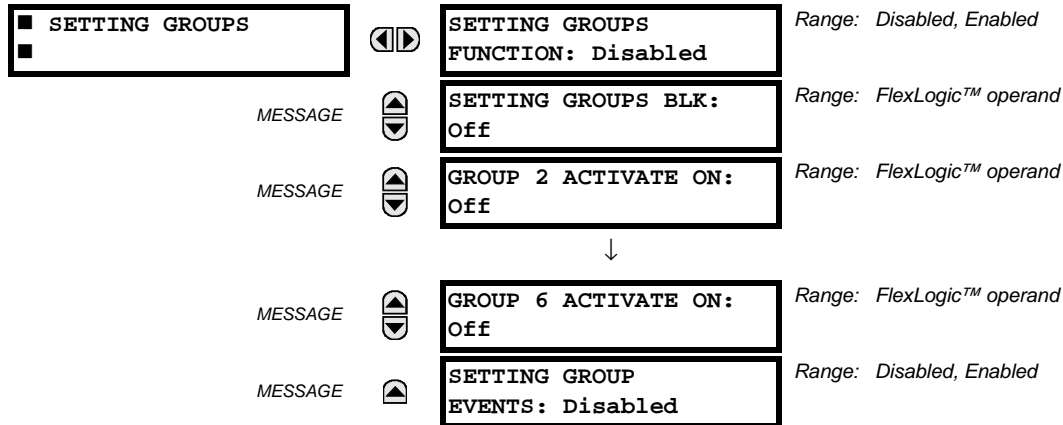
Figure 5-70: DIRECTIONAL POWER SCHEME LOGIC

5.6.1 OVERVIEW

Control elements are generally used for control rather than protection. See the Introduction to Elements section at the beginning of this chapter for further information.

5.6.2 SETTING GROUPS

PATH: SETTINGS ⇨ ⇩ CONTROL ELEMENTS ⇨ SETTINGS GROUPS



The Setting Groups menu controls the activation/deactivation of up to six possible groups of settings in the **GROUPED ELEMENTS** settings menu. The faceplate 'Settings in Use' LEDs indicate which active group (with a non-flashing energized LED) is in service.

The **SETTING GROUPS BLK** setting prevents the active setting group from changing when the FlexLogic™ parameter is set to "On". This can be useful in applications where it is undesirable to change the settings under certain conditions, such as the breaker being open.

Each **GROUP n ACTIVATE ON** setting selects a FlexLogic™ operand which, when set, will make the particular setting group active for use by any grouped element. A priority scheme ensures that only one group is active at a given time – the highest-numbered group which is activated by its **GROUP n ACTIVATE ON** parameter takes priority over the lower-numbered groups. There is no "activate on" setting for Group 1 (the default active group), because Group 1 automatically becomes active if no other group is active.

The relay can be set up via a FlexLogic™ equation to receive requests to activate or de-activate a particular non-default settings group. The following FlexLogic™ equation (see the figure below) illustrates requests via remote communications (e.g. VIRTUAL INPUT 1) or from a local contact input (e.g. H7a) to initiate the use of a particular settings group, and requests from several overcurrent pickup measuring elements to inhibit the use of the particular settings group. The assigned VIRTUAL OUTPUT 1 operand is used to control the ON state of a particular settings group.

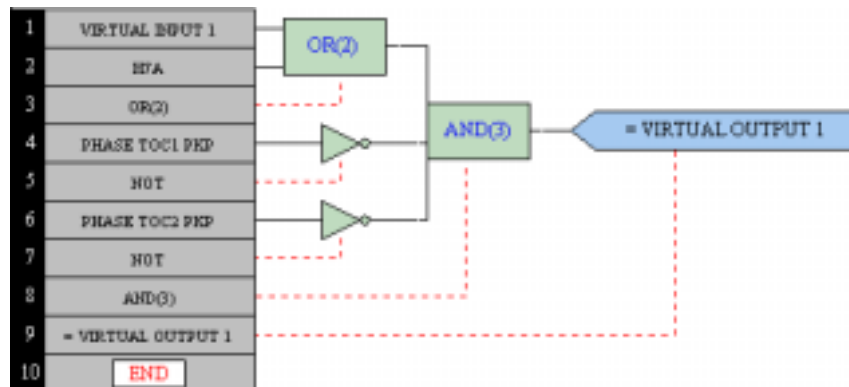


Figure 5-71: EXAMPLE FLEXLOGIC™ CONTROL OF A SETTINGS GROUP

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
MESSAGE	▲▼	SELECTOR 1 TARGETS: Disabled	Range: Disabled, Enabled
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 1 CHANGE FROM Y TO Z** target message is displayed, where **Y** is the present position and **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 1 CHANGE FROM Y TO Z** message. Typically, a user-programmable pushbutton is configured as the stepping up control input.
- **SELECTOR 1 STEP-UP MODE:** This setting defines the selector mode of operation. When set to “Time-out”, the selector will change its position after a pre-defined period of inactivity at the control input. The change is automatic and does not require any explicit confirmation of the intent to change the selector's position. When set to “Acknowledge”, the selector will change its position only after the intent is confirmed through a separate acknowledging signal. If the acknowledging signal does not appear within a pre-defined period of time, the selector does not accept the change and an alarm is established by setting the **SELECTOR STP ALARM** output FlexLogic™ operand for 3 seconds.
- **SELECTOR 1 ACK:** This setting specifies an acknowledging input for the stepping up control input. The pre-selected position is applied on the rising edge of the assigned operand. This setting is active only under “Acknowledge” mode of operation. The acknowledging signal must appear within the time defined by the **SELECTOR 1 TIME-OUT** setting after the last activity of the control input. A user-programmable pushbutton is typically configured as the acknowledging input.
- **SELECTOR 1 3BIT A0, A1, and A2:** These settings specify a 3-bit control input of the selector. The 3-bit control word pre-selects the position using the following encoding convention:

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

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

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

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

- **SELECTOR 1 POWER-UP MODE:** This setting specifies behavior of the element on power up of the relay. When set to “Restore”, the last selector position, stored in non-volatile memory, is restored after powering up the relay. When set to “Synchronize”, the selector sets to the current 3-bit control input after powering up the relay. This operation does not wait for time-out or the acknowledging input. When powering up, the rest position (0, 0, 0) and the out-of-range 3-bit control words are also ignored, the output is set to Position 0 (no output operand selected), and an alarm is established (SELECTOR 1 PWR ALARM). If the position restored from memory is out-of-range, Position 0 (no output operand selected) is applied and an alarm is set (SELECTOR 1 PWR ALARM).
- **SELECTOR 1 EVENTS:** If enabled, the following events are logged:

EVENT NAME	DESCRIPTION
SELECTOR 1 CHANGED FROM Y TO Z	Selector 1 changed its position to from Y to Z.
SELECTOR 1 STEP-UP ALARM	The selector position pre-selected via the stepping up control input has not been confirmed before the time out.
SELECTOR 1 3-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.

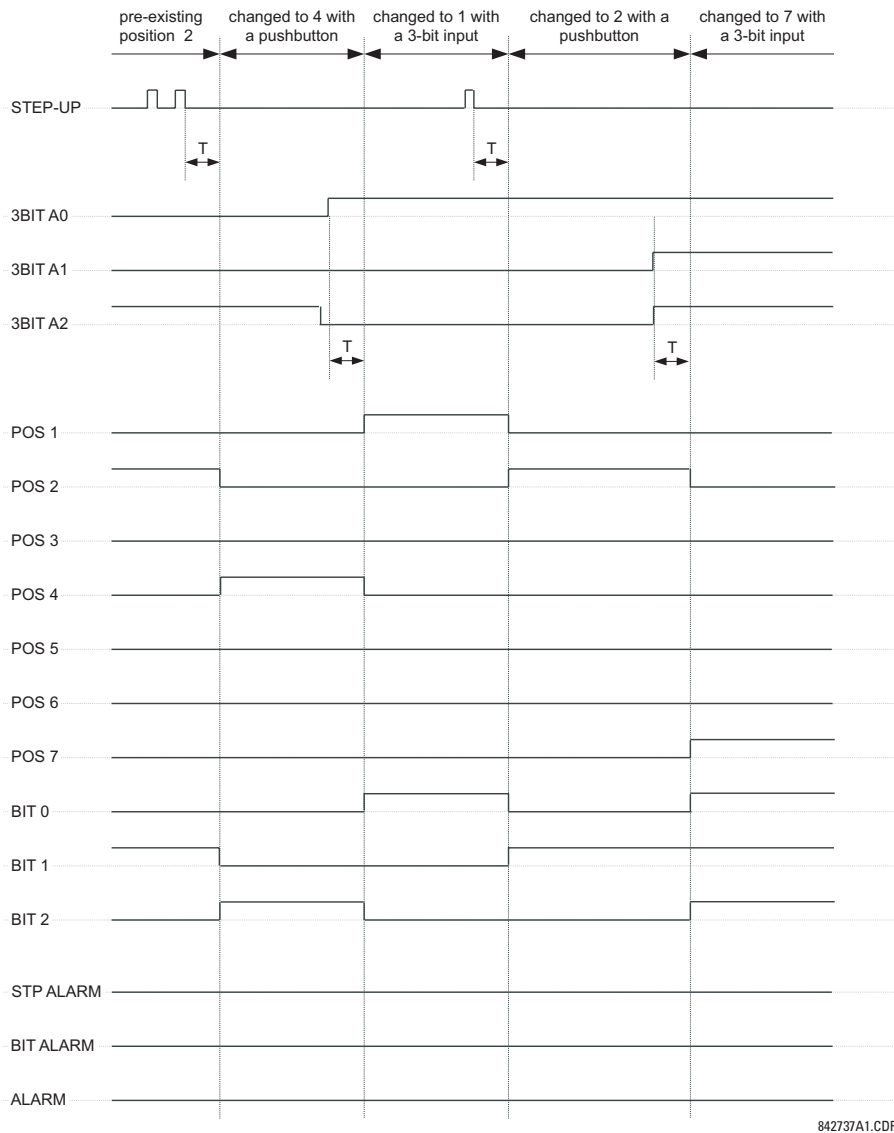


Figure 5–72: TIME-OUT MODE

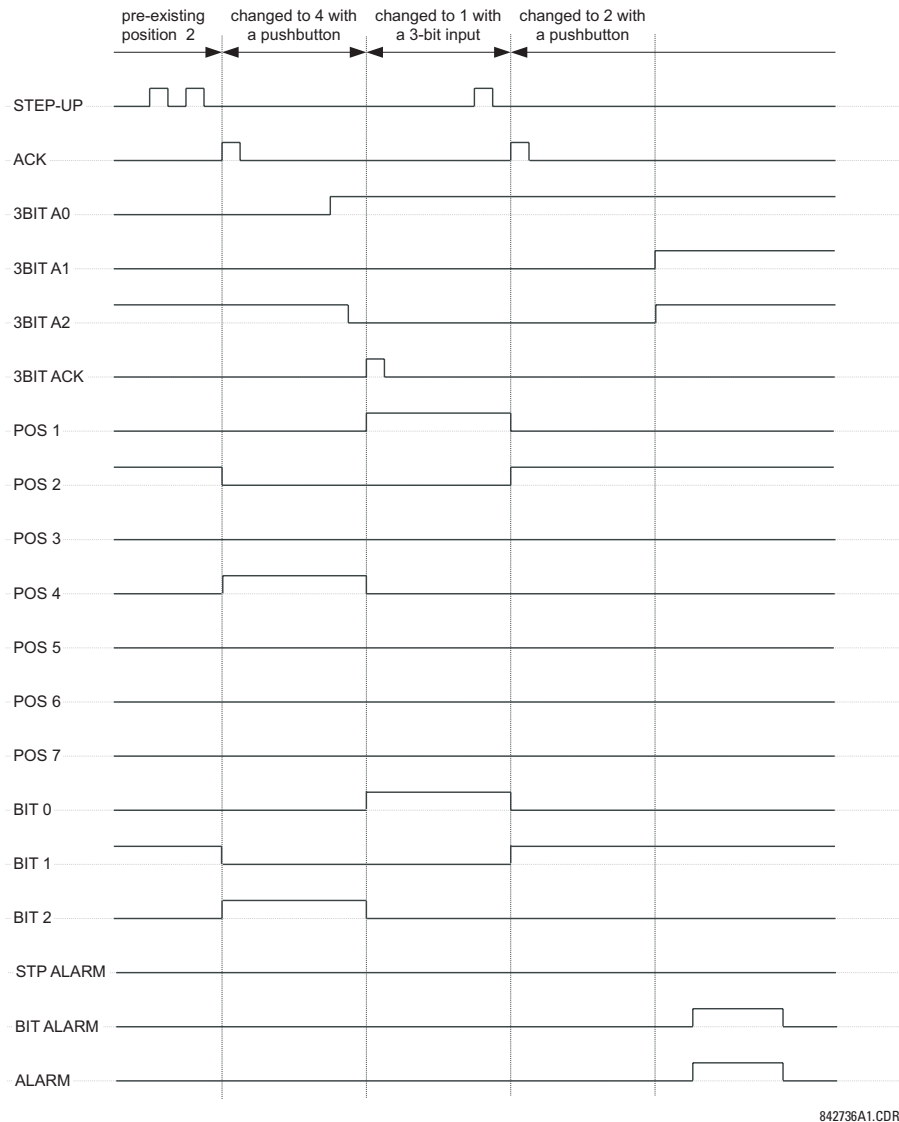


Figure 5–73: ACKNOWLEDGE MODE

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:

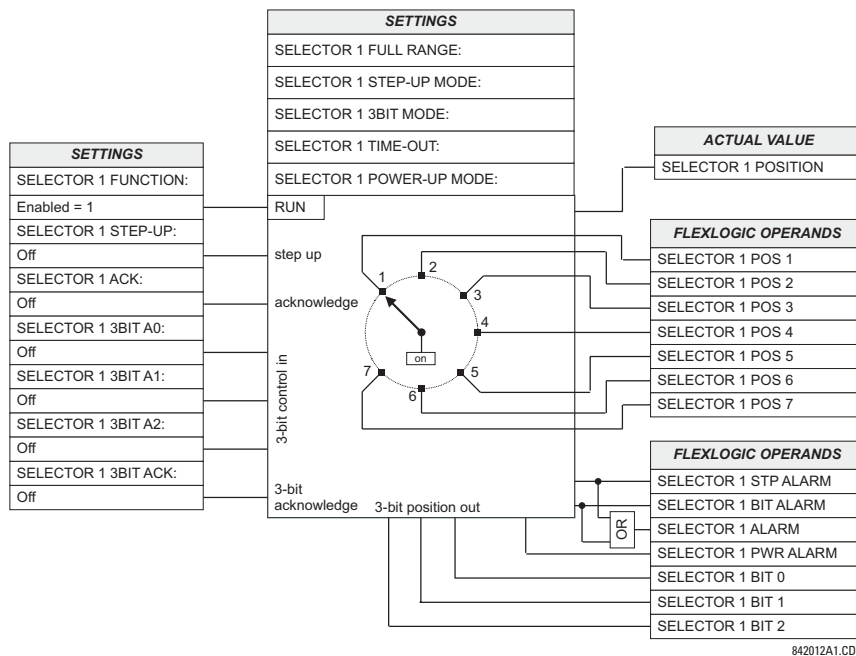


Figure 5-74: SELECTOR SWITCH LOGIC

5.6.4 UNDERFREQUENCY

PATH: SETTINGS ⇌ CONTROL ELEMENTS ⇌ UNDERFREQUENCY ⇌ UNDERFREQUENCY 1(6)

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

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.

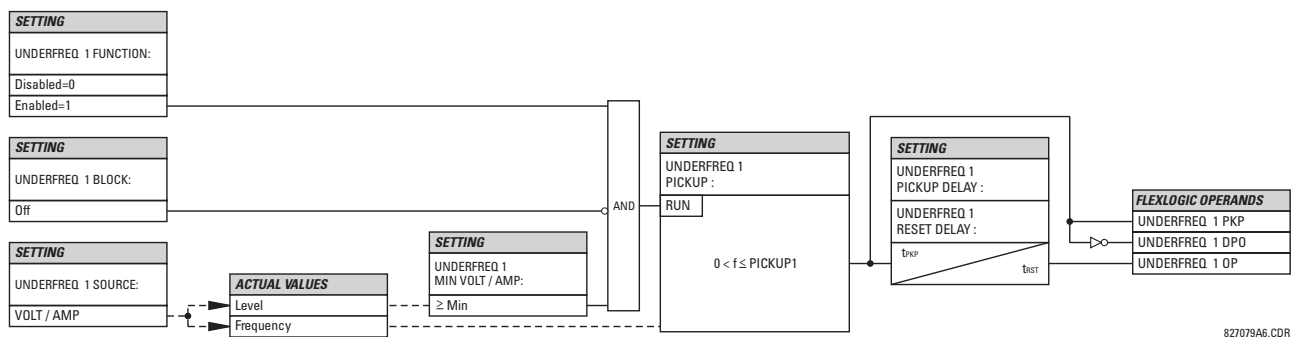


Figure 5-75: UNDERFREQUENCY SCHEME LOGIC

5.6.5 OVERFREQUENCY

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

<div>OVERFREQUENCY 1</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div>	<div>◀▶</div> <div>▲▼</div> <div>▲▼</div> <div>▲▼</div> <div>▲▼</div> <div>▲▼</div> <div>▲</div>	OVERFREQ 1 FUNCTION: Disabled	Range: Disabled, Enabled
		OVERFREQ 1 BLOCK: Off	Range: FlexLogic™ operand
		OVERFREQ 1 SOURCE: SRC 1	Range: SRC 1, SRC 2
		OVERFREQ 1 PICKUP: 60.50 Hz	Range: 20.00 to 65.00 Hz in steps of 0.01
		OVERFREQ 1 PICKUP DELAY: 0.500 s	Range: 0.000 to 65.535 s in steps of 0.001
		OVERFREQ 1 RESET DELAY : 0.500 s	Range: 0.000 to 65.535 s in steps of 0.001
		OVERFREQ 1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
		OVERFREQ 1 EVENTS: Disabled	Range: Disabled, Enabled

5

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.

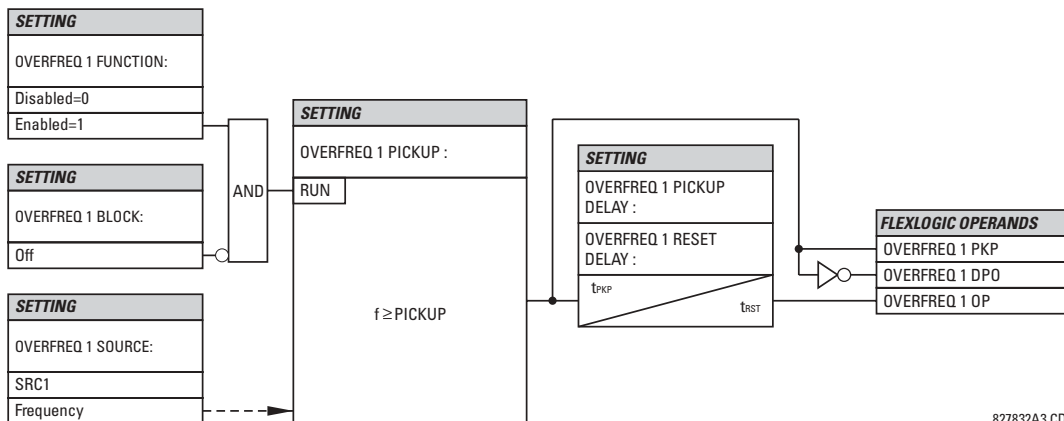


Figure 5-76: OVERFREQUENCY SCHEME LOGIC

5.6.6 FREQUENCY RATE OF CHANGE

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

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

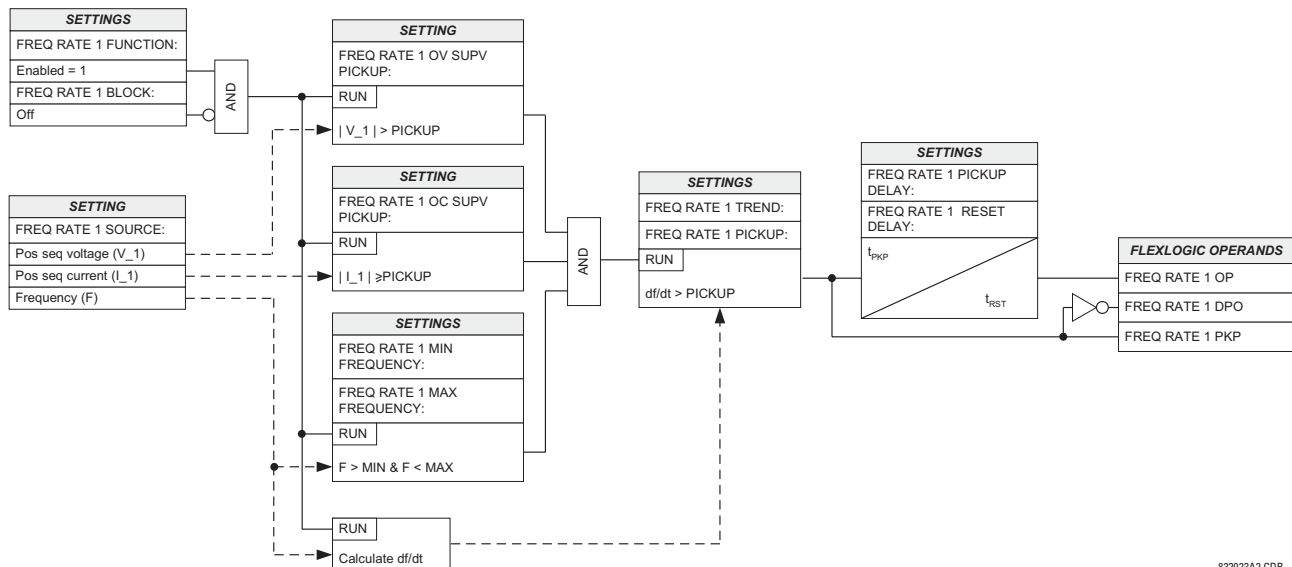
- **FREQ RATE 1 TREND:** This setting allows configuring the element to respond to increasing or decreasing frequency, or to frequency change in either direction.
- **FREQ RATE 1 PICKUP:** This setting specifies an intended df/dt pickup threshold. For applications monitoring a decreasing trend, set **FREQ 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.



832023A2.CDR

Figure 5-77: FREQUENCY RATE OF CHANGE SCHEME LOGIC

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 100000 V in steps of 1
MESSAGE	▲▼	SYNCHK1 MAX ANGLE DIFF: 30°	Range: 0 to 100° in steps of 1
MESSAGE	▲▼	SYNCHK1 MAX FREQ DIFF: 1.00 Hz	Range: 0.00 to 2.00 Hz in steps of 0.01
MESSAGE	▲▼	SYNCHK1 MAX FREQ HYSTERESIS: 0.06 Hz	Range: 0.00 to 0.10 Hz in steps of 0.01
MESSAGE	▲▼	SYNCHK1 DEAD SOURCE SELECT: LV1 and DV2	Range: None, LV1 and DV2, DV1 and LV2, DV1 or DV2, DV1 Xor DV2, DV1 and DV2
MESSAGE	▲▼	SYNCHK1 DEAD V1 MAX VOLT: 0.30 pu	Range: 0.00 to 1.25 pu in steps of 0.01
MESSAGE	▲▼	SYNCHK1 DEAD V2 MAX VOLT: 0.30 pu	Range: 0.00 to 1.25 pu in steps of 0.01
MESSAGE	▲▼	SYNCHK1 LIVE V1 MIN VOLT: 0.70 pu	Range: 0.00 to 1.25 pu in steps of 0.01
MESSAGE	▲▼	SYNCHK1 LIVE V2 MIN VOLT: 0.70 pu	Range: 0.00 to 1.25 pu in steps of 0.01
MESSAGE	▲▼	SYNCHK1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	▲	SYNCHK1 EVENTS: Disabled	Range: Disabled, Enabled

There are two identical synchrocheck elements available, numbered 1 and 2.

The synchronism check function is intended for supervising the paralleling of two parts of a system which are to be joined by the closure of a circuit breaker. The synchrocheck elements are typically used at locations where the two parts of the system are interconnected through at least one other point in the system.

Synchrocheck verifies that the voltages (V1 and V2) on the two sides of the supervised circuit breaker are within set limits of magnitude, angle and frequency differences. The time that the two voltages remain within the admissible angle difference is determined by the setting of the phase angle difference $\Delta\Phi$ and the frequency difference 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:

$$T = \frac{1}{\frac{360^\circ}{2 \times \Delta\Phi} \times \Delta F} \quad (\text{EQ 5.15})$$

where: $\Delta\Phi$ = phase angle difference in degrees; ΔF = frequency difference in Hz.

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

$$T = \frac{1}{\frac{360^\circ}{2 \times \Delta\Phi} \times \Delta F} = \frac{1}{\frac{360^\circ}{2 \times 30^\circ} \times 0.1 \text{ Hz}} = 1.66 \text{ sec.} \quad (\text{EQ 5.16})$$

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.



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.

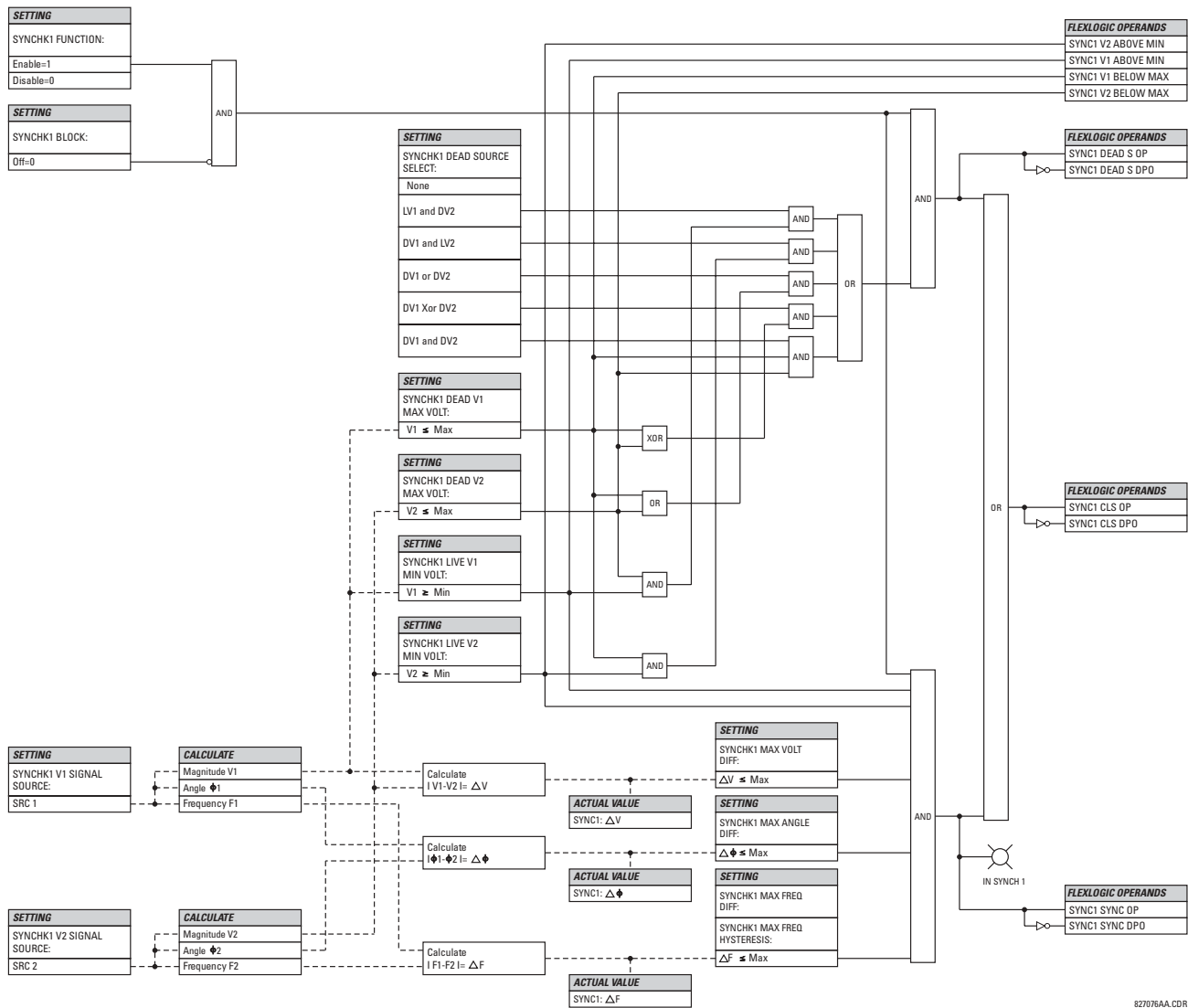


Figure 5-78: SYNCHROCHECK SCHEME LOGIC

5.6.8 AUTORECLOSE

PATH: SETTINGS ⇒ CONTROL ELEMENTS ⇒ AUTORECLOSE ⇒ AUTORECLOSE 1

■ 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 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 "AR Function" is set to Enabled.
- The scheme is not in the "Lockout" state.
- The "Block" input is not asserted.
- The "AR Block Time Upon Manual Close" timer is not active.

The autoreclose scheme is initiated by a trip signal from any selected protection feature operand. The scheme is initiated provided the circuit breaker is in the closed state before protection operation.

The Reclose-In-Progress (RIP) is set when a reclosing cycle begins following a reclose initiate signal. Once the cycle is successfully initiated, the RIP signal will seal-in and the scheme will continue through its sequence until one of the following conditions is satisfied:

- The close signal is issued when the dead timer times out, or
- The scheme goes to lockout.

While RIP is active, the scheme checks that the breaker is open and the shot number is below the limit, and then begins measuring the dead time.

Each of the four possible shots has an independently settable dead time. Two additional timers can be used to increase the initial set dead times 1 to 4 by a delay equal to AR1 DELAY 1 or AR1 DELAY 2 or the sum of these two delays depending on the selected settings. This offers enhanced setting flexibility using FlexLogic™ operands to turn the two additional timers "on" and "off". These operands may possibly include "AR x SHOT CNT =n", "SETTING GROUP ACT x", etc. The autoreclose provides up to maximum 4 selectable shots. Maximum number of shots can be dynamically modified through the settings AR1 REDUCE MAX TO 1 (2, 3), using the appropriate FlexLogic™ operand.

Scheme lockout blocks all phases of the reclosing cycle, preventing automatic reclosure, if any of the following occurs:

- The maximum shot number was reached.
- A "Block" input is in effect (for instance; Breaker Failure, bus differential protection operated, etc.).
- The "Incomplete Sequence" timer times out.

The recloser will be latched in the Lockout state until a "Reset from lockout" signal is asserted, either from a manual close of the breaker or from a manual reset command (local or remote). The reset from lockout can be accomplished by operator command, by manually closing the breaker, or whenever the breaker has been closed and stays closed for a preset time.

After the dead time elapses, the scheme issues the close signal. The close signal is latched until the breaker closes or the scheme goes to Lockout.

A reset timer output resets the recloser following a successful reclosure sequence. The reset time is based on the breaker "reclaim time" which is the minimum time required between successive reclose sequences.

SETTINGS:

- **AR1 INITIATE:** Selects the FlexLogic™ operand that initiates the scheme, typically the trip signal from protection.
- **AR1 BLOCK:** Selects the FlexLogic™ operand that blocks the Autoreclosure initiate (it could be from the Breaker Failure, Bus differential protection, etc.).
- **AR1 MAX NUMBER OF SHOTS:** Specifies the number of reclosures that can be attempted before reclosure goes to "Lockout" because the fault is permanent.
- **AR1 REDUCE MAX TO 1(3):** Selects the FlexLogic™ operand that changes the maximum number of shots from the initial setting to 1, 2, or 3, respectively.
- **AR1 MANUAL CLOSE:** Selects the logic input set when the breaker is manually closed.
- **AR1 MNL RST FRM LO:** Selects the FlexLogic™ operand that resets the autoreclosure from Lockout condition. Typically this is a manual reset from lockout, local or remote.
- **AR1 RESET LOCKOUT IF BREAKER CLOSED:** This setting allows the autoreclosure scheme to reset from Lockout if the breaker has been manually closed and stays closed for a preset time. In order for this setting to be effective, the next setting (AR1 RESET LOCKOUT ON MANUAL CLOSE) should be disabled.
- **AR 1 RESET LOCKOUT ON MANUAL CLOSE:** This setting allows the autoreclosure scheme to reset from Lockout when the breaker is manually closed regardless if the breaker remains closed or not. This setting overrides the previous setting (AR1 RESET LOCKOUT IF BREAKER CLOSED).
- **AR1 BLK TIME UPON MNL CLS:** The autoreclosure 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 autoreclosure scheme is enabled.
- **AR1 DEAD TIME 1 to AR DEAD TIME 4:** These are the intentional delays before first, second, third, and fourth breaker automatic reclosures (1st, 2nd, and 3rd shots), respectively, and should be set longer than the estimated deionizing time following a three pole trip.
- **AR1 ADD DELAY 1:** This setting selects the FlexLogic™ operand that introduces an additional delay (DELAY 1) to the initial set Dead Time (1 to 4). When this setting is "Off", DELAY 1 is by-passed.
- **AR1 DELAY 1:** This setting establishes the extent of the additional dead time DELAY 1.
- **AR1 ADD DELAY 2:** This setting selects the FlexLogic™ operand that introduces an additional delay (DELAY 2) to the initial set Dead Time (1 to 4). When this setting is "Off", DELAY 2 is by-passed.
- **AR1 DELAY 2:** This setting establishes the extent of the additional dead time DELAY 2.
- **AR1 RESET LOCKOUT DELAY:** This setting establishes how long the breaker should stay closed after a manual close command, in order for the autorecloser to reset from Lockout.
- **AR1 RESET TIME:** A reset timer output resets the recloser following a successful reclosure sequence. The setting is based on the breaker "reclaim time" which is the minimum time required between successive reclose sequences.
- **AR1 INCOMPLETE SEQ TIME:** This timer defines the maximum time interval allowed for a single reclose shot. It is started whenever a reclosure is initiated and is active when the scheme is in the "RECLOSE IN PROGRESS" state. If all conditions allowing a breaker closure are not satisfied when this time expires, the scheme goes to "Lockout".



This timer must be set to a delay less than the reset timer.

NOTE

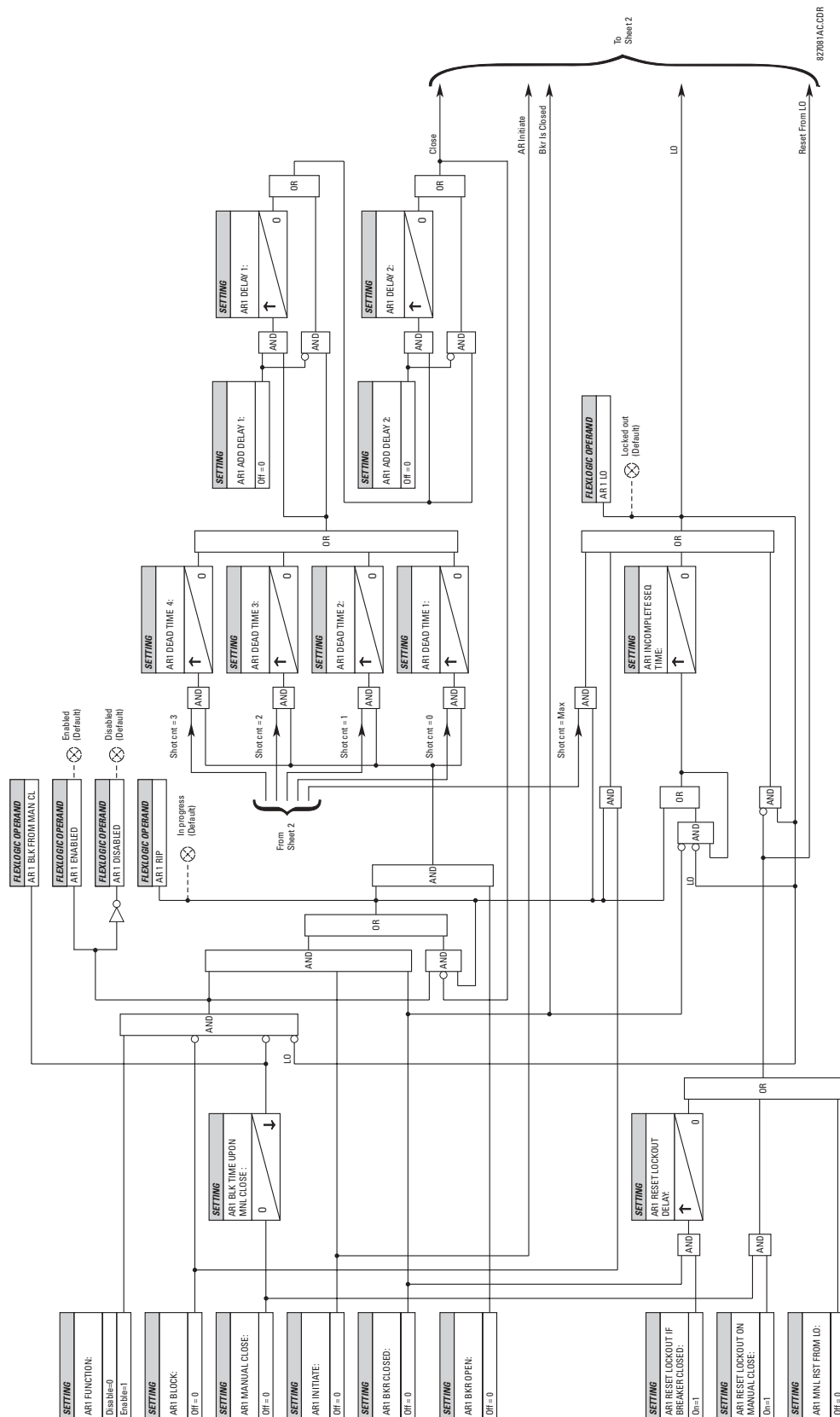


Figure 5-79: AUTORECLOSURE SCHEME LOGIC (Sheet 1 of 2)

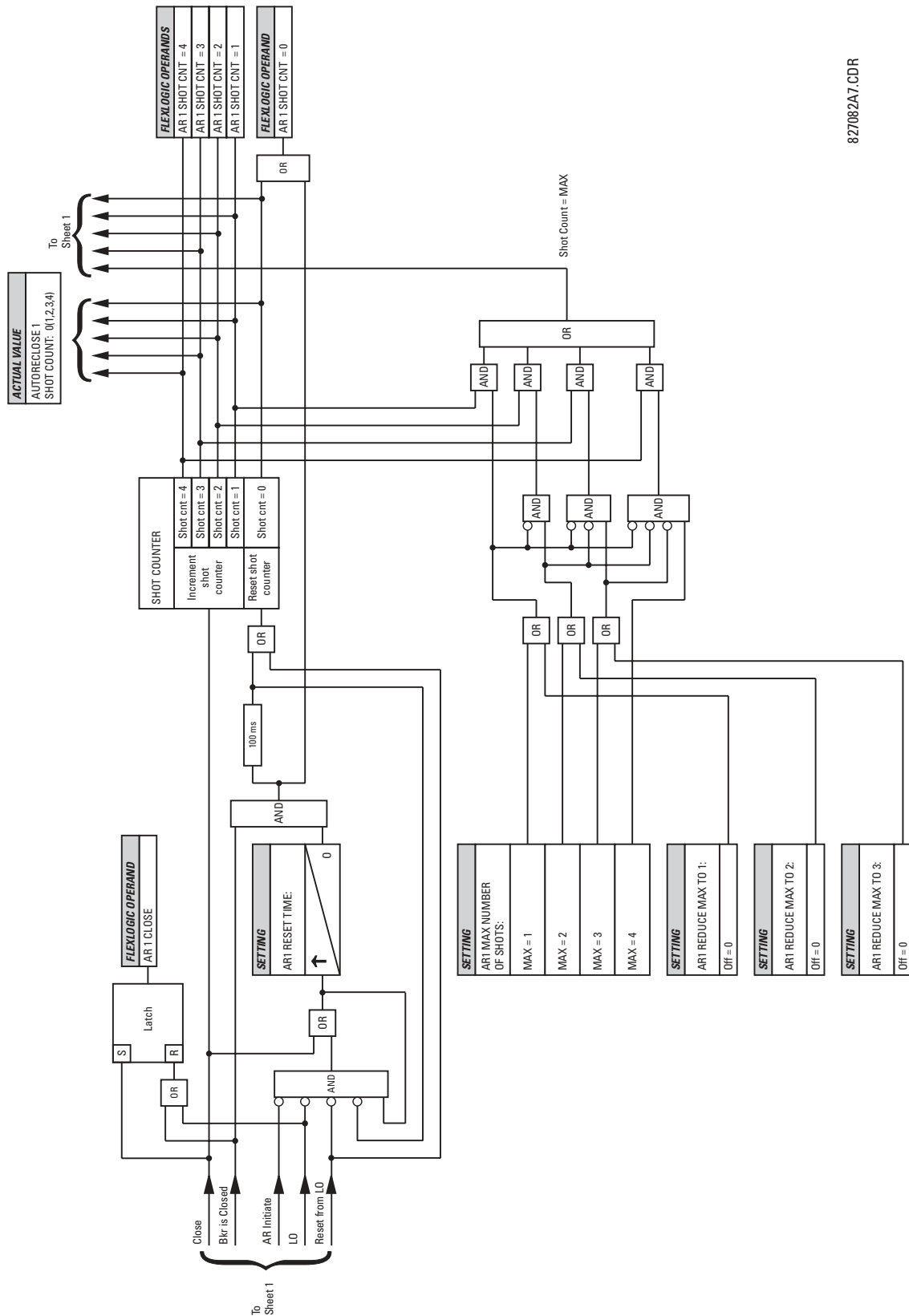


Figure 5–80: AUTORECLOSURE SCHEME LOGIC (Sheet 2 of 2)

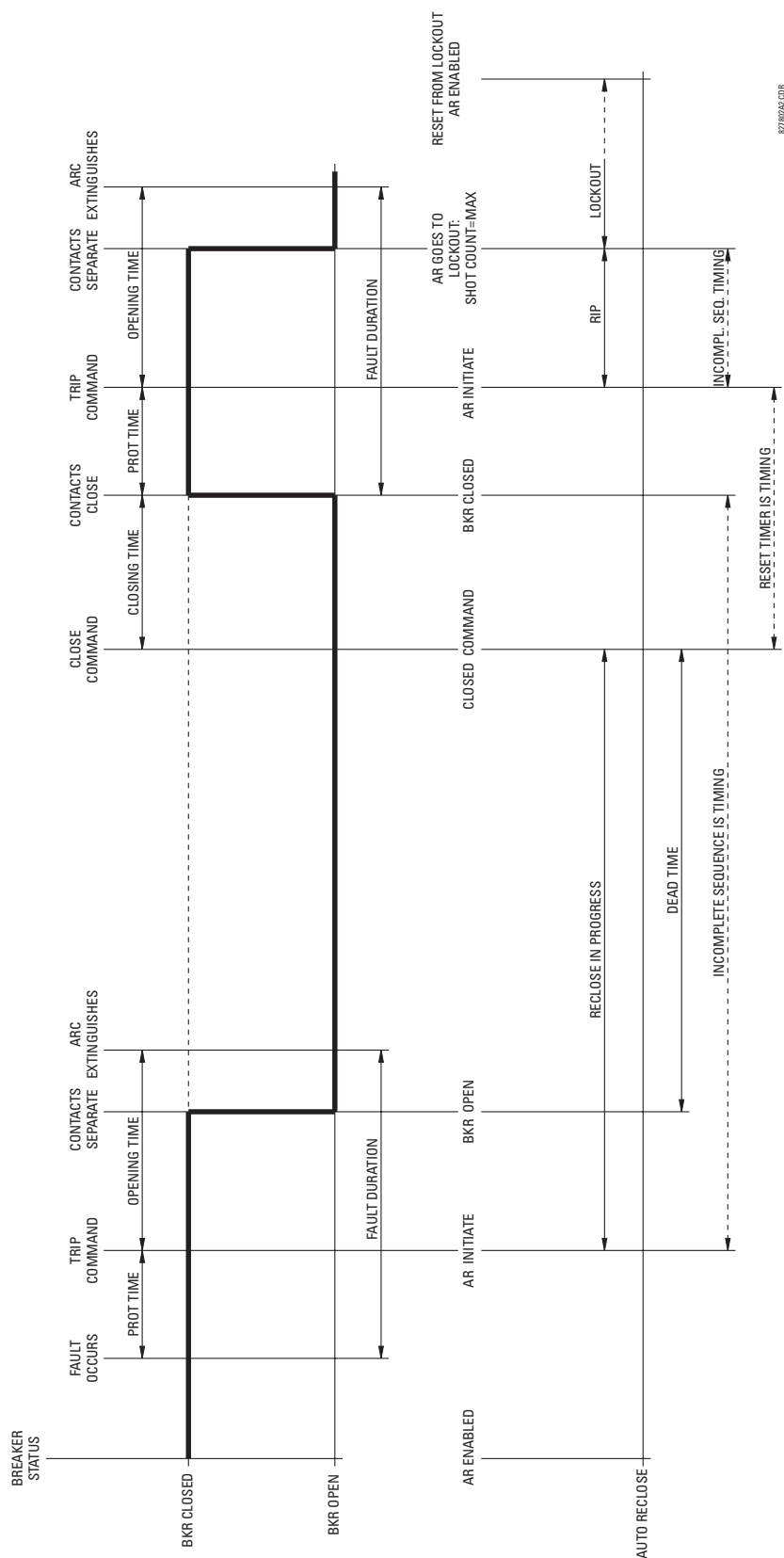


Figure 5–81: SINGLE SHOT AUTOECLOSING SEQUENCE - PERMANENT FAULT

5.6.9 DIGITAL ELEMENTS

PATH: SETTINGS ⇨ CONTROL ELEMENTS ⇨ DIGITAL ELEMENTS ⇨ DIGITAL ELEMENT 1(16)

■ DIGITAL ELEMENT 1	◀▶	DIGITAL ELEMENT 1 FUNCTION: Disabled	Range: Disabled, Enabled
MESSAGE	▲▼	DIG ELEM 1 NAME: Dig Element 1	Range: 16 alphanumeric characters
MESSAGE	▲▼	DIG ELEM 1 INPUT: Off	Range: FlexLogic™ operand
MESSAGE	▲▼	DIG ELEM 1 PICKUP DELAY: 0.000 s	Range: 0.000 to 999999.999 s in steps of 0.001
MESSAGE	▲▼	DIG ELEM 1 RESET DELAY: 0.000 s	Range: 0.000 to 999999.999 s in steps of 0.001
MESSAGE	▲▼	DIG ELEM 1 BLOCK: Off	Range: FlexLogic™ operand
MESSAGE	▲▼	DIGITAL ELEMENT 1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
MESSAGE	▲	DIGITAL ELEMENT 1 EVENTS: Disabled	Range: Disabled, Enabled

There are 16 identical Digital Elements available, numbered 1 to 16. A Digital Element can monitor any FlexLogic™ operand and present a target message and/or enable events recording depending on the output operand state. The digital element settings include a 'name' which will be referenced in any target message, a blocking input from any selected FlexLogic™ operand, and a timer for pickup and reset delays for the output operand.

- **DIGITAL ELEMENT 1 INPUT:** Selects a FlexLogic™ operand to be monitored by the Digital Element.
- **DIGITAL ELEMENT 1 PICKUP DELAY:** Sets the time delay to pickup. If a pickup delay is not required, set to "0".
- **DIGITAL ELEMENT 1 RESET DELAY:** Sets the time delay to reset. If a reset delay is not required, set to "0".

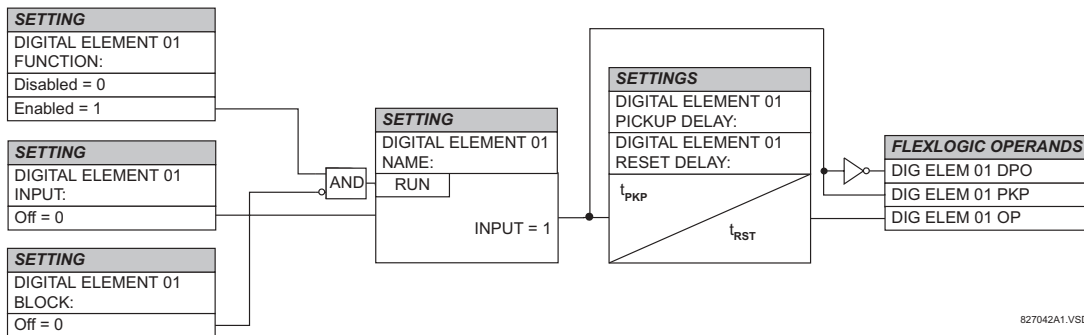


Figure 5-82: DIGITAL ELEMENT SCHEME LOGIC

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.

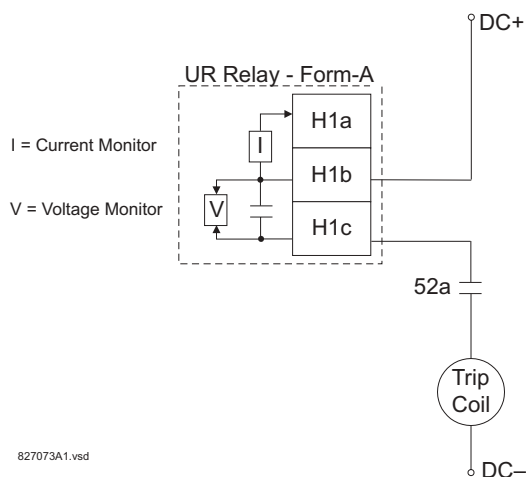


Figure 5-83: TRIP CIRCUIT EXAMPLE 1

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



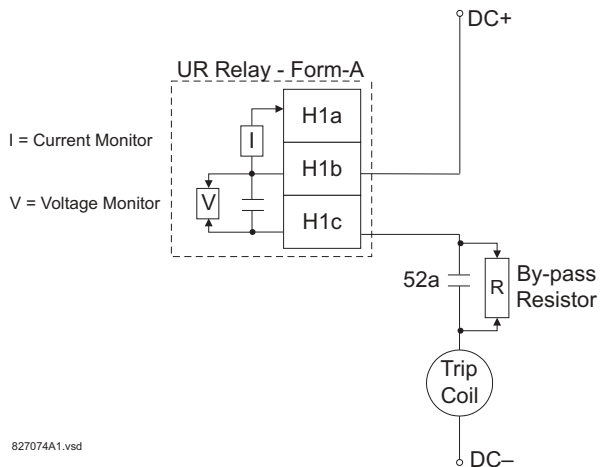
The PICKUP DELAY setting should be greater than the operating time of the breaker to avoid nuisance alarms.

NOTE

EXAMPLE 2: BREAKER TRIP CIRCUIT INTEGRITY MONITORING

If it is required to monitor the trip circuit continuously, independent of the breaker position (open or closed), a method to maintain the monitoring current flow through the trip circuit when the breaker is open must be provided (as shown in the figure below). This can be achieved by connecting a suitable resistor (see figure below) across the auxiliary contact in the trip circuit. In this case, it is not required to supervise the monitoring circuit with the breaker position – the **BLOCK** setting is selected to “Off”. In this case, the settings will be:

■ DIGITAL ELEMENT 1	◀▶	DIGITAL ELEMENT 1 FUNCTION: Enabled
MESSAGE ▲▼	▲▼	DIG ELEM 1 NAME: Bkr Trip Cct Out
MESSAGE ▲▼	▲▼	DIG ELEM 1 INPUT: Cont Op 1 Voff
MESSAGE ▲▼	▲▼	DIG ELEM 1 PICKUP DELAY: 0.200 s
MESSAGE ▲▼	▲▼	DIG ELEM 1 RESET DELAY: 0.100 s
MESSAGE ▲▼	▲▼	DIG ELEM 1 BLOCK: Off
MESSAGE ▲▼	▲▼	DIGITAL ELEMENT 1 TARGET: Self-reset
MESSAGE ▲	▲	DIGITAL ELEMENT 1 EVENTS: Enabled

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

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

Figure 5–84: TRIP CIRCUIT EXAMPLE 2

5.6.10 DIGITAL COUNTERS

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

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

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.

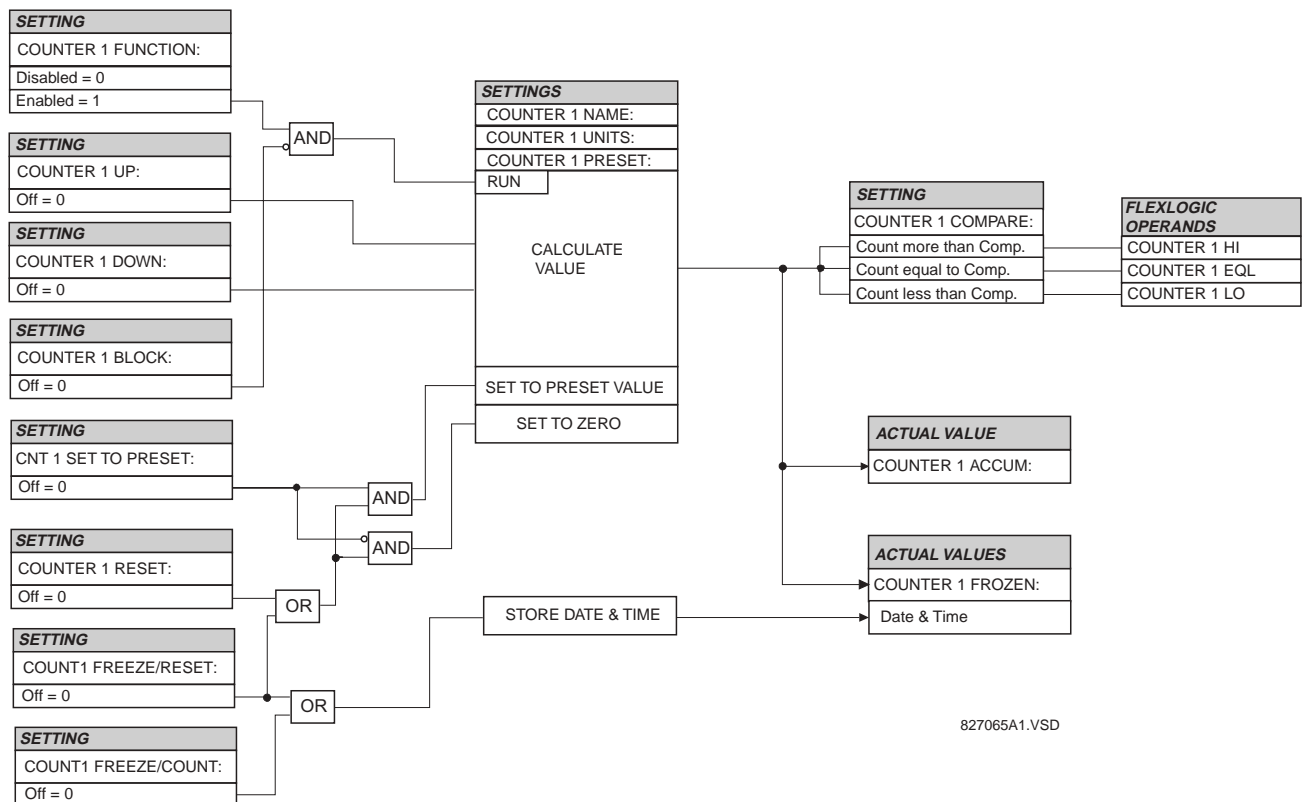


Figure 5-85: DIGITAL COUNTER SCHEME LOGIC

5.6.11 MONITORING ELEMENTS

a) MAIN MENU





PATH: SETTINGS ⇒ ↓ CONTROL ELEMENTS ⇒ ↓ MONITORING ELEMENTS

■ MONITORING ■ ELEMENTS	◀▶	■ HI-Z	See page 5-142.
MESSAGE	▲▼	■ BREAKER 1 ■ ARCING CURRENT	See page 5-148.
MESSAGE	▲▼	■ BREAKER 2 ■ ARCING CURRENT	See page 5-148.
MESSAGE	▲	■ VT FUSE FAILURE	See page 5-150.

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 BLOCK: Off	Range: FlexLogic™ operand
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 5–20: 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 5–21: 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 8A/8B 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.
- **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.



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.

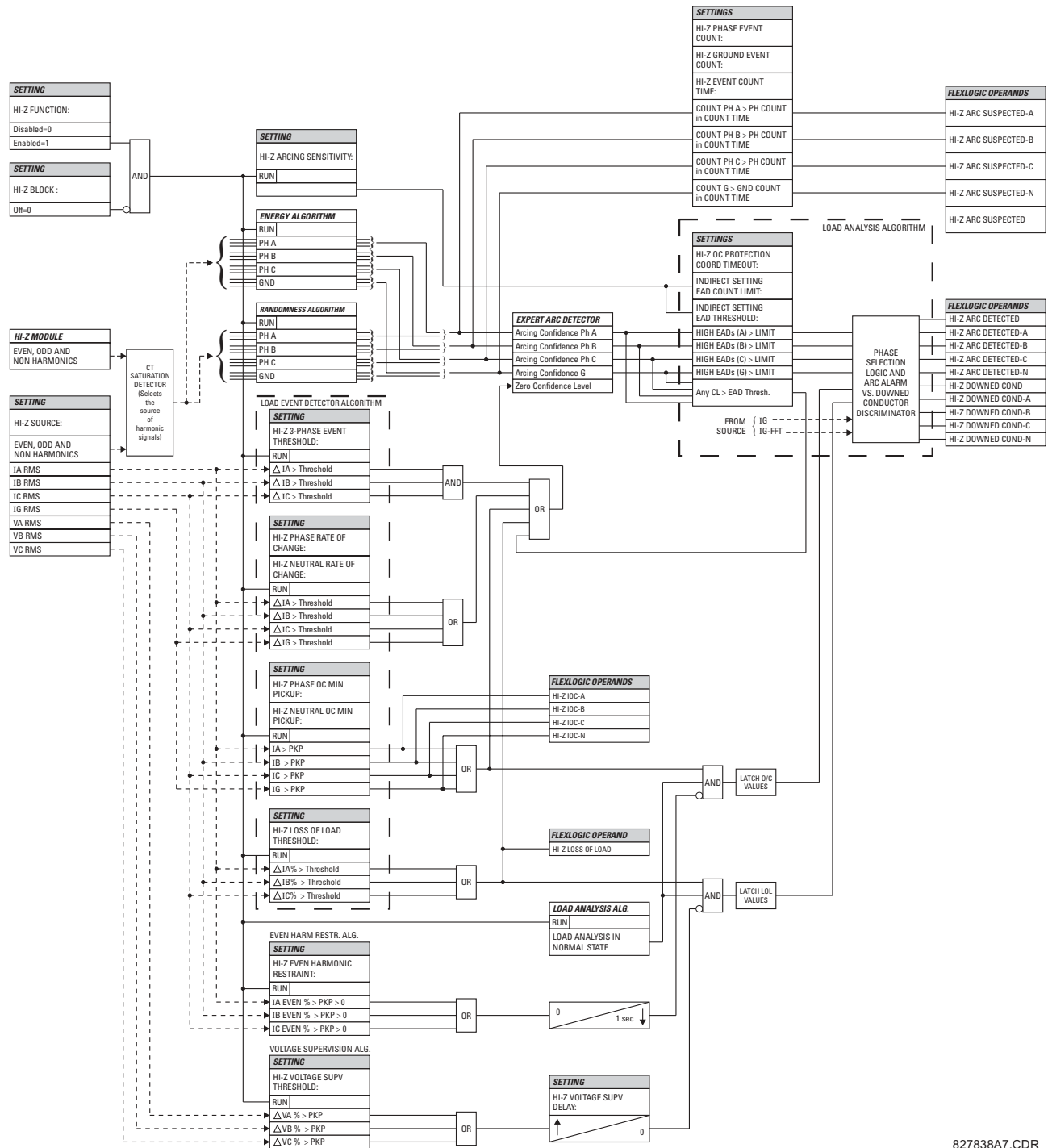


Figure 5-86: HI-Z SCHEME LOGIC

c) BREAKER ARCING CURRENT

PATH: SETTINGS ⇒ CONTROL ELEMENTS ⇒ MONITORING ELEMENTS ⇒ BREAKER 1(2) ARCING CURRENT

<div> <div>■ BREAKER 1</div> <div>■ ARCING CURRENT</div> </div>		<div> <div>◀▶</div> <div>BKR 1 ARC AMP</div> <div>FUNCTION: Disabled</div> </div>	Range: Disabled, Enabled
	MESSAGE	<div> <div>▲▼</div> <div>BKR 1 ARC AMP</div> <div>SOURCE: SRC 1</div> </div>	Range: SRC 1, SRC 2
	MESSAGE	<div> <div>▲▼</div> <div>BKR 1 ARC AMP INIT:</div> <div>Off</div> </div>	Range: FlexLogic™ operand
	MESSAGE	<div> <div>▲▼</div> <div>BKR 1 ARC AMP</div> <div>DELAY: 0.000 s</div> </div>	Range: 0.000 to 65.535 s in steps of 0.001
	MESSAGE	<div> <div>▲▼</div> <div>BKR 1 ARC AMP LIMIT:</div> <div>1000 kA²-cyc</div> </div>	Range: 0 to 50000 kA ² -cycle in steps of 1
	MESSAGE	<div> <div>▲▼</div> <div>BKR 1 ARC AMP BLOCK:</div> <div>Off</div> </div>	Range: FlexLogic™ operand
	MESSAGE	<div> <div>▲▼</div> <div>BKR 1 ARC AMP</div> <div>TARGET: Self-reset</div> </div>	Range: Self-reset, Latched, Disabled
	MESSAGE	<div> <div>▲</div> <div>BKR 1 ARC AMP</div> <div>EVENTS: Disabled</div> </div>	Range: Disabled, Enabled

5

There are 2 identical Breaker Arcing Current features available for Breakers 1 and 2. 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.

- **BKR 1(2) ARC AMP INIT:** Selects the same output operand that is selected to operate the output relay used to trip the breaker.
- **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.

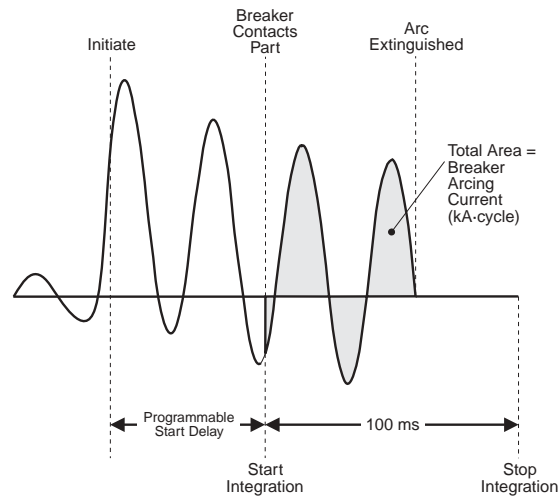


Figure 5-87: ARCING CURRENT MEASUREMENT

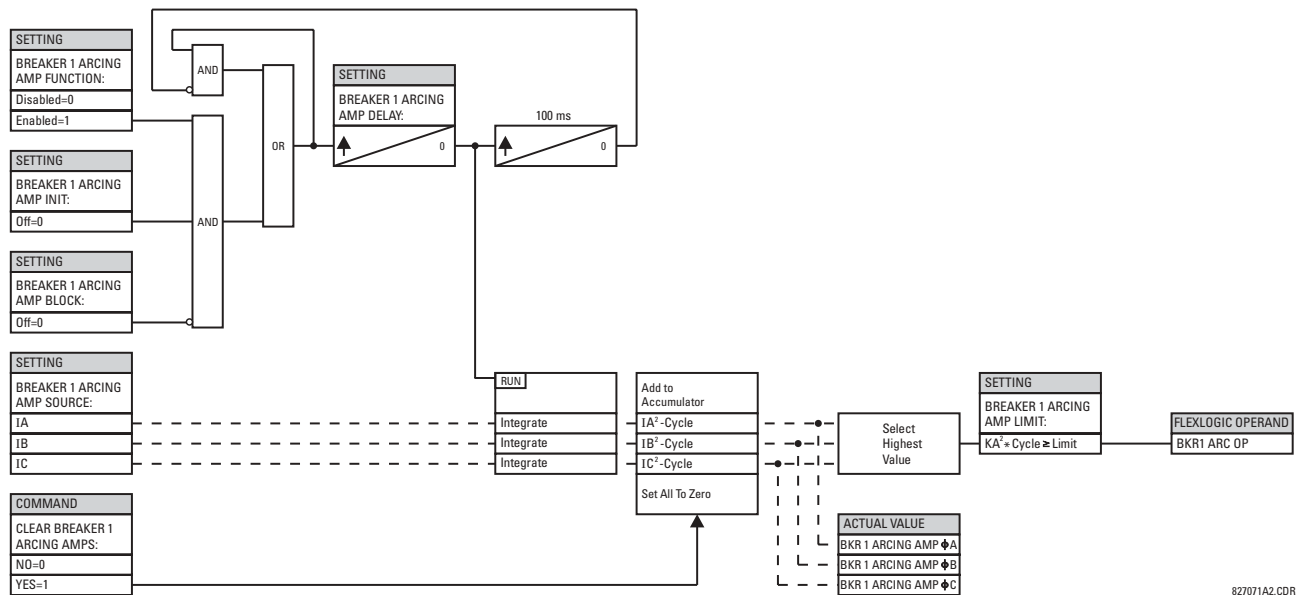
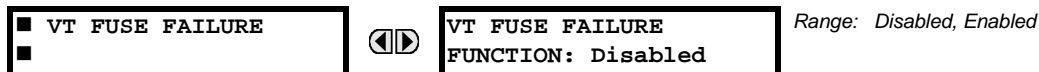


Figure 5-88: BREAKER ARCING CURRENT SCHEME LOGIC

827071A2.CDR

d) VT FUSE FAILURE

PATH: SETTINGS ⇨ CONTROL ELEMENTS ⇨ MONITORING ELEMENTS ⇨ VT FUSE FAILURE



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 common **VT FUSE FAILURE FUNCTION** setting enables/disables the fuse failure feature for all sources.

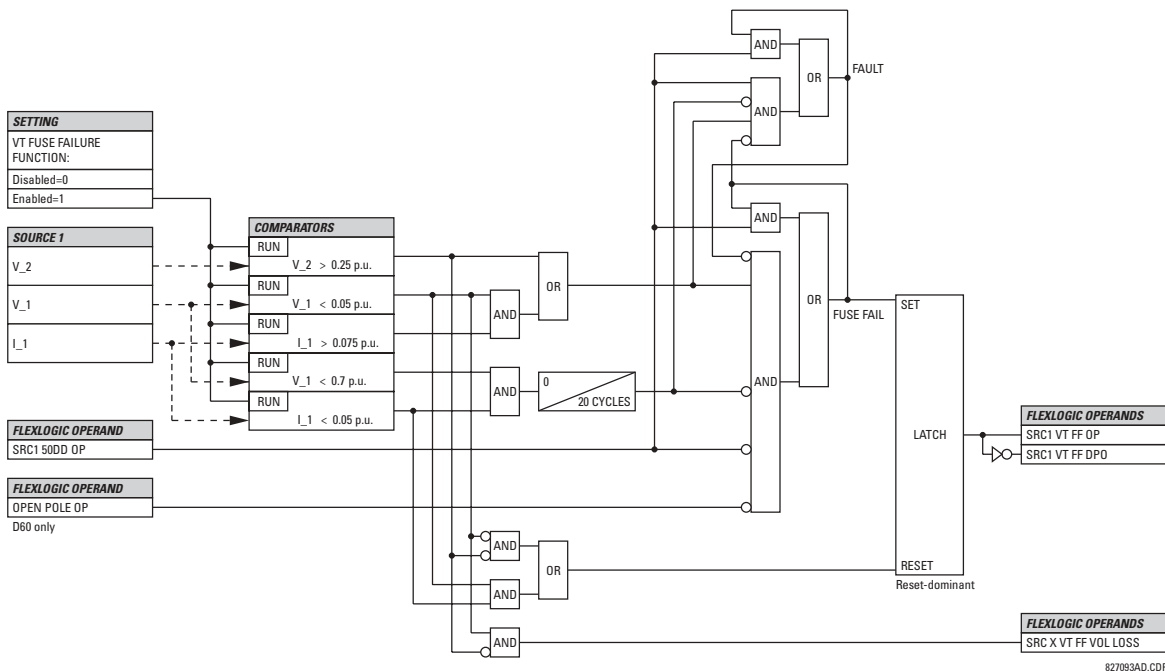


Figure 5-89: VT FUSE FAIL SCHEME LOGIC

827093AD.CDR

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 4 seconds.

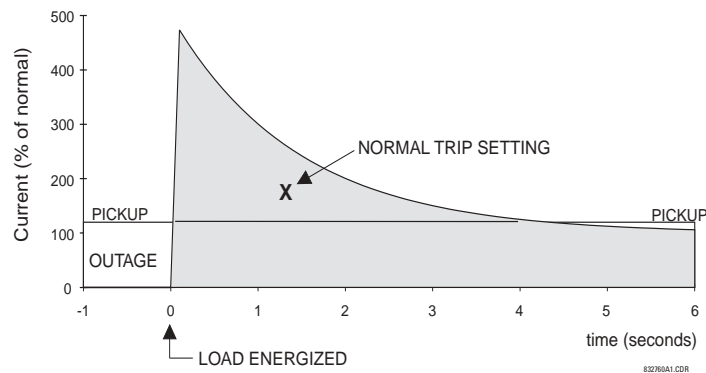


Figure 5-90: TYPICAL COLD LOAD PICKUP CHARACTERISTIC

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.

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.

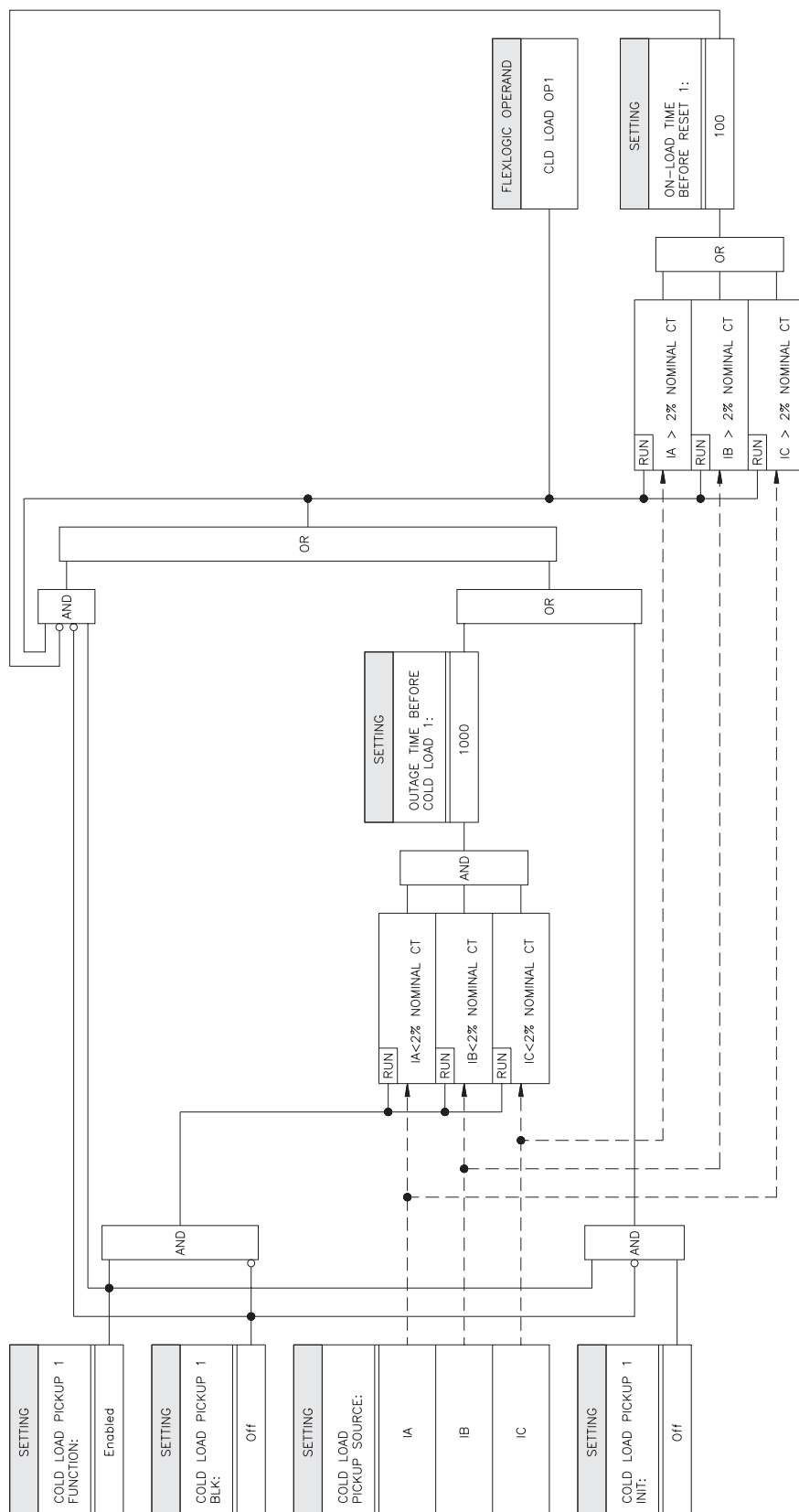
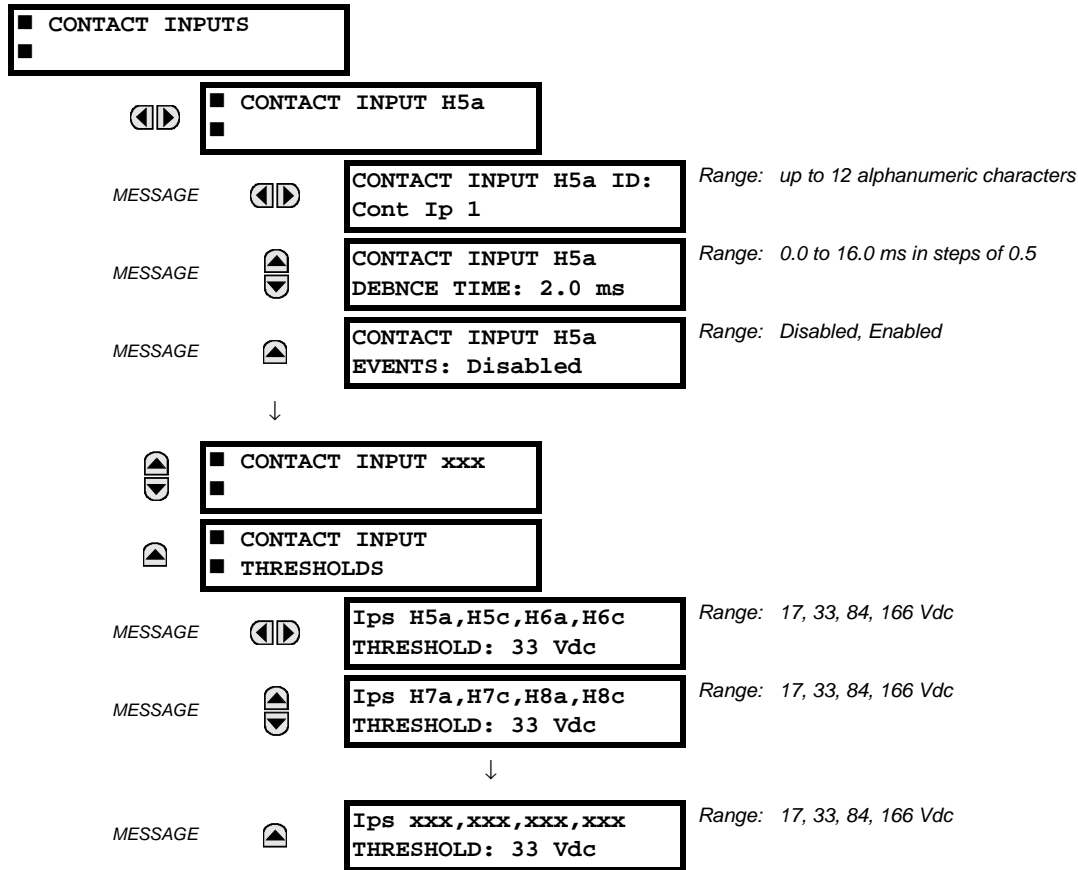


Figure 5–91: COLD LOAD PICKUP SCHEME LOGIC

5.7.1 CONTACT INPUTS

PATH: SETTINGS ⇒ INPUTS/OUTPUTS ⇒ CONTACT INPUTS



The contact inputs menu contains configuration settings for each contact input as well as voltage thresholds for each group of four contact inputs. Upon startup, the relay processor determines (from an assessment of the installed modules) which contact inputs are available and then display settings for only those inputs.

An alphanumeric ID may be assigned to a contact input for diagnostic, setting, and event recording purposes. The "Contact Ip X On" (Logic 1) FlexLogic™ operand corresponds to contact input "X" being closed, while "Contact Input 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 μ s 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.

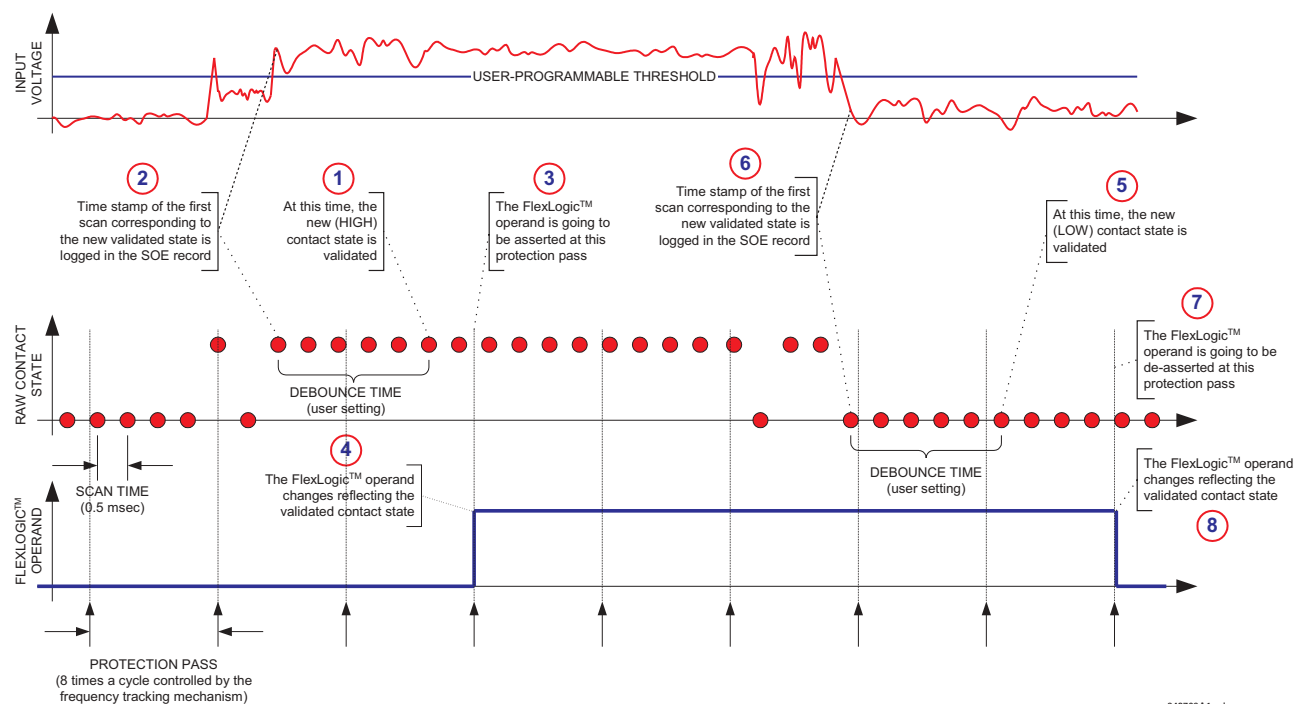


Figure 5-92: INPUT CONTACT DEBOUNCING MECHANISM AND TIME-STAMPING SAMPLE TIMING

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: 16 for 24 V sources, 30 for 48 V sources, 80 for 110 to 125 V sources and 140 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:

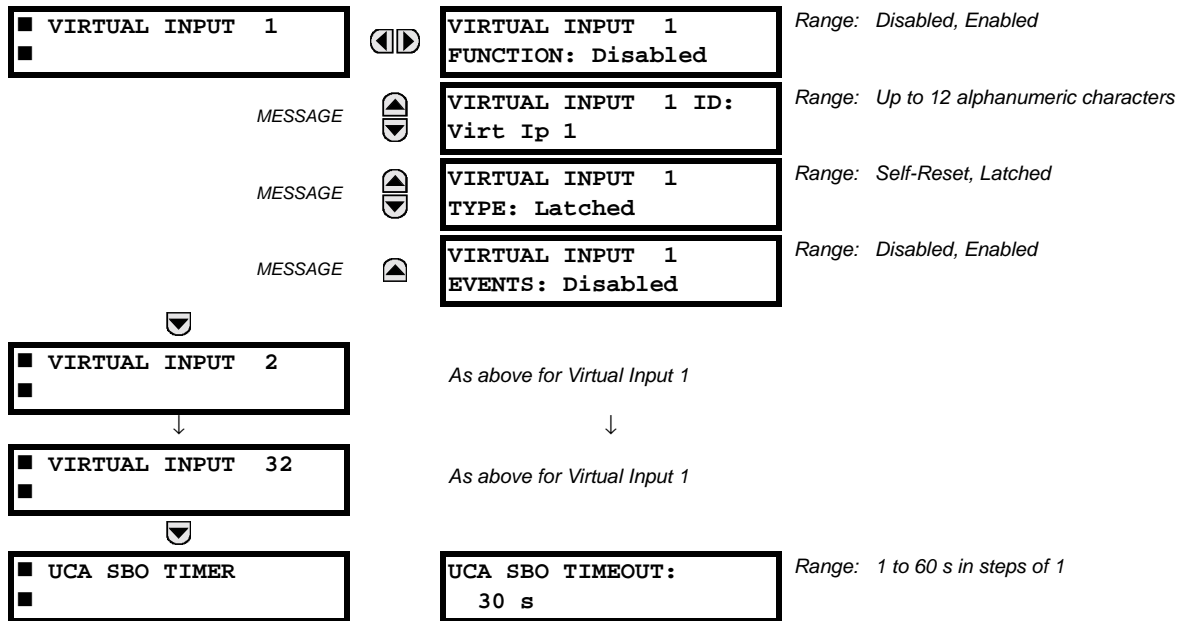
CONTACT INPUT H5A ID: "Breaker Closed (52b)"

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 ⇒



There are 32 virtual inputs that can be individually programmed to respond to input signals from the keypad (COMMANDS menu) and communications protocols. All virtual input operands are defaulted to OFF = 0 unless the appropriate input signal is received. **Virtual input states are preserved through a control power loss.**

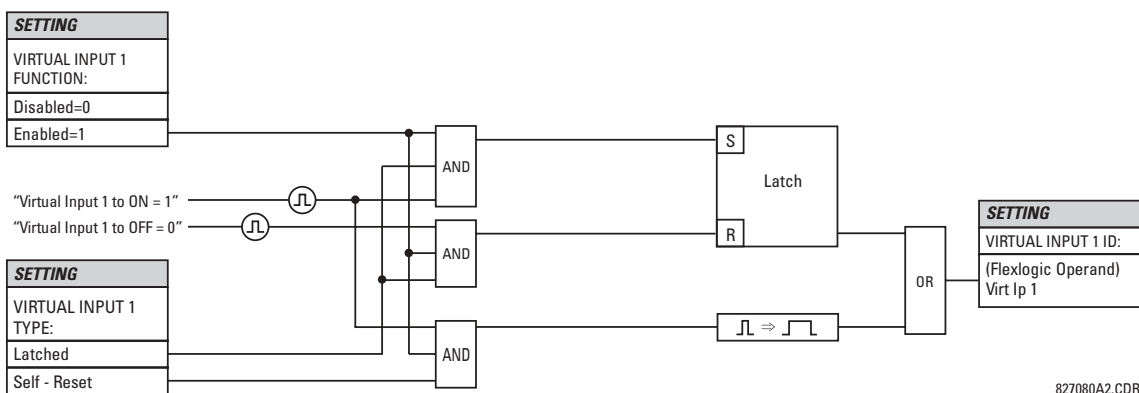
If the **VIRTUAL INPUT x FUNCTION** is to "Disabled", the input will be forced to 'OFF' (Logic 0) regardless of any attempt to alter the input. If set to "Enabled", the input operates as shown on the logic diagram and generates output FlexLogic™ operands in response to received input signals and the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

There are two types of operation: Self-Reset and Latched. If **VIRTUAL INPUT x TYPE** is "Self-Reset", when the input signal transits from OFF = 0 to ON = 1, the output operand will be set to ON = 1 for only one evaluation of the FlexLogic™ equations and then return to OFF = 0. If set to "Latched", the virtual input sets the state of the output operand to the same state as the most recent received input, ON = 1 or OFF = 0.



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.

The Select-Before-Operate timer sets the interval from the receipt of an Operate signal to the automatic de-selection of the virtual input, so that an input does not remain selected indefinitely (used only with the UCA Select-Before-Operate feature).



827080A2.CDR

Figure 5-93: VIRTUAL INPUTS SCHEME LOGIC

5.7.3 CONTACT OUTPUTS

PATH: SETTINGS ⇒ INPUTS/OUTPUTS ⇒ CONTACT OUTPUTS ⇒ CONTACT OUTPUT H1

<div> <div>CONTACT OUTPUT H1</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> </div>	<div>CONTACT OUTPUT H1 ID</div> <div>Cont Op 1</div>	Range: Up to 12 alphanumeric characters
	<div>OUTPUT H1 OPERATE:</div> <div>Off</div>	Range: FlexLogic™ operand
	<div>OUTPUT H1 SEAL-IN:</div> <div>Off</div>	Range: FlexLogic™ operand
	<div>CONTACT OUTPUT H1 EVENTS: Enabled</div>	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.

EXAMPLE:

The trip circuit current is monitored by providing a current threshold detector in series with some Form-A contacts (see the Trip Circuit Example in the Digital Elements section). The monitor will set a flag (see the Specifications for Form-A). The name of the FlexLogic™ operand set by the monitor, consists of the output relay designation, followed by the name of the flag; e.g. 'Cont Op 1 IOn' or 'Cont Op 1 IOff'.

In most breaker control circuits, the trip coil is connected in series with a breaker auxiliary contact used to interrupt current flow after the breaker has tripped, to prevent damage to the less robust initiating contact. This can be done by monitoring an auxiliary contact on the breaker which opens when the breaker has tripped, but this scheme is subject to incorrect operation caused by differences in timing between breaker auxiliary contact change-of-state and interruption of current in the trip circuit. The most dependable protection of the initiating contact is provided by directly measuring current in the tripping circuit, and using this parameter to control resetting of the initiating relay. This scheme is often called "trip seal-in".

This can be realized in the UR using the 'Cont Op 1 IOn' FlexLogic™ operand to seal-in the Contact Output as follows:

CONTACT OUTPUT H1 ID: "Cont Op 1"
 OUTPUT H1 OPERATE: any suitable FlexLogic™ operand
 OUTPUT H1 SEAL-IN: "Cont Op 1 IOn"
 CONTACT OUTPUT H1 EVENTS: "Enabled"

5.7.4 LATCHING OUTPUTS

PATH: SETTINGS ⇒ INPUTS/OUTPUTS ⇒ LATCHING OUTPUTS ⇒ LATCHING OUTPUT H1a

<div> <div>LATCHING</div> <div>OUTPUT H1a</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> <div>MESSAGE</div> </div>	<div>OUTPUT H1a ID</div> <div>L-Cont Op 1</div>	Range: Up to 12 alphanumeric characters
	<div>OUTPUT H1a OPERATE:</div> <div>Off</div>	Range: FlexLogic™ operand
	<div>OUTPUT H1a RESET:</div> <div>Off</div>	Range: FlexLogic™ operand
	<div>OUTPUT H1a TYPE:</div> <div>Operate-dominant</div>	Range: Operate-dominant, Reset-dominant
	<div>OUTPUT H1a EVENTS:</div> <div>Disabled</div>	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 H1 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, any activity exhibited by this input, such as subsequent chattering, will not have any effect.
- **OUTPUT H1 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, any activity exhibited by this input, such as subsequent chattering, will not have any effect.
- **OUTPUT H1 TYPE:** This setting specifies the contact response under conflicting control inputs; that is, when both the operate and reset signals are applied. With both control inputs applied simultaneously, the contact will close if set to “Operate-dominant” and will open if set to “Reset-dominant”.

Application Example 1:

A latching output contact H1a is to be controlled from two user-programmable pushbuttons (buttons number 1 and 2). The following settings should be applied.

Program the Latching Outputs by making the following changes in the **SETTINGS** ⇒ **INPUTS/OUTPUT** ⇒ **LATCHING OUTPUTS** ⇒ **LATCHING OUTPUT H1a** menu (assuming an H4L module):

OUTPUT H1a OPERATE: “PUSHBUTTON 1 ON”
OUTPUT H1a RESET: “PUSHBUTTON 2 ON”

Program the pushbuttons by making the following changes in the **PRODUCT SETUP** ⇒ **USER-PROGRAMMABLE PUSHBUTTONS** ⇒ **USER PUSHBUTTON 1** and **USER PUSHBUTTON 2** menus:

PUSHBUTTON 1 FUNCTION: “Self-reset” **PUSHBUTTON 2 FUNCTION:** “Self-reset”
PUSHBTN 1 DROP-OUT TIME: “0.00 s” **PUSHBTN 2 DROP-OUT TIME:** “0.00 s”

Application Example 2:

A relay, having two latching contacts H1a and H1c, is to be programmed. The H1a contact is to be a Type-a contact, while the H1c contact is to be a Type-b contact (Type-a means closed after exercising the operate input; Type-b means closed after exercising the reset input). The relay is to be controlled from virtual outputs: VO1 to operate and VO2 to reset.

Program the Latching Outputs by making the following changes in the **SETTINGS** ⇒ **INPUTS/OUTPUT** ⇒ **LATCHING OUTPUTS** ⇒ **LATCHING OUTPUT H1a** and **LATCHING OUTPUT H1c** menus (assuming an H4L module):

OUTPUT H1a OPERATE: “VO1” **OUTPUT H1c OPERATE:** “VO2”
OUTPUT H1a RESET: “VO2” **OUTPUT H1c RESET:** “VO1”

Since the two physical contacts in this example are mechanically separated and have individual control inputs, they will not operate at exactly the same time. A discrepancy in the range of a fraction of a maximum operating time may occur. Therefore, a pair of contacts programmed to be a multi-contact relay will not guarantee any specific sequence of operation (such as make before break). If required, the sequence of operation must be programmed explicitly by delaying some of the control inputs as shown in the next application example.

Application Example 3:

A make before break functionality must be added to the preceding example. An overlap of 20 ms is required to implement this functionality as described below:

Write the following FlexLogic™ equation (URPC example shown):

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	

Both timers (Timer 1 and Timer 2) should be set to 20 ms pickup and 0 ms dropout.

Program the Latching Outputs by making the following changes in the **SETTINGS** ⇒ **INPUTS/OUTPUT** ⇒ **LATCHING OUTPUTS** ⇒ **LATCHING OUTPUT H1a** and **LATCHING 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 (URPC example shown):

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	

Program the Latching Outputs by making the following changes in the **SETTINGS** ⇒ **INPUTS/OUTPUT** ⇒ **LATCHING OUTPUTS** ⇒ **LATCHING OUTPUT H1a** menu (assuming an H4L module):

OUTPUT H1a OPERATE: "VO1"

OUTPUT H1a RESET: "VO2"

5.7.5 VIRTUAL OUTPUTS

PATH: **SETTINGS** ⇒ **INPUTS/OUTPUTS** ⇒ **VIRTUAL OUTPUTS** ⇒ **VIRTUAL OUTPUT 1**

<div> <div>VIRTUAL OUTPUT 1</div> <div>MESSAGE</div> </div>	<div> <div>VIRTUAL OUTPUT 1 ID</div> <div>Virt Op 1</div> </div>	Range: Up to 12 alphanumeric characters
	<div> <div>VIRTUAL OUTPUT 1</div> <div>EVENTS: Disabled</div> </div>	Range: Disabled, Enabled

There are 64 virtual outputs that may be assigned via FlexLogic™. If not assigned, the output will be forced to 'OFF' (Logic 0). An ID may be assigned to each virtual output. Virtual outputs are resolved in each pass through the evaluation of the FlexLogic™ equations. Any change of state of a virtual output can be logged as an event if programmed to do so.

For example, if Virtual Output 1 is the trip signal from FlexLogic™ and the trip relay is used to signal events, the settings would be programmed as follows:

VIRTUAL OUTPUT 1 ID: "Trip"

VIRTUAL OUTPUT 1 EVENTS: "Disabled"

5.7.6 REMOTE DEVICES

a) REMOTE I/O OVERVIEW

Remote inputs and outputs, which are a means of exchanging information regarding the state of digital points between remote devices, are provided in accordance with the Electric Power Research Institute's (EPRI) UCA2 "Generic Object Oriented Substation Event (GOOSE)" specifications.



The UCA2 specification requires that communications between devices be implemented on Ethernet communications facilities. For UR relays, Ethernet communications is provided only on the type 9C and 9D versions of the CPU module.

The sharing of digital point state information between GOOSE equipped relays is essentially an extension to FlexLogic™ to allow distributed FlexLogic™ by making operands available to/from devices on a common communications network. In addition to digital point states, 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 from only those messages that have originated in selected devices.

GOOSE messages are designed to be short, high priority and with a high level of reliability. The GOOSE message structure contains space for 128 bit pairs representing digital point state information. The UCA specification provides 32 "DNA" bit pairs, which are status bits representing pre-defined events. All remaining bit pairs are "UserSt" bit pairs, which are status bits representing user-definable events. The UR implementation provides 32 of the 96 available UserSt bit pairs.

The UCA2 specification includes features that are used to cope with the loss of communication between transmitting and receiving devices. Each transmitting device will send a 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 to three times the programmed default time, which is required by the receiving device.

Receiving devices are constantly monitoring the communications network for messages they require, as recognized by the identification of the originating device carried in the message. Messages received from remote devices include the message "hold" time for the device. The receiving relay sets a timer assigned to the originating device to the "hold" time interval, and if it has not received another message from this device at time-out, the remote device is declared to be non-communicating, so it will use the programmed default state for all points from that specific remote device. This mechanism allows a receiving device to fail to detect a single transmission from a remote device which is sending messages at the slowest possible rate, as set by its "default update" timer, without reverting to use of the programmed default states. If a message is received from a remote device before the "hold" time expires, all points for that device are updated to the states contained in the message and the hold timer is restarted. The status of a remote device, where 'Offline' indicates 'non-communicating', can be displayed.

The GOOSE facility provides for 32 remote inputs and 64 remote outputs.

b) LOCAL DEVICES: ID OF DEVICE FOR TRANSMITTING GOOSE MESSAGES

In a UR 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 GOOSE MESSAGES

PATH: **SETTINGS** ⇒ **INPUTS/OUTPUTS** ⇒ **REMOTE DEVICES** ⇒ **REMOTE DEVICE 1(16)**

<div> <div>■</div> <div>REMOTE DEVICE 1</div> </div> <div> <div>■</div> <div></div> </div>	<div>◀▶</div>	<div> <div>REMOTE DEVICE 1 ID:</div> <div>Remote Device 1</div> </div>	<i>Range: up to 20 alphanumeric characters</i>
--	---------------	--	--

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.

5.7.7 REMOTE INPUTS

PATH: SETTINGS ⇒ INPUTS/OUTPUTS ⇒ REMOTE INPUTS ⇒ REMOTE INPUT 1(32)

■ REMOTE INPUT 1	◀▶	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 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 UCA2 specifications and is presented in the UCA2 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 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.

REMOTE IN 1 DEVICE selects the number (1 to 16) of the Remote Device which originates the required signal, as previously assigned to the remote device via the setting **REMOTE DEVICE NN ID** (see the Remote Devices section). **REMOTE IN 1 BIT PAIR** selects the specific bits of the 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 the GOOSE specification, refer to the Remote Devices section in this chapter and to Appendix C: UCA/MMS Communications.

5.7.8 REMOTE OUTPUTS

a) DNA BIT PAIRS

PATH: SETTINGS ⇒ INPUTS/OUTPUTS ⇒ REMOTE OUTPUTS DNA BIT PAIRS ⇒ REMOTE OUPUTS DNA- 1 BIT PAIR

☒ REMOTE OUTPUTS
☒ DNA- 1 BIT PAIR

DNA- 1 OPERAND:
 Off

Range: FlexLogic™ Operand

MESSAGE

DNA- 1 EVENTS:
 Disabled

Range: Disabled, Enabled

Remote Outputs (1 to 32) are FlexLogic™ operands inserted into 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 5–22: UCA DNA2 ASSIGNMENTS

DNA	DEFINITION	INTENDED FUNCTION	LOGIC 0	LOGIC 1
1	OperDev		Trip	Close
2	Lock Out		LockoutOff	LockoutOn
3	Initiate Reclosing	Initiate remote reclose sequence	InitRecloseOff	InitRecloseOn
4	Block Reclosing	Prevent/cancel remote reclose sequence	BlockOff	BlockOn
5	Breaker Failure Initiate	Initiate remote breaker failure scheme	BFIOff	BFION
6	Send Transfer Trip	Initiate remote trip operation	TxXfrTripOff	TxXfrTripOn
7	Receive Transfer Trip	Report receipt of remote transfer trip command	RxXfrTripOff	RxXfrTripOn
8	Send Perm	Report permissive affirmative	TxPermOff	TxPermOn
9	Receive Perm	Report receipt of permissive affirmative	RxPermOff	RxPermOn
10	Stop Perm	Override permissive affirmative	StopPermOff	StopPermOn
11	Send Block	Report block affirmative	TxBlockOff	TxBlockOn
12	Receive Block	Report receipt of block affirmative	RxBlockOff	RxBlockOn
13	Stop Block	Override block affirmative	StopBlockOff	StopBlockOn
14	BkrDS	Report breaker disconnect 3-phase state	Open	Closed
15	BkrPhsADS	Report breaker disconnect phase A state	Open	Closed
16	BkrPhsBDS	Report breaker disconnect phase B state	Open	Closed
17	BkrPhsCDS	Report breaker disconnect phase C state	Open	Closed
18	DiscSwDS		Open	Closed
19	Interlock DS		DSLCKOff	DSLCKOn
20	LineEndOpen	Report line open at local end	Open	Closed
21	Status	Report operating status of local GOOSE device	Offline	Available
22	Event		EventOff	EventOn
23	Fault Present		FaultOff	FaultOn
24	Sustained Arc	Report sustained arc	SustArcOff	SustArcOn
25	Downed Conductor	Report downed conductor	DownedOff	DownedOn
26	Sync Closing		SyncClsOff	SyncClsOn
27	Mode	Report mode status of local GOOSE device	Normal	Test
28→32	Reserved			



For more information on GOOSE specifications, see the Remote I/O Overview in the Remote Devices section.

NOTE

b) USERST BIT PAIRS

PATH: SETTINGS ⇒ INPUTS/OUTPUTS ⇒ REMOTE OUTPUTS UserSt BIT PAIRS ⇒ REMOTE OUTPUTS UserSt- 1 BIT PAIR

<input checked="" type="checkbox"/> REMOTE OUTPUTS <input checked="" type="checkbox"/> UserSt- 1 BIT PAIR	<input type="button" value="◀"/> <input type="button" value="▶"/>	UserSt- 1 OPERAND: Off	Range: FlexLogic™ operand
	MESSAGE <input type="button" value="▲"/>	UserSt- 1 EVENTS: Disabled	Range: Disabled, Enabled

Remote Outputs 1 to 32 originate as 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 GOOSE messages when there has been no change of state of any selected digital point. This setting is located in the **PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ UCA/MMS PROTOCOL** settings menu.

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



For more information on GOOSE specifications, see the Remote I/O Overview in the Remote Devices section.

5.7.9 RESETTING

PATH: SETTINGS ⇒ INPUTS/OUTPUTS ⇒ RESETTING

<input checked="" type="checkbox"/> RESETTING	<input type="button" value="◀"/> <input type="button" value="▶"/>	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 FlexLogic™ operand "RESET OP". Each individual source of a RESET command also creates its individual operand RESET OP (PUSHBUTTON), RESET OP (COMMS) or RESET OP (OPERAND) to identify the source of the command. The setting shown above selects the operand that will create the RESET OP (OPERAND) operand.

5.7.10 DIRECT INPUTS/OUTPUTS

a) DIRECT INPUTS

PATH: SETTINGS ⇒ INPUTS/OUTPUTS ⇒ DIRECT INPUTS ⇒ DIRECT INPUT 1(32)

<input checked="" type="checkbox"/> DIRECT INPUT 1	<input type="button" value="◀"/> <input type="button" value="▶"/>	DIRECT INPUT 1 DEVICE ID: 1	Range: 1 to 8
	MESSAGE <input type="button" value="▲"/>	DIRECT INPUT 1 BIT NUMBER: 1	Range: 1 to 32
	MESSAGE <input type="button" value="▲"/>	DIRECT INPUT 1 DEFAULT STATE: Off	Range: On, Off, Latest/On, Latest/Off
	MESSAGE <input type="button" value="▲"/>	DIRECT INPUT 1 EVENTS: Disabled	Range: Enabled, Disabled

These settings specify how the Direct Input information is processed. The **DIRECT INPUT DEVICE ID** represents the source of this Direct Input. The specified Direct Input is driven by the device identified here.

The **DIRECT INPUT 1 BIT NUMBER** is the bit number to extract the state for this Direct Input. Direct Input x is driven by the bit identified here as **DIRECT INPUT 1 BIT NUMBER**. This corresponds to the Direct Output Number of the sending device.

The **DIRECT INPUT 1 DEFAULT STATE** represents the state of the Direct Input when the associated Direct Device is offline. The following choices are available:

- Setting **DIRECT INPUT 1 DEFAULT STATE** to “On” value defaults the input to Logic 1.
- Setting **DIRECT INPUT 1 DEFAULT STATE** to “Off” value defaults the input to Logic 0.
- Setting **DIRECT INPUT 1 DEFAULT STATE** to “Latest/On” freezes the input in case of lost communications. If the latest state is not known, such as after relay power-up but before the first communication exchange, the input will default to Logic 1. When communication resumes, the input becomes fully operational.
- Setting **DIRECT INPUT 1 DEFAULT STATE** to “Latest/Off” freezes the input in case of lost communications. If the latest state is not known, such as after relay power-up but before the first communication exchange, the input will default to Logic 0. When communication resumes, the input becomes fully operational.

b) DIRECT OUTPUTS

PATH: SETTINGS ⇒ INPUTS/OUTPUTS ⇒ DIRECT OUTPUTS ⇒ DIRECT OUTPUT 1(32)

<div> <div>DIRECT OUTPUT 1</div> <div>MESSAGE</div> </div>	<div> <div>◀▶</div> <div>▲</div> </div>	<div>DIRECT OUT 1 OPERAND:</div> <div>Off</div>	Range: FlexLogic™ operand
		<div>DIRECT OUTPUT 1</div> <div>EVENTS: Disabled</div>	Range: Enabled, Disabled

The **DIR OUT 1 OPERAND** is the FlexLogic™ operand that determines the state of this Direct Output.

c) APPLICATION EXAMPLES

The example introduced in the Product Setup section for Direct I/Os is continued below to illustrate usage of the Direct Inputs and Outputs.

EXAMPLE 1: EXTENDING I/O 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 chassis. The problem is solved by adding an extra UR IED, such as the C30, to satisfy the additional I/Os and programmable logic requirements. The two IEDs are connected via single-channel digital communication cards as shown below.

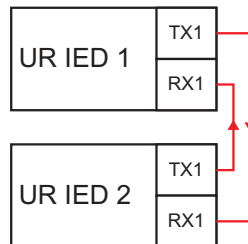


Figure 5–94: INPUT/OUTPUT EXTENSION VIA DIRECT I/OS

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.

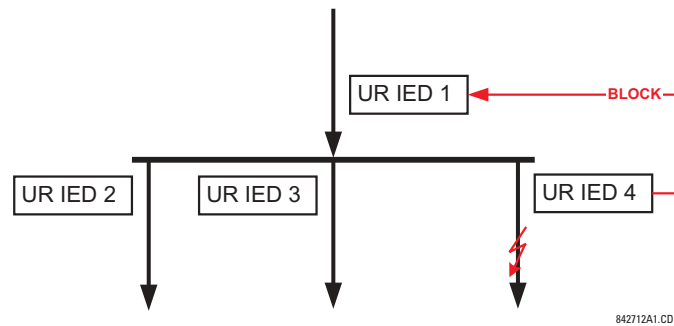


Figure 5-95: SAMPLE INTERLOCKING BUSBAR PROTECTION SCHEME

Assume that Phase IOC1 is used by Devices 2, 3, and 4 to block Device 1. If not blocked, Device 1 would trip the bus upon detecting a fault and applying a short coordination time delay.

The following settings should be applied (assume Bit 3 is used by all 3 devices to send the blocking signal and Direct Inputs 7, 8, and 9 are used by the receiving device to monitor the three blocking signals):

UR IED 2: **DIRECT OUT 3 OPERAND:** "PHASE IOC1 OP"

UR IED 3: **DIRECT OUT 3 OPERAND:** "PHASE IOC1 OP"

UR IED 4: **DIRECT OUT 3 OPERAND:** "PHASE IOC1 OP"

UR IED 1: **DIRECT INPUT 7 DEVICE ID:** "2"

DIRECT INPUT 7 BIT NUMBER: "3"

DIRECT INPUT 7 DEFAULT STATE: select "On" for security, select "Off" for dependability

DIRECT INPUT 8 DEVICE ID: "3"

DIRECT INPUT 8 BIT NUMBER: "3"

DIRECT INPUT 8 DEFAULT STATE: select "On" for security, select "Off" for dependability

DIRECT INPUT 9 DEVICE ID: "4"

DIRECT INPUT 9 BIT NUMBER: "3"

DIRECT INPUT 9 DEFAULT STATE: select "On" for security, select "Off" for dependability

Now the three blocking signals are available in UR IED 1 as "DIRECT INPUT 7 ON", "DIRECT INPUT 8 ON", and "DIRECT INPUT 9 ON". Upon losing communications or a device, the scheme is inclined to block (if any default state is set to "ON"), or to trip the bus on any overcurrent condition (all default states set to "OFF").

EXAMPLE 2: PILOT-AIDED SCHEMES

Consider a three-terminal line protection application shown in the figure below.

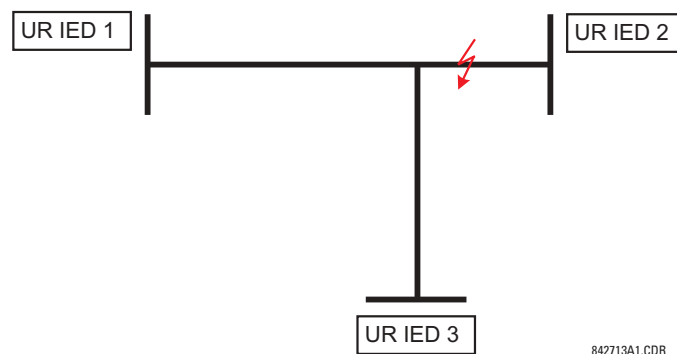


Figure 5-96: THREE-TERMINAL LINE APPLICATION

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.

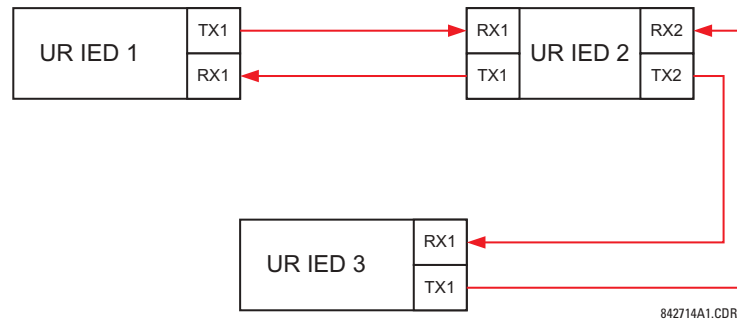


Figure 5-97: SINGLE-CHANNEL OPEN-LOOP CONFIGURATION

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:

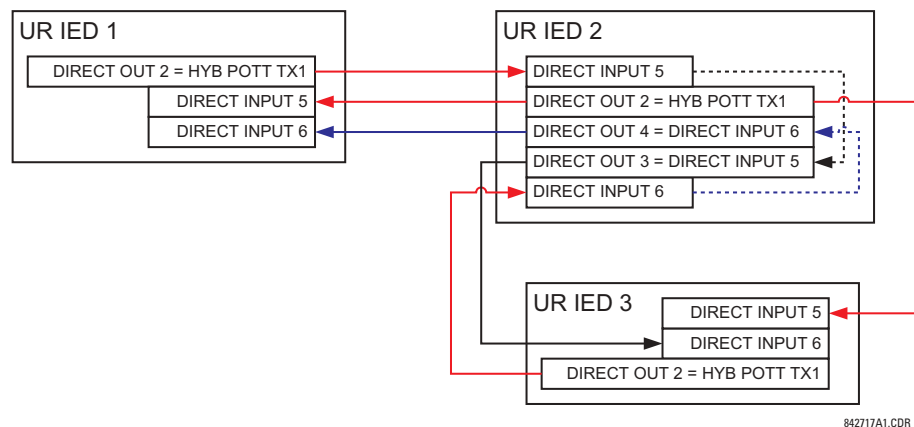
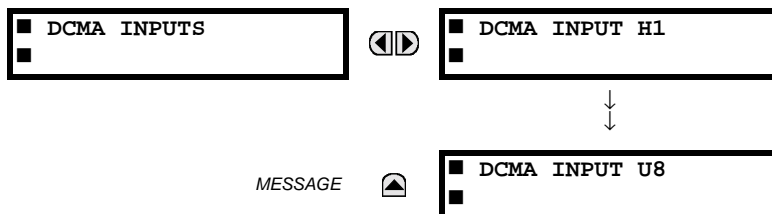


Figure 5-98: SIGNAL FLOW FOR DIRECT I/O EXAMPLE 3

In three-terminal applications, both the remote terminals must grant permission to trip. Therefore, at each terminal, Direct Inputs 5 and 6 should be ANDed in FlexLogic™ and the resulting operand configured as the permission to trip (HYB POTT RX1 setting).

5.8.1 DCMA INPUTS

PATH: SETTINGS ⇒ TRANSDUCER I/O ⇒ DCMA INPUTS



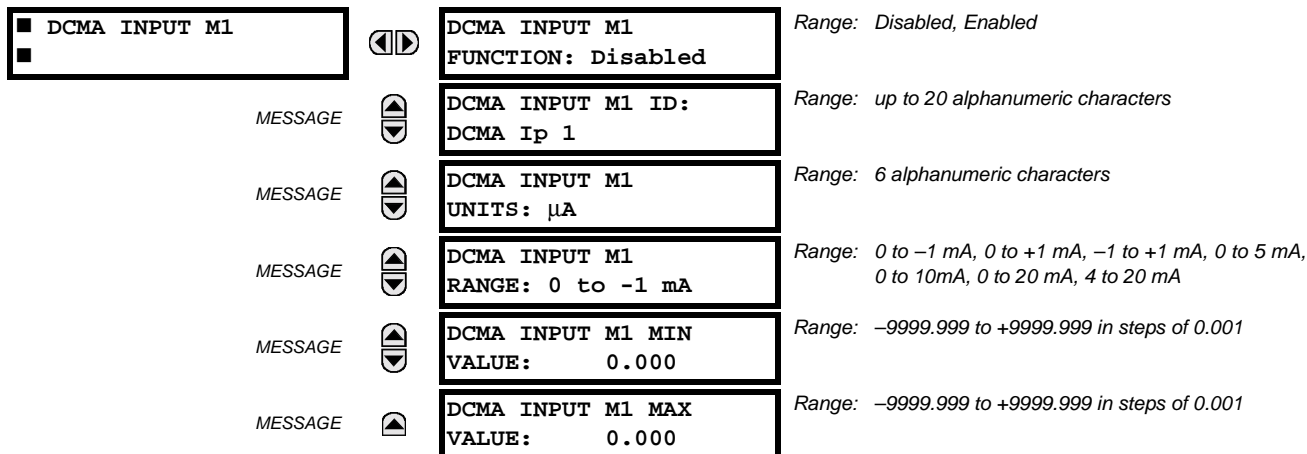
Hardware and software is provided to receive signals from external transducers and convert these signals into a digital format for use as required. The relay will accept inputs in the range of -1 to $+20$ mA DC, suitable for use with most common transducer output ranges; all inputs are assumed to be 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 below for the first channel of a type 5F transducer module installed in slot M.

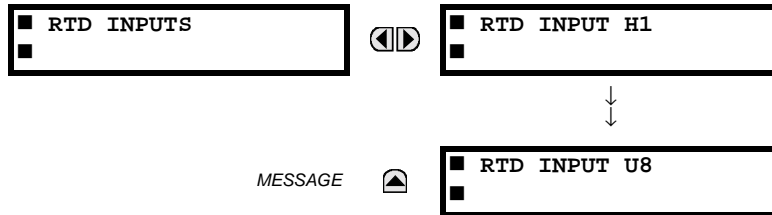


The function of the channel may be either "Enabled" or "Disabled." If "Disabled", no actual values are created for the channel. An alphanumeric "ID" is assigned to each channel; this ID will be included in the channel actual value, along with the programmed units associated with the parameter measured by the transducer, such as Volt, $^{\circ}$ 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 XX RANGE** setting specifies the mA DC range of the transducer connected to the input channel.

The **DCMA INPUT XX MIN VALUE** and **DCMA INPUT XX 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 XX MIN VALUE** value is "0" and the **DCMA INPUT XX MAX VALUE** value is "250". Another example would be a Watt transducer with a span from -20 to $+180$ MW; in this case the **DCMA INPUT XX MIN VALUE** value would be " -20 " and the **DCMA INPUT XX 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

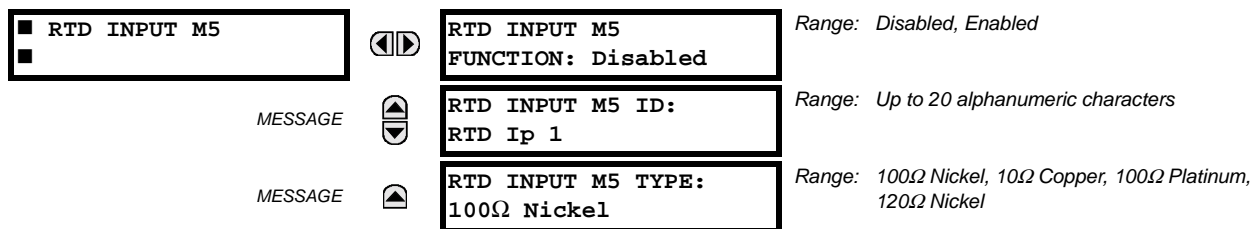


Hardware and software is provided to receive signals from external Resistance Temperature Detectors and convert these signals into a digital format for use as required. These channels are intended to be connected to any of the RTD types in common use. Specific hardware details are contained in Chapter 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 below for the first channel of a type 5C transducer module installed in slot M.

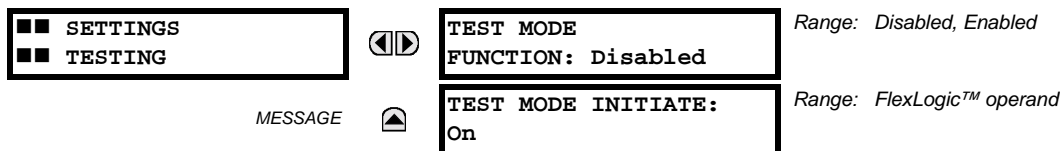


The function of the channel may be either “Enabled” or “Disabled.” If Disabled, there will not be an actual value created for the channel. An alphanumeric “ID” is assigned to the channel; this ID will be included in the channel actual values. It is also used to reference the channel as the input parameter 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.

5.9.1 TEST MODE

PATH: SETTINGS ⇒ TESTING ⇒ TEST MODE



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

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

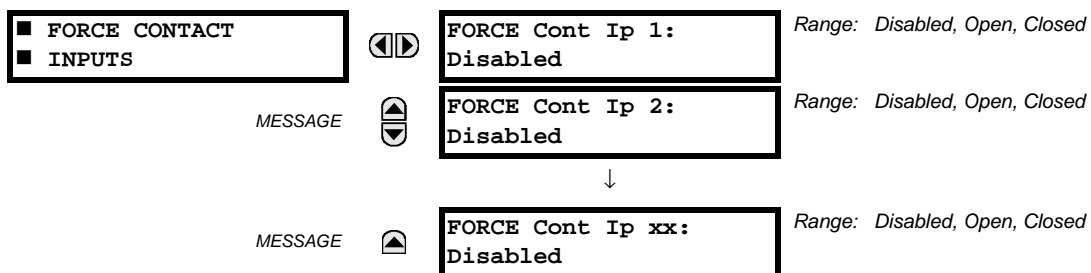
- To initiate Test Mode through relay settings, set **TEST MODE INITIATE** to “On”. The Test Mode starts when the **TEST MODE FUNCTION** setting is changed from “Disabled” to “Enabled”.
- To initiate Test Mode through a user-programmable condition, such as FlexLogic™ operand (pushbutton, digital input,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

When in Test Mode, the 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.

5.9.2 FORCE CONTACT INPUTS

PATH: SETTINGS ⇒ TESTING ⇒ FORCE CONTACT INPUTS



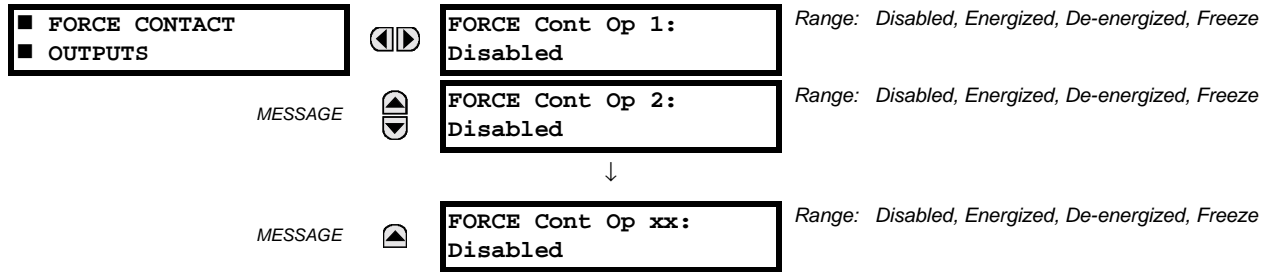
The relay digital inputs (contact inputs) could be pre-programmed to respond to the Test Mode in the following ways:

- If set to “Disabled”, the input remains fully operational. It is controlled by the voltage across its input terminals and can be turned on and off by external circuitry. This value should be selected if a given input must be operational during the test. This includes, for example, an input initiating the test, or being a part of a user pre-programmed test sequence.
- If set to “Open”, the input is forced to report as opened (Logic 0) for the entire duration of the Test Mode regardless of the voltage across the input terminals.
- If set to “Closed”, the input is forced to report as closed (Logic 1) for the entire duration of the Test Mode regardless of the voltage across the input terminals.

The Force Contact Inputs feature provides a method of performing checks on the function of all contact inputs. Once enabled, the relay is placed into Test Mode, allowing this feature to override the normal function of contact inputs. The Test Mode LED will be On, indicating that the relay is in Test Mode. The state of each contact input may be programmed as “Disabled”, “Open”, or “Closed”. All contact input operations return to normal when all settings for this feature are disabled.

5.9.3 FORCE CONTACT OUTPUTS

PATH: SETTINGS ⇒ TESTING ⇒ FORCE CONTACT OUTPUTS



The relay contact outputs can be pre-programmed to respond to the Test Mode.

If set to "Disabled", the contact output remains fully operational. If operates when its control operand is Logic 1 and will resets when its control operand is Logic 0. If set to "Energize", the output will close and remain closed for the entire duration of the Test Mode, regardless of the status of the operand configured to control the output contact. If set to "De-energize", the output will open and remain opened for the entire duration of the Test Mode regardless of the status of the operand configured to control the output contact. If set to "Freeze", the output retains its position from before entering the Test Mode, regardless of the status of the operand configured to control the output contact.

These settings are applied two ways. First, external circuits may be tested by energizing or de-energizing contacts. Second, by controlling the output contact state, relay logic may be tested and undesirable effects on external circuits avoided.

Example 1: Initiating a Test from User-Programmable Pushbutton 1

The Test Mode should be initiated from User-Programmable Pushbutton 1. The pushbutton will be programmed as "Latched" (pushbutton pressed to initiate the test, and pressed again to terminate the test). During the test, Digital Input 1 should remain operational, Digital Inputs 2 and 3 should open, and Digital Input 4 should close. Also, Contact Output 1 should freeze, Contact Output 2 should open, Contact Output 3 should close, and Contact Output 4 should remain fully operational. The required settings are shown below.

To enable User-Programmable Pushbutton 1 to initiate the Test mode, make the following changes in the **SETTINGS ⇒ TESTING ⇒ TEST MODE** menu:

TEST MODE FUNCTION: "Enabled" and **TEST MODE INITIATE:** "PUSHBUTTON 1 ON"

Make the following changes to configure the Contact I/Os. In the **SETTINGS ⇒ TESTING ⇒ FORCE CONTACT INPUTS** and **FORCE CONTACT OUTPUTS** menus, set:

FORCE Cont Ip 1: "Disabled", **FORCE Cont Ip 2:** "Open", **FORCE Cont Ip 3:** "Open", and **FORCE Cont Ip 4:** "Closed"

FORCE Cont Op 1: "Freeze", **FORCE Cont Op 2:** "De-energized", **FORCE Cont Op 3:** "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 (URPC example shown):

FLEXLOGIC ENTRY	TYPE	SYNTAX
View Graphics	View	View
FlexLogic Entry 1	Remote Inputs On	Remote IP 1 ON
FlexLogic Entry 2	Protection Element	PUSHBUTTON 1 ON
FlexLogic Entry 3	OR	2 Input
FlexLogic Entry 4	Wire Virtual Output(Assign)	= Virt Op 1 (VO1)
FlexLogic Entry 5	End of List	

Set the User Programmable Pushbutton as latching by changing **SETTINGS ⇒ PRODUCT SETUP ⇒ USER-PROGRAMMABLE PUSHBUTTONS ⇒ USER PUSHBUTTON 1 ⇒ PUSHBUTTON 1 FUNCTION** to "Latched". To enable either Pushbutton 1 or Remote Input 1 to initiate the Test mode, make the following changes in the **SETTINGS ⇒ TESTING ⇒ TEST MODE** menu:

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

6.1.1 ACTUAL VALUES MAIN MENU

<div> <div>■ ■ ACTUAL VALUES</div> <div>■ ■ STATUS</div> </div>	◀▶	<div>■ CONTACT INPUTS</div> <div>■</div>	See page 6-3.
▼	▲▼	<div>■ VIRTUAL INPUTS</div> <div>■</div>	See page 6-3.
	▲▼	<div>■ REMOTE INPUTS</div> <div>■</div>	See page 6-3.
	▲▼	<div>■ CONTACT OUTPUTS</div> <div>■</div>	See page 6-4.
	▲▼	<div>■ VIRTUAL OUTPUTS</div> <div>■</div>	See page 6-4.
	▲▼	<div>■ AUTORECLOSE</div> <div>■</div>	See page 6-4.
	▲▼	<div>■ REMOTE DEVICES</div> <div>■ STATUS</div>	See page 6-4.
	▲▼	<div>■ REMOTE DEVICES</div> <div>■ STATISTICS</div>	See page 6-5.
	▲▼	<div>■ DIGITAL COUNTERS</div> <div>■</div>	See page 6-5.
	▲▼	<div>■ SELECTOR SWITCHES</div> <div>■</div>	See page 6-5.
	▲▼	<div>■ FLEX STATES</div> <div>■</div>	See page 6-5.
	▲▼	<div>■ ETHERNET</div> <div>■</div>	See page 6-6.
	▲▼	<div>■ HIZ STATUS</div> <div>■</div>	See page 6-6.
	▲▼	<div>■ DIRECT INPUTS</div> <div>■</div>	See page 6-6.
▲	▲	<div>■ DIRECT DEVICES</div> <div>■ STATUS</div>	See page 6-7.
<div> <div>■ ■ ACTUAL VALUES</div> <div>■ ■ METERING</div> </div>	◀▶	<div>■ SOURCE SRC 1</div> <div>■</div>	See page 6-11.
▼	▲▼	<div>■ SOURCE SRC 2</div> <div>■</div>	See page 6-11.
	▲▼	<div>■ SENSITIVE</div> <div>■ DIRECTIONAL POWER</div>	See page 6-15.
	▲▼	<div>■ SYNCHROCHECK</div> <div>■</div>	See page 6-16.
	▲▼	<div>■ TRACKING FREQUENCY</div> <div>■</div>	See page 6-16.
	▲▼	<div>■ FREQUENCY RATE</div> <div>■ OF CHANGE</div>	See page 6-16.

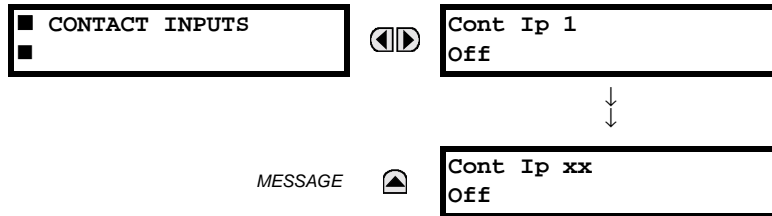
<div>▲</div> <div>■ ■ ACTUAL VALUES ■ ■ RECORDS</div> <div>▼</div>	▲ ▼	■ FLEXELEMENTS ■	See page 6-17.
	▲ ▼	■ TRANSDUCER I/O ■ DCMA INPUTS	See page 6-17.
	▲	■ TRANSDUCER I/O ■ RTD INPUTS	See page 6-17.
<div>▲</div> <div>■ ■ ACTUAL VALUES ■ ■ PRODUCT INFO</div> <div>▼</div>	◀▶	■ FAULT REPORTS ■	See page 6-18.
	▲ ▼	■ EVENT RECORDS ■	See page 6-20.
	▲ ▼	■ OSCILLOGRAPHY ■	See page 6-20.
	▲ ▼	■ DATA LOGGER ■	See page 6-20.
	▲ ▼	■ MAINTENANCE ■	See page 6-21.
	▲	■ HIZ RECORDS ■	See page 6-21.
<div>▲</div> <div>■ ■ ACTUAL VALUES ■ ■ PRODUCT INFO</div> <div>▼</div>	◀▶	■ MODEL INFORMATION ■	See page 6-22.
	▲	■ FIRMWARE REVISIONS ■	See page 6-22.



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

6.2.1 CONTACT INPUTS

PATH: ACTUAL VALUES ⇒ STATUS ⇒ CONTACT INPUTS



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

6.2.2 VIRTUAL INPUTS

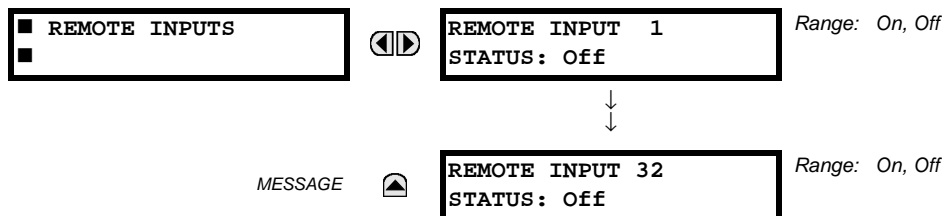
PATH: ACTUAL VALUES ⇒ STATUS ⇒ VIRTUAL INPUTS



The present status of the 32 virtual inputs is shown here. The first line of a message display indicates the ID of the virtual input. For example, 'Virt Ip 1' refers to the virtual input in terms of the default name-array index. The second line of the display indicates the logic state of the virtual input.

6.2.3 REMOTE INPUTS

PATH: ACTUAL VALUES ⇒ STATUS ⇒ REMOTE INPUTS

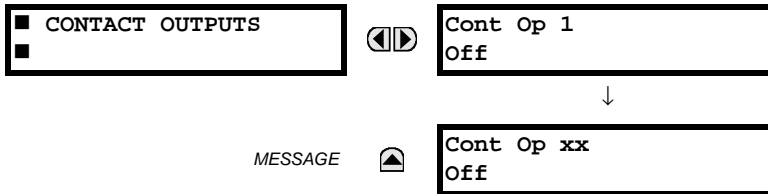


The present state of the 32 remote inputs is shown here.

The state displayed will be that of the remote point unless the remote device has been established to be "Offline" in which case the value shown is the programmed default state for the remote input.

6.2.4 CONTACT OUTPUTS

PATH: ACTUAL VALUES ⇒ STATUS ⇒ CONTACT OUTPUTS



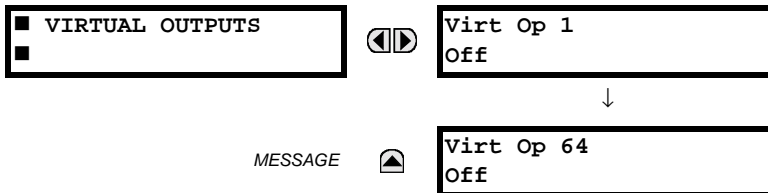
The present state of the contact outputs is shown here. The first line of a message display indicates the ID of the contact output. For example, 'Cont Op 1' refers to the contact output in terms of the default name-array index. The second line of the display indicates the logic state of the contact output.



For Form-A outputs, the state of the voltage(V) and/or current(I) detectors will show as: Off, VOff, IOff, On, VOn, and/or IOn. For Form-C outputs, the state will show as Off or On.

6.2.5 VIRTUAL OUTPUTS

PATH: ACTUAL VALUES ⇒ STATUS ⇒ VIRTUAL OUTPUTS



The present state of up to 64 virtual outputs is shown here. The first line of a message display indicates the ID of the virtual output. For example, 'Virt Op 1' refers to the virtual output in terms of the default name-array index. The second line of the display indicates the logic state of the virtual output, as calculated by the FlexLogic™ equation for that output.

6.2.6 AUTORECLOSE

PATH: ACTUAL VALUES ⇒ STATUS ⇒ AUTORECLOSE ⇒ AUTORECLOSE 1

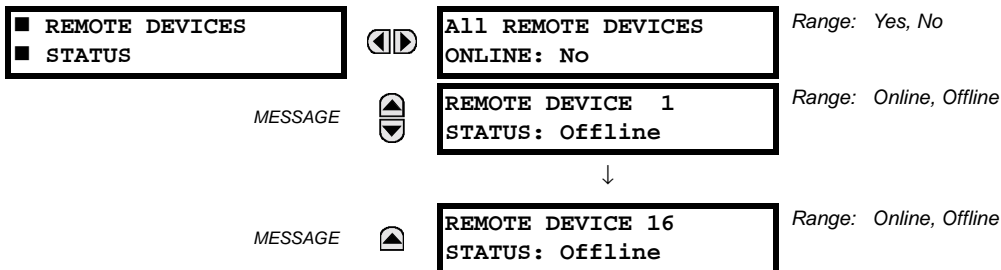


The automatic reclosure shot count is shown here.

6.2.7 REMOTE DEVICES

a) STATUS

PATH: ACTUAL VALUES ⇒ STATUS ⇒ REMOTE DEVICES STATUS



The present state of up to 16 programmed Remote Devices is shown here. The **ALL REMOTE DEVICES ONLINE** message indicates whether or not all programmed Remote Devices are online. If the corresponding state is "No", then at least one required Remote Device is not online.

b) STATISTICS

PATH: ACTUAL VALUES ⇒ STATUS ⇒ REMOTE DEVICES STATISTICS ⇒ REMOTE DEVICE 1(16)

■ REMOTE DEVICE 1	◀▶	REMOTE DEVICE 1 StNum: 0
■		
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 GOOSE message is sent. This number will rollover to zero when a count of 4,294,967,295 is incremented.

6.2.8 DIGITAL COUNTERS

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

■ DIGITAL COUNTERS	◀▶	Counter 1 ACCUM: 0
■ Counter 1		
MESSAGE ▲	▲▼	Counter 1 FROZEN: 0
MESSAGE ▲	▲▼	Counter 1 FROZEN: YYYY/MM/DD HH:MM:SS
MESSAGE ▲	▲▼	Counter 1 MICROS: 0

The present status of the 8 digital counters is shown here. The status of each counter, with the user-defined counter name, includes the accumulated and frozen counts (the count units label will also appear). Also included, is the date/time stamp for the frozen count. The **Counter n MICROS** value refers to the microsecond portion of the time stamp.

6.2.9 SELECTOR SWITCHES

PATH: ACTUAL VALUES ⇒ STATUS ⇒ SELECTOR SWITCHES

■ SELECTOR SWITCHES	◀▶	SELECTOR SWITCH 1 POSITION: 1/7	Range: Current Position / 7
■			
MESSAGE ▲	▲▼	SELECTOR SWITCH 2 POSITION: 1/7	Range: Current Position / 7

The display shows both the current position and the full range. The current position only (an integer from 0 through 7) is the actual value.

6.2.10 FLEX STATES

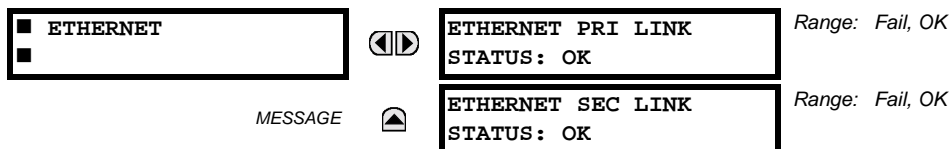
PATH: ACTUAL VALUES ⇒ STATUS ⇒ FLEX STATES

■ FLEX STATES	◀▶	PARAM 1: Off Off	Range: Off, On
■			
MESSAGE ▲	↓	PARAM 256: Off Off	Range: Off, On

There are 256 FlexState bits available. The second line value indicates the state of the given FlexState bit.

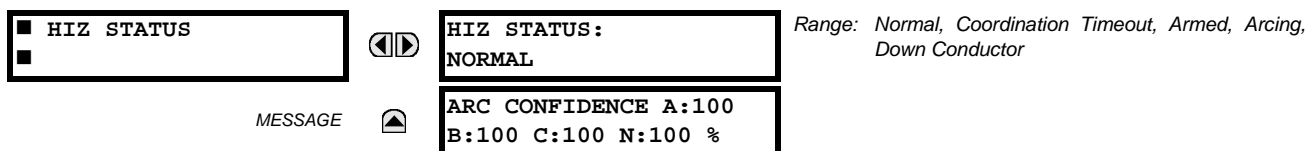
6.2.11 ETHERNET

PATH: ACTUAL VALUES ⇒ STATUS ⇒ ⚡ ETHERNET



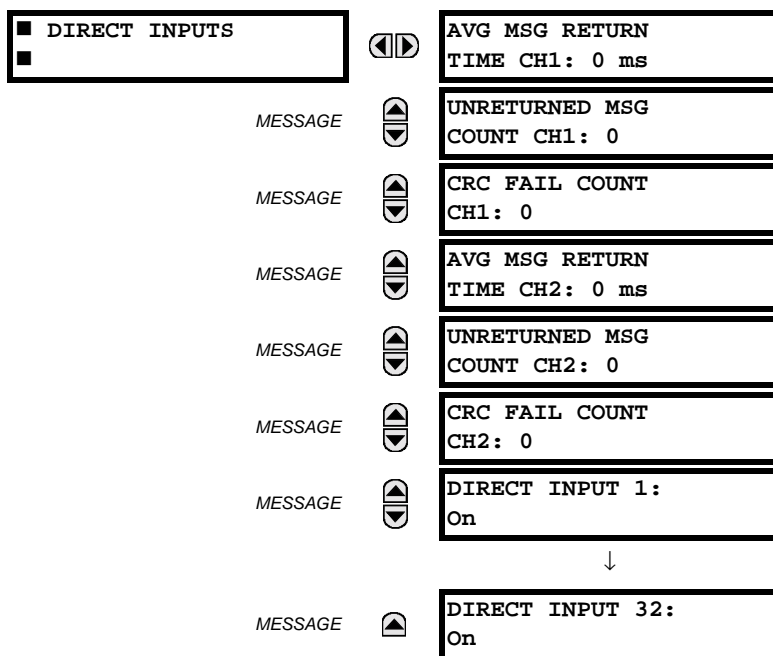
6.2.12 HI-Z STATUS

PATH: ACTUAL VALUES ⇒ STATUS ⇒ ⚡ HI-Z STATUS



6.2.13 DIRECT INPUTS

PATH: ACTUAL VALUES ⇒ STATUS ⇒ ⚡ DIRECT INPUTS



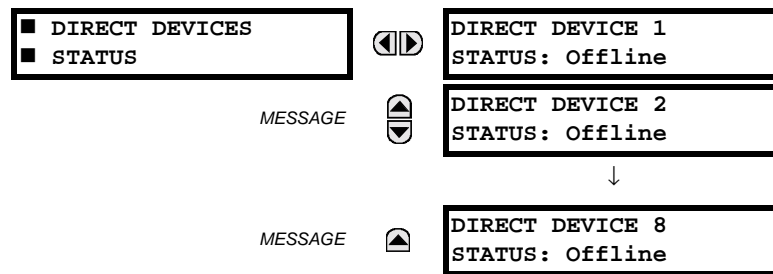
The **AVERAGE MSG RETURN TIME** is the time taken for Direct Output messages to return to the sender in a Direct I/O ring configuration (this value is not applicable for non-ring configurations). This is a rolling average calculated for the last 10 messages. There are two return times for dual-channel communications modules.

The **UNRETURNED MSG COUNT** values (one per communications channel) count the Direct Output messages that do not make the trip around the communications ring. The **CRC FAIL COUNT** values (one per communications channel) count the Direct Output messages that have been received but fail the CRC check. High values for either of these counts may indicate on a problem with wiring, the communication channel, or the relay(s). The **UNRETURNED MSG COUNT** and **CRC FAIL COUNT** values can be cleared using the **CLEAR DIRECT I/O COUNTERS** command.

The **DIRECT INPUT x** values represent the state of the x-th Direct Input.

6.2.14 DIRECT DEVICES STATUS

PATH: ACTUAL VALUES ⇒ STATUS ⇒ DIRECT DEVICES STATUS



These actual values represent the state of Direct Devices 1 through 8.

6.3.1 METERING CONVENTIONS

a) UR CONVENTION FOR MEASURING POWER AND ENERGY

The following figure illustrates the conventions established for use in UR relays.

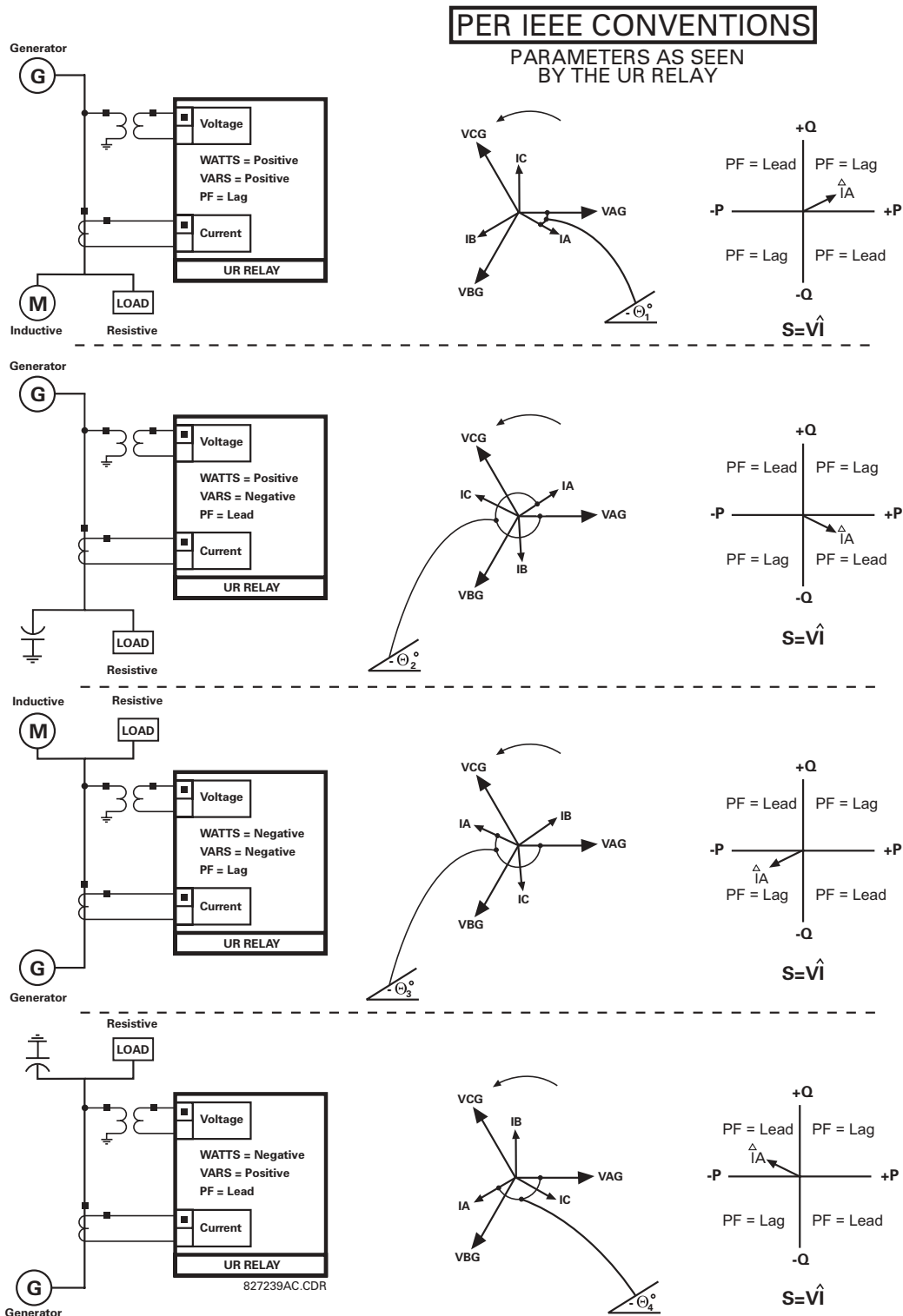


Figure 6-1: FLOW DIRECTION OF SIGNED VALUES FOR WATTS AND VARS

b) UR CONVENTION FOR MEASURING PHASE ANGLES

All phasors calculated by UR 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.

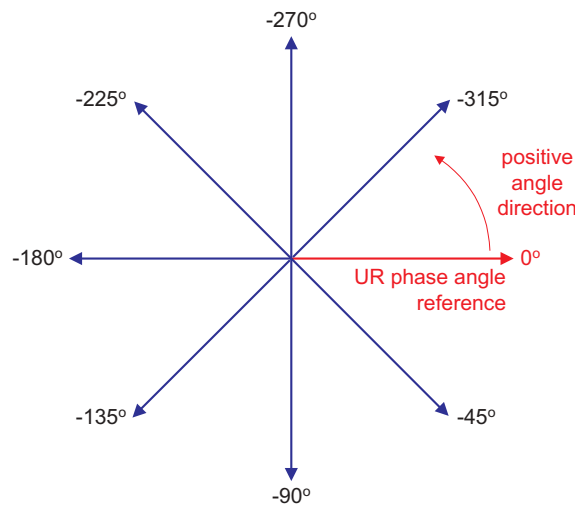


Figure 6-2: UR PHASE ANGLE MEASUREMENT CONVENTION

c) UR CONVENTION FOR SYMMETRICAL COMPONENTS

UR relays calculate voltage symmetrical components for the power system phase A line-to-neutral voltage, and symmetrical components of the currents for the power system phase A current. Owing to the above definition, phase angle relations between the symmetrical currents and voltages stay the same irrespective of the connection of instrument transformers. This is important for setting directional protection elements that use symmetrical voltages.

For display and oscillography purposes the phase angles of symmetrical components are referenced to a common reference as described in the previous sub-section.

WYE-Connected Instrument Transformers:

- ABC phase rotation:

$$V_{-0} = \frac{1}{3}(V_{AG} + V_{BG} + V_{CG})$$

$$V_{-1} = \frac{1}{3}(V_{AG} + aV_{BG} + a^2V_{CG})$$

$$V_{-2} = \frac{1}{3}(V_{AG} + a^2V_{BG} + aV_{CG})$$

- ACB phase rotation:

$$V_{-0} = \frac{1}{3}(V_{AG} + V_{BG} + V_{CG})$$

$$V_{-1} = \frac{1}{3}(V_{AG} + a^2V_{BG} + aV_{CG})$$

$$V_{-2} = \frac{1}{3}(V_{AG} + aV_{BG} + a^2V_{CG})$$

The above equations apply to currents as well.

DELTA-Connected Instrument Transformers:

- ABC phase rotation:

$$V_{-0} = \text{N/A}$$

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

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

- ACB phase rotation:

$$V_{-0} = \text{N/A}$$

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

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

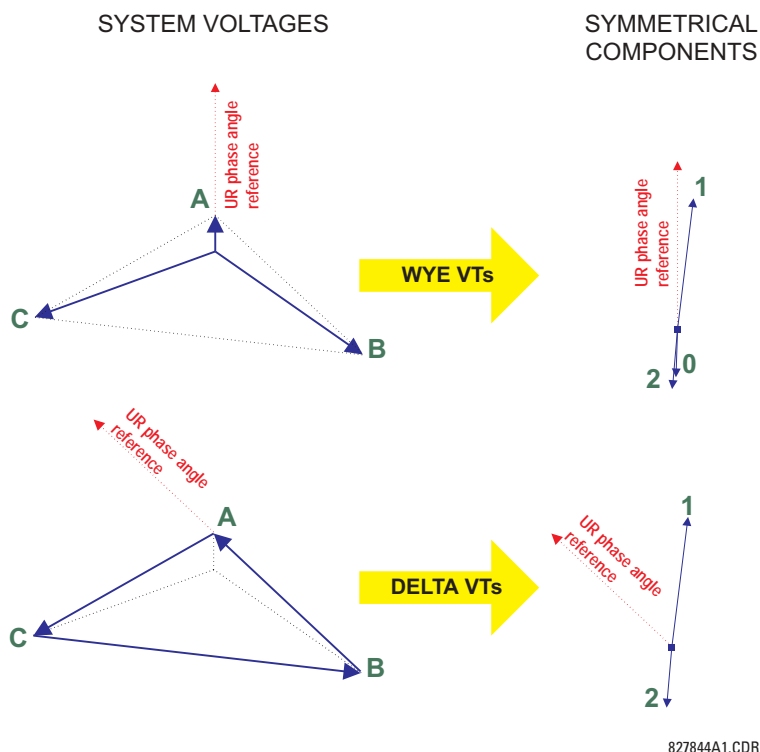
The zero-sequence voltage is not measurable under the Delta connection of instrument transformers and is defaulted to zero. The table below shows an example of symmetrical components calculations for the ABC phase rotation.

Table 6–1: SYMMETRICAL COMPONENTS CALCULATION EXAMPLE

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

- * The power system voltages are phase-referenced – for simplicity – to V_{AG} and V_{AB}, respectively. This, however, is a relative matter. It is important to remember that the UR displays are always referenced as specified under **SETTINGS**
⇒ **SYSTEM SETUP** ⇒ **POWER SYSTEM** ⇒ **FREQUENCY AND PHASE REFERENCE**.

The example above is illustrated in the following figure.



827844A1.CDR

Figure 6–3: MEASUREMENT CONVENTION FOR SYMMETRICAL COMPONENTS

6.3.2 SOURCES

PATH: ACTUAL VALUES ⇒ METERING ⇒ SOURCE SRC 1 ⇒



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

<input type="checkbox"/> PHASE CURRENT <input type="checkbox"/> SRC 1		<div>◀▶</div> <div>SRC 1 RMS Ia: 0.000 b: 0.000 c: 0.000 A</div>
MESSAGE	▲▼	<div>▲▼</div> <div>SRC 1 RMS Ia: 0.000 A</div>
MESSAGE	▲▼	<div>▲▼</div> <div>SRC 1 RMS Ib: 0.000 A</div>
MESSAGE	▲▼	<div>▲▼</div> <div>SRC 1 RMS Ic: 0.000 A</div>
MESSAGE	▲▼	<div>▲▼</div> <div>SRC 1 RMS In: 0.000 A</div>
MESSAGE	▲▼	<div>▲▼</div> <div>SRC 1 PHASOR Ia: 0.000 A 0.0°</div>
MESSAGE	▲▼	<div>▲▼</div> <div>SRC 1 PHASOR Ib: 0.000 A 0.0°</div>
MESSAGE	▲▼	<div>▲▼</div> <div>SRC 1 PHASOR Ic: 0.000 A 0.0°</div>
MESSAGE	▲▼	<div>▲▼</div> <div>SRC 1 PHASOR In: 0.000 A 0.0°</div>
MESSAGE	▲▼	<div>▲▼</div> <div>SRC 1 ZERO SEQ I0: 0.000 A 0.0°</div>
MESSAGE	▲▼	<div>▲▼</div> <div>SRC 1 POS SEQ I1: 0.000 A 0.0°</div>
MESSAGE	▲	<div>▲</div> <div>SRC 1 NEG SEQ I2: 0.000 A 0.0°</div>
▲		
<input type="checkbox"/> GROUND CURRENT <input type="checkbox"/> SRC 1		<div>◀▶</div> <div>SRC 1 RMS Ig: 0.000 A</div>
MESSAGE	▲▼	<div>▲▼</div> <div>SRC 1 PHASOR Ig: 0.000 A 0.0°</div>
MESSAGE	▲	<div>▲</div> <div>SRC 1 PHASOR Igd: 0.000 A 0.0°</div>
▲		
<input type="checkbox"/> PHASE VOLTAGE <input type="checkbox"/> SRC 1		<div>◀▶</div> <div>SRC 1 RMS Vag: 0.000 V</div>
MESSAGE	▲▼	<div>▲▼</div> <div>SRC 1 RMS Vbg: 0.000 V</div>
MESSAGE	▲▼	<div>▲▼</div> <div>SRC 1 RMS Vcg: 0.000 V</div>
MESSAGE	▲▼	<div>▲▼</div> <div>SRC 1 PHASOR Vag: 0.000 V 0.0°</div>

MESSAGE		SRC 1 PHASOR Vbg: 0.000 V 0.0°
MESSAGE		SRC 1 PHASOR Vcg: 0.000 V 0.0°
MESSAGE		SRC 1 RMS Vab: 0.000 V
MESSAGE		SRC 1 RMS Vbc: 0.000 V
MESSAGE		SRC 1 RMS Vca: 0.000 V
MESSAGE		SRC 1 PHASOR Vab: 0.000 V 0.0°
MESSAGE		SRC 1 PHASOR Vbc: 0.000 V 0.0°
MESSAGE		SRC 1 PHASOR Vca: 0.000 V 0.0°
MESSAGE		SRC 1 ZERO SEQ V0: 0.000 V 0.0°
MESSAGE		SRC 1 POS SEQ V1: 0.000 V 0.0°
MESSAGE		SRC 1 NEG SEQ V2: 0.000 V 0.0°
<div> <div> <div>6</div> <div> <div><input type="checkbox"/> AUXILIARY VOLTAGE</div> <div><input type="checkbox"/> SRC 1</div> </div> </div> </div>		
		SRC 1 RMS Vx: 0.000 V
MESSAGE		SRC 1 PHASOR Vx: 0.000 V 0.0°
<div> <div> <div><input type="checkbox"/> POWER</div> <div><input type="checkbox"/> SRC 1</div> </div> </div>		
		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 3 ϕ : 0.000 VA
MESSAGE		SRC 1 APPARENT PWR ϕ a: 0.000 VA
MESSAGE		SRC 1 APPARENT PWR ϕ b: 0.000 VA
MESSAGE		SRC 1 APPARENT PWR ϕ c: 0.000 VA
MESSAGE		SRC 1 POWER FACTOR 3 ϕ : 1.000
MESSAGE		SRC 1 POWER FACTOR ϕ a: 1.000
MESSAGE		SRC 1 POWER FACTOR ϕ b: 1.000
MESSAGE		SRC 1 POWER FACTOR ϕ c: 1.000
<div>■ ENERGY ■ SRC 1</div>		SRC 1 POS WATTHOUR: 0.000 Wh
MESSAGE		SRC 1 NEG WATTHOUR: 0.000 Wh
MESSAGE		SRC 1 POS VARHOUR: 0.000 varh
MESSAGE		SRC 1 NEG VARHOUR: 0.000 varh
<div>■ DEMAND ■ SRC 1</div>		SRC 1 DMD IA: 0.000 A
MESSAGE		SRC 1 DMD IA MAX: 0.000 A
MESSAGE		SRC 1 DMD IA DATE: 2001/07/31 16:30:07
MESSAGE		SRC 1 DMD IB: 0.000 A
MESSAGE		SRC 1 DMD IB MAX: 0.000 A
MESSAGE		SRC 1 DMD IB DATE: 2001/07/31 16:30:07
MESSAGE		SRC 1 DMD IC: 0.000 A
MESSAGE		SRC 1 DMD IC MAX: 0.000 A
MESSAGE		SRC 1 DMD IC DATE: 2001/07/31 16:30:07

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**).

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** \Rightarrow **PRODUCT SETUP** \Rightarrow **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** \Rightarrow **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** \Rightarrow **POWER SYSTEM** settings). The signal used for frequency estimation is low-pass filtered. The final frequency measurement is passed through a validation filter that eliminates false readings due to signal distortions and transients.

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)
- $k = 1, 2, \dots, N - 1$ is the index over one cycle for the FFT
- m is the last sample number for the sliding window
- $h = 1, 2, \dots, 25$ is the harmonic number

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

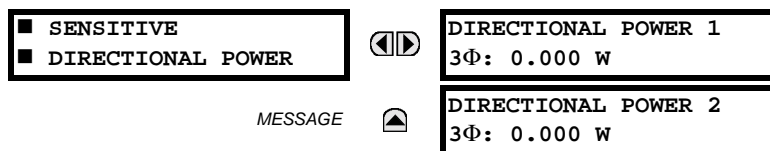
$$\begin{aligned}
 F_{\text{real}}(m, h) &= \frac{2}{N} \sum_k (f(m-k) \cdot \cos(h \cdot \omega_0 \cdot t(k))) \\
 F_{\text{imag}}(m, h) &= \frac{2}{N} \sum_k (f(m-k) \cdot \sin(h \cdot \omega_0 \cdot t(k))) \\
 F_{\text{ampl}}(m, h) &= \sqrt{F_{\text{real}}(m, h)^2 + F_{\text{imag}}(m, h)^2}
 \end{aligned}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

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

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

6.3.3 SENSITIVE DIRECTIONAL POWER

PATH: ACTUAL VALUES \Rightarrow **METERING** \Rightarrow **SENSITIVE DIRECTIONAL POWER**



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 set to "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 = $2000 \text{ kA}^2 \times \text{cycle}$
dcmA	BASE = maximum value of the DCMA INPUT MAX setting for the two transducers configured under the +IN and –IN inputs.
FREQUENCY	$f_{\text{BASE}} = 1 \text{ Hz}$
PHASE ANGLE	$\phi_{\text{BASE}} = 360 \text{ degrees}$ (see the UR angle referencing convention)
POWER FACTOR	$\text{PF}_{\text{BASE}} = 1.00$
RTDs	BASE = 100°C
SENSITIVE DIR POWER (Sns Dir Power)	$P_{\text{BASE}} = \text{maximum value of } 3 \times V_{\text{BASE}} \times I_{\text{BASE}} \text{ for the +IN and –IN inputs of the sources configured for the Sensitive Power Directional element(s).}$
SOURCE CURRENT	$I_{\text{BASE}} = \text{maximum nominal primary RMS value of the +IN and –IN inputs}$
SOURCE ENERGY (SRC X Positive and Negative Watthours); (SRC X Positive and Negative Varhours)	$E_{\text{BASE}} = 10000 \text{ MWh or MVAh, respectively}$
SOURCE POWER	$P_{\text{BASE}} = \text{maximum value of } V_{\text{BASE}} \times I_{\text{BASE}} \text{ for the +IN and –IN inputs}$
SOURCE THD & HARMONICS	BASE = 100% of fundamental frequency component
SOURCE VOLTAGE	$V_{\text{BASE}} = \text{maximum nominal primary RMS value of the +IN and –IN inputs}$
SYNCHROCHECK (Max Delta Volts)	$V_{\text{BASE}} = \text{maximum primary RMS value of all the sources related to the +IN and –IN inputs}$

6.3.8 TRANSDUCER I/O

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

NO FAULTS TO REPORT	
or	
<div> <div> <div>■</div> <div>FAULT REPORT #</div> </div> <div> <div>■</div> <div></div> </div> </div>	<div> <div> <div>◀▶</div> <div> <div>FAULT #</div> <div>2000/08/11</div> </div> </div> <div> <div>Range: YYYY/MM/DD</div> </div> </div>
MESSAGE	<div> <div> <div>▲▼</div> <div> <div>FAULT #</div> <div>TIME:</div> <div>00:00:00.000000</div> </div> </div> <div> <div>Range: HH:MM:SS.ssssss</div> </div> </div>
MESSAGE	<div> <div> <div>▲▼</div> <div> <div>FAULT #</div> <div>TYPE:</div> <div>ABG</div> </div> </div> <div> <div>where applicable</div> </div> </div>
MESSAGE	<div> <div> <div>▲▼</div> <div> <div>FAULT #</div> <div>LOCATION</div> <div>00.0 km</div> </div> </div> <div> <div>where applicable</div> </div> </div>
MESSAGE	<div> <div> <div>▲</div> <div> <div>FAULT #</div> <div>RECLOSE</div> <div>SHOT: 0</div> </div> </div> <div> <div>where applicable</div> </div> </div>

The latest 10 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 REPORT** menu for assigning the Source and Trigger for fault calculations. Refer to the **COMMANDS ⇒ CLEAR RECORDS** menu for clearing fault reports.

Fault Type determination is required for calculation of Fault Location – the algorithm uses the angle between the negative and positive sequence components of the relay currents. To improve accuracy and speed of operation, the fault components of the currents are used, i.e., the pre-fault phasors are subtracted from the measured current phasors. In addition to the angle relationships, certain extra checks are performed on magnitudes of the negative and zero sequence currents.

The single-ended fault location method assumes that the fault components of the currents supplied from the local (A) and remote (B) systems are in phase. The figure below shows an equivalent system for fault location.

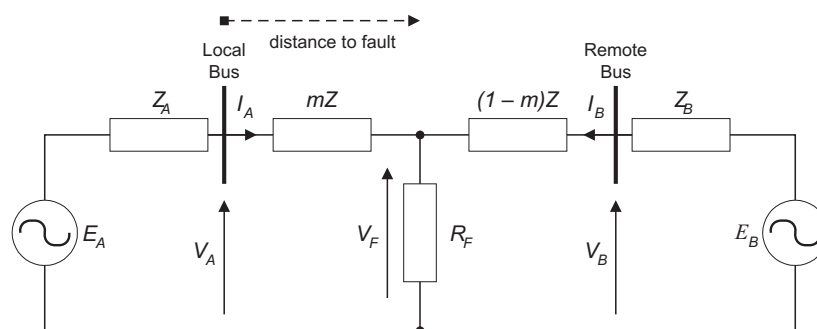


Figure 6-4: EQUIVALENT SYSTEM FOR FAULT LOCATION

The following equations hold true for this equivalent system.

$$V_A = m \cdot Z \cdot I_A + R_F \cdot (I_A + I_B) \quad (\text{EQ 6.3})$$

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:

$$I_A = I_{AF} + I_{Apre} \quad (\text{EQ 6.4})$$

and neglecting shunt parameters of the line:

$$I_B = I_{BF} - I_{Apre} \quad (\text{EQ 6.5})$$

Inserting Equations 6.4 and 6.5 into Equation 6.3 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: $\text{Im}()$ represents the imaginary part of a complex number. Equation 6.7 solved 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

$$I_{AF} = I_A - I_{Apre} \quad (\text{EQ 6.9})$$

Depending on the fault type, appropriate voltage and current signals are selected from the phase quantities before applying Equations 6.8 and 6.9 (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.

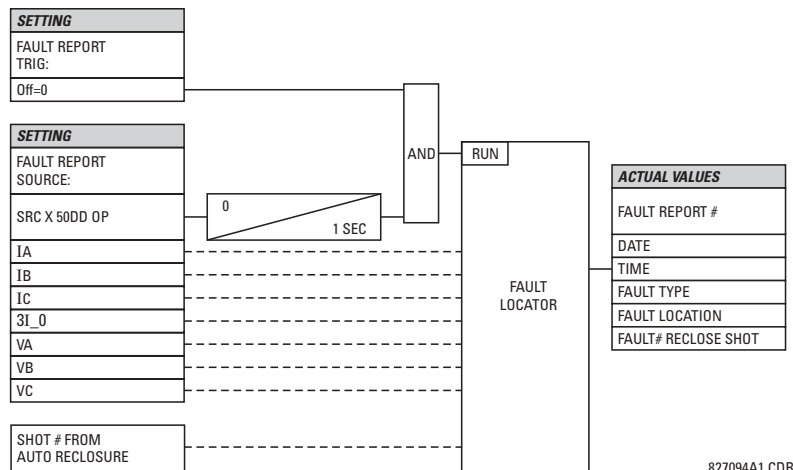
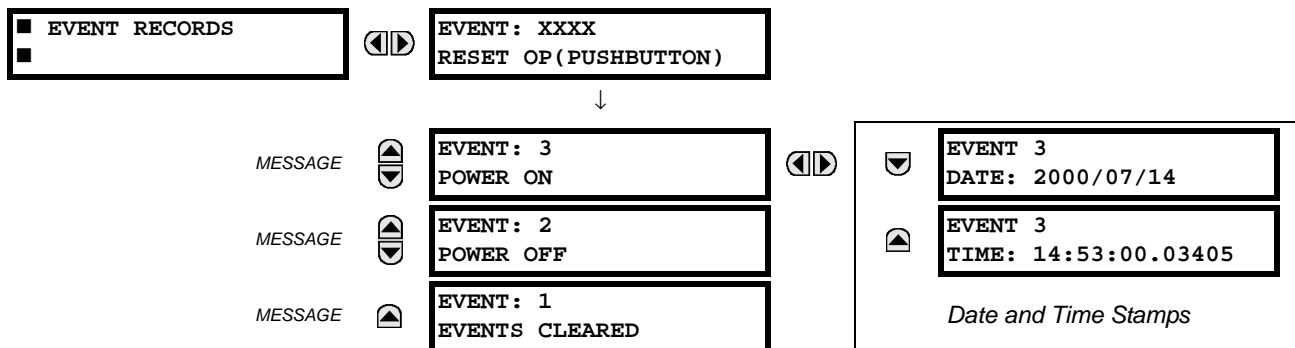


Figure 6-5: FAULT LOCATOR SCHEME

6.4.2 EVENT RECORDS

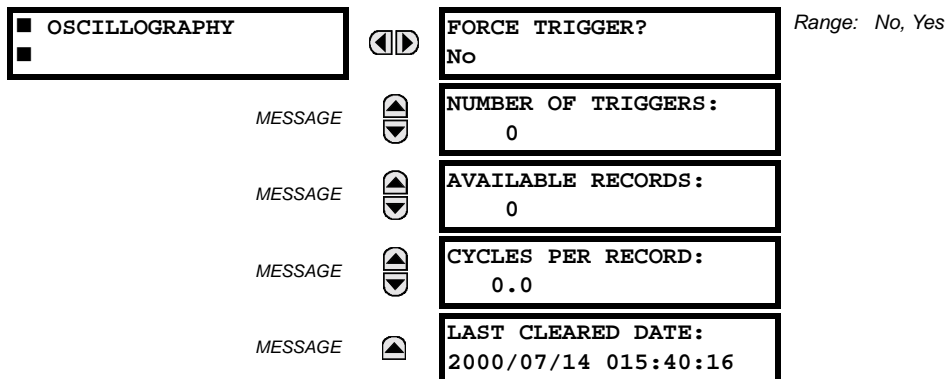
PATH: ACTUAL VALUES ⇒ RECORDS ⇒ EVENT RECORDS



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

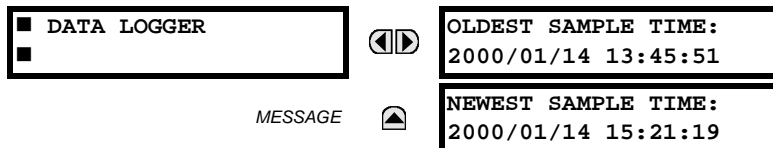


This menu allows the user to view the number of triggers involved and number of oscillography traces available. The 'cycles per record' value is calculated to account for the fixed amount of data storage for oscillography. See the Oscillography section of Chapter 5 for further details.

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



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 ϕ A: 0.00 kA ² -cyc
MESSAGE	▲▼	BKR 1 ARCING AMP ϕ B: 0.00 kA ² -cyc
MESSAGE	▲	BKR 1 ARCING AMP ϕ C: 0.00 kA ² -cyc

There is an identical Actual Value menu for each of the 2 Breakers. The **BKR 1 ARCING AMP** values are in units of kA²-cycles. Refer to the **COMMANDS** ⇒ **CLEAR RECORDS** menu for clearing breaker arcing current records.

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

6.5.1 MODEL INFORMATION

PATH: ACTUAL VALUES ⇒ ↓ PRODUCT INFO ⇒ MODEL INFORMATION

■ MODEL INFORMATION		◀▶	ORDER CODE LINE 1: F60-A00-HCH-F8A-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.

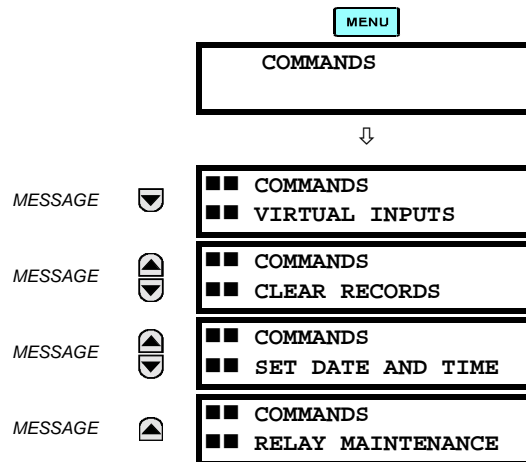
6.5.2 FIRMWARE REVISIONS

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

■ FIRMWARE REVISIONS		◀▶	F60 Feeder Relay REVISION: 3.30	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: 1.12	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: 2000/09/08 04:55:16	Range: Any valid date and time. Date and time when product firmware was built.
MESSAGE	▲		BOOT DATE: 2000/05/11 16:41:32	Range: Any valid date and time. Date and time when the boot program was built.

The shown data is illustrative only. A modification file number of 0 indicates that, currently, no modifications have been installed.

7.1.1 COMMANDS MENU

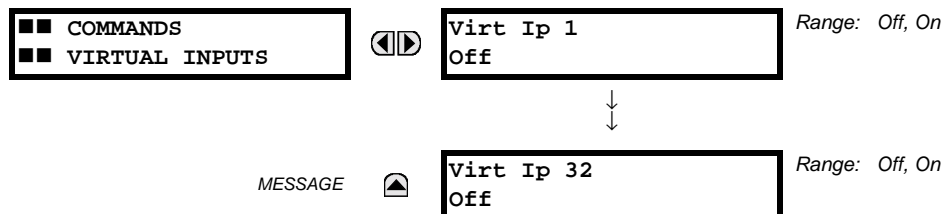


The Commands menu contains relay directives intended for operations personnel. All commands can be protected from unauthorized access via the Command Password; see the Password Security section of Chapter 5. The following flash message appears after successfully command entry:

COMMAND
EXECUTED

7.1.2 VIRTUAL INPUTS

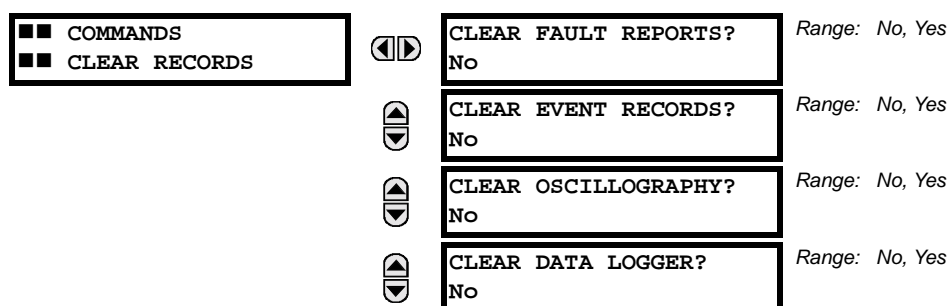
PATH: COMMANDS ↓ COMMANDS VIRTUAL INPUTS


















The states of up to 32 virtual inputs are changed here. The first line of the display indicates the ID of the virtual input. The second line indicates the current or selected status of the virtual input. This status will be a logical state 'Off' (0) or 'On' (1).

7.1.3 CLEAR RECORDS

PATH: COMMANDS ↓ COMMANDS CLEAR RECORDS





 	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
 	RESET UNAUTHORIZED ACCESS: No	Range: No, Yes
 	CLEAR DIRECT I/O COUNTERS: No	Range: No, Yes Valid only for units with Direct I/O module.
	CLEAR ALL RELAY RECORDS: No	Range: No, Yes

This menu contains commands for clearing historical data such as the Event Records. Data is cleared by changing a command setting to "Yes" and pressing the **ENTER** key. After clearing data, the command setting automatically reverts to "No".

7.1.4 SET DATE AND TIME




PATH: COMMANDS ↓ SET DATE AND TIME

 	<div> <div>■ ■ COMMANDS</div> <div>■ ■ SET DATE AND TIME</div> </div>	<div> <div>SET DATE AND TIME:</div> <div>2000/01/14 13:47:03</div> </div>	(YYYY/MM/DD HH:MM:SS)
--	---	---	-----------------------

The date and time can be entered here via the faceplate keypad only if the IRIG-B signal is not in use. The time setting is based on the 24-hour clock. The complete date, as a minimum, must be entered to allow execution of this command. The new time will take effect at the moment the **ENTER** key is clicked.

7.1.5 RELAY MAINTENANCE

PATH: COMMANDS ↓ RELAY MAINTENANCE

 	<div> <div>■ ■ COMMANDS</div> <div>■ ■ RELAY MAINTENANCE</div> </div>	<div> <div>PERFORM LAMPTEST?</div> <div>No</div> </div>	Range: No, Yes
		<div> <div>UPDATE ORDER CODE?</div> <div>No</div> </div>	Range: No, Yes

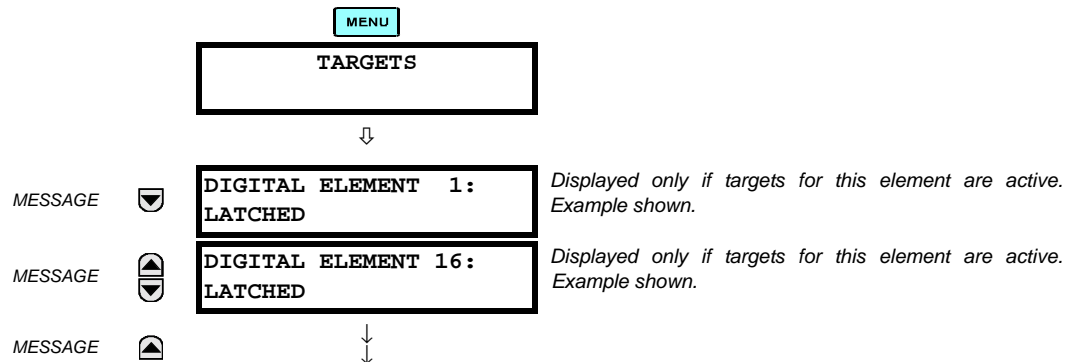
This menu contains commands for relay maintenance purposes. Commands are activated by changing a command setting to "Yes" and pressing the **ENTER** key. The command setting will then automatically revert to "No".

The **PERFORM 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



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 message	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 message	No	FlexLogic™ equations do not compile properly.	Event driven; whenever Flex-Logic™ equations are modified.	Finish all equation editing and use self test to debug any errors.
LATCHING OUTPUT ERROR	No	Discrepancy in the position of a latching contact between relay firmware and hardware has been detected.	Every 1/8th of a cycle.	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.
DIRECT RING BREAK	No	Direct I/O settings configured for a ring, but the connection is not in a ring.	Every second.	Check Direct I/O configuration and/or wiring.
DIRECT DEVICE OFF	No	Direct Device is configured but not connected	Every second.	Check Direct I/O configuration and/or wiring.
EEPROM DATA ERROR	Yes	The non-volatile memory has been corrupted.	On power up only.	Contact the factory.
IRIG-B FAILURE	No	Bad IRIG-B input signal.	Monitored whenever an IRIG-B signal is received.	Ensure 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 over-current 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.

8.1.12 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 PARAMETERS (Sheet 1 of 8)

SETTING	DISPLAY TEXT	DESCRIPTION
0	Off	Placeholder for unused settings
5760	Sns Dir Power 1	Sens Dir Power 1 Actual (W)
5762	Sns Dir Power 2	Sens Dir Power 2 Actual (W)
5856	Freq Rate 1 Value	Rate of Change 1 Actual (Hz/s)
5860	Freq Rate 2 Value	Rate of Change 2 Actual (Hz/s)
5864	Freq Rate 3 Value	Rate of Change 3 Actual (Hz/s)
5868	Freq Rate 4 Value	Rate of Change 4 Actual (Hz/s)
6144	SRC 1 Ia RMS	SRC 1 Phase A Current RMS (A)
6146	SRC 1 Ib RMS	SRC 1 Phase B Current RMS (A)
6148	SRC 1 Ic RMS	SRC 1 Phase C Current RMS (A)
6150	SRC 1 In RMS	SRC 1 Neutral Current RMS (A)
6152	SRC 1 Ia Mag	SRC 1 Phase A Current Magnitude (A)
6154	SRC 1 Ia Angle	SRC 1 Phase A Current Angle (x)
6155	SRC 1 Ib Mag	SRC 1 Phase B Current Magnitude (A)
6157	SRC 1 Ib Angle	SRC 1 Phase B Current Angle (x)
6158	SRC 1 Ic Mag	SRC 1 Phase C Current Magnitude (A)
6160	SRC 1 Ic Angle	SRC 1 Phase C Current Angle (x)
6161	SRC 1 In Mag	SRC 1 Neutral Current Magnitude (A)
6163	SRC 1 In Angle	SRC 1 Neutral Current Angle (x)
6164	SRC 1 Ig RMS	SRC 1 Ground Current RMS (A)
6166	SRC 1 Ig Mag	SRC 1 Ground Current Magnitude (A)
6168	SRC 1 Ig Angle	SRC 1 Ground Current Angle (x)
6169	SRC 1 I ₀ Mag	SRC 1 Zero Seq Current Magnitude (A)
6171	SRC 1 I ₀ Angle	SRC 1 Zero Seq Current Angle (x)
6172	SRC 1 I ₁ Mag	SRC 1 Positive Seq Current Magnitude (A)
6174	SRC 1 I ₁ Angle	SRC 1 Positive Seq Current Angle (x)
6175	SRC 1 I ₂ Mag	SRC 1 Negative Seq Current Magnitude (A)
6177	SRC 1 I ₂ Angle	SRC 1 Negative Seq Current Angle (x)
6178	SRC 1 Igd Mag	SRC 1 Differential Ground Current Magnitude (A)
6180	SRC 1 Igd Angle	SRC 1 Differential Ground Current Angle (x)
6208	SRC 2 Ia RMS	SRC 2 Phase A Current RMS (A)
6210	SRC 2 Ib RMS	SRC 2 Phase B Current RMS (A)
6212	SRC 2 Ic RMS	SRC 2 Phase C Current RMS (A)
6214	SRC 2 In RMS	SRC 2 Neutral Current RMS (A)
6216	SRC 2 Ia Mag	SRC 2 Phase A Current Magnitude (A)
6218	SRC 2 Ia Angle	SRC 2 Phase A Current Angle (x)
6219	SRC 2 Ib Mag	SRC 2 Phase B Current Magnitude (A)
6221	SRC 2 Ib Angle	SRC 2 Phase B Current Angle (x)
6222	SRC 2 Ic Mag	SRC 2 Phase C Current Magnitude (A)
6224	SRC 2 Ic Angle	SRC 2 Phase C Current Angle (x)
6225	SRC 2 In Mag	SRC 2 Neutral Current Magnitude (A)
6227	SRC 2 In Angle	SRC 2 Neutral Current Angle (x)
6228	SRC 2 Ig RMS	SRC 2 Ground Current RMS (A)
6230	SRC 2 Ig Mag	SRC 2 Ground Current Magnitude (A)
6232	SRC 2 Ig Angle	SRC 2 Ground Current Angle (x)
6233	SRC 2 I ₀ Mag	SRC 2 Zero Seq Current Magnitude (A)
6235	SRC 2 I ₀ Angle	SRC 2 Zero Seq Current Angle (x)

Table A–1: FLEXANALOG PARAMETERS (Sheet 2 of 8)

SETTING	DISPLAY TEXT	DESCRIPTION
6236	SRC 2 I ₁ Mag	SRC 2 Positive Seq Current Magnitude (A)
6238	SRC 2 I ₁ Angle	SRC 2 Positive Seq Current Angle (x)
6239	SRC 2 I ₂ Mag	SRC 2 Negative Seq Current Magnitude (A)
6241	SRC 2 I ₂ Angle	SRC 2 Negative Seq Current Angle (x)
6242	SRC 2 Igd Mag	SRC 2 Differential Ground Current Magnitude (A)
6244	SRC 2 Igd Angle	SRC 2 Differential Ground Current Angle (x)
6656	SRC 1 Vag RMS	SRC 1 Phase AG Voltage RMS (V)
6658	SRC 1 Vbg RMS	SRC 1 Phase BG Voltage RMS (V)
6660	SRC 1 Vcg RMS	SRC 1 Phase CG Voltage RMS (V)
6662	SRC 1 Vag Mag	SRC 1 Phase AG Voltage Magnitude (V)
6664	SRC 1 Vag Angle	SRC 1 Phase AG Voltage Angle (x)
6665	SRC 1 Vbg Mag	SRC 1 Phase BG Voltage Magnitude (V)
6667	SRC 1 Vbg Angle	SRC 1 Phase BG Voltage Angle (x)
6668	SRC 1 Vcg Mag	SRC 1 Phase CG Voltage Magnitude (V)
6670	SRC 1 Vcg Angle	SRC 1 Phase CG Voltage Angle (x)
6671	SRC 1 Vab RMS	SRC 1 Phase AB Voltage RMS (V)
6673	SRC 1 Vbc RMS	SRC 1 Phase BC Voltage RMS (V)
6675	SRC 1 Vca RMS	SRC 1 Phase CA Voltage RMS (V)
6677	SRC 1 Vab Mag	SRC 1 Phase AB Voltage Magnitude (V)
6679	SRC 1 Vab Angle	SRC 1 Phase AB Voltage Angle (x)
6680	SRC 1 Vbc Mag	SRC 1 Phase BC Voltage Magnitude (V)
6682	SRC 1 Vbc Angle	SRC 1 Phase BC Voltage Angle (x)
6683	SRC 1 Vca Mag	SRC 1 Phase CA Voltage Magnitude (V)
6685	SRC 1 Vca Angle	SRC 1 Phase CA Voltage Angle (x)
6686	SRC 1 Vx RMS	SRC 1 Auxiliary Voltage RMS (V)
6688	SRC 1 Vx Mag	SRC 1 Auxiliary Voltage Magnitude (V)
6690	SRC 1 Vx Angle	SRC 1 Auxiliary Voltage Angle (x)
6691	SRC 1 V ₀ Mag	SRC 1 Zero Seq Voltage Magnitude (V)
6693	SRC 1 V ₀ Angle	SRC 1 Zero Seq Voltage Angle (x)
6694	SRC 1 V ₁ Mag	SRC 1 Positive Seq Voltage Magnitude (V)
6696	SRC 1 V ₁ Angle	SRC 1 Positive Seq Voltage Angle (x)
6697	SRC 1 V ₂ Mag	SRC 1 Negative Seq Voltage Magnitude (V)
6699	SRC 1 V ₂ Angle	SRC 1 Negative Seq Voltage Angle (x)
6720	SRC 2 Vag RMS	SRC 2 Phase AG Voltage RMS (V)
6722	SRC 2 Vbg RMS	SRC 2 Phase BG Voltage RMS (V)
6724	SRC 2 Vcg RMS	SRC 2 Phase CG Voltage RMS (V)
6726	SRC 2 Vag Mag	SRC 2 Phase AG Voltage Magnitude (V)
6728	SRC 2 Vag Angle	SRC 2 Phase AG Voltage Angle (x)
6729	SRC 2 Vbg Mag	SRC 2 Phase BG Voltage Magnitude (V)
6731	SRC 2 Vbg Angle	SRC 2 Phase BG Voltage Angle (x)

A

Table A-1: FLEXANALOG PARAMETERS (Sheet 3 of 8)

SETTING	DISPLAY TEXT	DESCRIPTION
6732	SRC 2 Vcg Mag	SRC 2 Phase CG Voltage Magnitude (V)
6734	SRC 2 Vcg Angle	SRC 2 Phase CG Voltage Angle (x)
6735	SRC 2 Vab RMS	SRC 2 Phase AB Voltage RMS (V)
6737	SRC 2 Vbc RMS	SRC 2 Phase BC Voltage RMS (V)
6739	SRC 2 Vca RMS	SRC 2 Phase CA Voltage RMS (V)
6741	SRC 2 Vab Mag	SRC 2 Phase AB Voltage Magnitude (V)
6743	SRC 2 Vab Angle	SRC 2 Phase AB Voltage Angle (x)
6744	SRC 2 Vbc Mag	SRC 2 Phase BC Voltage Magnitude (V)
6746	SRC 2 Vbc Angle	SRC 2 Phase BC Voltage Angle (x)
6747	SRC 2 Vca Mag	SRC 2 Phase CA Voltage Magnitude (V)
6749	SRC 2 Vca Angle	SRC 2 Phase CA Voltage Angle (x)
6750	SRC 2 Vx RMS	SRC 2 Auxiliary Voltage RMS (V)
6752	SRC 2 Vx Mag	SRC 2 Auxiliary Voltage Magnitude (V)
6754	SRC 2 Vx Angle	SRC 2 Auxiliary Voltage Angle (x)
6755	SRC 2 V_0 Mag	SRC 2 Zero Seq Voltage Magnitude (V)
6757	SRC 2 V_0 Angle	SRC 2 Zero Seq Voltage Angle (x)
6758	SRC 2 V_1 Mag	SRC 2 Positive Seq Voltage Magnitude (V)
6760	SRC 2 V_1 Angle	SRC 2 Positive Seq Voltage Angle (x)
6761	SRC 2 V_2 Mag	SRC 2 Negative Seq Voltage Magnitude (V)
6763	SRC 2 V_2 Angle	SRC 2 Negative Seq Voltage Angle (x)
7168	SRC 1 P	SRC 1 Three Phase Real Power (W)
7170	SRC 1 Pa	SRC 1 Phase A Real Power (W)
7172	SRC 1 Pb	SRC 1 Phase B Real Power (W)
7174	SRC 1 Pc	SRC 1 Phase C Real Power (W)
7176	SRC 1 Q	SRC 1 Three Phase Reactive Power (var)
7178	SRC 1 Qa	SRC 1 Phase A Reactive Power (var)
7180	SRC 1 Qb	SRC 1 Phase B Reactive Power (var)
7182	SRC 1 Qc	SRC 1 Phase C Reactive Power (var)
7184	SRC 1 S	SRC 1 Three Phase Apparent Power (VA)
7186	SRC 1 Sa	SRC 1 Phase A Apparent Power (VA)
7188	SRC 1 Sb	SRC 1 Phase B Apparent Power (VA)
7190	SRC 1 Sc	SRC 1 Phase C Apparent Power (VA)
7192	SRC 1 PF	SRC 1 Three Phase Power Factor
7193	SRC 1 Phase A PF	SRC 1 Phase A Power Factor
7194	SRC 1 Phase B PF	SRC 1 Phase B Power Factor
7195	SRC 1 Phase C PF	SRC 1 Phase C Power Factor
7200	SRC 2 P	SRC 2 Three Phase Real Power (W)
7202	SRC 2 Pa	SRC 2 Phase A Real Power (W)
7204	SRC 2 Pb	SRC 2 Phase B Real Power (W)
7206	SRC 2 Pc	SRC 2 Phase C Real Power (W)
7208	SRC 2 Q	SRC 2 Three Phase Reactive Power (var)
7210	SRC 2 Qa	SRC 2 Phase A Reactive Power (var)
7212	SRC 2 Qb	SRC 2 Phase B Reactive Power (var)
7214	SRC 2 Qc	SRC 2 Phase C Reactive Power (var)
7216	SRC 2 S	SRC 2 Three Phase Apparent Power (VA)
7218	SRC 2 Sa	SRC 2 Phase A Apparent Power (VA)

Table A-1: FLEXANALOG PARAMETERS (Sheet 4 of 8)

SETTING	DISPLAY TEXT	DESCRIPTION
7220	SRC 2 Sb	SRC 2 Phase B Apparent Power (VA)
7222	SRC 2 Sc	SRC 2 Phase C Apparent Power (VA)
7224	SRC 2 PF	SRC 2 Three Phase Power Factor
7225	SRC 2 Phase A PF	SRC 2 Phase A Power Factor
7226	SRC 2 Phase B PF	SRC 2 Phase B Power Factor
7227	SRC 2 Phase C PF	SRC 2 Phase C Power Factor
7424	SRC 1 Pos Watthour	SRC 1 Positive Watthour (Wh)
7426	SRC 1 Neg Watthour	SRC 1 Negative Watthour (Wh)
7428	SRC 1 Pos varh	SRC 1 Positive Varhour (varh)
7430	SRC 1 Neg varh	SRC 1 Negative Varhour (varh)
7440	SRC 2 Pos Watthour	SRC 2 Positive Watthour (Wh)
7442	SRC 2 Neg Watthour	SRC 2 Negative Watthour (Wh)
7444	SRC 2 Pos varh	SRC 2 Positive Varhour (varh)
7446	SRC 2 Neg varh	SRC 2 Negative Varhour (varh)
7456	SRC 3 Pos Watthour	SRC 3 Positive Watthour (Wh)
7458	SRC 3 Neg Watthour	SRC 3 Negative Watthour (Wh)
7460	SRC 3 Pos varh	SRC 3 Positive Varhour (varh)
7462	SRC 3 Neg varh	SRC 3 Negative Varhour (varh)
7552	SRC 1 Frequency	SRC 1 Frequency (Hz)
7553	SRC 2 Frequency	SRC 2 Frequency (Hz)
7554	SRC 3 Frequency	SRC 3 Frequency (Hz)
7680	SRC 1 Demand Ia	SRC 1 Demand Ia (A)
7682	SRC 1 Demand Ib	SRC 1 Demand Ib (A)
7684	SRC 1 Demand Ic	SRC 1 Demand Ic (A)
7686	SRC 1 Demand Watt	SRC 1 Demand Watt (W)
7688	SRC 1 Demand var	SRC 1 Demand Var (var)
7690	SRC 1 Demand Va	SRC 1 Demand Va (VA)
7696	SRC 2 Demand Ia	SRC 2 Demand Ia (A)
7698	SRC 2 Demand Ib	SRC 2 Demand Ib (A)
7700	SRC 2 Demand Ic	SRC 2 Demand Ic (A)
7702	SRC 2 Demand Watt	SRC 2 Demand Watt (W)
7704	SRC 2 Demand var	SRC 2 Demand Var (var)
7706	SRC 2 Demand Va	SRC 2 Demand Va (VA)
8704	Brk 1 Arc Amp A	Breaker 1 Arcing Amp Phase A (kA2-cyc)
8706	Brk 1 Arc Amp B	Breaker 1 Arcing Amp Phase B (kA2-cyc)
8708	Brk 1 Arc Amp C	Breaker 1 Arcing Amp Phase C (kA2-cyc)
8710	Brk 2 Arc Amp A	Breaker 2 Arcing Amp Phase A (kA2-cyc)
8712	Brk 2 Arc Amp B	Breaker 2 Arcing Amp Phase B (kA2-cyc)
8714	Brk 2 Arc Amp C	Breaker 2 Arcing Amp Phase C (kA2-cyc)
8785	HIZ Phase A Arc Conf	HIZ Phase A Arc Confidence
8786	HIZ Phase B Arc Conf	HIZ Phase B Arc Confidence
8787	HIZ Phase C Arc Conf	HIZ Phase C Arc Confidence
8788	HIZ Neutral Arc Conf	HIZ Neutral Arc Confidence
9040	Prefault Ia Mag	Prefault Phase A Current Magnitude (A)
9042	Prefault Ib Mag	Prefault Phase B Current Magnitude (A)
9044	Prefault Ic Mag	Prefault Phase C Current Magnitude (A)

Table A-1: FLEXANALOG PARAMETERS (Sheet 5 of 8)

SETTING	DISPLAY TEXT	DESCRIPTION
9046	Prefault I_0 Mag	Prefault Zero Seq Current (A)
9048	Prefault I_1 Mag	Prefault Pos Seq Current (A)
9050	Prefault I_2 Mag	Prefault Neg Seq Current (A)
9052	Prefault Va Mag	Prefault Phase A Voltage (V)
9054	Prefault Vb Mag	Prefault Phase B Voltage (V)
9056	Prefault Vc Mag	Prefault Phase C Voltage (V)
9058	Fault Location	Last Fault Location
9216	Synchchk 1 Delta V	Synchrocheck 1 Delta Voltage (V)
9218	Synchchk 1 Delta F	Synchrocheck 1 Delta Frequency (Hz)
9219	Synchchk 1 Delta Phs	Synchrocheck 1 Delta Phase (x)
9220	Synchchk 2 Delta V	Synchrocheck 2 Delta Voltage (V)
9222	Synchchk 2 Delta F	Synchrocheck 2 Delta Frequency (Hz)
9223	Synchchk 2 Delta Phs	Synchrocheck 2 Delta Phase (x)
10240	SRC 1 Ia THD	SRC 1 Ia THD
10241	SRC 1 Ia Harm[0]	SRC 1 Ia 2nd Harmonic
10242	SRC 1 Ia Harm[1]	SRC 1 Ia 3rd Harmonic
10243	SRC 1 Ia Harm[2]	SRC 1 Ia 4th Harmonic
10244	SRC 1 Ia Harm[3]	SRC 1 Ia 5th Harmonic
10245	SRC 1 Ia Harm[4]	SRC 1 Ia 6th Harmonic
10246	SRC 1 Ia Harm[5]	SRC 1 Ia 7th Harmonic
10247	SRC 1 Ia Harm[6]	SRC 1 Ia 8th Harmonic
10248	SRC 1 Ia Harm[7]	SRC 1 Ia 9th Harmonic
10249	SRC 1 Ia Harm[8]	SRC 1 Ia 10th Harmonic
10250	SRC 1 Ia Harm[9]	SRC 1 Ia 11th Harmonic
10251	SRC 1 Ia Harm[10]	SRC 1 Ia 12th Harmonic
10252	SRC 1 Ia Harm[11]	SRC 1 Ia 13th Harmonic
10253	SRC 1 Ia Harm[12]	SRC 1 Ia 14th Harmonic
10254	SRC 1 Ia Harm[13]	SRC 1 Ia 15th Harmonic
10255	SRC 1 Ia Harm[14]	SRC 1 Ia 16th Harmonic
10256	SRC 1 Ia Harm[15]	SRC 1 Ia 17th Harmonic
10257	SRC 1 Ia Harm[16]	SRC 1 Ia 18th Harmonic
10258	SRC 1 Ia Harm[17]	SRC 1 Ia 19th Harmonic
10259	SRC 1 Ia Harm[18]	SRC 1 Ia 20th Harmonic
10260	SRC 1 Ia Harm[19]	SRC 1 Ia 21st Harmonic
10261	SRC 1 Ia Harm[20]	SRC 1 Ia 22nd Harmonic
10262	SRC 1 Ia Harm[21]	SRC 1 Ia 23rd Harmonic
10263	SRC 1 Ia Harm[22]	SRC 1 Ia 24th Harmonic
10264	SRC 1 Ia Harm[23]	SRC 1 Ia 25th Harmonic
10273	SRC 1 Ib THD	SRC 1 Ib THD
10274	SRC 1 Ib Harm[0]	SRC 1 Ib 2nd Harmonic
10275	SRC 1 Ib Harm[1]	SRC 1 Ib 3rd Harmonic
10276	SRC 1 Ib Harm[2]	SRC 1 Ib 4th Harmonic
10277	SRC 1 Ib Harm[3]	SRC 1 Ib 5th Harmonic
10278	SRC 1 Ib Harm[4]	SRC 1 Ib 6th Harmonic
10279	SRC 1 Ib Harm[5]	SRC 1 Ib 7th Harmonic
10280	SRC 1 Ib Harm[6]	SRC 1 Ib 8th Harmonic
10281	SRC 1 Ib Harm[7]	SRC 1 Ib 9th Harmonic
10282	SRC 1 Ib Harm[8]	SRC 1 Ib 10th Harmonic
10283	SRC 1 Ib Harm[9]	SRC 1 Ib 11th Harmonic
10284	SRC 1 Ib Harm[10]	SRC 1 Ib 12th Harmonic
10285	SRC 1 Ib Harm[11]	SRC 1 Ib 13th Harmonic
10286	SRC 1 Ib Harm[12]	SRC 1 Ib 14th Harmonic

Table A-1: FLEXANALOG PARAMETERS (Sheet 6 of 8)

SETTING	DISPLAY TEXT	DESCRIPTION
10287	SRC 1 Ib Harm[13]	SRC 1 Ib 15th Harmonic
10288	SRC 1 Ib Harm[14]	SRC 1 Ib 16th Harmonic
10289	SRC 1 Ib Harm[15]	SRC 1 Ib 17th Harmonic
10290	SRC 1 Ib Harm[16]	SRC 1 Ib 18th Harmonic
10291	SRC 1 Ib Harm[17]	SRC 1 Ib 19th Harmonic
10292	SRC 1 Ib Harm[18]	SRC 1 Ib 20th Harmonic
10293	SRC 1 Ib Harm[19]	SRC 1 Ib 21st Harmonic
10294	SRC 1 Ib Harm[20]	SRC 1 Ib 22nd Harmonic
10295	SRC 1 Ib Harm[21]	SRC 1 Ib 23rd Harmonic
10296	SRC 1 Ib Harm[22]	SRC 1 Ib 24th Harmonic
10297	SRC 1 Ib Harm[23]	SRC 1 Ib 25th Harmonic
10306	SRC 1 Ic THD	SRC 1 Ic THD
10307	SRC 1 Ic Harm[0]	SRC 1 Ic 2nd Harmonic
10308	SRC 1 Ic Harm[1]	SRC 1 Ic 3rd Harmonic
10309	SRC 1 Ic Harm[2]	SRC 1 Ic 4th Harmonic
10310	SRC 1 Ic Harm[3]	SRC 1 Ic 5th Harmonic
10311	SRC 1 Ic Harm[4]	SRC 1 Ic 6th Harmonic
10312	SRC 1 Ic Harm[5]	SRC 1 Ic 7th Harmonic
10313	SRC 1 Ic Harm[6]	SRC 1 Ic 8th Harmonic
10314	SRC 1 Ic Harm[7]	SRC 1 Ic 9th Harmonic
10315	SRC 1 Ic Harm[8]	SRC 1 Ic 10th Harmonic
10316	SRC 1 Ic Harm[9]	SRC 1 Ic 11th Harmonic
10317	SRC 1 Ic Harm[10]	SRC 1 Ic 12th Harmonic
10318	SRC 1 Ic Harm[11]	SRC 1 Ic 13th Harmonic
10319	SRC 1 Ic Harm[12]	SRC 1 Ic 14th Harmonic
10320	SRC 1 Ic Harm[13]	SRC 1 Ic 15th Harmonic
10321	SRC 1 Ic Harm[14]	SRC 1 Ic 16th Harmonic
10322	SRC 1 Ic Harm[15]	SRC 1 Ic 17th Harmonic
10323	SRC 1 Ic Harm[16]	SRC 1 Ic 18th Harmonic
10324	SRC 1 Ic Harm[17]	SRC 1 Ic 19th Harmonic
10325	SRC 1 Ic Harm[18]	SRC 1 Ic 20th Harmonic
10326	SRC 1 Ic Harm[19]	SRC 1 Ic 21st Harmonic
10327	SRC 1 Ic Harm[20]	SRC 1 Ic 22nd Harmonic
10328	SRC 1 Ic Harm[21]	SRC 1 Ic 23rd Harmonic
10329	SRC 1 Ic Harm[22]	SRC 1 Ic 24th Harmonic
10330	SRC 1 Ic Harm[23]	SRC 1 Ic 25th Harmonic
10339	SRC 2 Ia THD	SRC 2 Ia THD
10340	SRC 2 Ia Harm[0]	SRC 2 Ia 2nd Harmonic
10341	SRC 2 Ia Harm[1]	SRC 2 Ia 3rd Harmonic
10342	SRC 2 Ia Harm[2]	SRC 2 Ia 4th Harmonic
10343	SRC 2 Ia Harm[3]	SRC 2 Ia 5th Harmonic
10344	SRC 2 Ia Harm[4]	SRC 2 Ia 6th Harmonic
10345	SRC 2 Ia Harm[5]	SRC 2 Ia 7th Harmonic
10346	SRC 2 Ia Harm[6]	SRC 2 Ia 8th Harmonic
10347	SRC 2 Ia Harm[7]	SRC 2 Ia 9th Harmonic
10348	SRC 2 Ia Harm[8]	SRC 2 Ia 10th Harmonic
10349	SRC 2 Ia Harm[9]	SRC 2 Ia 11th Harmonic
10350	SRC 2 Ia Harm[10]	SRC 2 Ia 12th Harmonic
10351	SRC 2 Ia Harm[11]	SRC 2 Ia 13th Harmonic
10352	SRC 2 Ia Harm[12]	SRC 2 Ia 14th Harmonic
10353	SRC 2 Ia Harm[13]	SRC 2 Ia 15th Harmonic
10354	SRC 2 Ia Harm[14]	SRC 2 Ia 16th Harmonic

A

Table A-1: FLEXANALOG PARAMETERS (Sheet 7 of 8)

SETTING	DISPLAY TEXT	DESCRIPTION
10355	SRC 2 Ia Harm[15]	SRC 2 Ia 17th Harmonic
10356	SRC 2 Ia Harm[16]	SRC 2 Ia 18th Harmonic
10357	SRC 2 Ia Harm[17]	SRC 2 Ia 19th Harmonic
10358	SRC 2 Ia Harm[18]	SRC 2 Ia 20th Harmonic
10359	SRC 2 Ia Harm[19]	SRC 2 Ia 21st Harmonic
10360	SRC 2 Ia Harm[20]	SRC 2 Ia 22nd Harmonic
10361	SRC 2 Ia Harm[21]	SRC 2 Ia 23rd Harmonic
10362	SRC 2 Ia Harm[22]	SRC 2 Ia 24th Harmonic
10363	SRC 2 Ia Harm[23]	SRC 2 Ia 25th Harmonic
10372	SRC 2 Ib THD	SRC 2 Ib THD
10373	SRC 2 Ib Harm[0]	SRC 2 Ib 2nd Harmonic
10374	SRC 2 Ib Harm[1]	SRC 2 Ib 3rd Harmonic
10375	SRC 2 Ib Harm[2]	SRC 2 Ib 4th Harmonic
10376	SRC 2 Ib Harm[3]	SRC 2 Ib 5th Harmonic
10377	SRC 2 Ib Harm[4]	SRC 2 Ib 6th Harmonic
10378	SRC 2 Ib Harm[5]	SRC 2 Ib 7th Harmonic
10379	SRC 2 Ib Harm[6]	SRC 2 Ib 8th Harmonic
10380	SRC 2 Ib Harm[7]	SRC 2 Ib 9th Harmonic
10381	SRC 2 Ib Harm[8]	SRC 2 Ib 10th Harmonic
10382	SRC 2 Ib Harm[9]	SRC 2 Ib 11th Harmonic
10383	SRC 2 Ib Harm[10]	SRC 2 Ib 12th Harmonic
10384	SRC 2 Ib Harm[11]	SRC 2 Ib 13th Harmonic
10385	SRC 2 Ib Harm[12]	SRC 2 Ib 14th Harmonic
10386	SRC 2 Ib Harm[13]	SRC 2 Ib 15th Harmonic
10387	SRC 2 Ib Harm[14]	SRC 2 Ib 16th Harmonic
10388	SRC 2 Ib Harm[15]	SRC 2 Ib 17th Harmonic
10389	SRC 2 Ib Harm[16]	SRC 2 Ib 18th Harmonic
10390	SRC 2 Ib Harm[17]	SRC 2 Ib 19th Harmonic
10391	SRC 2 Ib Harm[18]	SRC 2 Ib 20th Harmonic
10392	SRC 2 Ib Harm[19]	SRC 2 Ib 21st Harmonic
10393	SRC 2 Ib Harm[20]	SRC 2 Ib 22nd Harmonic
10394	SRC 2 Ib Harm[21]	SRC 2 Ib 23rd Harmonic
10395	SRC 2 Ib Harm[22]	SRC 2 Ib 24th Harmonic
10396	SRC 2 Ib Harm[23]	SRC 2 Ib 25th Harmonic
10405	SRC 2 Ic THD	SRC 2 Ic THD
10406	SRC 2 Ic Harm[0]	SRC 2 Ic 2nd Harmonic
10407	SRC 2 Ic Harm[1]	SRC 2 Ic 3rd Harmonic
10408	SRC 2 Ic Harm[2]	SRC 2 Ic 4th Harmonic
10409	SRC 2 Ic Harm[3]	SRC 2 Ic 5th Harmonic
10410	SRC 2 Ic Harm[4]	SRC 2 Ic 6th Harmonic
10411	SRC 2 Ic Harm[5]	SRC 2 Ic 7th Harmonic
10412	SRC 2 Ic Harm[6]	SRC 2 Ic 8th Harmonic
10413	SRC 2 Ic Harm[7]	SRC 2 Ic 9th Harmonic
10414	SRC 2 Ic Harm[8]	SRC 2 Ic 10th Harmonic
10415	SRC 2 Ic Harm[9]	SRC 2 Ic 11th Harmonic
10416	SRC 2 Ic Harm[10]	SRC 2 Ic 12th Harmonic
10417	SRC 2 Ic Harm[11]	SRC 2 Ic 13th Harmonic
10418	SRC 2 Ic Harm[12]	SRC 2 Ic 14th Harmonic
10419	SRC 2 Ic Harm[13]	SRC 2 Ic 15th Harmonic
10420	SRC 2 Ic Harm[14]	SRC 2 Ic 16th Harmonic
10421	SRC 2 Ic Harm[15]	SRC 2 Ic 17th Harmonic
10422	SRC 2 Ic Harm[16]	SRC 2 Ic 18th Harmonic

Table A-1: FLEXANALOG PARAMETERS (Sheet 8 of 8)

SETTING	DISPLAY TEXT	DESCRIPTION
10423	SRC 2 Ic Harm[17]	SRC 2 Ic 19th Harmonic
10424	SRC 2 Ic Harm[18]	SRC 2 Ic 20th Harmonic
10425	SRC 2 Ic Harm[19]	SRC 2 Ic 21st Harmonic
10426	SRC 2 Ic Harm[20]	SRC 2 Ic 22nd Harmonic
10427	SRC 2 Ic Harm[21]	SRC 2 Ic 23rd Harmonic
10428	SRC 2 Ic Harm[22]	SRC 2 Ic 24th Harmonic
10429	SRC 2 Ic Harm[23]	SRC 2 Ic 25th Harmonic
32768	Tracking Frequency	Tracking Frequency (Hz)
39425	FlexElement 1 Value	FlexElement 1 Actual
39427	FlexElement 2 Value	FlexElement 2 Actual
39429	FlexElement 3 Value	FlexElement 3 Actual
39431	FlexElement 4 Value	FlexElement 4 Actual
39433	FlexElement 5 Value	FlexElement 5 Actual
39435	FlexElement 6 Value	FlexElement 6 Actual
39437	FlexElement 7 Value	FlexElement 7 Actual
39439	FlexElement 8 Value	FlexElement 8 Actual
40960	Communications Group	Communications Group
40971	Active Setting Group	Current 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 μ s at 115200 bps). Consequently, the transmitting device must not allow gaps between bytes longer than this interval. Once the dead time has expired without a new byte transmission, all slaves start listening for a new packet from the master except for the addressed slave.

B.1.4 CRC-16 ALGORITHM

The CRC-16 algorithm essentially treats the entire data stream (data bits only; start, stop and parity ignored) as one continuous binary number. This number is first shifted left 16 bits and then divided by a characteristic polynomial (11000000000000101B). The 16 bit remainder of the division is appended to the end of the packet, MSByte first. The resulting packet including CRC, when divided by the same polynomial at the receiver will give a zero remainder if no transmission errors have occurred. This algorithm requires the characteristic polynomial to be reverse bit ordered. The most significant bit of the characteristic polynomial is dropped, since it does not affect the value of the remainder.

A C programming language implementation of the CRC algorithm will be provided upon request.

Table B-2: CRC-16 ALGORITHM

SYMBOLS:	-->	data transfer	
	A	16 bit working register	
	A _{low}	low order byte of A	
	A _{high}	high order byte of A	
	CRC	16 bit CRC-16 result	
	i,j	loop counters	
	(+)	logical EXCLUSIVE-OR operator	
	N	total number of data bytes	
	D _i	i-th data byte (i = 0 to N-1)	
	G	16 bit characteristic polynomial = 1010000000000001 (binary) with MSbit dropped and bit order reversed	
	shr (x)	right shift operator (th LSbit of x is shifted into a carry flag, a '0' is shifted into the MSbit of x, all other bits are shifted right one location)	
ALGORITHM:	1.	FFFF (hex) --> A	
	2.	0 --> i	
	3.	0 --> j	
	4.	D _i (+) A _{low} --> A _{low}	
	5.	j + 1 --> j	
	6.	shr (A)	
	7.	Is there a carry?	No: go to 8; Yes: G (+) A --> A and continue.
	8.	Is j = 8?	No: go to 5; Yes: continue
	9.	i + 1 --> i	
	10.	Is i = N?	No: go to 3; Yes: continue
	11.	A --> CRC	

B.2.1 SUPPORTED FUNCTION CODES

Modbus[®] officially defines function codes from 1 to 127 though only a small subset is generally needed. The relay supports some of these functions, as summarized in the following table. Subsequent sections describe each function code in detail.

FUNCTION CODE		MODBUS DEFINITION	GE MULTILIN DEFINITION
HEX	DEC		
03	3	Read Holding Registers	Read Actual Values or Settings
04	4	Read Holding Registers	Read Actual Values or Settings
05	5	Force Single Coil	Execute Operation
06	6	Preset Single Register	Store Single Setting
10	16	Preset Multiple Registers	Store Multiple Settings

B.2.2 READ ACTUAL VALUES OR SETTINGS (FUNCTION CODE 03/04H)

This function code allows the master to read one or more consecutive data registers (actual values or settings) from a relay. Data registers are always 16 bit (two byte) values transmitted with high order byte first. The maximum number of registers that can be read in a single packet is 125. See the Modbus Memory Map table for exact details on the data registers.

Since some PLC implementations of Modbus[®] only support one of function codes 03h and 04h, the relay interpretation allows either function code to be used for reading one or more consecutive data registers. The data starting address will determine the type of data being read. Function codes 03h and 04h are therefore identical.

The following table shows the format of the master and slave packets. The example shows a master device requesting 3 register values starting at address 4050h from slave device 11h (17 decimal); the slave device responds with the values 40, 300, and 0 from registers 4050h, 4051h, and 4052h, respectively.

Table B-3: MASTER AND SLAVE DEVICE PACKET TRANSMISSION EXAMPLE

MASTER TRANSMISSION		SLAVE RESPONSE	
PACKET FORMAT	EXAMPLE (HEX)	PACKET FORMAT	EXAMPLE (HEX)
SLAVE ADDRESS	11	SLAVE ADDRESS	11
FUNCTION CODE	04	FUNCTION CODE	04
DATA STARTING ADDRESS - high	40	BYTE COUNT	06
DATA STARTING ADDRESS - low	50	DATA #1 - high	00
NUMBER OF REGISTERS - high	00	DATA #1 - low	28
NUMBER OF REGISTERS - low	03	DATA #2 - high	01
CRC - low	A7	DATA #2 - low	2C
CRC - high	4A	DATA #3 - high	00
		DATA #3 - low	00
		CRC - low	0D
		CRC - high	60

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 dec) to perform a reset. The high and low Code Value bytes always have the values “FF” and “00” respectively and are a remnant of the original Modbus® definition of this function code.

Table B-4: MASTER AND SLAVE DEVICE PACKET TRANSMISSION EXAMPLE

MASTER TRANSMISSION		SLAVE RESPONSE	
PACKET FORMAT	EXAMPLE (HEX)	PACKET FORMAT	EXAMPLE (HEX)
SLAVE ADDRESS	11	SLAVE ADDRESS	11
FUNCTION CODE	05	FUNCTION CODE	05
OPERATION CODE - high	00	OPERATION CODE - high	00
OPERATION CODE - low	01	OPERATION CODE - low	01
CODE VALUE - high	FF	CODE VALUE - high	FF
CODE VALUE - low	00	CODE VALUE - low	00
CRC - low	DF	CRC - low	DF
CRC - high	6A	CRC - high	6A

Table B-5: SUMMARY OF OPERATION CODES FOR FUNCTION 05H

OPERATION CODE (HEX)	DEFINITION	DESCRIPTION
0000	NO OPERATION	Does not do anything.
0001	RESET	Performs the same function as the faceplate RESET key.
0005	CLEAR EVENT RECORDS	Performs the same function as the faceplate CLEAR EVENT RECORDS menu command.
0006	CLEAR OSCILLOGRAPHY	Clears all oscillography records.
1000 to 101F	VIRTUAL IN 1-32 ON/OFF	Sets the states of Virtual Inputs 1 to 32 either “ON” or “OFF”.

B.2.4 STORE SINGLE SETTING (FUNCTION CODE 06H)

This function code allows the master to modify the contents of a single setting register in an relay. Setting registers are always 16 bit (two byte) values transmitted high order byte first. The following table shows the format of the master and slave packets. The example shows a master device storing the value 200 at memory map address 4051h to slave device 11h (17 dec).

Table B-6: MASTER AND SLAVE DEVICE PACKET TRANSMISSION EXAMPLE

MASTER TRANSMISSION		SLAVE RESPONSE	
PACKET FORMAT	EXAMPLE (HEX)	PACKET FORMAT	EXAMPLE (HEX)
SLAVE ADDRESS	11	SLAVE ADDRESS	11
FUNCTION CODE	06	FUNCTION CODE	06
DATA STARTING ADDRESS - high	40	DATA STARTING ADDRESS - high	40
DATA STARTING ADDRESS - low	51	DATA STARTING ADDRESS - low	51
DATA - high	00	DATA - high	00
DATA - low	C8	DATA - low	C8
CRC - low	CE	CRC - low	CE
CRC - high	DD	CRC - high	DD

B.2.5 STORE MULTIPLE SETTINGS (FUNCTION CODE 10H)

This function code allows the master to modify the contents of a one or more consecutive setting registers in a relay. Setting registers are 16-bit (two byte) values transmitted high order byte first. The maximum number of setting registers that can be stored in a single packet is 60. The following table shows the format of the master and slave packets. The example shows a master device storing the value 200 at memory map address 4051h, and the value 1 at memory map address 4052h to slave device 11h (17 decimal).

Table B-7: MASTER AND SLAVE DEVICE PACKET TRANSMISSION EXAMPLE

MASTER TRANSMISSION		SLAVE RESPONSE	
PACKET FORMAT	EXAMPLE (HEX)	PACKET FORMAT	EXAMPLE (HEX)
SLAVE ADDRESS	11	SLAVE ADDRESS	11
FUNCTION CODE	10	FUNCTION CODE	10
DATA STARTING ADDRESS - hi	40	DATA STARTING ADDRESS - hi	40
DATA STARTING ADDRESS - lo	51	DATA STARTING ADDRESS - lo	51
NUMBER OF SETTINGS - hi	00	NUMBER OF SETTINGS - hi	00
NUMBER OF SETTINGS - lo	02	NUMBER OF SETTINGS - lo	02
BYTE COUNT	04	CRC - lo	07
DATA #1 - high order byte	00	CRC - hi	64
DATA #1 - low order byte	C8		
DATA #2 - high order byte	00		
DATA #2 - low order byte	01		
CRC - low order byte	12		
CRC - high order byte	62		

B.2.6 EXCEPTION RESPONSES

Programming or operation errors usually happen because of illegal data in a packet. These errors result in an exception response from the slave. The slave detecting one of these errors sends a response packet to the master with the high order bit of the function code set to 1.

The following table shows the format of the master and slave packets. The example shows a master device sending the unsupported function code 39h to slave device 11.

Table B-8: MASTER AND SLAVE DEVICE PACKET TRANSMISSION EXAMPLE

MASTER TRANSMISSION		SLAVE RESPONSE	
PACKET FORMAT	EXAMPLE (HEX)	PACKET FORMAT	EXAMPLE (HEX)
SLAVE ADDRESS	11	SLAVE ADDRESS	11
FUNCTION CODE	39	FUNCTION CODE	B9
CRC - low order byte	CD	ERROR CODE	01
CRC - high order byte	F2	CRC - low order byte	93
		CRC - high order byte	95

B.3.1 OBTAINING RELAY FILES VIA MODBUS

a) DESCRIPTION

The UR relay has a generic file transfer facility, meaning that you use the same method to obtain all of the different types of files from the unit. The Modbus registers that implement file transfer are found in the "Modbus File Transfer (Read/Write)" and "Modbus File Transfer (Read Only)" modules, starting at address 3100 in the Modbus Memory Map. To read a file from the UR relay, use the following steps:

1. Write the filename to the "Name of file to read" register using a write multiple registers command. If the name is shorter than 80 characters, you may write only enough registers to include all the text of the filename. Filenames are not case sensitive.
2. Repeatedly read all the registers in "Modbus File Transfer (Read Only)" using a read multiple registers command. It is not necessary to read the entire data block, since the UR relay will remember which was the last register you read. The "position" register is initially zero and thereafter indicates how many bytes (2 times the number of registers) you have read so far. The "size of..." register indicates the number of bytes of data remaining to read, to a maximum of 244.
3. Keep reading until the "size of..." register is smaller than the number of bytes you are transferring. This condition indicates end of file. Discard any bytes you have read beyond the indicated block size.
4. If you need to re-try a block, read only the "size of..." and "block of data", without reading the position. The file pointer is only incremented when you read the position register, so the same data block will be returned as was read in the previous operation. On the next read, check to see if the position is where you expect it to be, and discard the previous block if it is not (this condition would indicate that the UR relay did not process your original read request).

The UR relay retains connection-specific file transfer information, so files may be read simultaneously on multiple Modbus connections.

b) OTHER PROTOCOLS

All the files available via Modbus may also be retrieved using the standard file transfer mechanisms in other protocols (for example, TFTP or MMS).

c) COMTRADE, OSCILLOGRAPHY, AND DATA LOGGER FILES

Oscillography and data logger files are formatted using the COMTRADE file format per IEEE PC37.111 Draft 7c (02 September 1997). The files may be obtained in either text or binary COMTRADE format.

d) READING OSCILLOGRAPHY FILES

Familiarity with the oscillography feature is required to understand the following description. Refer to the Oscillography section in Chapter 5 for additional details.

The Oscillography Number of Triggers register is incremented by one every time a new oscillography file is triggered (captured) and cleared to zero when oscillography data is cleared. When a new trigger occurs, the associated oscillography file is assigned a file identifier number equal to the incremented value of this register; the newest file number is equal to the Oscillography_Number_of_Triggers register. This register can be used to determine if any new data has been captured by periodically reading it to see if the value has changed; if the number has increased then new data is available.

The Oscillography Number of Records register specifies the maximum number of files (and the number of cycles of data per file) that can be stored in memory of the relay. The Oscillography Available Records register specifies the actual number of files that are stored and still available to be read out of the relay.

Writing "Yes" (i.e. the value 1) to the Oscillography Clear Data register clears oscillography data files, clears both the Oscillography Number of Triggers and Oscillography Available Records registers to zero, and sets the Oscillography Last Cleared Date to the present date and time.

To read binary COMTRADE oscillography files, read the following filenames:

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)

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.

B.4.1 MODBUS MEMORY MAP

Table B–9: MODBUS MEMORY MAP (Sheet 1 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
Product Information (Read Only)						
0000	UR Product Type	0 to 65535	---	1	F001	0
0002	Product Version	0 to 655.35	---	0.01	F001	1
Product Information (Read Only -- Written by Factory)						
0010	Serial Number	---	---	---	F203	"0"
0020	Manufacturing Date	0 to 4294967295	---	1	F050	0
0022	Modification Number	0 to 65535	---	1	F001	0
0040	Order Code	---	---	---	F204	"Order Code x "
0090	Ethernet MAC Address	---	---	---	F072	0
0093	Reserved (13 items)	---	---	---	F001	0
00A0	CPU Module Serial Number	---	---	---	F203	(none)
00B0	CPU Supplier Serial Number	---	---	---	F203	(none)
00C0	Ethernet Sub Module Serial Number (8 items)	---	---	---	F203	(none)
Self Test Targets (Read Only)						
0200	Self Test States (2 items)	0 to 4294967295	0	1	F143	0
Front Panel (Read Only)						
0204	LED Column x State (10 items)	0 to 65535	---	1	F501	0
0220	Display Message	---	---	---	F204	(none)
0248	Last Key Pressed	0 to 42	---	1	F530	0 (None)
Keypress Emulation (Read/Write)						
0280	Simulated keypress -- write zero before each keystroke	0 to 38	---	1	F190	0 (No key -- use between real keys)
Virtual Input Commands (Read/Write Command) (32 modules)						
0400	Virtual Input x State	0 to 1	---	1	F108	0 (Off)
0401	...Repeated for module number 2					
0402	...Repeated for module number 3					
0403	...Repeated for module number 4					
0404	...Repeated for module number 5					
0405	...Repeated for module number 6					
0406	...Repeated for module number 7					
0407	...Repeated for module number 8					
0408	...Repeated for module number 9					
0409	...Repeated for module number 10					
040A	...Repeated for module number 11					
040B	...Repeated for module number 12					
040C	...Repeated for module number 13					
040D	...Repeated for module number 14					
040E	...Repeated for module number 15					
040F	...Repeated for module number 16					
0410	...Repeated for module number 17					
0411	...Repeated for module number 18					
0412	...Repeated for module number 19					
0413	...Repeated for module number 20					
0414	...Repeated for module number 21					
0415	...Repeated for module number 22					
0416	...Repeated for module number 23					
0417	...Repeated for module number 24					
0418	...Repeated for module number 25					
0419	...Repeated for module number 26					
041A	...Repeated for module number 27					
041B	...Repeated for module number 28					

Table B-9: MODBUS MEMORY MAP (Sheet 2 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
041C	...Repeated for module number 29					
041D	...Repeated for module number 30					
041E	...Repeated for module number 31					
041F	...Repeated for module number 32					
Digital Counter States (Read Only Non-Volatile) (8 modules)						
0800	Digital Counter x Value	-2147483647 to 2147483647	---	1	F004	0
0802	Digital Counter x Frozen	-2147483647 to 2147483647	---	1	F004	0
0804	Digital Counter x Frozen Time Stamp	0 to 4294967295	---	1	F050	0
0806	Digital Counter x Frozen Time Stamp us	0 to 4294967295	---	1	F003	0
0808	...Repeated for module number 2					
0810	...Repeated for module number 3					
0818	...Repeated for module number 4					
0820	...Repeated for module number 5					
0828	...Repeated for module number 6					
0830	...Repeated for module number 7					
0838	...Repeated for module number 8					
FlexStates (Read Only)						
0900	FlexState Bits (16 items)	0 to 65535	---	1	F001	0
Element States (Read Only)						
1000	Element Operate States (64 items)	0 to 65535	---	1	F502	0
User Displays Actuals (Read Only)						
1080	Formatted user-definable displays (8 items)	---	---	---	F200	(none)
Modbus User Map Actuals (Read Only)						
1200	User Map Values (256 items)	0 to 65535	---	1	F001	0
Element Targets (Read Only)						
14C0	Target Sequence	0 to 65535	---	1	F001	0
14C1	Number of Targets	0 to 65535	---	1	F001	0
Element Targets (Read/Write)						
14C2	Target to Read	0 to 65535	---	1	F001	0
Element Targets (Read Only)						
14C3	Target Message	---	---	---	F200	" "
Digital I/O States (Read Only)						
1500	Contact Input States (6 items)	0 to 65535	---	1	F500	0
1508	Virtual Input States (2 items)	0 to 65535	---	1	F500	0
1510	Contact Output States (4 items)	0 to 65535	---	1	F500	0
1518	Contact Output Current States (4 items)	0 to 65535	---	1	F500	0
1520	Contact Output Voltage States (4 items)	0 to 65535	---	1	F500	0
1528	Virtual Output States (4 items)	0 to 65535	---	1	F500	0
1530	Contact Output Detectors (4 items)	0 to 65535	---	1	F500	0
Remote I/O States (Read Only)						
1540	Remote Device x States	0 to 65535	---	1	F500	0
1542	Remote Input States (2 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 x StNum	0 to 4294967295	---	1	F003	0
1553	Remote Device x SqNum	0 to 4294967295	---	1	F003	0
1555	...Repeated for module number 2					
1559	...Repeated for module number 3					
155D	...Repeated for module number 4					
1561	...Repeated for module number 5					
1565	...Repeated for module number 6					
1569	...Repeated for module number 7					
156D	...Repeated for module number 8					

Table B–9: MODBUS MEMORY MAP (Sheet 3 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
1571	...Repeated for module number 9					
1575	...Repeated for module number 10					
1579	...Repeated for module number 11					
157D	...Repeated for module number 12					
1581	...Repeated for module number 13					
1585	...Repeated for module number 14					
1589	...Repeated for module number 15					
158D	...Repeated for module number 16					
Platform Direct I/O States (Read Only)						
15C0	Direct Input States (6 items)	0 to 65535	---	1	F500	0
15C8	Platform Direct Outputs Average Msg Return Time 1	0 to 65535	ms	1	F001	0
15C9	Platform Direct Outputs Average Msg Return Time 2	0 to 65535	ms	1	F001	0
15D0	Direct Device States	0 to 65535	---	1	F500	0
15D1	Reserved					
15D2	Platform Direct I/O CRC Fail Count 1	0 to 65535	---	1	F001	0
15D3	Platform Direct I/O CRC Fail Count 2	0 to 65535	---	1	F001	0
Ethernet Fibre Channel Status (Read/Write)						
1610	Ethernet Primary Fibre Channel Status	0 to 2	---	1	F134	0 (Fail)
1611	Ethernet Secondary Fibre Channel Status	0 to 2	---	1	F134	0 (Fail)
Data Logger Actuals (Read Only)						
1618	Data Logger Channel Count	0 to 16	CHNL	1	F001	0
1619	Time of oldest available samples	0 to 4294967295	seconds	1	F050	0
161B	Time of newest available samples	0 to 4294967295	seconds	1	F050	0
161D	Data Logger Duration	0 to 999.9	DAYS	0.1	F001	0
Sensitive Directional Power Actuals (Read Only) (2 modules)						
1680	Sensitive Directional Power X Power	-2147483647 to 2147483647	W	1	F060	0
1682	...Repeated for module number 2					
Frequency Rate of Change Actuals (Read Only) (4 modules)						
16E0	Frequency Rate of Change	-327.67 to 327.67	Hz/s	0.01	F002	0
16E1	Rate of Change X Reserved (3 items)	0 to 65535	---	1	F001	0
16E4	...Repeated for module number 2					
16E8	...Repeated for module number 3					
16EC	...Repeated for module number 4					
Source Current (Read Only) (6 modules)						
1800	Phase A Current RMS	0 to 999999.999	A	0.001	F060	0
1802	Phase B Current RMS	0 to 999999.999	A	0.001	F060	0
1804	Phase C Current RMS	0 to 999999.999	A	0.001	F060	0
1806	Neutral Current RMS	0 to 999999.999	A	0.001	F060	0
1808	Phase A Current Magnitude	0 to 999999.999	A	0.001	F060	0
180A	Phase A Current Angle	-359.9 to 0	x	0.1	F002	0
180B	Phase B Current Magnitude	0 to 999999.999	A	0.001	F060	0
180D	Phase B Current Angle	-359.9 to 0	x	0.1	F002	0
180E	Phase C Current Magnitude	0 to 999999.999	A	0.001	F060	0
1810	Phase C Current Angle	-359.9 to 0	x	0.1	F002	0
1811	Neutral Current Magnitude	0 to 999999.999	A	0.001	F060	0
1813	Neutral Current Angle	-359.9 to 0	x	0.1	F002	0
1814	Ground Current RMS	0 to 999999.999	A	0.001	F060	0
1816	Ground Current Magnitude	0 to 999999.999	A	0.001	F060	0
1818	Ground Current Angle	-359.9 to 0	x	0.1	F002	0
1819	Zero Sequence Current Magnitude	0 to 999999.999	A	0.001	F060	0
181B	Zero Sequence Current Angle	-359.9 to 0	x	0.1	F002	0
181C	Positive Sequence Current Magnitude	0 to 999999.999	A	0.001	F060	0
181E	Positive Sequence Current Angle	-359.9 to 0	x	0.1	F002	0

Table B-9: MODBUS MEMORY MAP (Sheet 4 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
181F	Negative Sequence Current Magnitude	0 to 999999.999	A	0.001	F060	0
1821	Negative Sequence Current Angle	-359.9 to 0	x	0.1	F002	0
1822	Differential Ground Current Magnitude	0 to 999999.999	A	0.001	F060	0
1824	Differential Ground Current Angle	-359.9 to 0	x	0.1	F002	0
1825	Reserved (27 items)	---	---	---	F001	0
1840	...Repeated for module number 2					
1880	...Repeated for module number 3					
18C0	...Repeated for module number 4					
1900	...Repeated for module number 5					
1940	...Repeated for module number 6					
Source Voltage (Read Only) (6 modules)						
1A00	Phase AG Voltage RMS	0 to 999999.999	V	0.001	F060	0
1A02	Phase BG Voltage RMS	0 to 999999.999	V	0.001	F060	0
1A04	Phase CG Voltage RMS	0 to 999999.999	V	0.001	F060	0
1A06	Phase AG Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A08	Phase AG Voltage Angle	-359.9 to 0	x	0.1	F002	0
1A09	Phase BG Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A0B	Phase BG Voltage Angle	-359.9 to 0	x	0.1	F002	0
1A0C	Phase CG Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A0E	Phase CG Voltage Angle	-359.9 to 0	x	0.1	F002	0
1A0F	Phase AB or AC Voltage RMS	0 to 999999.999	V	0.001	F060	0
1A11	Phase BC or BA Voltage RMS	0 to 999999.999	V	0.001	F060	0
1A13	Phase CA or CB Voltage RMS	0 to 999999.999	V	0.001	F060	0
1A15	Phase AB or AC Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A17	Phase AB or AC Voltage Angle	-359.9 to 0	x	0.1	F002	0
1A18	Phase BC or BA Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A1A	Phase BC or BA Voltage Angle	-359.9 to 0	x	0.1	F002	0
1A1B	Phase CA or CB Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A1D	Phase CA or CB Voltage Angle	-359.9 to 0	x	0.1	F002	0
1A1E	Auxiliary Voltage RMS	0 to 999999.999	V	0.001	F060	0
1A20	Auxiliary Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A22	Auxiliary Voltage Angle	-359.9 to 0	x	0.1	F002	0
1A23	Zero Sequence Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A25	Zero Sequence Voltage Angle	-359.9 to 0	x	0.1	F002	0
1A26	Positive Sequence Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A28	Positive Sequence Voltage Angle	-359.9 to 0	x	0.1	F002	0
1A29	Negative Sequence Voltage Magnitude	0 to 999999.999	V	0.001	F060	0
1A2B	Negative Sequence Voltage Angle	-359.9 to 0	x	0.1	F002	0
1A2C	Reserved (20 items)	---	---	---	F001	0
1A40	...Repeated for module number 2					
1A80	...Repeated for module number 3					
1AC0	...Repeated for module number 4					
1B00	...Repeated for module number 5					
1B40	...Repeated for module number 6					
Source Power (Read Only) (6 modules)						
1C00	Three Phase Real Power	-1000000000000 to 1000000000000	W	0.001	F060	0
1C02	Phase A Real Power	-1000000000000 to 1000000000000	W	0.001	F060	0
1C04	Phase B Real Power	-1000000000000 to 1000000000000	W	0.001	F060	0
1C06	Phase C Real Power	-1000000000000 to 1000000000000	W	0.001	F060	0
1C08	Three Phase Reactive Power	-1000000000000 to 1000000000000	var	0.001	F060	0

Table B-9: MODBUS MEMORY MAP (Sheet 5 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
1C0A	Phase A Reactive Power	-1000000000000 to 1000000000000	var	0.001	F060	0
1C0C	Phase B Reactive Power	-1000000000000 to 1000000000000	var	0.001	F060	0
1C0E	Phase C Reactive Power	-1000000000000 to 1000000000000	var	0.001	F060	0
1C10	Three Phase Apparent Power	-1000000000000 to 1000000000000	VA	0.001	F060	0
1C12	Phase A Apparent Power	-1000000000000 to 1000000000000	VA	0.001	F060	0
1C14	Phase B Apparent Power	-1000000000000 to 1000000000000	VA	0.001	F060	0
1C16	Phase C Apparent Power	-1000000000000 to 1000000000000	VA	0.001	F060	0
1C18	Three Phase Power Factor	-0.999 to 1	---	0.001	F013	0
1C19	Phase A Power Factor	-0.999 to 1	---	0.001	F013	0
1C1A	Phase B Power Factor	-0.999 to 1	---	0.001	F013	0
1C1B	Phase C Power Factor	-0.999 to 1	---	0.001	F013	0
1C1C	Reserved (4 items)	---	---	---	F001	0
1C20	...Repeated for module number 2					
1C40	...Repeated for module number 3					
1C60	...Repeated for module number 4					
1C80	...Repeated for module number 5					
1CA0	...Repeated for module number 6					
Source Energy (Read Only Non-Volatile) (6 modules)						
1D00	Positive Watthour	0 to 1000000000000	Wh	0.001	F060	0
1D02	Negative Watthour	0 to 1000000000000	Wh	0.001	F060	0
1D04	Positive Varhour	0 to 1000000000000	varh	0.001	F060	0
1D06	Negative Varhour	0 to 1000000000000	varh	0.001	F060	0
1D08	Reserved (8 items)	---	---	---	F001	0
1D10	...Repeated for module number 2					
1D20	...Repeated for module number 3					
1D30	...Repeated for module number 4					
1D40	...Repeated for module number 5					
1D50	...Repeated for module number 6					
Energy Commands (Read/Write Command)						
1D60	Energy Clear Command	0 to 1	---	1	F126	0 (No)
Source Frequency (Read Only) (6 modules)						
1D80	Frequency	2 to 90	Hz	0.01	F001	0
1D81	...Repeated for module number 2					
1D82	...Repeated for module number 3					
1D83	...Repeated for module number 4					
1D84	...Repeated for module number 5					
1D85	...Repeated for module number 6					
Source Demand (Read Only) (6 modules)						
1E00	Demand Ia	0 to 999999.999	A	0.001	F060	0
1E02	Demand Ib	0 to 999999.999	A	0.001	F060	0
1E04	Demand Ic	0 to 999999.999	A	0.001	F060	0
1E06	Demand Watt	0 to 999999.999	W	0.001	F060	0
1E08	Demand Var	0 to 999999.999	var	0.001	F060	0
1E0A	Demand Va	0 to 999999.999	VA	0.001	F060	0
1E0C	Reserved (4 items)	---	---	---	F001	0
1E10	...Repeated for module number 2					
1E20	...Repeated for module number 3					
1E30	...Repeated for module number 4					
1E40	...Repeated for module number 5					

Table B-9: MODBUS MEMORY MAP (Sheet 6 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
1E50	...Repeated for module number 6					
Source Demand Peaks (Read Only Non-Volatile) (6 modules)						
1E80	SRC X Demand Ia Max	0 to 999999.999	A	0.001	F060	0
1E82	SRC X Demand Ia Max Date	0 to 4294967295	---	1	F050	0
1E84	SRC X Demand Ib Max	0 to 999999.999	A	0.001	F060	0
1E86	SRC X Demand Ib Max Date	0 to 4294967295	---	1	F050	0
1E88	SRC X Demand Ic Max	0 to 999999.999	A	0.001	F060	0
1E8A	SRC X Demand Ic Max Date	0 to 4294967295	---	1	F050	0
1E8C	SRC X Demand Watt Max	0 to 999999.999	W	0.001	F060	0
1E8E	SRC X Demand Watt Max Date	0 to 4294967295	---	1	F050	0
1E90	SRC X Demand Var	0 to 999999.999	var	0.001	F060	0
1E92	SRC X Demand Var Max Date	0 to 4294967295	---	1	F050	0
1E94	SRC X Demand Va Max	0 to 999999.999	VA	0.001	F060	0
1E96	SRC X Demand Va Max Date	0 to 4294967295	---	1	F050	0
1E98	Reserved (8 items)	---	---	---	F001	0
1EA0	...Repeated for module number 2					
1EC0	...Repeated for module number 3					
1EE0	...Repeated for module number 4					
1F00	...Repeated for module number 5					
1F20	...Repeated for module number 6					
Source Voltage THD And Harmonics (Read Only) (6 modules)						
1F80	Va THD	0 to 99.9	---	0.1	F001	0
1F81	Va Harmonics - 2nd to 25th (24 items)	0 to 99.9	---	0.1	F001	0
1F99	Vb THD	0 to 99.9	---	0.1	F001	0
1F9A	Vb Harmonics - 2nd to 25th (24 items)	0 to 99.9	---	0.1	F001	0
1FB2	Vc THD	0 to 99.9	---	0.1	F001	0
1FB3	Vc Harmonics - 2nd to 25th (24 items)	0 to 99.9	---	0.1	F001	0
1FCB	...Repeated for module number 2					
2016	...Repeated for module number 3					
2061	...Repeated for module number 4					
20AC	...Repeated for module number 5					
20F7	...Repeated for module number 6					
Breaker Arcing Current Actuals (Read Only Non-Volatile) (2 modules)						
2200	Breaker x Arcing Amp Phase A	0 to 999999999	kA2-cyc	1	F060	0
2202	Breaker x Arcing Amp Phase B	0 to 999999999	kA2-cyc	1	F060	0
2204	Breaker x Arcing Amp Phase C	0 to 999999999	kA2-cyc	1	F060	0
2206	...Repeated for module number 2					
Breaker Arcing Current Commands (Read/Write Command) (2 modules)						
220C	Breaker x Arcing Clear Command	0 to 1	---	1	F126	0 (No)
220D	...Repeated for module number 2					
Passwords Unauthorized Access (Read/Write Command)						
2230	Reset Unauthorized Access	0 to 1	---	1	F126	0 (No)
HIZ Commands (Read/Write Command)						
2240	HIZ Clear Oscillography	0 to 1	---	1	F126	0 (No)
2241	HIZ Oscillography Force Trigger	0 to 1	---	1	F126	0 (No)
2242	HIZ Oscillography Force Algorithm Capture	0 to 1	---	1	F126	0 (No)
2243	HIZ Reset Sigma Values	0 to 1	---	1	F126	0 (No)
HIZ Status (Read Only)						
2250	HIZ Status	0 to 9	---	1	F187	0 (NORMAL)
2251	HIZ Phase A Arc Confidence	0 to 100		1	F001	0
2252	HIZ Phase B Arc Confidence	0 to 100		1	F001	0
2253	HIZ Phase C Arc Confidence	0 to 100		1	F001	0
2254	HIZ Neutral Arc Confidence	0 to 100	---	1	F001	0
HIZ Records (Read Only) (4 modules)						

Table B-9: MODBUS MEMORY MAP (Sheet 7 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
2260	HIZ Capture Trigger Type	0 to 6	---	1	F188	0 (NONE)
2261	HIZ Capture Time	0 to 1	---	1	F050	0
2263	...Repeated for module number 2					
2266	...Repeated for module number 3					
2269	...Repeated for module number 4					
HIZ RMS Records (Read Only) (4 modules)						
2270	HIZ RMS Capture Trigger Type	0 to 6	---	1	F188	0 (NONE)
2271	HIZ RMS Capture Time	0 to 1	---	1	F050	0
2273	...Repeated for module number 2					
2276	...Repeated for module number 3					
2279	...Repeated for module number 4					
Fault Location (Read Only)						
2350	Prefault Phase A Current Magnitude	0 to 999999.999	A	0.001	F060	0
2352	Prefault Phase B Current Magnitude	0 to 999999.999	A	0.001	F060	0
2354	Prefault Phase C Current Magnitude	0 to 999999.999	A	0.001	F060	0
2356	Prefault Zero Seq Current	0 to 999999.999	A	0.001	F060	0
2358	Prefault Pos Seq Current	0 to 999999.999	A	0.001	F060	0
235A	Prefault Neg Seq Current	0 to 999999.999	A	0.001	F060	0
235C	Prefault Phase A Voltage	0 to 999999.999	V	0.001	F060	0
235E	Prefault Phase B Voltage	0 to 999999.999	V	0.001	F060	0
2360	Prefault Phase C Voltage	0 to 999999.999	V	0.001	F060	0
2362	Last Fault Location in Line length units (km or miles)	-3276.7 to 3276.7	---	0.1	F002	0
Synchrocheck Actuals (Read Only) (2 modules)						
2400	Synchrocheck X Delta Voltage	-1000000000000 to 1000000000000	V	1	F060	0
2402	Synchrocheck X Delta Frequency	0 to 655.35	Hz	0.01	F001	0
2403	Synchrocheck X Delta Phase	0 to 359.9	x	0.1	F001	0
2404	...Repeated for module number 2					
Autoreclose Status (Read Only) (6 modules)						
2410	Autoreclose Count	0 to 65535	---	1	F001	0
2411	...Repeated for module number 2					
2412	...Repeated for module number 3					
2413	...Repeated for module number 4					
2414	...Repeated for module number 5					
2415	...Repeated for module number 6					
Source Current THD And Harmonics (Read Only) (6 modules)						
2800	Ia THD	0 to 99.9	---	0.1	F001	0
2801	Ia Harmonics - 2nd to 25th (24 items)	0 to 99.9	---	0.1	F001	0
2821	Ib THD	0 to 99.9	---	0.1	F001	0
2822	Ib Harmonics - 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	0 to 99.9	---	0.1	F001	0
2843	Ic Harmonics - 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 module number 2					
28C6	...Repeated for module number 3					
2929	...Repeated for module number 4					
298C	...Repeated for module number 5					
29EF	...Repeated for module number 6					
Expanded FlexStates (Read Only)						
2B00	FlexStates, one per register (256 items)	0 to 1	---	1	F108	0 (Off)
Expanded Digital I/O 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)

Table B-9: MODBUS MEMORY MAP (Sheet 8 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
2E00	Virtual Output States, one per register (64 items)	0 to 1	---	1	F108	0 (Off)
Expanded Remote I/O 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 (32 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 Reports (Read Only Non-Volatile) (10 modules)						
3030	Fault Time	0 to 4294967295	---	1	F050	0
3032	...Repeated for module number 2					
3034	...Repeated for module number 3					
3036	...Repeated for module number 4					
3038	...Repeated for module number 5					
303A	...Repeated for module number 6					
303C	...Repeated for module number 7					
303E	...Repeated for module number 8					
3040	...Repeated for module number 9					
3042	...Repeated for module number 10					
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 x Value	-9999.999 to 9999.999	---	0.001	F004	0
34C2	...Repeated for module number 2					
34C4	...Repeated for module number 3					
34C6	...Repeated for module number 4					
34C8	...Repeated for module number 5					
34CA	...Repeated for module number 6					
34CC	...Repeated for module number 7					
34CE	...Repeated for module number 8					
34D0	...Repeated for module number 9					
34D2	...Repeated for module number 10					
34D4	...Repeated for module number 11					
34D6	...Repeated for module number 12					
34D8	...Repeated for module number 13					
34DA	...Repeated for module number 14					
34DC	...Repeated for module number 15					
34DE	...Repeated for module number 16					

Table B-9: MODBUS MEMORY MAP (Sheet 9 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
34E0	...Repeated for module number 17					
34E2	...Repeated for module number 18					
34E4	...Repeated for module number 19					
34E6	...Repeated for module number 20					
34E8	...Repeated for module number 21					
34EA	...Repeated for module number 22					
34EC	...Repeated for module number 23					
34EE	...Repeated for module number 24					
RTD Input Values (Read Only) (48 modules)						
34F0	RTD Inputs x Value	-32768 to 32767	°C	1	F002	0
34F1	...Repeated for module number 2					
34F2	...Repeated for module number 3					
34F3	...Repeated for module number 4					
34F4	...Repeated for module number 5					
34F5	...Repeated for module number 6					
34F6	...Repeated for module number 7					
34F7	...Repeated for module number 8					
34F8	...Repeated for module number 9					
34F9	...Repeated for module number 10					
34FA	...Repeated for module number 11					
34FB	...Repeated for module number 12					
34FC	...Repeated for module number 13					
34FD	...Repeated for module number 14					
34FE	...Repeated for module number 15					
34FF	...Repeated for module number 16					
3500	...Repeated for module number 17					
3501	...Repeated for module number 18					
3502	...Repeated for module number 19					
3503	...Repeated for module number 20					
3504	...Repeated for module number 21					
3505	...Repeated for module number 22					
3506	...Repeated for module number 23					
3507	...Repeated for module number 24					
3508	...Repeated for module number 25					
3509	...Repeated for module number 26					
350A	...Repeated for module number 27					
350B	...Repeated for module number 28					
350C	...Repeated for module number 29					
350D	...Repeated for module number 30					
350E	...Repeated for module number 31					
350F	...Repeated for module number 32					
3510	...Repeated for module number 33					
3511	...Repeated for module number 34					
3512	...Repeated for module number 35					
3513	...Repeated for module number 36					
3514	...Repeated for module number 37					
3515	...Repeated for module number 38					
3516	...Repeated for module number 39					
3517	...Repeated for module number 40					
3518	...Repeated for module number 41					
3519	...Repeated for module number 42					
351A	...Repeated for module number 43					
351B	...Repeated for module number 44					
351C	...Repeated for module number 45					

Table B-9: MODBUS MEMORY MAP (Sheet 10 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
351D	...Repeated for module number 46					
351E	...Repeated for module number 47					
351F	...Repeated for module number 48					
Ohm Input Values (Read Only) (2 modules)						
3520	Ohm Inputs x Value	0 to 65535		1	F001	0
3521	...Repeated for module number 2					
Expanded Platform Direct I/O 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)
Preferences (Read/Write Setting)						
4050	Flash Message Time	0.5 to 10	s	0.1	F001	10
4051	Default Message Timeout	10 to 900	s	1	F001	300
4052	Default Message Intensity	0 to 3	---	1	F101	0 (25%)
4053	Screen Saver Feature	0 to 1	---	1	F102	0 (Disabled)
4054	Screen Saver Wait Time	1 to 65535	min	1	F001	30
4055	Current Cutoff Level	0.002 to 0.02	pu	0.001	F001	20
4056	Voltage Cutoff Level	0.1 to 1	V	0.1	F001	10
Communications (Read/Write Setting)						
407E	COM1 minimum response time	0 to 1000	ms	10	F001	0
407F	COM2 minimum response time	0 to 1000	ms	10	F001	0
4080	Modbus Slave Address	1 to 254	---	1	F001	254
4083	RS485 Com1 Baud Rate	0 to 11	---	1	F112	8 (115200)
4084	RS485 Com1 Parity	0 to 2	---	1	F113	0 (None)
4085	RS485 Com2 Baud Rate	0 to 11	---	1	F112	8 (115200)
4086	RS485 Com2 Parity	0 to 2	---	1	F113	0 (None)
4087	IP Address	0 to 4294967295	---	1	F003	56554706
4089	IP Subnet Mask	0 to 4294967295	---	1	F003	4294966272
408B	Gateway IP Address	0 to 4294967295	---	1	F003	56554497
408D	Network Address NSAP	---	---	---	F074	0
4097	Default GOOSE Update Time	1 to 60	s	1	F001	60
409A	DNP Port	0 to 4	---	1	F177	0 (NONE)
409B	DNP Address	0 to 65519	---	1	F001	1
409C	DNP Client Addresses (2 items)	0 to 4294967295	---	1	F003	0
40A0	TCP Port Number for the Modbus protocol	1 to 65535	---	1	F001	502
40A1	TCP/UDP Port Number for the DNP Protocol	1 to 65535	---	1	F001	20000
40A2	TCP Port Number for the UCA/MMS Protocol	1 to 65535	---	1	F001	102
40A3	TCP Port Number for the HTTP (Web Server) Protocol	1 to 65535	---	1	F001	80
40A4	Main UDP Port Number for the TFTP Protocol	1 to 65535	---	1	F001	69
40A5	Data Transfer UDP Port Numbers for the TFTP Protocol (zero means "automatic") (2 items)	0 to 65535	---	1	F001	0
40A7	DNP Unsolicited Responses Function	0 to 1	---	1	F102	0 (Disabled)
40A8	DNP Unsolicited Responses Timeout	0 to 60	s	1	F001	5
40A9	DNP Unsolicited Responses Max Retries	1 to 255	---	1	F001	10
40AA	DNP Unsolicited Responses Destination Address	0 to 65519	---	1	F001	1

Table B–9: MODBUS MEMORY MAP (Sheet 11 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
40AB	Ethernet Operation Mode	0 to 1	---	1	F192	0 (Half-Duplex)
40AC	DNP User Map Function	0 to 1	---	1	F102	0 (Disabled)
40AD	DNP Number of Sources used in Analog points list	1 to 6	---	1	F001	1
40AE	DNP Current Scale Factor	0 to 8	---	1	F194	2 (1)
40AF	DNP Voltage Scale Factor	0 to 8	---	1	F194	2 (1)
40B0	DNP Power Scale Factor	0 to 8	---	1	F194	2 (1)
40B1	DNP Energy Scale Factor	0 to 8	---	1	F194	2 (1)
40B2	DNP Other Scale Factor	0 to 8	---	1	F194	2 (1)
40B3	DNP Current Default Deadband	0 to 65535	---	1	F001	30000
40B4	DNP Voltage Default Deadband	0 to 65535	---	1	F001	30000
40B5	DNP Power Default Deadband	0 to 65535	---	1	F001	30000
40B6	DNP Energy Default Deadband	0 to 65535	---	1	F001	30000
40B7	DNP Other Default Deadband	0 to 65535	---	1	F001	30000
40B8	DNP IIN Time Sync Bit Period	1 to 10080	min	1	F001	1440
40B9	DNP Message Fragment Size	30 to 2048	---	1	F001	240
40BA	DNP Client Address 3	0 to 4294967295	---	1	F003	0
40BC	DNP Client Address 4	0 to 4294967295	---	1	F003	0
40BE	DNP Client Address 5	0 to 4294967295	---	1	F003	0
40C0	DNP Communications Reserved (8 items)	0 to 1	---	1	F001	0
40C8	UCA Logical Device Name	---	---	---	F203	"UCADevice"
40D0	GOOSE Function	0 to 1	---	1	F102	1 (Enabled)
40D1	UCA GLOBE.ST.LocRemDS Flexlogic Operand	0 to 65535	---	1	F300	0
40D2	UCA Communications Reserved (14 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 Tx Period	1 to 65535	s	1	F001	60
40E4	IEC Number of Sources used in M_ME_NC_1 point list	1 to 6	---	1	F001	1
40E5	IEC Current Default Threshold	0 to 65535	---	1	F001	30000
40E6	IEC Voltage Default Threshold	0 to 65535	---	1	F001	30000
40E7	IEC Power Default Threshold	0 to 65535	---	1	F001	30000
40E8	IEC Energy Default Threshold	0 to 65535	---	1	F001	30000
40E9	IEC Other Default Threshold	0 to 65535	---	1	F001	30000
40EA	IEC Communications Reserved (22 items)	0 to 1	---	1	F001	0
4100	DNP Binary Input Block of 16 Points (58 items)	0 to 58	---	1	F197	0 (Not Used)
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 Addr	0 to 4294967295	---	1	F003	0
416B	Simple Network Time Protocol (SNTP) UDP Port No.	1 to 65535	---	1	F001	123
Data Logger Commands (Read/Write Command)						
4170	Clear Data Logger	0 to 1	---	1	F126	0 (No)
Data Logger (Read/Write Setting)						
4180	Data Logger Rate	0 to 7	---	1	F178	1 (1 min)
4181	Data Logger Channel Settings (16 items)	---	---	---	F600	0
Clock (Read/Write Command)						
41A0	RTC 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)
Fault Report Settings and Commands (Read/Write Setting)						
41B0	Fault Report Source	0 to 5	---	1	F167	0 (SRC 1)
41B1	Fault Report Trigger	0 to 65535	---	1	F300	0

Table B–9: MODBUS MEMORY MAP (Sheet 12 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
Fault Report Settings and 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 X (16 items)	0 to 65535	---	1	F600	0
4200	Oscillography Digital Channel X (63 items)	0 to 65535	---	1	F300	0
Trip and Alarm LEDs (Read/Write Setting)						
4260	Trip LED Input FlexLogic Operand	0 to 65535	---	1	F300	0
4261	Alarm LED Input FlexLogic Operand	0 to 65535	---	1	F300	0
User Programmable LEDs (Read/Write Setting) (48 modules)						
4280	FlexLogic Operand to Activate LED	0 to 65535	---	1	F300	0
4281	User LED type (latched or self-resetting)	0 to 1	---	1	F127	1 (Self-Reset)
4282	...Repeated for module number 2					
4284	...Repeated for module number 3					
4286	...Repeated for module number 4					
4288	...Repeated for module number 5					
428A	...Repeated for module number 6					
428C	...Repeated for module number 7					
428E	...Repeated for module number 8					
4290	...Repeated for module number 9					
4292	...Repeated for module number 10					
4294	...Repeated for module number 11					
4296	...Repeated for module number 12					
4298	...Repeated for module number 13					
429A	...Repeated for module number 14					
429C	...Repeated for module number 15					
429E	...Repeated for module number 16					
42A0	...Repeated for module number 17					
42A2	...Repeated for module number 18					
42A4	...Repeated for module number 19					
42A6	...Repeated for module number 20					
42A8	...Repeated for module number 21					
42AA	...Repeated for module number 22					
42AC	...Repeated for module number 23					
42AE	...Repeated for module number 24					
42B0	...Repeated for module number 25					
42B2	...Repeated for module number 26					
42B4	...Repeated for module number 27					
42B6	...Repeated for module number 28					
42B8	...Repeated for module number 29					
42BA	...Repeated for module number 30					
42BC	...Repeated for module number 31					
42BE	...Repeated for module number 32					
42C0	...Repeated for module number 33					
42C2	...Repeated for module number 34					
42C4	...Repeated for module number 35					
42C6	...Repeated for module number 36					
42C8	...Repeated for module number 37					
42CA	...Repeated for module number 38					
42CC	...Repeated for module number 39					

Table B–9: MODBUS MEMORY MAP (Sheet 13 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
42CE	...Repeated for module number 40					
42D0	...Repeated for module number 41					
42D2	...Repeated for module number 42					
42D4	...Repeated for module number 43					
42D6	...Repeated for module number 44					
42D8	...Repeated for module number 45					
42DA	...Repeated for module number 46					
42DC	...Repeated for module number 47					
42DE	...Repeated for module number 48					
Installation (Read/Write Setting)						
43E0	Relay Programmed State	0 to 1	---	1	F133	0 (Not Programmed)
43E1	Relay Name	---	---	---	F202	"Relay-1"
User Programmable Self Tests (Read/Write Setting)						
4441	User Programmable Detect Ring Break Function	0 to 1	---	1	F102	1 (Enabled)
4442	User Programmable Direct Device Off Function	0 to 1	---	1	F102	1 (Enabled)
4443	User Programmable Remote Device Off Function	0 to 1	---	1	F102	1 (Enabled)
4444	User Programmable Primary Ethernet Fail Function	0 to 1	---	1	F102	0 (Disabled)
4445	User Programmable Secondary Ethernet Fail Function	0 to 1	---	1	F102	0 (Disabled)
4446	User Programmable Battery Fail Function	0 to 1	---	1	F102	1 (Enabled)
4447	User Programmable SNTP Fail Function	0 to 1	---	1	F102	1 (Enabled)
4448	User Programmable IRIG-B Fail Function	0 to 1	---	1	F102	1 (Enabled)
CT Settings (Read/Write Setting) (6 modules)						
4480	Phase CT Primary	1 to 65000	A	1	F001	1
4481	Phase CT Secondary	0 to 1	---	1	F123	0 (1 A)
4482	Ground CT Primary	1 to 65000	A	1	F001	1
4483	Ground CT Secondary	0 to 1	---	1	F123	0 (1 A)
4484	...Repeated for module number 2					
4488	...Repeated for module number 3					
448C	...Repeated for module number 4					
4490	...Repeated for module number 5					
4494	...Repeated for module number 6					
VT Settings (Read/Write Setting) (3 modules)						
4500	Phase VT Connection	0 to 1	---	1	F100	0 (Wye)
4501	Phase VT Secondary	50 to 240	V	0.1	F001	664
4502	Phase VT Ratio	1 to 24000	:1	1	F060	1
4504	Auxiliary VT Connection	0 to 6	---	1	F166	1 (Vag)
4505	Auxiliary VT Secondary	50 to 240	V	0.1	F001	664
4506	Auxiliary VT Ratio	1 to 24000	:1	1	F060	1
4508	...Repeated for module number 2					
4510	...Repeated for module number 3					
Source Settings (Read/Write Setting) (6 modules)						
4580	Source Name	---	---	---	F206	"SRC 1 "
4583	Source Phase CT	0 to 63	---	1	F400	0
4584	Source Ground CT	0 to 63	---	1	F400	0
4585	Source Phase VT	0 to 63	---	1	F400	0
4586	Source Auxiliary VT	0 to 63	---	1	F400	0
4587	...Repeated for module number 2					
458E	...Repeated for module number 3					
4595	...Repeated for module number 4					
459C	...Repeated for module number 5					
45A3	...Repeated for module number 6					
Power System (Read/Write Setting)						
4600	Nominal Frequency	25 to 60	Hz	1	F001	60
4601	Phase Rotation	0 to 1	---	1	F106	0 (ABC)

Table B-9: MODBUS MEMORY MAP (Sheet 14 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
4602	Frequency And Phase Reference	0 to 5	---	1	F167	0 (SRC 1)
4603	Frequency Tracking Function	0 to 1	---	1	F102	1 (Enabled)
Line (Read/Write Setting)						
46D0	Line Pos Seq Impedance	0.01 to 250	?	0.01	F001	300
46D1	Line Pos Seq Impedance Angle	25 to 90	x	1	F001	75
46D2	Line Zero Seq Impedance	0.01 to 650	?	0.01	F001	900
46D3	Line Zero Seq Impedance Angle	25 to 90	x	1	F001	75
46D4	Line Length Units	0 to 1	---	1	F147	0 (km)
46D5	Line Length	0 to 2000	---	0.1	F001	1000
Breaker Control Global Settings (Read/Write Setting)						
46F0	UCA XCBR x SelTimOut	1 to 60	s	1	F001	30
Breaker Control (Read/Write Setting) (2 modules)						
4700	Breaker x Function	0 to 1	---	1	F102	0 (Disabled)
4701	Breaker x Name	---	---	---	F206	"Bkr 1 "
4704	Breaker x Mode	0 to 1	---	1	F157	0 (3-Pole)
4705	Breaker x Open	0 to 65535	---	1	F300	0
4706	Breaker x Close	0 to 65535	---	1	F300	0
4707	Breaker x Phase A 3 Pole	0 to 65535	---	1	F300	0
4708	Breaker x Phase B	0 to 65535	---	1	F300	0
4709	Breaker x Phase C	0 to 65535	---	1	F300	0
470A	Breaker x External Alarm	0 to 65535	---	1	F300	0
470B	Breaker x Alarm Delay	0 to 1000000	s	0.001	F003	0
470D	Breaker x Push Button Control	0 to 1	---	1	F102	0 (Disabled)
470E	Breaker x Manual Close Recal Time	0 to 1000000	s	0.001	F003	0
4710	Breaker x UCA XCBR x SBOClass	1 to 2	---	1	F001	1
4711	Breaker x UCA XCBR x SBOEna	0 to 1	---	1	F102	0 (Disabled)
4712	Breaker x Out Of Service	0 to 65535	---	1	F300	0
4713	UCA XCBR PwrSupSt Bit 0 Operand	0 to 65535	---	1	F300	0
4714	UCA XCBR x PresSt Operand	0 to 65535	---	1	F300	0
4715	UCA XCBR x TrpCoil Operand	0 to 65535	---	1	F300	0
4716	Reserved (2 items)	0 to 65535		1	F001	0
4718	...Repeated for module number 2					
Synchrocheck (Read/Write Setting) (2 modules)						
4780	Synchrocheck Function	0 to 1	---	1	F102	0 (Disabled)
4781	Synchrocheck V1 Source	0 to 5	---	1	F167	0 (SRC 1)
4782	Synchrocheck V2 Source	0 to 5	---	1	F167	1 (SRC 2)
4783	Synchrocheck Max Volt Diff	0 to 100000	V	1	F060	10000
4785	Synchrocheck Max Angle Diff	0 to 100	x	1	F001	30
4786	Synchrocheck Max Freq Diff	0 to 2	Hz	0.01	F001	100
4787	Synchrocheck Dead Source Select	0 to 5	---	1	F176	1 (LV1 and DV2)
4788	Synchrocheck Dead V1 Max Volt	0 to 1.25	pu	0.01	F001	30
4789	Synchrocheck Dead V2 Max Volt	0 to 1.25	pu	0.01	F001	30
478A	Synchrocheck Live V1 Min Volt	0 to 1.25	pu	0.01	F001	70
478B	Synchrocheck Live V2 Min Volt	0 to 1.25	pu	0.01	F001	70
478C	Synchrocheck Target	0 to 2	---	1	F109	0 (Self-reset)
478D	Synchrocheck Events	0 to 1	---	1	F102	0 (Disabled)
478E	Synchrocheck Block	0 to 65535	---	1	F300	0
478F	Synchrocheck Frequency Hysteresis	0 to 0.1	Hz	0.01	F001	6
4790	...Repeated for module number 2					
Demand (Read/Write Setting)						
47D0	Demand Current Method	0 to 2	---	1	F139	0 (Therm Exponential)
47D1	Demand Power Method	0 to 2	---	1	F139	0 (Therm Exponential)
47D2	Demand Interval	0 to 5	---	1	F132	2 (15 MIN)
47D3	Demand Input	0 to 65535	---	1	F300	0

Table B–9: MODBUS MEMORY MAP (Sheet 15 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
Demand (Read/Write Command)						
47D4	Demand Clear Record	0 to 1	---	1	F126	0 (No)
Flexcurve A (Read/Write Setting)						
4800	FlexCurve A (120 items)	0 to 65535	ms	1	F011	0
Flexcurve B (Read/Write Setting)						
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) (8 modules)						
4C00	User display top line text	---	---	---	F202	" "
4C0A	User display bottom line text	---	---	---	F202	" "
4C14	Modbus addresses of displayed items (5 items)	0 to 65535	---	1	F001	0
4C19	Reserved (7 items)	---	---	---	F001	0
4C20	...Repeated for module number 2					
4C40	...Repeated for module number 3					
4C60	...Repeated for module number 4					
4C80	...Repeated for module number 5					
4CA0	...Repeated for module number 6					
4CC0	...Repeated for module number 7					
4CE0	...Repeated for module number 8					
User Programmable Pushbuttons (Read/Write Setting) (12 modules)						
4E00	User Programmable Pushbutton Function	0 to 2	---	1	F109	2 (Disabled)
4E01	Programmable Pushbutton Top Line	---	---	---	F202	(none)
4E0B	Prog Pushbutton On Text	---	---	---	F202	(none)
4E15	Prog Pushbutton Off Text	---	---	---	F202	(none)
4E1F	Programmable Pushbutton Drop-Out Time	0 to 60	s	0.05	F001	0
4E20	Programmable Pushbutton Target	0 to 2	---	1	F109	0 (Self-reset)
4E21	User Programmable Pushbutton Events	0 to 1	---	1	F102	0 (Disabled)
4E22	Programmable Pushbutton Reserved (2 items)	0 to 65535	---	1	F001	0
4E24	...Repeated for module number 2					
4E48	...Repeated for module number 3					
4E6C	...Repeated for module number 4					
4E90	...Repeated for module number 5					
4EB4	...Repeated for module number 6					
4ED8	...Repeated for module number 7					
4EFC	...Repeated for module number 8					
4F20	...Repeated for module number 9					
4F44	...Repeated for module number 10					
4F68	...Repeated for module number 11					
4F8C	...Repeated for module number 12					
Flexlogic (Read/Write Setting)						
5000	FlexLogic Entry (512 items)	0 to 65535	---	1	F300	16384
Flexlogic Timers (Read/Write Setting) (32 modules)						
5800	Timer x Type	0 to 2	---	1	F129	0 (millisecond)
5801	Timer x Pickup Delay	0 to 60000	---	1	F001	0
5802	Timer x Dropout Delay	0 to 60000	---	1	F001	0
5803	Timer x Reserved (5 items)	0 to 65535	---	1	F001	0
5808	...Repeated for module number 2					
5810	...Repeated for module number 3					
5818	...Repeated for module number 4					
5820	...Repeated for module number 5					
5828	...Repeated for module number 6					
5830	...Repeated for module number 7					
5838	...Repeated for module number 8					

Table B-9: MODBUS MEMORY MAP (Sheet 16 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
5840	...Repeated for module number 9					
5848	...Repeated for module number 10					
5850	...Repeated for module number 11					
5858	...Repeated for module number 12					
5860	...Repeated for module number 13					
5868	...Repeated for module number 14					
5870	...Repeated for module number 15					
5878	...Repeated for module number 16					
5880	...Repeated for module number 17					
5888	...Repeated for module number 18					
5890	...Repeated for module number 19					
5898	...Repeated for module number 20					
58A0	...Repeated for module number 21					
58A8	...Repeated for module number 22					
58B0	...Repeated for module number 23					
58B8	...Repeated for module number 24					
58C0	...Repeated for module number 25					
58C8	...Repeated for module number 26					
58D0	...Repeated for module number 27					
58D8	...Repeated for module number 28					
58E0	...Repeated for module number 29					
58E8	...Repeated for module number 30					
58F0	...Repeated for module number 31					
58F8	...Repeated for module number 32					
Phase TOC (Read/Write Grouped Setting) (6 modules)						
5900	Phase TOC Function	0 to 1	---	1	F102	0 (Disabled)
5901	Phase TOC Signal Source	0 to 5	---	1	F167	0 (SRC 1)
5902	Phase TOC Input	0 to 1	---	1	F122	0 (Phasor)
5903	Phase TOC Pickup	0 to 30	pu	0.001	F001	1000
5904	Phase TOC Curve	0 to 16	---	1	F103	0 (IEEE Mod Inv)
5905	Phase TOC Multiplier	0 to 600	---	0.01	F001	100
5906	Phase TOC Reset	0 to 1	---	1	F104	0 (Instantaneous)
5907	Phase TOC Voltage Restraint	0 to 1	---	1	F102	0 (Disabled)
5908	Phase TOC Block For Each Phase (3 items)	0 to 65535	---	1	F300	0
590B	Phase TOC Target	0 to 2	---	1	F109	0 (Self-reset)
590C	Phase TOC Events	0 to 1	---	1	F102	0 (Disabled)
590D	Reserved (3 items)	0 to 1	---	1	F001	0
5910	...Repeated for module number 2					
5920	...Repeated for module number 3					
5930	...Repeated for module number 4					
5940	...Repeated for module number 5					
5950	...Repeated for module number 6					
Phase IOC (Read/Write Grouped Setting) (12 modules)						
5A00	Phase IOC1 Function	0 to 1	---	1	F102	0 (Disabled)
5A01	Phase IOC1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
5A02	Phase IOC1 Pickup	0 to 30	pu	0.001	F001	1000
5A03	Phase IOC1 Delay	0 to 600	s	0.01	F001	0
5A04	Phase IOC1 Reset Delay	0 to 600	s	0.01	F001	0
5A05	Phase IOC1 Block For Each Phase (3 items)	0 to 65535	---	1	F300	0
5A08	Phase IOC1 Target	0 to 2	---	1	F109	0 (Self-reset)
5A09	Phase IOC1 Events	0 to 1	---	1	F102	0 (Disabled)
5A0A	Reserved (6 items)	0 to 1	---	1	F001	0
5A10	...Repeated for module number 2					
5A20	...Repeated for module number 3					

Table B–9: MODBUS MEMORY MAP (Sheet 17 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
5A30	...Repeated for module number 4					
5A40	...Repeated for module number 5					
5A50	...Repeated for module number 6					
5A60	...Repeated for module number 7					
5A70	...Repeated for module number 8					
5A80	...Repeated for module number 9					
5A90	...Repeated for module number 10					
5AA0	...Repeated for module number 11					
5AB0	...Repeated for module number 12					
Neutral TOC (Read/Write Grouped Setting) (6 modules)						
5B00	Neutral TOC1 Function	0 to 1	---	1	F102	0 (Disabled)
5B01	Neutral TOC1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
5B02	Neutral TOC1 Input	0 to 1	---	1	F122	0 (Phasor)
5B03	Neutral TOC1 Pickup	0 to 30	pu	0.001	F001	1000
5B04	Neutral TOC1 Curve	0 to 16	---	1	F103	0 (IEEE Mod Inv)
5B05	Neutral TOC1 Multiplier	0 to 600	---	0.01	F001	100
5B06	Neutral TOC1 Reset	0 to 1	---	1	F104	0 (Instantaneous)
5B07	Neutral TOC1 Block	0 to 65535	---	1	F300	0
5B08	Neutral TOC1 Target	0 to 2	---	1	F109	0 (Self-reset)
5B09	Neutral TOC1 Events	0 to 1	---	1	F102	0 (Disabled)
5B0A	Reserved (6 items)	0 to 1	---	1	F001	0
5B10	...Repeated for module number 2					
5B20	...Repeated for module number 3					
5B30	...Repeated for module number 4					
5B40	...Repeated for module number 5					
5B50	...Repeated for module number 6					
Neutral IOC (Read/Write Grouped Setting) (12 modules)						
5C00	Neutral IOC1 Function	0 to 1	---	1	F102	0 (Disabled)
5C01	Neutral IOC1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
5C02	Neutral IOC1 Pickup	0 to 30	pu	0.001	F001	1000
5C03	Neutral IOC1 Delay	0 to 600	s	0.01	F001	0
5C04	Neutral IOC1 Reset Delay	0 to 600	s	0.01	F001	0
5C05	Neutral IOC1 Block	0 to 65535	---	1	F300	0
5C06	Neutral IOC1 Target	0 to 2	---	1	F109	0 (Self-reset)
5C07	Neutral IOC1 Events	0 to 1	---	1	F102	0 (Disabled)
5C08	Reserved (8 items)	0 to 1	---	1	F001	0
5C10	...Repeated for module number 2					
5C20	...Repeated for module number 3					
5C30	...Repeated for module number 4					
5C40	...Repeated for module number 5					
5C50	...Repeated for module number 6					
5C60	...Repeated for module number 7					
5C70	...Repeated for module number 8					
5C80	...Repeated for module number 9					
5C90	...Repeated for module number 10					
5CA0	...Repeated for module number 11					
5CB0	...Repeated for module number 12					
Ground TOC (Read/Write Grouped Setting) (6 modules)						
5D00	Ground TOC1 Function	0 to 1	---	1	F102	0 (Disabled)
5D01	Ground TOC1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
5D02	Ground TOC1 Input	0 to 1	---	1	F122	0 (Phasor)
5D03	Ground TOC1 Pickup	0 to 30	pu	0.001	F001	1000
5D04	Ground TOC1 Curve	0 to 16	---	1	F103	0 (IEEE Mod Inv)
5D05	Ground TOC1 Multiplier	0 to 600	---	0.01	F001	100

Table B-9: MODBUS MEMORY MAP (Sheet 18 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
5D06	Ground TOC1 Reset	0 to 1	---	1	F104	0 (Instantaneous)
5D07	Ground TOC1 Block	0 to 65535	---	1	F300	0
5D08	Ground TOC1 Target	0 to 2	---	1	F109	0 (Self-reset)
5D09	Ground TOC1 Events	0 to 1	---	1	F102	0 (Disabled)
5D0A	Reserved (6 items)	0 to 1	---	1	F001	0
5D10	...Repeated for module number 2					
5D20	...Repeated for module number 3					
5D30	...Repeated for module number 4					
5D40	...Repeated for module number 5					
5D50	...Repeated for module number 6					
Ground IOC (Read/Write Grouped Setting) (12 modules)						
5E00	Ground IOC1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
5E01	Ground IOC1 Function	0 to 1	---	1	F102	0 (Disabled)
5E02	Ground IOC1 Pickup	0 to 30	pu	0.001	F001	1000
5E03	Ground IOC1 Delay	0 to 600	s	0.01	F001	0
5E04	Ground IOC1 Reset Delay	0 to 600	s	0.01	F001	0
5E05	Ground IOC1 Block	0 to 65535	---	1	F300	0
5E06	Ground IOC1 Target	0 to 2	---	1	F109	0 (Self-reset)
5E07	Ground IOC1 Events	0 to 1	---	1	F102	0 (Disabled)
5E08	Reserved (8 items)	0 to 1	---	1	F001	0
5E10	...Repeated for module number 2					
5E20	...Repeated for module number 3					
5E30	...Repeated for module number 4					
5E40	...Repeated for module number 5					
5E50	...Repeated for module number 6					
5E60	...Repeated for module number 7					
5E70	...Repeated for module number 8					
5E80	...Repeated for module number 9					
5E90	...Repeated for module number 10					
5EA0	...Repeated for module number 11					
5EB0	...Repeated for module number 12					
Autoreclose (Read/Write Setting) (6 modules)						
6240	Autoreclose Function	0 to 1	---	1	F102	0 (Disabled)
6241	Autoreclose Initiate	0 to 65535	---	1	F300	0
6242	Autoreclose Block	0 to 65535	---	1	F300	0
6243	Autoreclose Max Number of Shots	1 to 4	---	1	F001	1
6244	Autoreclose Manual Close	0 to 65535	---	1	F300	0
6245	Autoreclose Manual Reset from LO	0 to 65535	---	1	F300	0
6246	Autoreclose Reset Lockout if Breaker Closed	0 to 1	---	1	F108	0 (Off)
6247	Autoreclose Reset Lockout On Manual Close	0 to 1	---	1	F108	0 (Off)
6248	Autoreclose Breaker Closed	0 to 65535	---	1	F300	0
6249	Autoreclose Breaker Open	0 to 65535	---	1	F300	0
624A	Autoreclose Block Time Upon Manual Close	0 to 655.35	s	0.01	F001	1000
624B	Autoreclose Dead Time Shot 1	0 to 655.35	s	0.01	F001	100
624C	Autoreclose Dead Time Shot 2	0 to 655.35	s	0.01	F001	200
624D	Autoreclose Dead Time Shot 3	0 to 655.35	s	0.01	F001	300
624E	Autoreclose Dead Time Shot 4	0 to 655.35	s	0.01	F001	400
624F	Autoreclose Reset Lockout Delay	0 to 655.35	s	0.01	F001	6000
6250	Autoreclose Reset Time	0 to 655.35	s	0.01	F001	6000
6251	Autoreclose Incomplete Sequence Time	0 to 655.35	s	0.01	F001	500
6252	Autoreclose Events	0 to 1	---	1	F102	0 (Disabled)
6253	Autoreclose Reduce Max 1	0 to 65535	---	1	F300	0
6254	Autoreclose Reduce Max 2	0 to 65535	---	1	F300	0
6255	Autoreclose Reduce Max 3	0 to 65535	---	1	F300	0

Table B-9: MODBUS MEMORY MAP (Sheet 19 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
6256	Autoreclose Add Delay 1	0 to 65535	---	1	F300	0
6257	Autoreclose Delay 1	0 to 655.35	s	0.01	F001	0
6258	Autoreclose Add Delay 2	0 to 65535	---	1	F300	0
6259	Autoreclose Delay 2	0 to 655.35	s	0.01	F001	0
625A	Autoreclose Reserved (4 items)	0 to 0.001	---	0.001	F001	0
625E	...Repeated for module number 2					
627C	...Repeated for module number 3					
629A	...Repeated for module number 4					
62B8	...Repeated for module number 5					
62D6	...Repeated for module number 6					
Negative Sequence TOC (Read/Write Grouped Setting) (2 modules)						
6300	Negative Sequence TOC1 Function	0 to 1	---	1	F102	0 (Disabled)
6301	Negative Sequence TOC1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
6302	Negative Sequence TOC1 Pickup	0 to 30	pu	0.001	F001	1000
6303	Negative Sequence TOC1 Curve	0 to 16	---	1	F103	0 (IEEE Mod Inv)
6304	Negative Sequence TOC1 Multiplier	0 to 600	---	0.01	F001	100
6305	Negative Sequence TOC1 Reset	0 to 1	---	1	F104	0 (Instantaneous)
6306	Negative Sequence TOC1 Block	0 to 65535	---	1	F300	0
6307	Negative Sequence TOC1 Target	0 to 2	---	1	F109	0 (Self-reset)
6308	Negative Sequence TOC1 Events	0 to 1	---	1	F102	0 (Disabled)
6309	Reserved (7 items)	0 to 1	---	1	F001	0
6310	...Repeated for module number 2					
Negative Sequence IOC (Read/Write Grouped Setting) (2 modules)						
6400	Negative Sequence IOC1 Function	0 to 1	---	1	F102	0 (Disabled)
6401	Negative Sequence IOC1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
6402	Negative Sequence IOC1 Pickup	0 to 30	pu	0.001	F001	1000
6403	Negative Sequence IOC1 Delay	0 to 600	s	0.01	F001	0
6404	Negative Sequence IOC1 Reset Delay	0 to 600	s	0.01	F001	0
6405	Negative Sequence IOC1 Block	0 to 65535	---	1	F300	0
6406	Negative Sequence IOC1 Target	0 to 2	---	1	F109	0 (Self-reset)
6407	Negative Sequence IOC1 Events	0 to 1	---	1	F102	0 (Disabled)
6408	Reserved (8 items)	0 to 1	---	1	F001	0
6410	...Repeated for module number 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 Function	0 to 1	---	1	F102	0 (Disabled)
64D1	Overfrequency Block	0 to 65535	---	1	F300	0
64D2	Overfrequency Source	0 to 5	---	1	F167	0 (SRC 1)
64D3	Overfrequency Pickup	20 to 65	Hz	0.01	F001	6050
64D4	Overfrequency Pickup Delay	0 to 65.535	s	0.001	F001	500
64D5	Overfrequency Reset Delay	0 to 65.535	s	0.001	F001	500
64D6	Overfrequency Target	0 to 2	---	1	F109	0 (Self-reset)
64D7	Overfrequency Events	0 to 1	---	1	F102	0 (Disabled)
64D8	Reserved (4 items)	0 to 1	---	1	F001	0
64DC	...Repeated for module number 2					
64E8	...Repeated for module number 3					

Table B-9: MODBUS MEMORY MAP (Sheet 20 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
64F4	...Repeated for module number 4					
Sensitive Directional Power (Read/Write Grouped Setting) (2 modules)						
66A0	Sensitive Directional Power Function	0 to 1	---	1	F102	0 (Disabled)
66A1	Sensitive Directional Power Signal Source	0 to 5	---	1	F167	0 (SRC 1)
66A2	Sensitive Directional Power RCA	0 to 359	x	1	F001	0
66A3	Sensitive Directional Power Calibration	0 to 0.95	x	0.05	F001	0
66A4	Sensitive Directional Power STG1 SMIN	-1.2 to 1.2	pu	0.001	F002	100
66A5	Sensitive Directional Power STG1 Delay	0 to 600	s	0.01	F001	50
66A6	Sensitive Directional Power STG2 SMIN	-1.2 to 1.2	pu	0.001	F002	100
66A7	Sensitive Directional Power STG2 Delay	0 to 600	s	0.01	F001	2000
66A8	Sensitive Directional Power Block	---	---	---	F001	0
66A9	Sensitive Directional Power Target	0 to 2	---	1	F109	0 (Self-reset)
66AA	Sensitive Directional Power Events	0 to 1	---	1	F102	0 (Disabled)
66AB	Sensitive Directional Power X Reserved (5 items)	0 to 65535	---	1	F001	0
66B0	...Repeated for module number 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 Min Volt	0 to 3	pu	0.001	F001	250
6703	Load Encroachment Reach	0.02 to 250	?	0.01	F001	100
6704	Load Encroachment Angle	5 to 50	x	1	F001	30
6705	Load Encroachment Pkp Delay	0 to 65.535	s	0.001	F001	0
6706	Load Encroachment Rst 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	Load Encroachment Reserved (6 items)	0 to 65535	---	1	F001	0
Phase Undervoltage (Read/Write Grouped Setting) (2 modules)						
7000	Phase UV1 Function	0 to 1	---	1	F102	0 (Disabled)
7001	Phase UV1 Signal Source	0 to 5	---	1	F167	0 (SRC 1)
7002	Phase UV1 Pickup	0 to 3	pu	0.001	F001	1000
7003	Phase UV1 Curve	0 to 1	---	1	F111	0 (Definite Time)
7004	Phase UV1 Delay	0 to 600	s	0.01	F001	100
7005	Phase UV1 Minimum Voltage	0 to 3	pu	0.001	F001	100
7006	Phase UV1 Block	0 to 65535	---	1	F300	0
7007	Phase UV1 Target	0 to 2	---	1	F109	0 (Self-reset)
7008	Phase UV1 Events	0 to 1	---	1	F102	0 (Disabled)
7009	Phase UV Measurement Mode	0 to 1	---	1	F186	0 (Phase to Ground)
700A	Reserved (6 items)	0 to 1	---	1	F001	0
7013	...Repeated for module number 2					
Phase Overvoltage (Read/Write Grouped Setting)						
7100	Phase OV1 Function	0 to 1	---	1	F102	0 (Disabled)
7101	Phase OV1 Source	0 to 5	---	1	F167	0 (SRC 1)
7102	Phase OV1 Pickup	0 to 3	pu	0.001	F001	1000
7103	Phase OV1 Delay	0 to 600	s	0.01	F001	100
7104	Phase OV1 Reset Delay	0 to 600	s	0.01	F001	100
7105	Phase OV1 Block	0 to 65535	---	1	F300	0
7106	Phase OV1 Target	0 to 2	---	1	F109	0 (Self-reset)
7107	Phase OV1 Events	0 to 1	---	1	F102	0 (Disabled)
7108	Reserved (8 items)	0 to 1	---	1	F001	0
Breaker Failure (Read/Write Grouped Setting) (2 modules)						
7200	Breaker Failure x Function	0 to 1	---	1	F102	0 (Disabled)
7201	Breaker Failure x Mode	0 to 1	---	1	F157	0 (3-Pole)
7208	Breaker Failure x Source	0 to 5	---	1	F167	0 (SRC 1)

Table B–9: MODBUS MEMORY MAP (Sheet 21 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
7209	Breaker Failure x Amp Supervision	0 to 1	---	1	F126	1 (Yes)
720A	Breaker Failure x Use Seal-In	0 to 1	---	1	F126	1 (Yes)
720B	Breaker Failure x Three Pole Initiate	0 to 65535	---	1	F300	0
720C	Breaker Failure x Block	0 to 65535	---	1	F300	0
720D	Breaker Failure x Phase Amp Supv Pickup	0.001 to 30	pu	0.001	F001	1050
720E	Breaker Failure x Neutral Amp Supv Pickup	0.001 to 30	pu	0.001	F001	1050
720F	Breaker Failure x Use Timer 1	0 to 1	---	1	F126	1 (Yes)
7210	Breaker Failure x Timer 1 Pickup	0 to 65.535	s	0.001	F001	0
7211	Breaker Failure x Use Timer 2	0 to 1	---	1	F126	1 (Yes)
7212	Breaker Failure x Timer 2 Pickup	0 to 65.535	s	0.001	F001	0
7213	Breaker Failure x Use Timer 3	0 to 1	---	1	F126	1 (Yes)
7214	Breaker Failure x Timer 3 Pickup	0 to 65.535	s	0.001	F001	0
7215	Breaker Failure x Breaker Status 1 Phase A/3P	0 to 65535	---	1	F300	0
7216	Breaker Failure x Breaker Status 2 Phase A/3P	0 to 65535	---	1	F300	0
7217	Breaker Failure x Breaker Test On	0 to 65535	---	1	F300	0
7218	Breaker Failure x Phase Amp Hiset Pickup	0.001 to 30	pu	0.001	F001	1050
7219	Breaker Failure x Neutral Amp Hiset Pickup	0.001 to 30	pu	0.001	F001	1050
721A	Breaker Failure x Phase Amp Loset Pickup	0.001 to 30	pu	0.001	F001	1050
721B	Breaker Failure x Neutral Amp Loset Pickup	0.001 to 30	pu	0.001	F001	1050
721C	Breaker Failure x Loset Time	0 to 65.535	s	0.001	F001	0
721D	Breaker Failure x Trip Dropout Delay	0 to 65.535	s	0.001	F001	0
721E	Breaker Failure x Target	0 to 2	---	1	F109	0 (Self-reset)
721F	Breaker Failure x Events	0 to 1	---	1	F102	0 (Disabled)
7220	Breaker Failure x Phase A Initiate	0 to 65535	---	1	F300	0
7221	Breaker Failure x Phase B Initiate	0 to 65535	---	1	F300	0
7222	Breaker Failure x Phase C Initiate	0 to 65535	---	1	F300	0
7223	Breaker Failure x Breaker Status 1 Phase B	0 to 65535	---	1	F300	0
7224	Breaker Failure x Breaker Status 1 Phase C	0 to 65535	---	1	F300	0
7225	Breaker Failure x Breaker Status 2 Phase B	0 to 65535	---	1	F300	0
7226	Breaker Failure x Breaker Status 2 Phase C	0 to 65535	---	1	F300	0
7227	...Repeated for module number 2					
Phase Directional (Read/Write Grouped Setting) (2 modules)						
7260	Phase DIR 1 Function	0 to 1	---	1	F102	0 (Disabled)
7261	Phase DIR 1 Source	0 to 5	---	1	F167	0 (SRC 1)
7262	Phase DIR 1 Block	0 to 65535	---	1	F300	0
7263	Phase DIR 1 ECA	0 to 359	---	1	F001	30
7264	Phase DIR 1 Pol V Threshold	0 to 3	pu	0.001	F001	700
7265	Phase DIR 1 Block OC	0 to 1	---	1	F126	0 (No)
7266	Phase DIR 1 Target	0 to 2	---	1	F109	0 (Self-reset)
7267	Phase DIR 1 Events	0 to 1	---	1	F102	0 (Disabled)
7268	Reserved (8 items)	0 to 1	---	1	F001	0
7270	...Repeated for module number 2					
Neutral Directional OC (Read/Write Grouped Setting) (2 modules)						
7280	Neutral DIR OC1 Function	0 to 1	---	1	F102	0 (Disabled)
7281	Neutral DIR OC1 Source	0 to 5	---	1	F167	0 (SRC 1)
7282	Neutral DIR OC1 Polarizing	0 to 2	---	1	F230	0 (Voltage)
7283	Neutral DIR OC1 Forward ECA	-90 to 90	x Lag	1	F002	75
7284	Neutral DIR OC1 Forward Limit Angle	40 to 90	x	1	F001	90
7285	Neutral DIR OC1 Forward Pickup	0.002 to 30	pu	0.001	F001	50
7286	Neutral DIR OC1 Reverse Limit Angle	40 to 90	x	1	F001	90
7287	Neutral DIR OC1 Reverse Pickup	0.002 to 30	pu	0.001	F001	50
7288	Neutral DIR OC1 Target	0 to 2	---	1	F109	0 (Self-reset)
7289	Neutral DIR OC1 Block	0 to 65535	---	1	F300	0
728A	Neutral DIR OC1 Events	0 to 1	---	1	F102	0 (Disabled)

Table B–9: MODBUS MEMORY MAP (Sheet 22 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
728B	Neutral DIR OC X Polarizing Voltage	0 to 1	---	1	F231	0 (Calculated V0)
728C	Neutral DIR OC X Op Current	0 to 1	---	1	F196	0 (Calculated 3I0)
728D	Neutral DIR OC X Offset	0 to 250	?	0.01	F001	0
728E	Reserved (2 items)	0 to 1	---	1	F001	0
7290	...Repeated for module number 2					
Negative Sequence Directional OC (Read/Write Grouped Setting) (2 modules)						
72A0	Negative Sequence DIR OC1 Function	0 to 1	---	1	F102	0 (Disabled)
72A1	Negative Sequence DIR OC1 Source	0 to 5	---	1	F167	0 (SRC 1)
72A2	Negative Sequence DIR OC1 Type	0 to 1	---	1	F179	0 (Neg Sequence)
72A3	Negative Sequence DIR OC1 Forward ECA	0 to 90	x Lag	1	F002	75
72A4	Negative Sequence DIR OC1 Forward Limit Angle	40 to 90	x	1	F001	90
72A5	Negative Sequence DIR OC1 Forward Pickup	0.05 to 30	pu	0.01	F001	5
72A6	Negative Sequence DIR OC1 Reverse Limit Angle	40 to 90	x	1	F001	90
72A7	Negative Sequence DIR OC1 Reverse Pickup	0.05 to 30	pu	0.01	F001	5
72A8	Negative Sequence DIR OC1 Target	0 to 2	---	1	F109	0 (Self-reset)
72A9	Negative Sequence DIR OC1 Block	0 to 65535	---	1	F300	0
72AA	Negative Sequence DIR OC1 Events	0 to 1	---	1	F102	0 (Disabled)
72AB	Negative Sequence DIR OC X Offset	0 to 250	?	0.01	F001	0
72AC	Reserved (4 items)	0 to 1	---	1	F001	0
72B0	...Repeated for module number 2					
Breaker Arcing Current Settings (Read/Write Setting) (2 modules)						
72C0	Breaker x Arcing Amp Function	0 to 1	---	1	F102	0 (Disabled)
72C1	Breaker x Arcing Amp Source	0 to 5	---	1	F167	0 (SRC 1)
72C2	Breaker x Arcing Amp Init	0 to 65535	---	1	F300	0
72C3	Breaker x Arcing Amp Delay	0 to 65.535	s	0.001	F001	0
72C4	Breaker x Arcing Amp Limit	0 to 50000	kA2-cyc	1	F001	1000
72C5	Breaker x Arcing Amp Block	0 to 65535	---	1	F300	0
72C6	Breaker x Arcing Amp Target	0 to 2	---	1	F109	0 (Self-reset)
72C7	Breaker x Arcing Amp Events	0 to 1	---	1	F102	0 (Disabled)
72C8	...Repeated for module number 2					
DCMA Inputs (Read/Write Setting) (24 modules)						
7300	DCMA Inputs x Function	0 to 1	---	1	F102	0 (Disabled)
7301	DCMA Inputs x ID	---	---	---	F205	"DCMA Ip 1 "
7307	DCMA Inputs x Reserved 1 (4 items)	0 to 65535	---	1	F001	0
730B	DCMA Inputs x Units	---	---	---	F206	"mA"
730E	DCMA Inputs x Range	0 to 6	---	1	F173	6 (4 to 20 mA)
730F	DCMA Inputs x Minimum Value	-9999.999 to 9999.999	---	0.001	F004	4000
7311	DCMA Inputs x Maximum Value	-9999.999 to 9999.999	---	0.001	F004	20000
7313	DCMA Inputs x Reserved (5 items)	0 to 65535	---	1	F001	0
7318	...Repeated for module number 2					
7330	...Repeated for module number 3					
7348	...Repeated for module number 4					
7360	...Repeated for module number 5					
7378	...Repeated for module number 6					
7390	...Repeated for module number 7					
73A8	...Repeated for module number 8					
73C0	...Repeated for module number 9					
73D8	...Repeated for module number 10					
73F0	...Repeated for module number 11					
7408	...Repeated for module number 12					
7420	...Repeated for module number 13					
7438	...Repeated for module number 14					
7450	...Repeated for module number 15					
7468	...Repeated for module number 16					

Table B–9: MODBUS MEMORY MAP (Sheet 23 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
7480	...Repeated for module number 17					
7498	...Repeated for module number 18					
74B0	...Repeated for module number 19					
74C8	...Repeated for module number 20					
74E0	...Repeated for module number 21					
74F8	...Repeated for module number 22					
7510	...Repeated for module number 23					
7528	...Repeated for module number 24					
RTD Inputs (Read/Write Setting) (48 modules)						
7540	RTD Inputs x Function	0 to 1	---	1	F102	0 (Disabled)
7541	RTD Inputs x ID	---	---	---	F205	"RTD Ip 1 "
7547	RTD Inputs x Reserved 1 (4 items)	0 to 65535	---	1	F001	0
754B	RTD Inputs x Type	0 to 3	---	1	F174	0 (100 Ω Platinum)
754C	RTD Inputs x Reserved 2 (4 items)	0 to 65535	---	1	F001	0
7550	...Repeated for module number 2					
7560	...Repeated for module number 3					
7570	...Repeated for module number 4					
7580	...Repeated for module number 5					
7590	...Repeated for module number 6					
75A0	...Repeated for module number 7					
75B0	...Repeated for module number 8					
75C0	...Repeated for module number 9					
75D0	...Repeated for module number 10					
75E0	...Repeated for module number 11					
75F0	...Repeated for module number 12					
7600	...Repeated for module number 13					
7610	...Repeated for module number 14					
7620	...Repeated for module number 15					
7630	...Repeated for module number 16					
7640	...Repeated for module number 17					
7650	...Repeated for module number 18					
7660	...Repeated for module number 19					
7670	...Repeated for module number 20					
7680	...Repeated for module number 21					
7690	...Repeated for module number 22					
76A0	...Repeated for module number 23					
76B0	...Repeated for module number 24					
76C0	...Repeated for module number 25					
76D0	...Repeated for module number 26					
76E0	...Repeated for module number 27					
76F0	...Repeated for module number 28					
7700	...Repeated for module number 29					
7710	...Repeated for module number 30					
7720	...Repeated for module number 31					
7730	...Repeated for module number 32					
7740	...Repeated for module number 33					
7750	...Repeated for module number 34					
7760	...Repeated for module number 35					
7770	...Repeated for module number 36					
7780	...Repeated for module number 37					
7790	...Repeated for module number 38					
77A0	...Repeated for module number 39					
77B0	...Repeated for module number 40					
77C0	...Repeated for module number 41					

Table B-9: MODBUS MEMORY MAP (Sheet 24 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
77D0	...Repeated for module number 42					
77E0	...Repeated for module number 43					
77F0	...Repeated for module number 44					
7800	...Repeated for module number 45					
7810	...Repeated for module number 46					
7820	...Repeated for module number 47					
7830	...Repeated for module number 48					
Ohm Inputs (Read/Write Setting) (2 modules)						
7840	Ohm Inputs x Function	0 to 1	---	1	F102	0 (Disabled)
7841	Ohm Inputs x ID	---	---	---	F205	"Ohm Ip 1 "
7847	Ohm Inputs x Reserved (9 items)	0 to 65535	---	1	F001	0
7850	...Repeated for module number 2					
HIZ 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 OC Protection Coord Timeout	10 to 200	s	1	F001	15
7A08	Hi-Z Phase OC Min Pickup	0.01 to 10	pu	0.01	F001	150
7A09	Hi-Z Neutral OC Min 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 Supv Threshold	0 to 100	%	1	F001	5
7A0F	Hi-Z Voltage Supv 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 Block	0 to 65535	---	1	F300	0
7E02	Min Current	0.1 to 1.25	pu	0.01	F001	10
7E03	Underfrequency Pickup	20 to 65	Hz	0.01	F001	5950
7E04	Pickup Delay	0 to 65.535	s	0.001	F001	2000
7E05	Reset Delay	0 to 65.535	s	0.001	F001	2000
7E06	Underfrequency Source	0 to 5	---	1	F167	0 (SRC 1)
7E07	Underfrequency Events	0 to 1	---	1	F102	0 (Disabled)
7E08	Underfrequency Target	0 to 2	---	1	F109	0 (Self-reset)
7E09	Underfrequency X Reserved (8 items)	0 to 1	---	1	F001	0
7E19	...Repeated for module number 2					
7E25	...Repeated for module number 3					
73E1	...Repeated for module number 4					
7E44	...Repeated for module number 5					
7E55	...Repeated for module number 6					
Neutral Overvoltage (Read/Write Grouped Setting) (3 modules)						
7F00	Neutral OV X Function	0 to 1	---	1	F102	0 (Disabled)
7F01	Neutral OV X Signal Source	0 to 5	---	1	F167	0 (SRC 1)
7F02	Neutral OV X Pickup	0 to 1.25	pu	0.001	F001	300
7F03	Neutral OV X Pickup Delay	0 to 600	s	0.01	F001	100
7F04	Neutral OV X Reset Delay	0 to 600	s	0.01	F001	100
7F05	Neutral OV X Block	0 to 65535	---	1	F300	0

Table B–9: MODBUS MEMORY MAP (Sheet 25 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
7F06	Neutral OV X Target	0 to 2	---	1	F109	0 (Self-reset)
7F07	Neutral OV X Events	0 to 1	---	1	F102	0 (Disabled)
7F08	Neutral OV Reserved (8 items)	0 to 65535	---	1	F001	0
7F10	...Repeated for module number 2					
7F20	...Repeated for module number 3					
Auxiliary Overvoltage (Read/Write Grouped Setting) (3 modules)						
7F30	Auxiliary OV X Function	0 to 1	---	1	F102	0 (Disabled)
7F31	Auxiliary OV X Signal Source	0 to 5	---	1	F167	0 (SRC 1)
7F32	Auxiliary OV X Pickup	0 to 3	pu	0.001	F001	300
7F33	Auxiliary OV X Pickup Delay	0 to 600	s	0.01	F001	100
7F34	Auxiliary OV X Reset Delay	0 to 600	s	0.01	F001	100
7F35	Auxiliary OV X Block	0 to 65535	---	1	F300	0
7F36	Auxiliary OV X Target	0 to 2	---	1	F109	0 (Self-reset)
7F37	Auxiliary OV X Events	0 to 1	---	1	F102	0 (Disabled)
7F38	Auxiliary OV X Reserved (8 items)	0 to 65535	---	1	F001	0
7F40	...Repeated for module number 2					
7F50	...Repeated for module number 3					
Auxiliary Undervoltage (Read/Write Grouped Setting) (3 modules)						
7F60	Auxiliary UV X Function	0 to 1	---	1	F102	0 (Disabled)
7F61	Auxiliary UV X Signal Source	0 to 5	---	1	F167	0 (SRC 1)
7F62	Auxiliary UV X Pickup	0 to 3	pu	0.001	F001	700
7F63	Auxiliary UV X Delay	0 to 600	s	0.01	F001	100
7F64	Auxiliary UV X Curve	0 to 1	---	1	F111	0 (Definite Time)
7F65	Auxiliary UV X Minimum Voltage	0 to 3	pu	0.001	F001	100
7F66	Auxiliary UV X Block	0 to 65535	---	1	F300	0
7F67	Auxiliary UV X Target	0 to 2	---	1	F109	0 (Self-reset)
7F68	Auxiliary UV X Events	0 to 1	---	1	F102	0 (Disabled)
7F69	Auxiliary UV X Reserved (7 items)	0 to 65535	---	1	F001	0
7F70	...Repeated for module number 2					
7F80	...Repeated for module number 3					
Frequency (Read Only)						
8000	Tracking Frequency	2 to 90	Hz	0.01	F001	0
FlexState Settings (Read/Write Setting)						
8800	FlexState Parameters (256 items)	---	---	---	F300	0
FlexElement (Read/Write Setting) (16 modules)						
9000	FlexElement Function	0 to 1	---	1	F102	0 (Disabled)
9001	FlexElement Name	---	---	---	F206	"FxE 1 "
9004	FlexElement InputP	0 to 65535	---	1	F600	0
9005	FlexElement InputM	0 to 65535	---	1	F600	0
9006	FlexElement Compare	0 to 1	---	1	F516	0 (LEVEL)
9007	FlexElement Input	0 to 1	---	1	F515	0 (SIGNED)
9008	FlexElement Direction	0 to 1	---	1	F517	0 (OVER)
9009	FlexElement Hysteresis	0.1 to 50	%	0.1	F001	30
900A	FlexElement Pickup	-90 to 90	pu	0.001	F004	1000
900C	FlexElement DeltaT Units	0 to 2	---	1	F518	0 (Milliseconds)
900D	FlexElement DeltaT	20 to 86400	---	1	F003	20
900F	FlexElement Pkp Delay	0 to 65.535	s	0.001	F001	0
9010	FlexElement Rst Delay	0 to 65.535	s	0.001	F001	0
9011	FlexElement Block	0 to 65535	---	1	F300	0
9012	FlexElement Target	0 to 2	---	1	F109	0 (Self-reset)
9013	FlexElement Events	0 to 1	---	1	F102	0 (Disabled)
9014	...Repeated for module number 2					
9028	...Repeated for module number 3					
903C	...Repeated for module number 4					

Table B-9: MODBUS MEMORY MAP (Sheet 26 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
9050	...Repeated for module number 5					
9064	...Repeated for module number 6					
9078	...Repeated for module number 7					
908C	...Repeated for module number 8					
90A0	...Repeated for module number 9					
90B4	...Repeated for module number 10					
90C8	...Repeated for module number 11					
90DC	...Repeated for module number 12					
90F0	...Repeated for module number 13					
9104	...Repeated for module number 14					
9118	...Repeated for module number 15					
912C	...Repeated for module number 16					
FlexElement Actuals (Read Only) (16 modules)						
9A01	FlexElement Actual	-2147483.647 to 2147483.647	---	0.001	F004	0
9A03	...Repeated for module number 2					
9A05	...Repeated for module number 3					
9A07	...Repeated for module number 4					
9A09	...Repeated for module number 5					
9A0B	...Repeated for module number 6					
9A0D	...Repeated for module number 7					
9A0F	...Repeated for module number 8					
9A11	...Repeated for module number 9					
9A13	...Repeated for module number 10					
9A15	...Repeated for module number 11					
9A17	...Repeated for module number 12					
9A19	...Repeated for module number 13					
9A1B	...Repeated for module number 14					
9A1D	...Repeated for module number 15					
9A1F	...Repeated for module number 16					
Setting Groups (Read/Write Setting)						
A000	Setting Group for Modbus Comms (0 means group 1)	0 to 5	---	1	F001	0
A001	Setting Groups Block	0 to 65535	---	1	F300	0
A002	FlexLogic Operands to Activate Groups 2 to 8 (5 items)	0 to 65535	---	1	F300	0
A009	Setting Group Function	0 to 1	---	1	F102	0 (Disabled)
A00A	Setting Group Events	0 to 1	---	1	F102	0 (Disabled)
Setting Groups (Read Only)						
A00B	Current Setting Group	0 to 5	---	1	F001	0
Cold Load Pickup (Read/Write Setting) (2 modules)						
A010	Cold Load Pickup x Function	0 to 1	---	1	F102	0 (Disabled)
A011	Cold Load Pickup x Init	0 to 65535	---	1	F300	0
A012	Cold Load Pickup x Block	0 to 65535	---	1	F300	0
A013	Outage Time Before Cold Load Pickup x	0 to 1000	s	1	F001	1000
A014	On Load Time Before Reset x	0 to 1000000	s	0.001	F003	100000
A016	Cold Load Pickup x Source	0 to 5	---	1	F167	0 (SRC 1)
A017	Cold Load Pickup x Reserved	0 to 65535	---	1	F001	0
A018	...Repeated for module number 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					

Table B–9: MODBUS MEMORY MAP (Sheet 27 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
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 Grouped Setting) (2 modules)						
A410	Selector x Function	0 to 1	---	1	F102	0 (Disabled)
A411	Selector x Range	1 to 7	---	1	F001	7
A412	Selector x Timeout	3 to 60	s	0.1	F001	50
A413	Selector x Step Up	0 to 65535	---	1	F300	0
A414	Selector x Step Mode	0 to 1	---	1	F083	0 (Time-out)
A415	Selector x Ack	0 to 65535	---	1	F300	0
A416	Selector x Bit0	0 to 65535	---	1	F300	0
A417	Selector x Bit1	0 to 65535	---	1	F300	0
A418	Selector x Bit2	0 to 65535	---	1	F300	0
A419	Selector x Bit Mode	0 to 1	---	1	F083	0 (Time-out)
A41A	Selector x Bit Ack	0 to 65535	---	1	F300	0
A41B	Power Up Mode	0 to 1	---	1	F084	0 (Restore)
A41C	Selector x Target	0 to 2	---	1	F109	0 (Self-reset)
A41D	Selector x Events	0 to 1	---	1	F102	0 (Disabled)
A41E	Selector x Reserved (10 items)	---	---	---	---	---
A428	...Repeated for module number 2					
Flexcurve C (Read/Write Setting)						
AC00	FlexCurve C (120 items)	0 to 65535	ms	1	F011	0
Flexcurve D (Read/Write Setting)						
AC78	FlexCurve D (120 items)	0 to 65535	ms	1	F011	0
Non Volatile Latches (Read/Write Setting) (16 modules)						
AD00	Latch x Function	0 to 1	---	1	F102	0 (Disabled)
AD01	Latch x Type	0 to 1	---	1	F519	0 (Reset Dominant)
AD02	Latch x Set	0 to 65535	---	1	F300	0
AD03	Latch x Reset	0 to 65535	---	1	F300	0
AD04	Latch x Target	0 to 2	---	1	F109	0 (Self-reset)
AD05	Latch x Events	0 to 1	---	1	F102	0 (Disabled)
AD06	Latch x Reserved (4 items)	---	---	---	F001	0
AD0A	...Repeated for module number 2					
AD14	...Repeated for module number 3					
AD1E	...Repeated for module number 4					
AD28	...Repeated for module number 5					
AD32	...Repeated for module number 6					
AD3C	...Repeated for module number 7					
AD46	...Repeated for module number 8					
AD50	...Repeated for module number 9					
AD5A	...Repeated for module number 10					
AD64	...Repeated for module number 11					
AD6E	...Repeated for module number 12					
AD78	...Repeated for module number 13					
AD82	...Repeated for module number 14					
AD8C	...Repeated for module number 15					
AD96	...Repeated for module number 16					
Digital Elements (Read/Write Setting) (16 modules)						
B000	Digital Element x Function	0 to 1	---	1	F102	0 (Disabled)
B001	Digital Element x Name	---	---	---	F203	"Dig Element 1 "
B015	Digital Element x Input	0 to 65535	---	1	F300	0
B016	Digital Element x Pickup Delay	0 to 999999.999	s	0.001	F003	0
B018	Digital Element x Reset Delay	0 to 999999.999	s	0.001	F003	0
B01A	Digital Element x Block	0 to 65535	---	1	F300	0

Table B-9: MODBUS MEMORY MAP (Sheet 28 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
B01B	Digital Element x Target	0 to 2	---	1	F109	0 (Self-reset)
B01C	Digital Element x Events	0 to 1	---	1	F102	0 (Disabled)
B01D	Digital Element x Reserved (3 items)	---	---	---	F001	0
B020	...Repeated for module number 2					
B040	...Repeated for module number 3					
B060	...Repeated for module number 4					
B080	...Repeated for module number 5					
B0A0	...Repeated for module number 6					
B0C0	...Repeated for module number 7					
B0E0	...Repeated for module number 8					
B100	...Repeated for module number 9					
B120	...Repeated for module number 10					
B140	...Repeated for module number 11					
B160	...Repeated for module number 12					
B180	...Repeated for module number 13					
B1A0	...Repeated for module number 14					
B1C0	...Repeated for module number 15					
B1E0	...Repeated for module number 16					
Digital Counter (Read/Write Setting) (8 modules)						
B300	Digital Counter x Function	0 to 1	---	1	F102	0 (Disabled)
B301	Digital Counter x Name	---	---	---	F205	"Counter 1 "
B307	Digital Counter x Units	---	---	---	F206	(none)
B30A	Digital Counter x Block	0 to 65535	---	1	F300	0
B30B	Digital Counter x Up	0 to 65535	---	1	F300	0
B30C	Digital Counter x Down	0 to 65535	---	1	F300	0
B30D	Digital Counter x Preset	-2147483647 to 2147483647	---	1	F004	0
B30F	Digital Counter x Compare	-2147483647 to 2147483647	---	1	F004	0
B311	Digital Counter x Reset	0 to 65535	---	1	F300	0
B312	Digital Counter x Freeze/Reset	0 to 65535	---	1	F300	0
B313	Digital Counter x Freeze/Count	0 to 65535	---	1	F300	0
B314	Digital Counter Set To Preset	0 to 65535	---	1	F300	0
B315	Digital Counter x Reserved (11 items)	---	---	---	F001	0
B320	...Repeated for module number 2					
B340	...Repeated for module number 3					
B360	...Repeated for module number 4					
B380	...Repeated for module number 5					
B3A0	...Repeated for module number 6					
B3C0	...Repeated for module number 7					
B3E0	...Repeated for module number 8					
Frequency Rate of Change (Read/Write Setting) (4 modules)						
B500	Frequency Rate of Change X Function	0 to 1	---	1	F102	0 (Disabled)
B501	Frequency Rate of Change X OC Supervision	0 to 30	pu	0.001	F001	200
B502	Frequency Rate of Change X Min	20 to 80	Hz	0.01	F001	4500
B503	Frequency Rate of Change X Max	20 to 80	Hz	0.01	F001	6500
B504	Frequency Rate of Change X Pickup Delay	0 to 65.535	s	0.001	F001	0
B505	Frequency Rate of Change X Reset Delay	0 to 65.535	s	0.001	F001	0
B506	Frequency Rate of Change X Block	0 to 65535	---	1	F300	0
B507	Frequency Rate of Change X Target	0 to 2	---	1	F109	0 (Self-reset)
B508	Frequency Rate of Change X Events	0 to 1	---	1	F102	0 (Disabled)
B509	Frequency Rate of Change X Source	0 to 5	---	1	F167	0 (SRC 1)
B50A	Frequency Rate of Change X Trend	0 to 2	---	1	F224	0 (Increasing)
B50B	Frequency Rate of Change X Pickup	0.1 to 15	Hz/s	0.01	F001	50
B50C	Frequency Rate of Change X OV Supervision	0.1 to 3	pu	0.001	F001	700

Table B–9: MODBUS MEMORY MAP (Sheet 29 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
B50D	Frequency Rate of Change X Reserved (3 items)	0 to 1	---	1	F001	0
B510	...Repeated for module number 2					
B520	...Repeated for module number 3					
B530	...Repeated for module number 4					
Contact Inputs (Read/Write Setting) (96 modules)						
C000	Contact Input x Name	---	---	---	F205	"Cont Ip 1 "
C006	Contact Input x Events	0 to 1	---	1	F102	0 (Disabled)
C007	Contact Input x Debounce Time	0 to 16	ms	0.5	F001	20
C008	...Repeated for module number 2					
C010	...Repeated for module number 3					
C018	...Repeated for module number 4					
C020	...Repeated for module number 5					
C028	...Repeated for module number 6					
C030	...Repeated for module number 7					
C038	...Repeated for module number 8					
C040	...Repeated for module number 9					
C048	...Repeated for module number 10					
C050	...Repeated for module number 11					
C058	...Repeated for module number 12					
C060	...Repeated for module number 13					
C068	...Repeated for module number 14					
C070	...Repeated for module number 15					
C078	...Repeated for module number 16					
C080	...Repeated for module number 17					
C088	...Repeated for module number 18					
C090	...Repeated for module number 19					
C098	...Repeated for module number 20					
C0A0	...Repeated for module number 21					
C0A8	...Repeated for module number 22					
C0B0	...Repeated for module number 23					
C0B8	...Repeated for module number 24					
C0C0	...Repeated for module number 25					
C0C8	...Repeated for module number 26					
C0D0	...Repeated for module number 27					
C0D8	...Repeated for module number 28					
C0E0	...Repeated for module number 29					
C0E8	...Repeated for module number 30					
C0F0	...Repeated for module number 31					
C0F8	...Repeated for module number 32					
C100	...Repeated for module number 33					
C108	...Repeated for module number 34					
C110	...Repeated for module number 35					
C118	...Repeated for module number 36					
C120	...Repeated for module number 37					
C128	...Repeated for module number 38					
C130	...Repeated for module number 39					
C138	...Repeated for module number 40					
C140	...Repeated for module number 41					
C148	...Repeated for module number 42					
C150	...Repeated for module number 43					
C158	...Repeated for module number 44					
C160	...Repeated for module number 45					
C168	...Repeated for module number 46					
C170	...Repeated for module number 47					

Table B-9: MODBUS MEMORY MAP (Sheet 30 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
C178	...Repeated for module number 48					
C180	...Repeated for module number 49					
C188	...Repeated for module number 50					
C190	...Repeated for module number 51					
C198	...Repeated for module number 52					
C1A0	...Repeated for module number 53					
C1A8	...Repeated for module number 54					
C1B0	...Repeated for module number 55					
C1B8	...Repeated for module number 56					
C1C0	...Repeated for module number 57					
C1C8	...Repeated for module number 58					
C1D0	...Repeated for module number 59					
C1D8	...Repeated for module number 60					
C1E0	...Repeated for module number 61					
C1E8	...Repeated for module number 62					
C1F0	...Repeated for module number 63					
C1F8	...Repeated for module number 64					
C200	...Repeated for module number 65					
C208	...Repeated for module number 66					
C210	...Repeated for module number 67					
C218	...Repeated for module number 68					
C220	...Repeated for module number 69					
C228	...Repeated for module number 70					
C230	...Repeated for module number 71					
C238	...Repeated for module number 72					
C240	...Repeated for module number 73					
C248	...Repeated for module number 74					
C250	...Repeated for module number 75					
C258	...Repeated for module number 76					
C260	...Repeated for module number 77					
C268	...Repeated for module number 78					
C270	...Repeated for module number 79					
C278	...Repeated for module number 80					
C280	...Repeated for module number 81					
C288	...Repeated for module number 82					
C290	...Repeated for module number 83					
C298	...Repeated for module number 84					
C2A0	...Repeated for module number 85					
C2A8	...Repeated for module number 86					
C2B0	...Repeated for module number 87					
C2B8	...Repeated for module number 88					
C2C0	...Repeated for module number 89					
C2C8	...Repeated for module number 90					
C2D0	...Repeated for module number 91					
C2D8	...Repeated for module number 92					
C2E0	...Repeated for module number 93					
C2E8	...Repeated for module number 94					
C2F0	...Repeated for module number 95					
C2F8	...Repeated for module number 96					
Contact Input Thresholds (Read/Write Setting)						
C600	Contact Input x Threshold (24 items)	0 to 3	---	1	F128	1 (33 Vdc)
Virtual Inputs Global Settings (Read/Write Setting)						
C680	Virtual Inputs SBO Timeout	1 to 60	s	1	F001	30

Table B-9: MODBUS MEMORY MAP (Sheet 31 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
Virtual Inputs (Read/Write Setting) (32 modules)						
C690	Virtual Input x Function	0 to 1	---	1	F102	0 (Disabled)
C691	Virtual Input x Name	---	---	---	F205	"Virt Ip 1 "
C69B	Virtual Input x Programmed Type	0 to 1	---	1	F127	0 (Latched)
C69C	Virtual Input x Events	0 to 1	---	1	F102	0 (Disabled)
C69D	Virtual Input x UCA SBOClass	1 to 2	---	1	F001	1
C69E	Virtual Input x UCA SBOEna	0 to 1	---	1	F102	0 (Disabled)
C69F	Virtual Input x Reserved	---	---	---	F001	0
C6A0	...Repeated for module number 2					
C6B0	...Repeated for module number 3					
C6C0	...Repeated for module number 4					
C6D0	...Repeated for module number 5					
C6E0	...Repeated for module number 6					
C6F0	...Repeated for module number 7					
C700	...Repeated for module number 8					
C710	...Repeated for module number 9					
C720	...Repeated for module number 10					
C730	...Repeated for module number 11					
C740	...Repeated for module number 12					
C750	...Repeated for module number 13					
C760	...Repeated for module number 14					
C770	...Repeated for module number 15					
C780	...Repeated for module number 16					
C790	...Repeated for module number 17					
C7A0	...Repeated for module number 18					
C7B0	...Repeated for module number 19					
C7C0	...Repeated for module number 20					
C7D0	...Repeated for module number 21					
C7E0	...Repeated for module number 22					
C7F0	...Repeated for module number 23					
C800	...Repeated for module number 24					
C810	...Repeated for module number 25					
C820	...Repeated for module number 26					
C830	...Repeated for module number 27					
C840	...Repeated for module number 28					
C850	...Repeated for module number 29					
C860	...Repeated for module number 30					
C870	...Repeated for module number 31					
C880	...Repeated for module number 32					
Virtual Outputs (Read/Write Setting) (64 modules)						
CC90	Virtual Output x Name	---	---	---	F205	"Virt Op 1 "
CC9A	Virtual Output x Events	0 to 1	---	1	F102	0 (Disabled)
CC9B	Virtual Output x Reserved (5 items)	---	---	---	F001	0
CCA0	...Repeated for module number 2					
CCB0	...Repeated for module number 3					
CCC0	...Repeated for module number 4					
CCD0	...Repeated for module number 5					
CCE0	...Repeated for module number 6					
CCF0	...Repeated for module number 7					
CD00	...Repeated for module number 8					
CD10	...Repeated for module number 9					
CD20	...Repeated for module number 10					
CD30	...Repeated for module number 11					
CD40	...Repeated for module number 12					

Table B-9: MODBUS MEMORY MAP (Sheet 32 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
CD50	...Repeated for module number 13					
CD60	...Repeated for module number 14					
CD70	...Repeated for module number 15					
CD80	...Repeated for module number 16					
CD90	...Repeated for module number 17					
CDA0	...Repeated for module number 18					
CDB0	...Repeated for module number 19					
CDC0	...Repeated for module number 20					
CDD0	...Repeated for module number 21					
CDE0	...Repeated for module number 22					
CDF0	...Repeated for module number 23					
CE00	...Repeated for module number 24					
CE10	...Repeated for module number 25					
CE20	...Repeated for module number 26					
CE30	...Repeated for module number 27					
CE40	...Repeated for module number 28					
CE50	...Repeated for module number 29					
CE60	...Repeated for module number 30					
CE70	...Repeated for module number 31					
CE80	...Repeated for module number 32					
CE90	...Repeated for module number 33					
CEA0	...Repeated for module number 34					
CEB0	...Repeated for module number 35					
CEC0	...Repeated for module number 36					
CED0	...Repeated for module number 37					
CEE0	...Repeated for module number 38					
CEF0	...Repeated for module number 39					
CF00	...Repeated for module number 40					
CF10	...Repeated for module number 41					
CF20	...Repeated for module number 42					
CF30	...Repeated for module number 43					
CF40	...Repeated for module number 44					
CF50	...Repeated for module number 45					
CF60	...Repeated for module number 46					
CF70	...Repeated for module number 47					
CF80	...Repeated for module number 48					
CF90	...Repeated for module number 49					
CFA0	...Repeated for module number 50					
CFB0	...Repeated for module number 51					
CFC0	...Repeated for module number 52					
CFD0	...Repeated for module number 53					
CFE0	...Repeated for module number 54					
CFF0	...Repeated for module number 55					
D000	...Repeated for module number 56					
D010	...Repeated for module number 57					
D020	...Repeated for module number 58					
D030	...Repeated for module number 59					
D040	...Repeated for module number 60					
D050	...Repeated for module number 61					
D060	...Repeated for module number 62					
D070	...Repeated for module number 63					
D080	...Repeated for module number 64					
Mandatory (Read/Write)						
D280	Test Mode Function	0 to 1	---	1	F102	0 (Disabled)

Table B-9: MODBUS MEMORY MAP (Sheet 33 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
D281	Force VFD and LED	0 to 1	---	1	F126	0 (No)
Contact Outputs (Read/Write Setting) (64 modules)						
D290	Contact Output x Name	---	---	---	F205	"Cont Op 1 "
D29A	Contact Output x Operation	0 to 65535	---	1	F300	0
D29B	Contact Output x Seal In	0 to 65535	---	1	F300	0
D29C	Reserved	---	---	1	F001	0
D29D	Contact Output x Events	0 to 1	---	1	F102	1 (Enabled)
D29E	Reserved (2 items)	---	---	---	F001	0
D2A0	...Repeated for module number 2					
D2B0	...Repeated for module number 3					
D2C0	...Repeated for module number 4					
D2D0	...Repeated for module number 5					
D2E0	...Repeated for module number 6					
D2F0	...Repeated for module number 7					
D300	...Repeated for module number 8					
D310	...Repeated for module number 9					
D320	...Repeated for module number 10					
D330	...Repeated for module number 11					
D340	...Repeated for module number 12					
D350	...Repeated for module number 13					
D360	...Repeated for module number 14					
D370	...Repeated for module number 15					
D380	...Repeated for module number 16					
D390	...Repeated for module number 17					
D3A0	...Repeated for module number 18					
D3B0	...Repeated for module number 19					
D3C0	...Repeated for module number 20					
D3D0	...Repeated for module number 21					
D3E0	...Repeated for module number 22					
D3F0	...Repeated for module number 23					
D400	...Repeated for module number 24					
D410	...Repeated for module number 25					
D420	...Repeated for module number 26					
D430	...Repeated for module number 27					
D440	...Repeated for module number 28					
D450	...Repeated for module number 29					
D460	...Repeated for module number 30					
D470	...Repeated for module number 31					
D480	...Repeated for module number 32					
D490	...Repeated for module number 33					
D4A0	...Repeated for module number 34					
D4B0	...Repeated for module number 35					
D4C0	...Repeated for module number 36					
D4D0	...Repeated for module number 37					
D4E0	...Repeated for module number 38					
D4F0	...Repeated for module number 39					
D500	...Repeated for module number 40					
D510	...Repeated for module number 41					
D520	...Repeated for module number 42					
D530	...Repeated for module number 43					
D540	...Repeated for module number 44					
D550	...Repeated for module number 45					
D560	...Repeated for module number 46					
D570	...Repeated for module number 47					

Table B-9: MODBUS MEMORY MAP (Sheet 34 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
D580	...Repeated for module number 48					
D590	...Repeated for module number 49					
D5A0	...Repeated for module number 50					
D5B0	...Repeated for module number 51					
D5C0	...Repeated for module number 52					
D5D0	...Repeated for module number 53					
D5E0	...Repeated for module number 54					
D5F0	...Repeated for module number 55					
D600	...Repeated for module number 56					
D610	...Repeated for module number 57					
D620	...Repeated for module number 58					
D630	...Repeated for module number 59					
D640	...Repeated for module number 60					
D650	...Repeated for module number 61					
D660	...Repeated for module number 62					
D670	...Repeated for module number 63					
D680	...Repeated for module number 64					
Reset (Read/Write Setting)						
D800	FlexLogic operand which initiates a reset	0 to 65535	---	1	F300	0
Control Pushbuttons (Read/Write Setting) (3 modules)						
D810	Control Pushbutton x Function	0 to 1	---	1	F102	0 (Disabled)
D811	Control Pushbutton x Events	0 to 1	---	1	F102	0 (Disabled)
D812	Control Pushbutton x Reserved	0 to 1	---	1	F001	0
D814	...Repeated for module number 2					
D818	...Repeated for module number 3					
Clear Relay Records (Read/Write Setting)						
D820	Clear Fault Reports Operand	0 to 65535	---	1	F300	0
D822	Clear Event Records Operand	0 to 65535	---	1	F300	0
D823	Clear Oscillography Operand	0 to 65535	---	1	F300	0
D824	Clear Data Logger Operand	0 to 65535	---	1	F300	0
D825	Clear Breaker Arcing Amps 1 Operand	0 to 65535	---	1	F300	0
D826	Clear Breaker Arcing Amps 2 Operand	0 to 65535	---	1	F300	0
D827	Clear Demand Operand	0 to 65535	---	1	F300	0
D829	Clear Energy Operand	0 to 65535	---	1	F300	0
D82A	Clear Hi-Z Records Operand	0 to 65535	---	1	F300	0
D82B	Clear Unauthorized Access Operand	0 to 65535	---	1	F300	0
D82D	Clear Platform Direct I/O Stats Operand	0 to 65535	---	1	F300	0
D82E	Clear Relay Records Reserved					
Force Contact Inputs (Read/Write Setting)						
D8B0	Force Contact Input x State (96 items)	0 to 2	---	1	F144	0 (Disabled)
Force Contact Outputs (Read/Write Setting)						
D910	Force Contact Output x State (64 items)	0 to 3	---	1	F131	0 (Disabled)
Platform Direct I/O (Read/Write Setting)						
DB40	Direct Device ID	1 to 8	---	1	F001	1
DB41	Platform Direct I/O Ring Ch 1 Configuration Function	0 to 1	---	1	F126	0 (No)
DB42	Platform Direct I/O Data Rate	64 to 128	kbps	64	F001	64
DB41	Platform Direct I/O Ring Ch 2 Configuration Function	0 to 1	---	1	F126	0 (No)
DB42	Platform Direct I/O Crossover Function	0 to 1	---	1	F102	0 (Disabled)
Platform Direct Inputs (Read/Write Setting) (96 modules)						
DB50	Direct Input x Device Number	0 to 8	---	1	F001	0
DB51	Direct Input x Number	0 to 96	---	1	F001	0
DB52	Direct Input x Default State	0 to 1	---	1	F108	0 (Off)
DB53	Direct Input x Events	0 to 1	---	1	F102	0 (Disabled)
DB54	...Repeated for module number 2					

Table B–9: MODBUS MEMORY MAP (Sheet 35 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
DB58	...Repeated for module number 3					
DB5C	...Repeated for module number 4					
DB60	...Repeated for module number 5					
DB64	...Repeated for module number 6					
DB68	...Repeated for module number 7					
DB6C	...Repeated for module number 8					
DB70	...Repeated for module number 9					
DB74	...Repeated for module number 10					
DB78	...Repeated for module number 11					
DB7C	...Repeated for module number 12					
DB80	...Repeated for module number 13					
DB84	...Repeated for module number 14					
DB88	...Repeated for module number 15					
DB8C	...Repeated for module number 16					
DB90	...Repeated for module number 17					
DB94	...Repeated for module number 18					
DB98	...Repeated for module number 19					
DB9C	...Repeated for module number 20					
DBA0	...Repeated for module number 21					
DBA4	...Repeated for module number 22					
DBA8	...Repeated for module number 23					
DBAC	...Repeated for module number 24					
DBB0	...Repeated for module number 25					
DBB4	...Repeated for module number 26					
DBB8	...Repeated for module number 27					
DBBC	...Repeated for module number 28					
DBC0	...Repeated for module number 29					
DBC4	...Repeated for module number 30					
DBC8	...Repeated for module number 31					
DBCC	...Repeated for module number 32					
DBD0	...Repeated for module number 33					
DBD4	...Repeated for module number 34					
DBD8	...Repeated for module number 35					
DBDC	...Repeated for module number 36					
DBE0	...Repeated for module number 37					
DBE4	...Repeated for module number 38					
DBE8	...Repeated for module number 39					
DBEC	...Repeated for module number 40					
DBF0	...Repeated for module number 41					
DBF4	...Repeated for module number 42					
DBF8	...Repeated for module number 43					
DBFC	...Repeated for module number 44					
DC00	...Repeated for module number 45					
DC04	...Repeated for module number 46					
DC08	...Repeated for module number 47					
DC0C	...Repeated for module number 48					
DC10	...Repeated for module number 49					
DC14	...Repeated for module number 50					
DC18	...Repeated for module number 51					
DC1C	...Repeated for module number 52					
DC20	...Repeated for module number 53					
DC24	...Repeated for module number 54					
DC28	...Repeated for module number 55					
DC2C	...Repeated for module number 56					

Table B-9: MODBUS MEMORY MAP (Sheet 36 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
DC30	...Repeated for module number 57					
DC34	...Repeated for module number 58					
DC38	...Repeated for module number 59					
DC3C	...Repeated for module number 60					
DC40	...Repeated for module number 61					
DC44	...Repeated for module number 62					
DC48	...Repeated for module number 63					
DC4C	...Repeated for module number 64					
DC50	...Repeated for module number 65					
DC54	...Repeated for module number 66					
DC58	...Repeated for module number 67					
DC5C	...Repeated for module number 68					
DC60	...Repeated for module number 69					
DC64	...Repeated for module number 70					
DC68	...Repeated for module number 71					
DC6C	...Repeated for module number 72					
DC70	...Repeated for module number 73					
DC74	...Repeated for module number 74					
DC78	...Repeated for module number 75					
DC7C	...Repeated for module number 76					
DC80	...Repeated for module number 77					
DC84	...Repeated for module number 78					
DC88	...Repeated for module number 79					
DC8C	...Repeated for module number 80					
DC90	...Repeated for module number 81					
DC94	...Repeated for module number 82					
DC98	...Repeated for module number 83					
DC9C	...Repeated for module number 84					
DCA0	...Repeated for module number 85					
DCA4	...Repeated for module number 86					
DCA8	...Repeated for module number 87					
DCAC	...Repeated for module number 88					
DCB0	...Repeated for module number 89					
DCB4	...Repeated for module number 90					
DCB8	...Repeated for module number 91					
DCBC	...Repeated for module number 92					
DCC0	...Repeated for module number 93					
DCC4	...Repeated for module number 94					
DCC8	...Repeated for module number 95					
DCCC	...Repeated for module number 96					
Platform Direct Outputs (Read/Write Setting) (96 modules)						
DD00	Direct Output x Operand	0 to 65535	---	1	F300	0
DD01	Direct Output x Events	0 to 1	---	1	F102	0 (Disabled)
DD02	...Repeated for module number 2					
DD04	...Repeated for module number 3					
DD06	...Repeated for module number 4					
DD08	...Repeated for module number 5					
DD0A	...Repeated for module number 6					
DD0C	...Repeated for module number 7					
DD0E	...Repeated for module number 8					
DD10	...Repeated for module number 9					
DD12	...Repeated for module number 10					
DD14	...Repeated for module number 11					
DD16	...Repeated for module number 12					

Table B–9: MODBUS MEMORY MAP (Sheet 37 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
DD18	...Repeated for module number 13					
DD1A	...Repeated for module number 14					
DD1C	...Repeated for module number 15					
DD1E	...Repeated for module number 16					
DD20	...Repeated for module number 17					
DD22	...Repeated for module number 18					
DD24	...Repeated for module number 19					
DD26	...Repeated for module number 20					
DD28	...Repeated for module number 21					
DD2A	...Repeated for module number 22					
DD2C	...Repeated for module number 23					
DD2E	...Repeated for module number 24					
DD30	...Repeated for module number 25					
DD32	...Repeated for module number 26					
DD34	...Repeated for module number 27					
DD36	...Repeated for module number 28					
DD38	...Repeated for module number 29					
DD3A	...Repeated for module number 30					
DD3C	...Repeated for module number 31					
DD3E	...Repeated for module number 32					
DD40	...Repeated for module number 33					
DD42	...Repeated for module number 34					
DD44	...Repeated for module number 35					
DD46	...Repeated for module number 36					
DD48	...Repeated for module number 37					
DD4A	...Repeated for module number 38					
DD4C	...Repeated for module number 39					
DD4E	...Repeated for module number 40					
DD50	...Repeated for module number 41					
DD52	...Repeated for module number 42					
DD54	...Repeated for module number 43					
DD56	...Repeated for module number 44					
DD58	...Repeated for module number 45					
DD5A	...Repeated for module number 46					
DD5C	...Repeated for module number 47					
DD5E	...Repeated for module number 48					
DD60	...Repeated for module number 49					
DD62	...Repeated for module number 50					
DD64	...Repeated for module number 51					
DD66	...Repeated for module number 52					
DD68	...Repeated for module number 53					
DD6A	...Repeated for module number 54					
DD6C	...Repeated for module number 55					
DD6E	...Repeated for module number 56					
DD70	...Repeated for module number 57					
DD72	...Repeated for module number 58					
DD74	...Repeated for module number 59					
DD76	...Repeated for module number 60					
DD78	...Repeated for module number 61					
DD7A	...Repeated for module number 62					
DD7C	...Repeated for module number 63					
DD7E	...Repeated for module number 64					
DD80	...Repeated for module number 65					
DD82	...Repeated for module number 66					

Table B-9: MODBUS MEMORY MAP (Sheet 38 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
DD84	...Repeated for module number 67					
DD86	...Repeated for module number 68					
DD88	...Repeated for module number 69					
DD8A	...Repeated for module number 70					
DD8C	...Repeated for module number 71					
DD8E	...Repeated for module number 72					
DD90	...Repeated for module number 73					
DD92	...Repeated for module number 74					
DD94	...Repeated for module number 75					
DD96	...Repeated for module number 76					
DD98	...Repeated for module number 77					
DD9A	...Repeated for module number 78					
DD9C	...Repeated for module number 79					
DD9E	...Repeated for module number 80					
DDA0	...Repeated for module number 81					
DDA2	...Repeated for module number 82					
DDA4	...Repeated for module number 83					
DDA6	...Repeated for module number 84					
DDA8	...Repeated for module number 85					
DDAA	...Repeated for module number 86					
DDAC	...Repeated for module number 87					
DDAE	...Repeated for module number 88					
DDB0	...Repeated for module number 89					
DDB2	...Repeated for module number 90					
DDB4	...Repeated for module number 91					
DDB6	...Repeated for module number 92					
DDB8	...Repeated for module number 93					
DDBA	...Repeated for module number 94					
DDBC	...Repeated for module number 95					
DDBE	...Repeated for module number 96					
Remote Devices (Read/Write Setting) (16 modules)						
E000	Remote Device x ID	---	---	---	F202	"Remote Device 1 "
E00A	...Repeated for module number 2					
E014	...Repeated for module number 3					
E01E	...Repeated for module number 4					
E028	...Repeated for module number 5					
E032	...Repeated for module number 6					
E03C	...Repeated for module number 7					
E046	...Repeated for module number 8					
E050	...Repeated for module number 9					
E05A	...Repeated for module number 10					
E064	...Repeated for module number 11					
E06E	...Repeated for module number 12					
E078	...Repeated for module number 13					
E082	...Repeated for module number 14					
E08C	...Repeated for module number 15					
E096	...Repeated for module number 16					
Remote Inputs (Read/Write Setting) (32 modules)						
E100	Remote Input x Device	1 to 16	---	1	F001	1
E101	Remote Input x Bit Pair	0 to 64	---	1	F156	0 (None)
E102	Remote Input x Default State	0 to 1	---	1	F108	0 (Off)
E103	Remote Input x Events	0 to 1	---	1	F102	0 (Disabled)
E104	...Repeated for module number 2					
E108	...Repeated for module number 3					

Table B–9: MODBUS MEMORY MAP (Sheet 39 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
E10C	...Repeated for module number 4					
E110	...Repeated for module number 5					
E114	...Repeated for module number 6					
E118	...Repeated for module number 7					
E11C	...Repeated for module number 8					
E120	...Repeated for module number 9					
E124	...Repeated for module number 10					
E128	...Repeated for module number 11					
E12C	...Repeated for module number 12					
E130	...Repeated for module number 13					
E134	...Repeated for module number 14					
E138	...Repeated for module number 15					
E13C	...Repeated for module number 16					
E140	...Repeated for module number 17					
E144	...Repeated for module number 18					
E148	...Repeated for module number 19					
E14C	...Repeated for module number 20					
E150	...Repeated for module number 21					
E154	...Repeated for module number 22					
E158	...Repeated for module number 23					
E15C	...Repeated for module number 24					
E160	...Repeated for module number 25					
E164	...Repeated for module number 26					
E168	...Repeated for module number 27					
E16C	...Repeated for module number 28					
E170	...Repeated for module number 29					
E174	...Repeated for module number 30					
E178	...Repeated for module number 31					
E17C	...Repeated for module number 32					
Remote Output DNA Pairs (Read/Write Setting) (32 modules)						
E600	Remote Output DNA x Operand	0 to 65535	---	1	F300	0
E601	Remote Output DNA x Events	0 to 1	---	1	F102	0 (Disabled)
E602	Remote Output DNA x Reserved (2 items)	0 to 1	---	1	F001	0
E604	...Repeated for module number 2					
E608	...Repeated for module number 3					
E60C	...Repeated for module number 4					
E610	...Repeated for module number 5					
E614	...Repeated for module number 6					
E618	...Repeated for module number 7					
E61C	...Repeated for module number 8					
E620	...Repeated for module number 9					
E624	...Repeated for module number 10					
E628	...Repeated for module number 11					
E62C	...Repeated for module number 12					
E630	...Repeated for module number 13					
E634	...Repeated for module number 14					
E638	...Repeated for module number 15					
E63C	...Repeated for module number 16					
E640	...Repeated for module number 17					
E644	...Repeated for module number 18					
E648	...Repeated for module number 19					
E64C	...Repeated for module number 20					
E650	...Repeated for module number 21					
E654	...Repeated for module number 22					

Table B-9: MODBUS MEMORY MAP (Sheet 40 of 40)

ADDR	REGISTER NAME	RANGE	UNITS	STEP	FORMAT	DEFAULT
E658	...Repeated for module number 23					
E65C	...Repeated for module number 24					
E660	...Repeated for module number 25					
E664	...Repeated for module number 26					
E668	...Repeated for module number 27					
E66C	...Repeated for module number 28					
E670	...Repeated for module number 29					
E674	...Repeated for module number 30					
E678	...Repeated for module number 31					
E67C	...Repeated for module number 32					
Remote Output UserSt Pairs (Read/Write Setting) (32 modules)						
E680	Remote Output UserSt x Operand	0 to 65535	---	1	F300	0
E681	Remote Output UserSt x Events	0 to 1	---	1	F102	0 (Disabled)
E682	Remote Output UserSt x Reserved (2 items)	0 to 1	---	1	F001	0
E684	...Repeated for module number 2					
E688	...Repeated for module number 3					
E68C	...Repeated for module number 4					
E690	...Repeated for module number 5					
E694	...Repeated for module number 6					
E698	...Repeated for module number 7					
E69C	...Repeated for module number 8					
E6A0	...Repeated for module number 9					
E6A4	...Repeated for module number 10					
E6A8	...Repeated for module number 11					
E6AC	...Repeated for module number 12					
E6B0	...Repeated for module number 13					
E6B4	...Repeated for module number 14					
E6B8	...Repeated for module number 15					
E6BC	...Repeated for module number 16					
E6C0	...Repeated for module number 17					
E6C4	...Repeated for module number 18					
E6C8	...Repeated for module number 19					
E6CC	...Repeated for module number 20					
E6D0	...Repeated for module number 21					
E6D4	...Repeated for module number 22					
E6D8	...Repeated for module number 23					
E6DC	...Repeated for module number 24					
E6E0	...Repeated for module number 25					
E6E4	...Repeated for module number 26					
E6E8	...Repeated for module number 27					
E6EC	...Repeated for module number 28					
E6F0	...Repeated for module number 29					
E6F4	...Repeated for module number 30					
E6F8	...Repeated for module number 31					
E6FC	...Repeated for module number 32					

B.4.2 DATA FORMATS

B

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 PWR 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 IEE 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

F100
ENUMERATION: VT CONNECTION TYPE

0 = Wye; 1 = Delta

F101
ENUMERATION: MESSAGE DISPLAY INTENSITY

0 = 25%, 1 = 50%, 2 = 75%, 3 = 100%

F102**ENUMERATION: DISABLED/ENABLED**

0 = Disabled; 1 = Enabled

F103**ENUMERATION: CURVE SHAPES**

bitmask	curve shape
0	IEEE Mod Inv
1	IEEE Very Inv
2	IEEE Ext Inv
3	IEC Curve A
4	IEC Curve B
5	IEC Curve C
6	IEC Short Inv
7	IAC Ext Inv
8	IAC Very Inv

bitmask	curve shape
9	IAC Inverse
10	IAC Short Inv
11	I2t
12	Definite Time
13	FlexCurve™ A
14	FlexCurve™ B
15	FlexCurve™ C
16	FlexCurve™ D

F104**ENUMERATION: RESET TYPE**

0 = Instantaneous, 1 = Timed, 2 = Linear

F105**ENUMERATION: LOGIC INPUT**

0 = Disabled, 1 = Input 1, 2 = Input 2

F106**ENUMERATION: PHASE ROTATION**

0 = ABC, 1 = ACB

F108**ENUMERATION: OFF/ON**

0 = Off, 1 = On

F109**ENUMERATION: CONTACT OUTPUT OPERATION**

0 = Self-reset, 1 = Latched, 2 = Disabled

F110**ENUMERATION: CONTACT OUTPUT LED CONTROL**

0 = Trip, 1 = Alarm, 2 = None

F111**ENUMERATION: UNDERVOLTAGE CURVE SHAPES**

0 = Definite Time, 1 = Inverse Time

F112**ENUMERATION: RS485 BAUD RATES**

bitmask	value
0	300
1	1200
2	2400
3	4800

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

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

B

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 IOC1
1	PHASE IOC2
2	PHASE IOC3
3	PHASE IOC4
4	PHASE IOC5

bitmask	element
5	PHASE IOC6
6	PHASE IOC7
7	PHASE IOC8
8	PHASE IOC9
9	PHASE IOC10
10	PHASE IOC11
11	PHASE IOC12
16	PHASE TOC1
17	PHASE TOC2
18	PHASE TOC3
19	PHASE TOC4
20	PHASE TOC5
21	PHASE TOC6
24	PH DIR1
25	PH DIR2
32	NEUTRAL IOC1
33	NEUTRAL IOC2
34	NEUTRAL IOC3
35	NEUTRAL IOC4
36	NEUTRAL IOC5
37	NEUTRAL IOC6
38	NEUTRAL IOC7
39	NEUTRAL IOC8
40	NEUTRAL IOC9
41	NEUTRAL IOC10
42	NEUTRAL IOC11
43	NEUTRAL IOC12
48	NEUTRAL TOC1
49	NEUTRAL TOC2
50	NEUTRAL TOC3
51	NEUTRAL TOC4
52	NEUTRAL TOC5
53	NEUTRAL TOC6
56	NTRL DIR OC1
57	NTRL DIR OC2
60	NEG SEQ DIR OC1
61	NEG SEQ DIR OC2
64	GROUND IOC1
65	GROUND IOC2
66	GROUND IOC3
67	GROUND IOC4
68	GROUND IOC5
69	GROUND IOC6
70	GROUND IOC7
71	GROUND IOC8
72	GROUND IOC9
73	GROUND IOC10
74	GROUND IOC11
75	GROUND IOC12
80	GROUND TOC1
81	GROUND TOC2
82	GROUND TOC3
83	GROUND TOC4

bitmask	element
84	GROUND TOC5
85	GROUND TOC6
96	NEG SEQ IOC1
97	NEG SEQ IOC2
112	NEG SEQ TOC1
113	NEG SEQ TOC2
120	NEG SEQ OV
128	HI-Z
140	AUX UV1
144	PHASE UV1
145	PHASE UV2
148	AUX OV1
152	PHASE OV1
156	NEUTRAL OV1
180	LOAD ENCHR
190	POWER SWING
224	SRC1 VT FF
225	SRC2 VT FF
226	SRC3 VT FF
227	SRC4 VT FF
228	SRC5 VT FF
229	SRC6 VT FF
232	SRC1 50DD
233	SRC2 50DD
234	SRC3 50DD
235	SRC4 50DD
236	SRC5 50DD
237	SRC6 50DD
244	50DD
245	CONT MONITOR
246	CT FAIL
265	STATOR DIFF
272	BREAKER 1
273	BREAKER 2
280	BKR FAIL
281	BKR FAIL
288	BKR ARC
289	BKR ARC
296	ACCDNT ENRG
300	LOSS EXCIT
304	AR 1
305	AR 2
306	AR 3
307	AR 4
308	AR 5
309	AR 6
312	SYNC 1
313	SYNC 2
320	COLD LOAD 1
321	COLD LOAD 2
324	AMP UNBALANCE 1
325	AMP UNBALANCE 2
330	3RD HARM

bitmask	element
336	SETTING GROUP
337	RESET
344	OVERFREQ 1
345	OVERFREQ 2
346	OVERFREQ 3
347	OVERFREQ 4
352	UNDERFREQ 1
353	UNDERFREQ 2
354	UNDERFREQ 3
355	UNDERFREQ 4
356	UNDERFREQ 5
357	UNDERFREQ 6
376	AR
377	STARTS-PER-HOUR
378	TIME-BTWN-STARTS
379	RESTART DELAY
380	MECHANICAL JAM
400	FLEX ELEMENT 1
401	FLEX ELEMENT 2
402	FLEX ELEMENT 3
403	FLEX ELEMENT 4
404	FLEX ELEMENT 5
405	FLEX ELEMENT 6
406	FLEX ELEMENT 7
407	FLEX ELEMENT 8
408	FLEX ELEMENT 9
409	FLEX ELEMENT 10
410	FLEX ELEMENT 11
411	FLEX ELEMENT 12
412	FLEX ELEMENT 13
413	FLEX ELEMENT 14
414	FLEX ELEMENT 15
415	FLEX ELEMENT 16
420	LATCH 1
421	LATCH 2
422	LATCH 3
423	LATCH 4
424	LATCH 5
425	LATCH 6
426	LATCH 7
427	LATCH 8
428	LATCH 9
429	LATCH 10
430	LATCH 11
431	LATCH 12
432	LATCH 13
433	LATCH 14
434	LATCH 15
435	LATCH 16
512	DIG ELEM 1
513	DIG ELEM 2
514	DIG ELEM 3
515	DIG ELEM 4

bitmask	element
516	DIG ELEM 5
517	DIG ELEM 6
518	DIG ELEM 7
519	DIG ELEM 8
520	DIG ELEM 9
521	DIG ELEM 10
522	DIG ELEM 11
523	DIG ELEM 12
524	DIG ELEM 13
525	DIG ELEM 14
526	DIG ELEM 15
527	DIG ELEM 16
544	COUNTER 1
545	COUNTER 2
546	COUNTER 3
547	COUNTER 4
548	COUNTER 5
549	COUNTER 6
550	COUNTER 7
551	COUNTER 8
680	PUSHBUTTON 1
681	PUSHBUTTON 2
682	PUSHBUTTON 3
683	PUSHBUTTON 4
684	PUSHBUTTON 5
685	PUSHBUTTON 6
686	PUSHBUTTON 7
687	PUSHBUTTON 8
688	PUSHBUTTON 9
689	PUSHBUTTON 10
690	PUSHBUTTON 11
691	PUSHBUTTON 12

F125 ENUMERATION: ACCESS LEVEL

0 = Restricted; 1 = Command, 2 = Setting, 3 = Factory Service

F126 ENUMERATION: NO/YES CHOICE

0 = No, 1 = Yes

F127 ENUMERATION: LATCHED OR SELF-RESETTING

0 = Latched, 1 = Self-Reset

F128 ENUMERATION: CONTACT INPUT THRESHOLD

0 = 17 V DC, 1 = 33 V DC, 2 = 84 V DC, 3 = 166 V DC

F129 ENUMERATION: FLEXLOGIC TIMER TYPE

0 = millisecond, 1 = second, 2 = minute

F130 ENUMERATION: SIMULATION MODE

0 = Off. 1 = Pre-Fault, 2 = Fault, 3 = Post-Fault

F131 ENUMERATION: FORCED CONTACT OUTPUT STATE

0 = Disabled, 1 = Energized, 2 = De-energized, 3 = Freeze

F132 ENUMERATION: DEMAND INTERVAL

0 = 5 min, 1 = 10 min, 2 = 15 min, 3 = 20 min, 4 = 30 min, 5 = 60 min

F133 ENUMERATION: PROGRAM STATE

0 = Not Programmed, 1 = Programmed

F134 ENUMERATION: PASS/FAIL

0 = Fail, 1 = OK, 2 = n/a

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 ERR TOKEN
11	EQUIPMENT MISMATCH
13	UNIT NOT PROGRAMMED
14	SYSTEM EXCEPTION
19	BATTERY FAIL
20	PRI ETHERNET FAIL
21	SEC ETHERNET FAIL
22	EEPROM DATA ERROR
23	SRAM DATA ERROR
24	PROGRAM MEMORY
25	WATCHDOG ERROR
26	LOW ON MEMORY
27	REMOTE DEVICE OFF
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: MISC. EVENT CAUSES**

bitmask	definition
0	EVENTS CLEARED
1	OSCILLOGRAPHY TRIGGERED
2	DATE/TIME CHANGED
3	DEF 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

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	RTD#	bitmask	RTD#	bitmask	RTD#
0	NONE	22	DNA-22	44	UserSt-12
1	DNA-1	23	DNA-23	45	UserSt-13
2	DNA-2	24	DNA-24	46	UserSt-14
3	DNA-3	25	DNA-25	47	UserSt-15
4	DNA-4	26	DNA-26	48	UserSt-16
5	DNA-5	27	DNA-27	49	UserSt-17
6	DNA-6	28	DNA-28	50	UserSt-18
7	DNA-7	29	DNA-29	51	UserSt-19
8	DNA-8	30	DNA-30	52	UserSt-20
9	DNA-9	31	DNA-31	53	UserSt-21
10	DNA-10	32	DNA-32	54	UserSt-22
11	DNA-11	33	UserSt-1	55	UserSt-23
12	DNA-12	34	UserSt-2	56	UserSt-24
13	DNA-13	35	UserSt-3	57	UserSt-25
14	DNA-14	36	UserSt-4	58	UserSt-26
15	DNA-15	37	UserSt-5	59	UserSt-27
16	DNA-16	38	UserSt-6	60	UserSt-28
17	DNA-17	39	UserSt-7	61	UserSt-29
18	DNA-18	40	UserSt-8	62	UserSt-30
19	DNA-19	41	UserSt-9	63	UserSt-31
20	DNA-20	42	UserSt-10	64	UserSt-32
21	DNA-21	43	UserSt-11		

F157**ENUMERATION: BREAKER MODE**

0 = 3-Pole, 1 = 1-Pole

F159**ENUMERATION: BREAKER AUX CONTACT KEYING**

0 = 52a, 1 = 52b, 2 = None

F166**ENUMERATION: AUXILIARY VT CONNECTION TYPE**

0 = Vn, 1 = Vag, 2 = Vbg, 3 = Vcg, 4 = Vab, 5 = Vbc, 6 = Vca

F167**ENUMERATION: SIGNAL SOURCE**

0 = SRC 1, 1 = SRC 2, 2 = SRC 3, 3 = SRC 4,
 4 = SRC 5, 5 = SRC 6

F168**ENUMERATION: INRUSH INHIBIT FUNCTION**

0 = Disabled, 1 = 2nd

F169**ENUMERATION: OVEREXCITATION INHIBIT FUNCTION**

0 = Disabled, 1 = 5th

F170**ENUMERATION: LOW/HIGH OFFSET & GAIN
TRANSDUCER I/O SELECTION**

0 = LOW, 1 = HIGH

F171**ENUMERATION: TRANSDUCER CHANNEL INPUT TYPE**

0 = dc mA IN, 1 = OHMS IN, 2 = RTD IN, 3 = dc mA OUT

F172**ENUMERATION: SLOT LETTERS**

bitmask	slot	bitmask	slot	bitmask	slot	bitmask	slot
0	F	4	K	8	P	12	U
1	G	5	L	9	R	13	V
2	H	6	M	10	S	14	W
3	J	7	N	11	T	15	X

F173**ENUMERATION: TRANSDUCER DCMA I/O RANGE**

bitmask	dc mA I/O range
0	0 to -1 mA
1	0 to 1 mA
2	-1 to 1 mA
3	0 to 5 mA
4	0 to 10 mA
5	0 to 20 mA
6	4 to 20 mA

F174**ENUMERATION: TRANSDUCER RTD INPUT TYPE**0 = 100 Ohm Platinum, 1 = 120 Ohm Nickel,
2 = 100 Ohm Nickel, 3 = 10 Ohm Copper**F175****ENUMERATION: PHASE LETTERS**

0 = A, 1 = B, 2 = C

F176**ENUMERATION: SYNCHROCHECK DEAD SOURCE SELECT**

bitmask	synchrocheck dead source
0	None
1	LV1 and DV2
2	DV1 and LV2
3	DV1 or DV2
4	DV1 Xor DV2
5	DV1 and DV2

F177**ENUMERATION: COMMUNICATION PORT**0 = NONE, 1 = COM1-RS485, 2 = COM2-RS485,
3 = FRONT PANEL-RS232, 4 = NETWORK**F178****ENUMERATION: DATA LOGGER RATES**0 = 1 sec, 1 = 1 min, 2 = 5 min, 3 = 10 min, 4 = 15 min,
5 = 20 min, 6 = 30 min, 7 = 60 min**F179****ENUMERATION: NEGATIVE SEQUENCE DIR OC 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 / ARC-
ING / 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 HIZ States

bitmask	HI-Z State
0	NORMAL
1	COORDINAT ION TIMEOUT
2	ARMED
5	ARCING
9	DOWNED CONDUCTOR

F188
ENUMERATION HIZ 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

bitmask	keypress	bitmask	keypress
0	--- use between real keys	13	Value Up
1	1	14	Value Down
2	2	15	Message Up
3	3	16	Message Down
4	4	17	Message Left
5	5	18	Message Right
6	6	19	Menu
7	7	20	Help
8	8	21	Escape
9	9	22	Enter
10	0	23	Reset
11	Decimal Pt	24	User 1
12	Plus/Minus	25	User 2
		26	User 3

F191
ENUMERATION HIZ 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

F196
ENUMERATION NEUTRAL DIR OC OPERATE CURRENT

0 = Calculated 3I0, 1 = Measured IG

F197
ENUMERATION DNP BINARY INPUT POINT BLOCK

bitmask	Input Point Block
0	Not Used
1	Virtual Inputs 1 to 16
2	Virtual Inputs 17 to 32
3	Virtual Outputs 1 to 16
4	Virtual Outputs 17 to 32
5	Virtual Outputs 33 to 48
6	Virtual Outputs 49 to 64

bitmask	Input Point Block
7	Contact Inputs 1 to 16
8	Contact Inputs 17 to 32
9	Contact Inputs 33 to 48
10	Contact Inputs 49 to 64
11	Contact Inputs 65 to 80
12	Contact Inputs 81 to 96
13	Contact Outputs 1 to 16
14	Contact Outputs 17 to 32
15	Contact Outputs 33 to 48
16	Contact Outputs 49 to 64
17	Remote Inputs 1 to 16
18	Remote Inputs 17 to 32
19	Remote Devs 1 to 16
20	Elements 1 to 16
21	Elements 17 to 32
22	Elements 33 to 48
23	Elements 49 to 64
24	Elements 65 to 80
25	Elements 81 to 96
26	Elements 97 to 112
27	Elements 113 to 128
28	Elements 129 to 144
29	Elements 145 to 160
30	Elements 161 to 176
31	Elements 177 to 192
32	Elements 193 to 208
33	Elements 209 to 224
34	Elements 225 to 240
35	Elements 241 to 256
36	Elements 257 to 272
37	Elements 273 to 288
38	Elements 289 to 304
39	Elements 305 to 320
40	Elements 321 to 336
41	Elements 337 to 352
42	Elements 353 to 368
43	Elements 369 to 384
44	Elements 385 to 400
45	Elements 401 to 406
46	Elements 417 to 432
47	Elements 433 to 448
48	Elements 449 to 464
49	Elements 465 to 480
50	Elements 481 to 496
51	Elements 497 to 512
52	Elements 513 to 528
53	Elements 529 to 544
54	Elements 545 to 560
55	LED States 1 to 16
56	LED States 17 to 32
57	Self Tests 1 to 16
58	Self Tests 17 to 32

F200**TEXT40 40 CHARACTER ASCII TEXT**

20 registers, 16 Bits: 1st Char MSB, 2nd Char. LSB

F201**TEXT8 8 CHARACTER ASCII PASSCODE**

4 registers, 16 Bits: 1st Char MSB, 2nd Char. LSB

F202**TEXT20 20 CHARACTER ASCII TEXT**

10 registers, 16 Bits: 1st Char MSB, 2nd Char. LSB

F203**TEXT16 16 CHARACTER ASCII TEXT****F204****TEXT80 80 CHARACTER ASCII TEXT****F205****TEXT12 12 CHARACTER ASCII TEXT****F206****TEXT6 6 CHARACTER ASCII TEXT****F207****TEXT4 4 CHARACTER ASCII TEXT****F208****TEXT2 2 CHARACTER ASCII TEXT****F222****ENUMERATION TEST ENUMERATION**

0 = Test Enumeration 0, 1 = Test Enumeration 1

F300**UR_UINT16 FLEXLOGIC™ BASE TYPE (6 bit type)**

The FlexLogic™ BASE type is 6 bits and is combined with a 9 bit descriptor and 1 bit for protection element to form a 16 bit value. The combined bits are of the form: PTTTTTDDDDDDDDDD, where P bit if set, indicates that the FlexLogic™ type is associated with a protection element state and T represents bits for the BASE type, and D represents bits for the descriptor.

The values in square brackets indicate the base type with P prefix [PTTTTTT] and the values in round brackets indicate the descriptor range.

[0] Off(0) this is boolean FALSE value

[0] On (1) This is boolean TRUE value

[2] CONTACT INPUTS (1 - 96)

[3] CONTACT INPUTS OFF (1-96)

[4] VIRTUAL INPUTS (1-64)

[6] VIRTUAL OUTPUTS (1-64)
 [10] CONTACT OUTPUTS VOLTAGE DETECTED (1-64)
 [11] CONTACT OUTPUTS VOLTAGE OFF DETECTED (1-64)
 [12] CONTACT OUTPUTS CURRENT DETECTED (1-64)
 [13] CONTACT OUTPUTS CURRENT OFF DETECTED (1-64)
 [14] REMOTE INPUTS (1-32)
 [28] INSERT (Via Keypad only)
 [32] END
 [34] NOT (1 INPUT)
 [36] 2 INPUT XOR (0)
 [38] LATCH SET/RESET (2 inputs)
 [40] OR (2 to 16 inputs)
 [42] AND (2 to 16 inputs)
 [44] NOR (2 to 16 inputs)
 [46] NAND (2 to 16 inputs)
 [48] TIMER (1 to 32)
 [50] ASSIGN VIRTUAL OUTPUT (1 to 64)
 [52] SELF-TEST ERROR (see F141 for range)
 [56] ACTIVE SETTING GROUP (1 to 6)
 [62] MISCELLANEOUS EVENTS (see F146 for range)
 [64 to 127] ELEMENT STATES

F400**UR_UINT16 CT/VT BANK SELECTION**

bitmask	bank selection
0	Card 1 Contact 1 to 4
1	Card 1 Contact 5 to 8
2	Card 2 Contact 1 to 4
3	Card 2 Contact 5 to 8
4	Card 3 Contact 1 to 4
5	Card 3 Contact 5 to 8

F500**UR_UINT16 PACKED BITFIELD**

First register indicates I/O state with bits 0(MSB)-15(LSB) corresponding to I/O state 1-16. The second register indicates I/O state with bits 0-15 corresponding to I/O state 17-32 (if required). The third register indicates I/O state with bits 0-15 corresponding to I/O state 33-48 (if required). The fourth register indicates I/O state with bits 0-15 corresponding to I/O state 49-64 (if required).

The number of registers required is determined by the specific data item. A bit value of 0 = Off, 1 = On

F501**UR_UINT16 LED STATUS**

Low byte of register indicates LED status with bit 0 representing the top LED and bit 7 the bottom LED. A bit value of 1 indicates the LED is on, 0 indicates the LED is off.

F502**BITFIELD ELEMENT OPERATE STATES**

Each bit contains the operate state for an element. See the F124 format code for a list of element IDs. The operate bit for element ID X is bit [X mod 16] in register [X/16].

F504**BITFIELD 3 PHASE ELEMENT STATE**

bitmask	element state
0	Pickup
1	Operate
2	Pickup Phase A
3	Pickup Phase B
4	Pickup Phase C
5	Operate Phase A
6	Operate Phase B
7	Operate Phase C

F505**BITFIELD CONTACT OUTPUT STATE**

0 = Contact State, 1 = Voltage Detected, 2 = Current Detected

F506**BITFIELD 1 PHASE ELEMENT STATE**

0 = Pickup, 1 = Operate

F507**BITFIELD COUNTER ELEMENT STATE**

0 = Count Greater Than, 1 = Count Equal To, 2 = Count Less Than

F509**BITFIELD SIMPLE ELEMENT STATE**

0 = Operate

F511**BITFIELD 3 PHASE SIMPLE ELEMENT STATE**

0 = Operate, 1 = Operate A, 2 = Operate B, 3 = Operate C

F512**ENUMERATION HARMONIC NUMBER**

bitmask	harmonic	bitmask	harmonic
0	2ND	12	14TH
1	3RD	13	15TH
2	4TH	14	16TH
3	5TH	15	17TH
4	6TH	16	18TH
5	7TH	17	19TH
6	8TH	18	20TH
7	9TH	19	21ST
8	10TH	20	22ND
9	11TH	21	23RD
10	12TH	22	24TH
11	13TH	23	25TH

F515
ENUMERATION ELEMENT INPUT MODE

0 = SIGNED, 1 = ABSOLUTE

F516
ENUMERATION ELEMENT COMPARE MODE

0 = LEVEL, 1 = DELTA

F517
ENUMERATION ELEMENT DIRECTION OPERATION

0 = OVER, 1 = UNDER

F518
ENUMERATION FlexElement Units

0 = Milliseconds, 1 = Seconds, 2 = Minutes

F600
UR_UINT16 FlexAnalog Parameter

The 16-bit value corresponds to the modbus address of the value to be used when this parameter is selected. Only certain values may be used as FlexAnalog (basically all the metering quantities used in protection)

MMI_FLASH ENUMERATION
Flash message definitions for Front-panel MMI

bitmask	Flash Message
1	ADJUSTED VALUE HAS BEEN STORED
2	ENTERED PASSCODE IS INVALID
3	COMMAND EXECUTED
4	DEFAULT MESSAGE HAS BEEN ADDED
5	DEFAULT MESSAGE HAS BEEN REMOVED
6	INPUT FUNCTION IS ALREADY ASSIGNED
7	PRESS [ENTER] TO ADD AS DEFAULT
8	PRESS [ENTER] TO REMOVE MESSAGE
9	PRESS [ENTER] TO BEGIN TEXT EDIT
10	ENTRY MISMATCH - CODE NOT STORED
11	PRESSED KEY IS INVALID HERE

bitmask	Flash Message
12	INVALID KEY: MUST BE IN LOCAL MODE
13	NEW PASSWORD HAS BEEN STORED
14	PLEASE ENTER A NON-ZERO PASSCODE
15	NO ACTIVE TARGETS (TESTING LEDS)
16	OUT OF RANGE - VALUE NOT STORED
17	RESETTING LATCHED CONDITIONS
18	SETPOINT ACCESS IS NOW ALLOWED
19	SETPOINT ACCESS DENIED (PASSCODE)
20	SETPOINT ACCESS IS NOW RESTRICTED
21	NEW SETTING HAS BEEN STORED
22	SETPOINT ACCESS DENIED (SWITCH)
23	DATA NOT ACCEPTED
24	NOT ALL CONDITIONS HAVE BEEN RESET
25	DATE NOT ACCEPTED IRIGB IS ENABLED
26	NOT EXECUTED
27	DISPLAY ADDED TO USER DISPLAY LIST
28	DISPLAY NOT ADDED TO USER DISPLAY LIST
29	DISPLAY REMOVED FROM USER DISPLAY LIST

MMI_PASSWORD_TYPE ENUMERATION
Password types for display in password prompts

bitmask	password type
0	No
1	MASTER
2	SETTING
3	COMMAND
4	FACTORY

MMI_SETTING_TYPE ENUMERATION
Setting types for display in web pages

bitmask	Setting Type
0	Unrestricted Setting
1	Master-accessed Setting
2	Setting
3	Command
4	Factory Setting

B

C.1.1 UCA

The **Utility Communications Architecture (UCA)** Version 2 represents an attempt by utilities and vendors of electronic equipment to produce standardized communications systems. There is a set of reference documents available from the Electric Power Research Institute (EPRI) and vendors of UCA/MMS software libraries that describe the complete capabilities of the UCA. Following, is a description of the subset of UCA/MMS features that are supported by the UR relay. The reference document set includes:

- Introduction to UCA version 2
- Generic Object Models for Substation and Feeder Equipment (GOMSFE)
- Common Application Service Models (CASM) and Mapping to MMS
- UCA Version 2 Profiles

These documents can be obtained from the UCA User's Group at <http://www.ucausersgroup.org>. It is strongly recommended that all those involved with any UCA implementation obtain this document set.

COMMUNICATION PROFILES:

The UCA specifies a number of possibilities for communicating with electronic devices based on the OSI Reference Model. The UR relay uses the seven layer OSI stack (TP4/CLNP and TCP/IP profiles). Refer to the "UCA Version 2 Profiles" reference document for details.

The TP4/CLNP profile requires the UR relay to have a network address or Network Service Access Point (NSAP) in order to establish a communication link. The TCP/IP profile requires the UR relay to have an IP address in order to establish a communication link. These addresses are set in the **SETTINGS** ⇒ **PRODUCT SETUP** ⇒ **COMMUNICATIONS** ⇒ **NETWORK** menu. Note that the UR relay supports UCA operation over the TP4/CLNP or the TCP/IP stacks and also supports operation over both stacks simultaneously. It is possible to have up to two simultaneous connections. This is in addition to DNP and Modbus/TCP (non-UCA) connections.

C.1.2 MMS

a) DESCRIPTION

The UCA 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. Data can be grouped to form objects and be mapped to MMS services. Refer to the "GOMSFE" and "CASM" reference documents for details.

SUPPORTED OBJECTS:

The "GOMSFE" document describes a number of communication objects. Within these objects are items, some of which are mandatory and some of which are optional, depending on the implementation. The UR relay supports the following GOMSFE objects:

• DI (device identity)	• PHIZ (high impedance ground detector)
• GCTL (generic control)	• PIOC (instantaneous overcurrent relay)
• GIND (generic indicator)	• POVR (overvoltage relay)
• GLOBE (global data)	• PTOC (time overcurrent relay)
• MMXU (polyphase measurement unit)	• PUVR (under voltage relay)
• PBRL (phase balance current relay)	• PVPH (volts per hertz relay)
• PBRO (basic relay object)	• ctRATO (CT ratio information)
• PDIF (differential relay)	• vtRATO (VT ratio information)
• PDIS (distance)	• RREC (reclosing relay)
• PDOC (directional overcurrent)	• RSYN (synchronizing or synchronism-check relay)
• PDPR (directional power relay)	• XCBR (circuit breaker)
• PFRQ (frequency relay)	

UCA data can be accessed through the "UCADevice" MMS domain.

PEER-TO-PEER COMMUNICATION:

Peer-to-peer communication of digital state information, using the UCA GOOSE data object, is supported via the use of the UR Remote Inputs/Outputs feature. This feature allows digital points to be transferred between any UCA conforming devices.

FILE SERVICES:

MMS file services are supported to allow transfer of Oscillography, Event Record, or other files from a UR relay.

COMMUNICATION SOFTWARE UTILITIES:

The exact structure and values of the implemented objects can be seen by connecting to a UR relay with an MMS browser, such as the "MMS Object Explorer and AXS4-MMS DDE/OPC" server from Sisco Inc.

NON-UCA DATA:

The UR relay makes available a number of non-UCA data items. These data items can be accessed through the "UR" MMS domain. UCA data can be accessed through the "UCADevice" MMS domain.

b) PROTOCOL IMPLEMENTATION AND CONFORMANCE STATEMENT (PICS)

The UR relay functions as a server only; a UR relay cannot be configured as a client. Thus, the following list of supported services is for server operation only:

The MMS supported services are as follows:

CONNECTION MANAGEMENT SERVICES:

- Initiate
- Conclude
- Cancel
- Abort
- Reject

VMD SUPPORT SERVICES:

- Status
- GetNameList
- Identify

VARIABLE ACCESS SERVICES:

- Read
- Write
- InformationReport
- GetVariableAccessAttributes
- GetNamedVariableListAttributes

OPERATOR COMMUNICATION SERVICES:

(none)

SEMAPHORE MANAGEMENT SERVICES:

(none)

DOMAIN MANAGEMENT SERVICES:

- GetDomainAttributes

PROGRAM INVOCATION MANAGEMENT SERVICES:

(none)

EVENT MANAGEMENT SERVICES:

(none)

JOURNAL MANAGEMENT SERVICES:

(none)

FILE MANAGEMENT SERVICES:

- ObtainFile
- FileOpen
- FileRead
- FileClose
- FileDirectory

The following MMS parameters are supported:

- STR1 (Arrays)
- STR2 (Structures)
- NEST (Nesting Levels of STR1 and STR2) - 1
- VNAME (Named Variables)
- VADR (Unnamed Variables)
- VALT (Alternate Access Variables)
- VLIS (Named Variable Lists)
- REAL (ASN.1 REAL Type)

c) MODEL IMPLEMENTATION CONFORMANCE (MIC)

This section provides details of the UCA object models supported by the UR series relays. Note that not all of the protective device functions are applicable to all the UR series relays.

Table C-1: DEVICE IDENTITY – DI

NAME	M/O	RWEC
Name	m	rw
Class	o	rw
d	o	rw
Own	o	rw
Loc	o	rw
VndID	m	r

Table C-2: GENERIC CONTROL – GCTL

FC	NAME	CLASS	RWECS	DESCRIPTION
ST	BO<n>	SI	rw	Generic Single Point Indication
CO	BO<n>	SI	rw	Generic Binary Output
CF	BO<n>	SBOCF	rw	SBO Configuration
DC	LN	d	rw	Description for brick
	BO<n>	d	rw	Description for each point



Actual instantiation of GCTL objects is as follows:

GCTL1 = Virtual Inputs (32 total points – SI1 to SI32); includes SBO functionality.

Table C-3: GENERIC INDICATORS – GIND 1 TO 6

FC	NAME	CLASS	RWECS	DESCRIPTION
ST	SIG<n>	SIG	r	Generic Indication (block of 16)
DC	LN	d	rw	Description for brick
RP	BrcbST	BasRCB	rw	Controls reporting of STATUS

Table C-4: GENERIC INDICATOR – GIND7

FC	OBJECT NAME	CLASS	RWECS	DESCRIPTION
ST	SI<n>	SI	r	Generic single point indication
DC	LN	d	rw	Description for brick
	SI<n>	d	rw	Description for all included SI
RP	BrcbST	BasRCB	rw	Controls reporting of STATUS



Actual instantiation of GIND objects is as follows:

GIND1 = Contact Inputs (96 total points – SIG1 to SIG6)
 GIND2 = Contact Outputs (64 total points – SIG1 to SIG4)
 GIND3 = Virtual Inputs (32 total points – SIG1 to SIG2)
 GIND4 = Virtual Outputs (64 total points – SIG1 to SIG4)
 GIND5 = Remote Inputs (32 total points – SIG1 to SIG2)
 GIND6 = Flex States (16 total points – SIG1 representing Flex States 1 to 16)
 GIND7 = Flex States (16 total points – SI1 to SI16 representing Flex States 1 to 16)

Table C-5: GLOBAL DATA – GLOBE

FC	OBJECT NAME	CLASS	RWECS	DESCRIPTION
ST	ModeDS	SIT	r	Device is: in test, off-line, available, or unhealthy
	LocRemDS	SIT	r	The mode of control, local or remote (DevST)
	ActSG	INT8U	r	Active Settings Group
	EditSG	INT8u	r	Settings Group selected for read/write operation
CO	CopySG	INT8U	w	Selects Settings Group for read/write operation
	IndRs	BOOL	w	Resets ALL targets
CF	ClockTOD	BTIME	rw	Date and time
RP	GOOSE	PACT	rw	Reports IED Inputs and Outputs

Table C-6: MEASUREMENT UNIT (POLYPHASE) – MMXU

FC	OBJECT NAME	CLASS	RWECS	DESCRIPTION
MX	V	WYE	rw	Voltage on phase A, B, C to G
	PPV	DELTA	rw	Voltage on AB, BC, CA
	A	WYE	rw	Current in phase A, B, C, and N
	W	WYE	rw	Watts in phase A, B, C
	TotW	AI	rw	Total watts in all three phases
	Var	WYE	rw	Vars in phase A, B, C
	TotVar	AI	rw	Total vars in all three phases
	VA	WYE	rw	VA in phase A, B, C
	TotVA	AI	rw	Total VA in all 3 phases
	PF	WYE	rw	Power Factor for phase A, B, C
	AvgPF	AI	rw	Average Power Factor for all three phases
	Hz	AI	rw	Power system frequency
CF	All MMXU.MX	ACF	rw	Configuration of ALL included MMXU.MX
DC	LN	d	rw	Description for brick
	All MMXU.MX	d	rw	Description of ALL included MMXU.MX
RP	BrcbMX	BasRCB	rw	Controls reporting of measurements



Actual instantiation of MMXU objects is as follows:

1 MMXU per Source (as determined from the 'product order code')

Table C-7: PROTECTIVE ELEMENTS

FC	OBJECT NAME	CLASS	RWECS	DESCRIPTION
ST	Out	BOOL	r	1 = Element operated, 0 = Element not operated
	Tar	PhsTar	r	Targets since last reset
	FctDS	SIT	r	Function is enabled/disabled
	PuGrp	INT8U	r	Settings group selected for use
CO	EnaDisFct	DCO	w	1 = Element function enabled, 0 = disabled
	RsTar	BO	w	Reset ALL Elements/Targets
	RsLat	BO	w	Reset ALL Elements/Targets
DC	LN	d	rw	Description for brick
	ElementSt	d	r	Element state string

The following GOMSFE objects are defined by the object model described via the above table:

- PBRO (basic relay object)
- PDIF (differential relay)
- PDIS (distance)
- PDOC (directional overcurrent)
- PDPR (directional power relay)
- PFRQ (frequency relay)
- PHIZ (high impedance ground detector)
- PIOC (instantaneous overcurrent relay)
- POVR (over voltage relay)
- PTOC (time overcurrent relay)
- PUVR (under voltage relay)
- RSYN (synchronizing or synchronism-check relay)
- POVR (overvoltage)
- PVPH (volts per hertz relay)
- PBRL (phase balance current relay)



Actual instantiation of these objects is determined by the number of the corresponding elements present in the UR as per the 'product order code'.

Table C-8: CT RATIO INFORMATION – ctRATO

OBJECT NAME	CLASS	RWECS	DESCRIPTION
PhsARat	RATIO	rw	Primary/secondary winding ratio
NeutARat	RATIO	rw	Primary/secondary winding ratio
LN	d	rw	Description for brick (current bank ID)

Table C-9: VT RATIO INFORMATION – vtRATO

OBJECT NAME	CLASS	RWECS	DESCRIPTION
PhsVRat	RATIO	rw	Primary/secondary winding ratio
LN	d	rw	Description for brick (current bank ID)



Actual instantiation of ctRATO and vtRATO objects is as follows:

- 1 ctRATO per Source (as determined from the product order code).
- 1 vtRATO per Source (as determined from the product order code).

Table C-10: RECLOSING RELAY – RREC

FC	OBJECT NAME	CLASS	RWECS	DESCRIPTION
ST	Out	BOOL	r	1 = Element operated, 0 = Element not operated
	FctDS	SIT	r	Function is enabled/disabled
	PuGrp	INT8U	r	Settings group selected for use
SG	RecISeq	SHOTS	rw	Reclosing Sequence
CO	EnaDisFct	DCO	w	1 = Element function enabled, 0 = disabled
	RsTar	BO	w	Reset ALL Elements/Targets
	RsLat	BO	w	Reset ALL Elements/Targets
CF	RecISeq	ACF	rw	Configuration for RREC.SG
DC	LN	d	rw	Description for brick
	ElementSt	d	r	Element state string



Actual instantiation of RREC objects is determined by the number of autoreclose elements present in the UR as per the product order code.

Also note that the Shots class data (i.e. Tmr1, Tmr2, Tmr3, Tmr4, RsTmr) is specified to be of type INT16S (16 bit signed integer); this data type is not large enough to properly display the full range of these settings from the UR. Numbers larger than 32768 will be displayed incorrectly.

Table C-11: CIRCUIT BREAKER – XCBR

FC	OBJECT NAME	CLASS	RWECS	DESCRIPTION
ST	SwDS	SIT	rw	Switch Device Status
	SwPoleDS	BSTR8	rw	Switch Pole Device Status
	PwrSupSt	SIG	rw	Health of the power supply
	PresSt	SIT	rw	The condition of the insulating medium pressure
	PoleDiscSt	SI	rw	All CB poles did not operate within time interval
	TrpCoil	SI	rw	Trip coil supervision
CO	ODSw	DCO	rw	The command to open/close the switch
CF	ODSwSBO	SBOCF	rw	Configuration for all included XCBR.CO
DC	LN	d	rw	Description for brick
RP	brcbST	BasRCB	rw	Controls reporting of Status Points



Actual instantiation of XCBR objects is determined by the number of breaker control elements present in the UR as per the product order code.

C.1.3 UCA REPORTING

A built-in TCP/IP connection timeout of two minutes is employed by the UR 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 UR. This frees up the connection to be used by other clients. Therefore, when using UCA reporting, clients should configure BasRCB objects such that an integrity report will be issued at least every 2 minutes (120000 ms). This ensures that the UR 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.

D.1.1 INTEROPERABILITY DOCUMENT

This document is adapted from the IEC 60870-5-104 standard. For this section the boxes indicate the following: ☒ – used in standard direction; ☐ – not used; ☐ – cannot be selected in IEC 60870-5-104 standard.

1. SYSTEM OR DEVICE:

- ☐ System Definition
☐ Controlling Station Definition (Master)
☒ Controlled Station Definition (Slave)

2. NETWORK CONFIGURATION:

- ☐ Point-to-Point ☐ Multipoint
☐ Multiple Point-to-Point ☐ Multipoint Star

3. PHYSICAL LAYER

Transmission Speed (control direction):

Unbalanced Interchange Circuit V.24/V.28 Standard:	Unbalanced Interchange Circuit V.24/V.28 Recommended if >1200 bits/s:	Balanced Interchange Circuit X.24/X.27:
<input type="checkbox"/> 100 bits/sec. <input type="checkbox"/> 200 bits/sec. <input type="checkbox"/> 300 bits/sec. <input type="checkbox"/> 600 bits/sec. <input type="checkbox"/> 1200 bits/sec.	<input type="checkbox"/> 2400 bits/sec. <input type="checkbox"/> 4800 bits/sec. <input type="checkbox"/> 9600 bits/sec.	<input type="checkbox"/> 2400 bits/sec. <input type="checkbox"/> 4800 bits/sec. <input type="checkbox"/> 9600 bits/sec. <input type="checkbox"/> 19200 bits/sec. <input type="checkbox"/> 38400 bits/sec. <input type="checkbox"/> 56000 bits/sec. <input type="checkbox"/> 64000 bits/sec.

Transmission Speed (monitor direction):

Unbalanced Interchange Circuit V.24/V.28 Standard:	Unbalanced Interchange Circuit V.24/V.28 Recommended if >1200 bits/s:	Balanced Interchange Circuit X.24/X.27:
<input type="checkbox"/> 100 bits/sec. <input type="checkbox"/> 200 bits/sec. <input type="checkbox"/> 300 bits/sec. <input type="checkbox"/> 600 bits/sec. <input type="checkbox"/> 1200 bits/sec.	<input type="checkbox"/> 2400 bits/sec. <input type="checkbox"/> 4800 bits/sec. <input type="checkbox"/> 9600 bits/sec.	<input type="checkbox"/> 2400 bits/sec. <input type="checkbox"/> 4800 bits/sec. <input type="checkbox"/> 9600 bits/sec. <input type="checkbox"/> 19200 bits/sec. <input type="checkbox"/> 38400 bits/sec. <input type="checkbox"/> 56000 bits/sec. <input type="checkbox"/> 64000 bits/sec.

4. LINK LAYER

Link Transmission Procedure:	Address Field of the Link:
<input type="checkbox"/> Balanced Transmission <input type="checkbox"/> Unbalanced Transmission	<input type="checkbox"/> Not Present (Balanced Transmission Only) <input type="checkbox"/> One Octet <input type="checkbox"/> Two Octets <input type="checkbox"/> Structured <input type="checkbox"/> Unstructured
Frame Length (maximum length, number of octets): Not selectable in companion IEC 60870-5-104 standard	

When using an unbalanced link layer, the following ADSU types are returned in class 2 messages (low priority) with the indicated causes of transmission:

- ☐ The standard assignment of ADSUs to class 2 messages is used as follows:
- ☐ A special assignment of ADSUs to class 2 messages is used as follows:

5. APPLICATION LAYER

Transmission Mode for Application Data:

Mode 1 (least significant octet first), as defined in Clause 4.10 of IEC 60870-5-4, is used exclusively in this companion standard.

Common Address of ADSU:

- ☐ One Octet
- ☒ Two Octets

Information Object Address:

- ☐ One Octet ☒ Structured
- ☐ Two Octets ☒ Unstructured
- ☒ Three Octets

Cause of Transmission:

- ☐ One Octet
- ☒ Two Octets (with originator address). Originator address is set to zero if not used.

Maximum Length of APDU: 253 (the maximum length may be reduced by the system).

Selection of standard ASDUs:

For the following lists, the boxes indicate the following: ☒ – used in standard direction; ☐ – not used; ☐ – cannot be selected in IEC 60870-5-104 standard.

Process information in monitor direction

<input checked="" type="checkbox"/> <1> := Single-point information	M_SP_NA_1
<input type="checkbox"/> <2> := Single-point information with time tag	M_SP_TA_1
<input type="checkbox"/> <3> := Double-point information	M_DP_NA_1
<input type="checkbox"/> <4> := Double-point information with time tag	M_DP_TA_1
<input type="checkbox"/> <5> := Step position information	M_ST_NA_1
<input type="checkbox"/> <6> := Step position information with time tag	M_ST_TA_1
<input type="checkbox"/> <7> := Bitstring of 32 bits	M_BO_NA_1
<input type="checkbox"/> <8> := Bitstring of 32 bits with time tag	M_BO_TA_1
<input type="checkbox"/> <9> := Measured value, normalized value	M_ME_NA_1
<input type="checkbox"/> <10> := Measured value, normalized value with time tag	M_ME_TA_1
<input type="checkbox"/> <11> := Measured value, scaled value	M_ME_NB_1
<input type="checkbox"/> <12> := Measured value, scaled value with time tag	M_ME_TB_1
<input checked="" type="checkbox"/> <13> := Measured value, short floating point value	M_ME_NC_1
<input type="checkbox"/> <14> := Measured value, short floating point value with time tag	M_ME_TC_1
<input checked="" type="checkbox"/> <15> := Integrated totals	M_IT_NA_1
<input type="checkbox"/> <16> := Integrated totals with time tag	M_IT_TA_1
<input type="checkbox"/> <17> := Event of protection equipment with time tag	M_EP_TA_1
<input type="checkbox"/> <18> := Packed start events of protection equipment with time tag	M_EP_TB_1
<input type="checkbox"/> <19> := Packed output circuit information of protection equipment with time tag	M_EP_TC_1
<input type="checkbox"/> <20> := Packed single-point information with status change detection	M_SP_NA_1

<input type="checkbox"/> <21> := Measured value, normalized value without quantity descriptor	M_ME_ND_1
<input checked="" type="checkbox"/> <30> := Single-point information with time tag CP56Time2a	M_SP_TB_1
<input type="checkbox"/> <31> := Double-point information with time tag CP56Time2a	M_DP_TB_1
<input type="checkbox"/> <32> := Step position information with time tag CP56Time2a	M_ST_TB_1
<input type="checkbox"/> <33> := Bitstring of 32 bits with time tag CP56Time2a	M_BO_TB_1
<input type="checkbox"/> <34> := Measured value, normalized value with time tag CP56Time2a	M_ME_TD_1
<input type="checkbox"/> <35> := Measured value, scaled value with time tag CP56Time2a	M_ME_TE_1
<input type="checkbox"/> <36> := Measured value, short floating point value with time tag CP56Time2a	M_ME_TF_1
<input checked="" type="checkbox"/> <37> := Integrated totals with time tag CP56Time2a	M_IT_TB_1
<input type="checkbox"/> <38> := Event of protection equipment with time tag CP56Time2a	M_EP_TD_1
<input type="checkbox"/> <39> := Packed start events of protection equipment with time tag CP56Time2a	M_EP_TE_1
<input type="checkbox"/> <40> := Packed output circuit information of protection equipment with time tag CP56Time2a	M_EP_TF_1

Either the ASDUs of the set <2>, <4>, <6>, <8>, <10>, <12>, <14>, <16>, <17>, <18>, and <19> or of the set <30> to <40> are used.

Process information in control direction

<input checked="" type="checkbox"/> <45> := Single command	C_SC_NA_1
<input type="checkbox"/> <46> := Double command	C_DC_NA_1
<input type="checkbox"/> <47> := Regulating step command	C_RC_NA_1
<input type="checkbox"/> <48> := Set point command, normalized value	C_SE_NA_1
<input type="checkbox"/> <49> := Set point command, scaled value	C_SE_NB_1
<input type="checkbox"/> <50> := Set point command, short floating point value	C_SE_NC_1
<input type="checkbox"/> <51> := Bitstring of 32 bits	C_BO_NA_1
<input checked="" type="checkbox"/> <58> := Single command with time tag CP56Time2a	C_SC_TA_1
<input type="checkbox"/> <59> := Double command with time tag CP56Time2a	C_DC_TA_1
<input type="checkbox"/> <60> := Regulating step command with time tag CP56Time2a	C_RC_TA_1
<input type="checkbox"/> <61> := Set point command, normalized value with time tag CP56Time2a	C_SE_TA_1
<input type="checkbox"/> <62> := Set point command, scaled value with time tag CP56Time2a	C_SE_TB_1
<input type="checkbox"/> <63> := Set point command, short floating point value with time tag CP56Time2a	C_SE_TC_1
<input type="checkbox"/> <64> := Bitstring of 32 bits with time tag CP56Time2a	C_BO_TA_1

Either the ASDUs of the set <45> to <51> or of the set <58> to <64> are used.

System information in monitor direction

<input checked="" type="checkbox"/> <70> := End of initialization	M_EI_NA_1
---	-----------

System information in control direction

<input checked="" type="checkbox"/> <100> := Interrogation command	C_IC_NA_1
<input checked="" type="checkbox"/> <101> := Counter interrogation command	C_CI_NA_1
<input checked="" type="checkbox"/> <102> := Read command	C_RD_NA_1
<input checked="" type="checkbox"/> <103> := Clock synchronization command (see Clause 7.6 in standard)	C_CS_NA_1
<input checked="" type="checkbox"/> <104> := Test command	C_TS_NA_1
<input checked="" type="checkbox"/> <105> := Reset process command	C_RP_NA_1
<input checked="" type="checkbox"/> <106> := Delay acquisition command	C_CD_NA_1
<input checked="" type="checkbox"/> <107> := Test command with time tag CP56Time2a	C_TS_TA_1

Parameter in control direction

<input type="checkbox"/> <110> := Parameter of measured value, normalized value	PE_ME_NA_1
<input type="checkbox"/> <111> := Parameter of measured value, scaled value	PE_ME_NB_1
<input checked="" type="checkbox"/> <112> := Parameter of measured value, short floating point value	PE_ME_NC_1
<input type="checkbox"/> <113> := Parameter activation	PE_AC_NA_1

File transfer

<input type="checkbox"/> <120> := File Ready	F_FR_NA_1
<input type="checkbox"/> <121> := Section Ready	F_SR_NA_1
<input type="checkbox"/> <122> := Call directory, select file, call file, call section	F_SC_NA_1
<input type="checkbox"/> <123> := Last section, last segment	F_LS_NA_1
<input type="checkbox"/> <124> := Ack file, ack section	F_AF_NA_1
<input type="checkbox"/> <125> := Segment	F_SG_NA_1
<input type="checkbox"/> <126> := Directory (blank or X, available only in monitor [standard] direction)	C_CD_NA_1

Type identifier and cause of transmission assignments

(station-specific parameters)

In the following table:

- Shaded boxes are not required.
- Black boxes are not permitted in this companion standard.
- Blank boxes indicate functions or ASDU not used.
- 'X' if only used in the standard direction

TYPE IDENTIFICATION		CAUSE OF TRANSMISSION																		
		PERIODIC, CYCLIC	BACKGROUND SCAN	SPONTANEOUS	INITIALIZED	REQUEST OR REQUESTED	ACTIVATION	ACTIVATION CONFIRMATION	DEACTIVATION	DEACTIVATION CONFIRMATION	ACTIVATION TERMINATION	RETURN INFO CAUSED BY LOCAL CMD	FILE TRANSFER	INTERROGATED BY GROUP <NUMBER>	REQUEST BY GROUP <N> COUNTER REQ	UNKNOWN TYPE IDENTIFICATION	UNKNOWN CAUSE OF TRANSMISSION	UNKNOWN COMMON ADDRESS OF ADSU	UNKNOWN INFORMATION OBJECT ADDR	UNKNOWN INFORMATION OBJECT ADDR
NO.	MNEMONIC	1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<1>	M_SP_NA_1			X		X						X	X		X					
<2>	M_SP_TA_1																			
<3>	M_DP_NA_1																			
<4>	M_DP_TA_1																			
<5>	M_ST_NA_1																			
<6>	M_ST_TA_1																			
<7>	M_BO_NA_1																			
<8>	M_BO_TA_1																			

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						X													
<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:

- | | | | |
|---|---|--|--|
| <input checked="" type="checkbox"/> Global | | | |
| <input checked="" type="checkbox"/> Group 1 | <input checked="" type="checkbox"/> Group 5 | <input checked="" type="checkbox"/> Group 9 | <input checked="" type="checkbox"/> Group 13 |
| <input checked="" type="checkbox"/> Group 2 | <input checked="" type="checkbox"/> Group 6 | <input checked="" type="checkbox"/> Group 10 | <input checked="" type="checkbox"/> Group 14 |
| <input checked="" type="checkbox"/> Group 3 | <input checked="" type="checkbox"/> Group 7 | <input checked="" type="checkbox"/> Group 11 | <input checked="" type="checkbox"/> Group 15 |
| <input checked="" type="checkbox"/> Group 4 | <input checked="" type="checkbox"/> Group 8 | <input checked="" type="checkbox"/> Group 12 | <input checked="" type="checkbox"/> Group 16 |

Clock synchronization:

- ☒ Clock synchronization (optional, see Clause 7.6)

Command transmission:

- ☒ Direct command transmission
- ☐ Direct setpoint command transmission
- ☒ Select and execute command
- ☐ Select and execute setpoint command
- ☒ C_SE ACTTERM used
- ☒ No additional definition
- ☒ Short pulse duration (duration determined by a system parameter in the outstation)
- ☒ Long pulse duration (duration determined by a system parameter in the outstation)
- ☒ Persistent output

- ☒ Supervision of maximum delay in command direction of commands and setpoint commands

Maximum allowable delay of commands and setpoint commands: **10 s**

Transmission of integrated totals:

- ☒ Mode A: Local freeze with spontaneous transmission
- ☒ Mode B: Local freeze with counter interrogation
- ☒ Mode C: Freeze and transmit by counter-interrogation commands
- ☒ Mode D: Freeze by counter-interrogation command, frozen values reported simultaneously

- ☒ Counter read
- ☒ Counter freeze without reset
- ☒ Counter freeze with reset
- ☒ Counter reset

- ☒ General request counter
- ☒ Request counter group 1
- ☒ Request counter group 2
- ☒ Request counter group 3
- ☒ Request counter group 4

Parameter loading:

- ☒ Threshold value
- ☐ Smoothing factor
- ☐ Low limit for transmission of measured values
- ☐ High limit for transmission of measured values

Parameter activation:

- ☐ Activation/deactivation of persistent cyclic or periodic transmission of the addressed object

Test procedure:

- ☐ Test procedure

File transfer:

File transfer in monitor direction:

- ☐ Transparent file
- ☐ Transmission of disturbance data of protection equipment
- ☐ Transmission of sequences of events
- ☐ Transmission of sequences of recorded analog values

File transfer in control direction:

- ☐ Transparent file

Background scan:

- ☐ Background scan

Acquisition of transmission delay:

- ☒ Acquisition of transmission delay

Definition of time outs:

PARAMETER	DEFAULT VALUE	REMARKS	SELECTED VALUE
t_0	30 s	Timeout of connection establishment	120 s
t_1	15 s	Timeout of send or test APDUs	15 s
t_2	10 s	Timeout for acknowledgements in case of no data messages $t_2 < t_1$	10 s
t_3	20 s	Timeout for sending test frames in case of a long idle state	20 s

Maximum range of values for all time outs: 1 to 255 s, accuracy 1 s

Maximum number of outstanding I-format APDUs k and latest acknowledge APDUs (w):

PARAMETER	DEFAULT VALUE	REMARKS	SELECTED VALUE
k	12 APDUs	Maximum difference receive sequence number to send state variable	12 APDUs
w	8 APDUs	Latest acknowledge after receiving w I-format APDUs	8 APDUs

Maximum range of values k : 1 to 32767 ($2^{15} - 1$) APDUs, accuracy 1 APDU

Maximum range of values w : 1 to 32767 APDUs, accuracy 1 APDU

Recommendation: w should not exceed two-thirds of k .

Portnumber:

PARAMETER	VALUE	REMARKS
Portnumber	2404	In all cases

RFC 2200 suite:

RFC 2200 is an official Internet Standard which describes the state of standardization of protocols used in the Internet as determined by the Internet Architecture Board (IAB). It offers a broad spectrum of actual standards used in the Internet. The suitable selection of documents from RFC 2200 defined in this standard for given projects has to be chosen by the user of this standard.

- ☒ Ethernet 802.3
- ☐ Serial X.21 interface
- ☐ Other selection(s) from RFC 2200 (list below if selected)

D.1.2 IEC 60870-5-104 POINT LIST

Table D-1: IEC 60870-5-104 POINTS (SHEET 1 OF 6)

POINT	DESCRIPTION
M_ME_NC_1 Points	
2000	SRC 1 Phase A Current RMS
2001	SRC 1 Phase B Current RMS
2002	SRC 1 Phase C Current RMS
2003	SRC 1 Neutral Current RMS
2004	SRC 1 Phase A Current Magnitude
2005	SRC 1 Phase A Current Angle
2006	SRC 1 Phase B Current Magnitude
2007	SRC 1 Phase B Current Angle
2008	SRC 1 Phase C Current Magnitude
2009	SRC 1 Phase C Current Angle
2010	SRC 1 Neutral Current Magnitude
2011	SRC 1 Neutral Current Angle
2012	SRC 1 Ground Current RMS
2013	SRC 1 Ground Current Magnitude
2014	SRC 1 Ground Current Angle
2015	SRC 1 Zero Sequence Current Magnitude
2016	SRC 1 Zero Sequence Current Angle
2017	SRC 1 Positive Sequence Current Magnitude
2018	SRC 1 Positive Sequence Current Angle
2019	SRC 1 Negative Sequence Current Magnitude
2020	SRC 1 Negative Sequence Current Angle
2021	SRC 1 Differential Ground Current Magnitude
2022	SRC 1 Differential Ground Current Angle
2023	SRC 1 Phase AG Voltage RMS
2024	SRC 1 Phase BG Voltage RMS
2025	SRC 1 Phase CG Voltage RMS
2026	SRC 1 Phase AG Voltage Magnitude
2027	SRC 1 Phase AG Voltage Angle
2028	SRC 1 Phase BG Voltage Magnitude
2029	SRC 1 Phase BG Voltage Angle
2030	SRC 1 Phase CG Voltage Magnitude
2031	SRC 1 Phase CG Voltage Angle
2032	SRC 1 Phase AB Voltage RMS
2033	SRC 1 Phase BC Voltage RMS
2034	SRC 1 Phase CA Voltage RMS
2035	SRC 1 Phase AB Voltage Magnitude
2036	SRC 1 Phase AB Voltage Angle
2037	SRC 1 Phase BC Voltage Magnitude
2038	SRC 1 Phase BC Voltage Angle
2039	SRC 1 Phase CA Voltage Magnitude
2040	SRC 1 Phase CA Voltage Angle
2041	SRC 1 Auxiliary Voltage RMS
2042	SRC 1 Auxiliary Voltage Magnitude
2043	SRC 1 Auxiliary Voltage Angle
2044	SRC 1 Zero Sequence Voltage Magnitude
2045	SRC 1 Zero Sequence Voltage Angle
2046	SRC 1 Positive Sequence Voltage Magnitude

Table D-1: IEC 60870-5-104 POINTS (SHEET 2 OF 6)

POINT	DESCRIPTION
2047	SRC 1 Positive Sequence Voltage Angle
2048	SRC 1 Negative Sequence Voltage Magnitude
2049	SRC 1 Negative Sequence Voltage Angle
2050	SRC 1 Three Phase Real Power
2051	SRC 1 Phase A Real Power
2052	SRC 1 Phase B Real Power
2053	SRC 1 Phase C Real Power
2054	SRC 1 Three Phase Reactive Power
2055	SRC 1 Phase A Reactive Power
2056	SRC 1 Phase B Reactive Power
2057	SRC 1 Phase C Reactive Power
2058	SRC 1 Three Phase Apparent Power
2059	SRC 1 Phase A Apparent Power
2060	SRC 1 Phase B Apparent Power
2061	SRC 1 Phase C Apparent Power
2062	SRC 1 Three Phase Power Factor
2063	SRC 1 Phase A Power Factor
2064	SRC 1 Phase B Power Factor
2065	SRC 1 Phase C Power Factor
2066	SRC 1 Positive Watthour
2067	SRC 1 Negative Watthour
2068	SRC 1 Positive Varhour
2069	SRC 1 Negative Varhour
2070	SRC 1 Frequency
2071	SRC 1 Demand Ia
2072	SRC 1 Demand Ib
2073	SRC 1 Demand Ic
2074	SRC 1 Demand Watt
2075	SRC 1 Demand Var
2076	SRC 1 Demand Va
2077	SRC 1 Va THD
2078	SRC 1 Va Harmonics[0]
2079	SRC 1 Va Harmonics[1]
2080	SRC 1 Va Harmonics[2]
2081	SRC 1 Va Harmonics[3]
2082	SRC 1 Va Harmonics[4]
2083	SRC 1 Va Harmonics[5]
2084	SRC 1 Va Harmonics[6]
2085	SRC 1 Va Harmonics[7]
2086	SRC 1 Va Harmonics[8]
2087	SRC 1 Va Harmonics[9]
2088	SRC 1 Va Harmonics[10]
2089	SRC 1 Va Harmonics[11]
2090	SRC 1 Va Harmonics[12]
2091	SRC 1 Va Harmonics[13]
2092	SRC 1 Va Harmonics[14]
2093	SRC 1 Va Harmonics[15]
2094	SRC 1 Va Harmonics[16]

Table D–1: IEC 60870-5-104 POINTS (SHEET 3 OF 6)

POINT	DESCRIPTION
2095	SRC 1 Va Harmonics[17]
2096	SRC 1 Va Harmonics[18]
2097	SRC 1 Va Harmonics[19]
2098	SRC 1 Va Harmonics[20]
2099	SRC 1 Va Harmonics[21]
2100	SRC 1 Va Harmonics[22]
2101	SRC 1 Va Harmonics[23]
2102	SRC 1 Vb THD
2103	SRC 1 Vb Harmonics[0]
2104	SRC 1 Vb Harmonics[1]
2105	SRC 1 Vb Harmonics[2]
2106	SRC 1 Vb Harmonics[3]
2107	SRC 1 Vb Harmonics[4]
2108	SRC 1 Vb Harmonics[5]
2109	SRC 1 Vb Harmonics[6]
2110	SRC 1 Vb Harmonics[7]
2111	SRC 1 Vb Harmonics[8]
2112	SRC 1 Vb Harmonics[9]
2113	SRC 1 Vb Harmonics[10]
2114	SRC 1 Vb Harmonics[11]
2115	SRC 1 Vb Harmonics[12]
2116	SRC 1 Vb Harmonics[13]
2117	SRC 1 Vb Harmonics[14]
2118	SRC 1 Vb Harmonics[15]
2119	SRC 1 Vb Harmonics[16]
2120	SRC 1 Vb Harmonics[17]
2121	SRC 1 Vb Harmonics[18]
2122	SRC 1 Vb Harmonics[19]
2123	SRC 1 Vb Harmonics[20]
2124	SRC 1 Vb Harmonics[21]
2125	SRC 1 Vb Harmonics[22]
2126	SRC 1 Vb Harmonics[23]
2127	SRC 1 Vc THD
2128	SRC 1 Vc Harmonics[0]
2129	SRC 1 Vc Harmonics[1]
2130	SRC 1 Vc Harmonics[2]
2131	SRC 1 Vc Harmonics[3]
2132	SRC 1 Vc Harmonics[4]
2133	SRC 1 Vc Harmonics[5]
2134	SRC 1 Vc Harmonics[6]
2135	SRC 1 Vc Harmonics[7]
2136	SRC 1 Vc Harmonics[8]
2137	SRC 1 Vc Harmonics[9]
2138	SRC 1 Vc Harmonics[10]
2139	SRC 1 Vc Harmonics[11]
2140	SRC 1 Vc Harmonics[12]
2141	SRC 1 Vc Harmonics[13]
2142	SRC 1 Vc Harmonics[14]
2143	SRC 1 Vc Harmonics[15]
2144	SRC 1 Vc Harmonics[16]
2145	SRC 1 Vc Harmonics[17]

Table D–1: IEC 60870-5-104 POINTS (SHEET 4 OF 6)

POINT	DESCRIPTION
2146	SRC 1 Vc Harmonics[18]
2147	SRC 1 Vc Harmonics[19]
2148	SRC 1 Vc Harmonics[20]
2149	SRC 1 Vc Harmonics[21]
2150	SRC 1 Vc Harmonics[22]
2151	SRC 1 Vc Harmonics[23]
2152	SRC 1 Ia THD
2153	SRC 1 Ia Harmonics[0]
2154	SRC 1 Ia Harmonics[1]
2155	SRC 1 Ia Harmonics[2]
2156	SRC 1 Ia Harmonics[3]
2157	SRC 1 Ia Harmonics[4]
2158	SRC 1 Ia Harmonics[5]
2159	SRC 1 Ia Harmonics[6]
2160	SRC 1 Ia Harmonics[7]
2161	SRC 1 Ia Harmonics[8]
2162	SRC 1 Ia Harmonics[9]
2163	SRC 1 Ia Harmonics[10]
2164	SRC 1 Ia Harmonics[11]
2165	SRC 1 Ia Harmonics[12]
2166	SRC 1 Ia Harmonics[13]
2167	SRC 1 Ia Harmonics[14]
2168	SRC 1 Ia Harmonics[15]
2169	SRC 1 Ia Harmonics[16]
2170	SRC 1 Ia Harmonics[17]
2171	SRC 1 Ia Harmonics[18]
2172	SRC 1 Ia Harmonics[19]
2173	SRC 1 Ia Harmonics[20]
2174	SRC 1 Ia Harmonics[21]
2175	SRC 1 Ia Harmonics[22]
2176	SRC 1 Ia Harmonics[23]
2177	SRC 1 Ib THD
2178	SRC 1 Ib Harmonics[0]
2179	SRC 1 Ib Harmonics[1]
2180	SRC 1 Ib Harmonics[2]
2181	SRC 1 Ib Harmonics[3]
2182	SRC 1 Ib Harmonics[4]
2183	SRC 1 Ib Harmonics[5]
2184	SRC 1 Ib Harmonics[6]
2185	SRC 1 Ib Harmonics[7]
2186	SRC 1 Ib Harmonics[8]
2187	SRC 1 Ib Harmonics[9]
2188	SRC 1 Ib Harmonics[10]
2189	SRC 1 Ib Harmonics[11]
2190	SRC 1 Ib Harmonics[12]
2191	SRC 1 Ib Harmonics[13]
2192	SRC 1 Ib Harmonics[14]
2193	SRC 1 Ib Harmonics[15]
2194	SRC 1 Ib Harmonics[16]
2195	SRC 1 Ib Harmonics[17]
2196	SRC 1 Ib Harmonics[18]

Table D-1: IEC 60870-5-104 POINTS (SHEET 5 OF 6)

POINT	DESCRIPTION
2197	SRC 1 Ib Harmonics[19]
2198	SRC 1 Ib Harmonics[20]
2199	SRC 1 Ib Harmonics[21]
2200	SRC 1 Ib Harmonics[22]
2201	SRC 1 Ib Harmonics[23]
2202	SRC 1 Ic THD
2203	SRC 1 Ic Harmonics[0]
2204	SRC 1 Ic Harmonics[1]
2205	SRC 1 Ic Harmonics[2]
2206	SRC 1 Ic Harmonics[3]
2207	SRC 1 Ic Harmonics[4]
2208	SRC 1 Ic Harmonics[5]
2209	SRC 1 Ic Harmonics[6]
2210	SRC 1 Ic Harmonics[7]
2211	SRC 1 Ic Harmonics[8]
2212	SRC 1 Ic Harmonics[9]
2213	SRC 1 Ic Harmonics[10]
2214	SRC 1 Ic Harmonics[11]
2215	SRC 1 Ic Harmonics[12]
2216	SRC 1 Ic Harmonics[13]
2217	SRC 1 Ic Harmonics[14]
2218	SRC 1 Ic Harmonics[15]
2219	SRC 1 Ic Harmonics[16]
2220	SRC 1 Ic Harmonics[17]
2221	SRC 1 Ic Harmonics[18]
2222	SRC 1 Ic Harmonics[19]
2223	SRC 1 Ic Harmonics[20]
2224	SRC 1 Ic Harmonics[21]
2225	SRC 1 Ic Harmonics[22]
2226	SRC 1 Ic Harmonics[23]
2227	Sens Dir Power 1 Actual
2228	Sens Dir Power 2 Actual
2229	Breaker 1 Arcing Amp Phase A
2230	Breaker 1 Arcing Amp Phase B
2231	Breaker 1 Arcing Amp Phase C
2232	Breaker 2 Arcing Amp Phase A
2233	Breaker 2 Arcing Amp Phase B
2234	Breaker 2 Arcing Amp Phase C
2235	HIZ Phase A Arc Confidence
2236	HIZ Phase B Arc Confidence
2237	HIZ Phase C Arc Confidence
2238	HIZ Neutral Arc Confidence
2239	Synchrocheck 1 Delta Voltage
2240	Synchrocheck 1 Delta Frequency
2241	Synchrocheck 1 Delta Phase
2242	Synchrocheck 2 Delta Voltage
2243	Synchrocheck 2 Delta Frequency
2244	Synchrocheck 2 Delta Phase
2245	Tracking Frequency
2246	FlexElement 1 Actual
2247	FlexElement 2 Actual

Table D-1: IEC 60870-5-104 POINTS (SHEET 6 OF 6)

POINT	DESCRIPTION
2248	FlexElement 3 Actual
2249	FlexElement 4 Actual
2250	FlexElement 5 Actual
2251	FlexElement 6 Actual
2252	FlexElement 7 Actual
2253	FlexElement 8 Actual
2254	FlexElement 9 Actual
2255	FlexElement 10 Actual
2256	FlexElement 11 Actual
2257	FlexElement 12 Actual
2258	FlexElement 13 Actual
2259	FlexElement 14 Actual
2260	FlexElement 15 Actual
2261	FlexElement 16 Actual
2262	Current Setting Group
P_ME_NC_1 Points	
5000 - 5262	Threshold values for M_ME_NC_1 points
M_SP_NA_1 Points	
100 - 115	Virtual Input States[0]
116 - 131	Virtual Input States[1]
132 - 147	Virtual Output States[0]
148 - 163	Virtual Output States[1]
164 - 179	Virtual Output States[2]
180 - 195	Virtual Output States[3]
196 - 211	Contact Input States[0]
212 - 227	Contact Input States[1]
228 - 243	Contact Input States[2]
244 - 259	Contact Input States[3]
260 - 275	Contact Input States[4]
276 - 291	Contact Input States[5]
292 - 307	Contact Output States[0]
308 - 323	Contact Output States[1]
324 - 339	Contact Output States[2]
340 - 355	Contact Output States[3]
356 - 371	Remote Input x States[0]
372 - 387	Remote Input x States[1]
388 - 403	Remote Device x States
404 - 419	LED Column x State[0]
420 - 435	LED Column x State[1]
C_SC_NA_1 Points	
1100 - 1115	Virtual Input States[0] - No Select Required
1116 - 1131	Virtual Input States[1] - Select Required
M_IT_NA_1 Points	
4000	Digital Counter 1 Value
4001	Digital Counter 2 Value
4002	Digital Counter 3 Value
4003	Digital Counter 4 Value
4004	Digital Counter 5 Value
4005	Digital Counter 6 Value
4006	Digital Counter 7 Value
4007	Digital Counter 8 Value

E.1.1 DEVICE PROFILE DOCUMENT

The following table provides a 'Device Profile Document' in the standard format defined in the DNP 3.0 Subset Definitions Document.

Table E-1: DNP V3.00 DEVICE PROFILE (Sheet 1 of 3)

(Also see the IMPLEMENTATION TABLE in the following section)	
Vendor Name: General Electric Multilin	
Device Name: UR Series Relay	
Highest DNP Level Supported: For Requests: Level 2 For Responses: Level 2	Device Function: <input type="checkbox"/> Master <input checked="" type="checkbox"/> Slave
Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the attached table): Binary Inputs (Object 1) Binary Input Changes (Object 2) Binary Outputs (Object 10) 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)	
Maximum Data Link Frame Size (octets): Transmitted: 292 Received: 292	Maximum Application Fragment Size (octets): Transmitted: 240 Received: 2048
Maximum Data Link Re-tries: <input type="checkbox"/> None <input checked="" type="checkbox"/> Fixed at 2 <input type="checkbox"/> Configurable	Maximum Application Layer Re-tries: <input checked="" type="checkbox"/> None <input type="checkbox"/> Configurable
Requires Data Link Layer Confirmation: <input checked="" type="checkbox"/> Never <input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Configurable	

Table E–1: DNP V3.00 DEVICE PROFILE (Sheet 2 of 3)

Requires Application Layer Confirmation:				
<input type="checkbox"/> Never <input type="checkbox"/> Always <input checked="" type="checkbox"/> When reporting Event Data <input checked="" type="checkbox"/> When sending multi-fragment responses <input type="checkbox"/> Sometimes <input type="checkbox"/> Configurable				
Timeouts while waiting for:				
Data Link Confirm:	<input type="checkbox"/> None	<input checked="" type="checkbox"/> Fixed at 3 s	<input type="checkbox"/> Variable	<input type="checkbox"/> Configurable
Complete Appl. Fragment:	<input checked="" type="checkbox"/> None	<input type="checkbox"/> Fixed at ____	<input type="checkbox"/> Variable	<input type="checkbox"/> Configurable
Application Confirm:	<input type="checkbox"/> None	<input checked="" type="checkbox"/> Fixed at 4 s	<input type="checkbox"/> Variable	<input type="checkbox"/> Configurable
Complete Appl. Response:	<input checked="" type="checkbox"/> None	<input type="checkbox"/> Fixed at ____	<input type="checkbox"/> Variable	<input type="checkbox"/> Configurable
Others:				
Transmission Delay:	No intentional delay			
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	<input checked="" type="checkbox"/> Never	<input type="checkbox"/> Always	<input type="checkbox"/> Sometimes	<input type="checkbox"/> Configurable
SELECT/OPERATE	<input type="checkbox"/> Never	<input checked="" type="checkbox"/> Always	<input type="checkbox"/> Sometimes	<input type="checkbox"/> Configurable
DIRECT OPERATE	<input type="checkbox"/> Never	<input checked="" type="checkbox"/> Always	<input type="checkbox"/> Sometimes	<input type="checkbox"/> Configurable
DIRECT OPERATE – NO ACK	<input type="checkbox"/> Never	<input checked="" type="checkbox"/> Always	<input type="checkbox"/> Sometimes	<input type="checkbox"/> Configurable
Count > 1	<input checked="" type="checkbox"/> Never	<input type="checkbox"/> Always	<input type="checkbox"/> Sometimes	<input type="checkbox"/> Configurable
Pulse On	<input type="checkbox"/> Never	<input type="checkbox"/> Always	<input checked="" type="checkbox"/> Sometimes	<input type="checkbox"/> Configurable
Pulse Off	<input type="checkbox"/> Never	<input type="checkbox"/> Always	<input checked="" type="checkbox"/> Sometimes	<input type="checkbox"/> Configurable
Latch On	<input type="checkbox"/> Never	<input type="checkbox"/> Always	<input checked="" type="checkbox"/> Sometimes	<input type="checkbox"/> Configurable
Latch Off	<input type="checkbox"/> Never	<input type="checkbox"/> Always	<input checked="" type="checkbox"/> Sometimes	<input type="checkbox"/> Configurable
Queue	<input checked="" type="checkbox"/> Never	<input type="checkbox"/> Always	<input type="checkbox"/> Sometimes	<input type="checkbox"/> Configurable
Clear Queue	<input checked="" type="checkbox"/> Never	<input type="checkbox"/> Always	<input type="checkbox"/> Sometimes	<input type="checkbox"/> Configurable
Explanation of 'Sometimes': Object 12 points are mapped to UR Virtual Inputs. The persistence of Virtual Inputs is determined by the VIRTUAL INPUT X TYPE settings. Both "Pulse On" and "Latch On" operations perform the same function in the UR; that is, the appropriate Virtual Input is put into the "On" state. If the Virtual Input is set to "Self-Reset", it will reset after one pass of FlexLogic™. The On/Off times and Count value are ignored. "Pulse Off" and "Latch Off" operations put the appropriate Virtual Input into the "Off" state. "Trip" and "Close" operations both put the appropriate Virtual Input into the "On" state.				

Table E-1: DNP V3.00 DEVICE PROFILE (Sheet 3 of 3)

Reports Binary Input Change Events when no specific variation requested: <ul style="list-style-type: none"> <input type="checkbox"/> Never <input checked="" type="checkbox"/> Only time-tagged <input type="checkbox"/> Only non-time-tagged <input type="checkbox"/> Configurable 	Reports time-tagged Binary Input Change Events when no specific variation requested: <ul style="list-style-type: none"> <input type="checkbox"/> Never <input checked="" type="checkbox"/> Binary Input Change With Time <input type="checkbox"/> Binary Input Change With Relative Time <input type="checkbox"/> Configurable (attach explanation)
Sends Unsolicited Responses: <ul style="list-style-type: none"> <input type="checkbox"/> Never <input checked="" type="checkbox"/> Configurable <input type="checkbox"/> Only certain objects <input type="checkbox"/> Sometimes (attach explanation) <input checked="" type="checkbox"/> ENABLE/DISABLE unsolicited Function codes supported 	Sends Static Data in Unsolicited Responses: <ul style="list-style-type: none"> <input checked="" type="checkbox"/> Never <input type="checkbox"/> When Device Restarts <input type="checkbox"/> When Status Flags Change <p>No other options are permitted.</p>
Default Counter Object/Variation: <ul style="list-style-type: none"> <input type="checkbox"/> No Counters Reported <input type="checkbox"/> Configurable (attach explanation) <input checked="" type="checkbox"/> Default Object: 20 <input checked="" type="checkbox"/> Default Variation: 1 <input checked="" type="checkbox"/> Point-by-point list attached 	Counters Roll Over at: <ul style="list-style-type: none"> <input type="checkbox"/> No Counters Reported <input type="checkbox"/> Configurable (attach explanation) <input checked="" type="checkbox"/> 16 Bits (Counter 8) <input checked="" type="checkbox"/> 32 Bits (Counters 0 to 7, 9) <input type="checkbox"/> Other Value: _____ <input checked="" type="checkbox"/> Point-by-point list attached
Sends Multi-Fragment Responses: <ul style="list-style-type: none"> <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No 	

E.1.2 DNP IMPLEMENTATION

The following table identifies the variations, function codes, and qualifiers supported by the UR 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 (default – see Note 1)	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 (default – see Note 1)	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 (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)
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 (default – see Note 1)	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. Type 30 (Analog Input) data is limited to data that is actually possible to be used in the UR, based on the product order code. For example, Signal Source data from source numbers that cannot be used is not included. 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 UR is not restarted, but the DNP process is restarted.

Table E–2: IMPLEMENTATION TABLE (Sheet 2 of 4)

OBJECT			REQUEST		RESPONSE	
OBJECT NO.	VARIATION NO.	DESCRIPTION	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)
20 cont'd	2	16-Bit Binary Counter	1 (read) 7 (freeze) 8 (freeze noack) 9 (freeze clear) 10 (frz. cl. noack) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) (see Note 2)
	5	32-Bit Binary Counter without Flag	1 (read) 7 (freeze) 8 (freeze noack) 9 (freeze clear) 10 (frz. cl. noack) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) (see Note 2)
	6	16-Bit Binary Counter without Flag	1 (read) 7 (freeze) 8 (freeze noack) 9 (freeze clear) 10 (frz. cl. noack) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) (see Note 2)
21	0	Frozen Counter (Variation 0 is used to request default variation)	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)		
	1	32-Bit Frozen Counter (default – see Note 1)	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 (default – see Note 1)	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 (default – see Note 1)	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. Type 30 (Analog Input) data is limited to data that is actually possible to be used in the UR, based on the product order code. For example, Signal Source data from source numbers that cannot be used is not included. 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 UR 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 (default – see Note 1)	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 (default – see Note 1)	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. Type 30 (Analog Input) data is limited to data that is actually possible to be used in the UR, based on the product order code. For example, Signal Source data from source numbers that cannot be used is not included. 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 UR is not restarted, but the DNP process is restarted.

Table E–2: IMPLEMENTATION TABLE (Sheet 4 of 4)

OBJECT			REQUEST		RESPONSE	
OBJECT NO.	VARIATION NO.	DESCRIPTION	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)	FUNCTION CODES (DEC)	QUALIFIER CODES (HEX)
34 cont'd	2	32-bit Analog Input Reporting Deadband (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)		
	3	Short floating point Analog Input Reporting Deadband	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) (see Note 2)
50	0	Time and Date	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) (see Note 2)
	1	Time and Date (default – see Note 1)	1 (read) 2 (write)	00, 01 (start-stop) 06 (no range, or all) 07 (limited qty=1) 08 (limited quantity) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) (see Note 2)
52	2	Time Delay Fine			129 (response)	07 (limited quantity) (quantity = 1)
60	0	Class 0, 1, 2, and 3 Data	1 (read) 20 (enable unsol) 21 (disable unsol) 22 (assign class)	06 (no range, or all)		
	1	Class 0 Data	1 (read) 22 (assign class)	06 (no range, or all)		
	2	Class 1 Data	1 (read) 20 (enable unsol) 21 (disable unsol) 22 (assign class)	06 (no range, or all) 07, 08 (limited quantity)		
	3	Class 2 Data	1 (read) 20 (enable unsol) 21 (disable unsol) 22 (assign class)	06 (no range, or all) 07, 08 (limited quantity)		
	4	Class 3 Data	1 (read) 20 (enable unsol) 21 (disable unsol) 22 (assign class)	06 (no range, or all) 07, 08 (limited quantity)		
80	1	Internal Indications	2 (write)	00 (start-stop) (index must =7)		
---		No Object (function code only) see Note 3	13 (cold restart)			
---		No Object (function code only)	14 (warm restart)			
---		No Object (function code only)	23 (delay meas.)			

Note 1: A Default variation refers to the variation responded when variation 0 is requested and/or in class 0, 1, 2, or 3 scans. Type 30 (Analog Input) data is limited to data that is actually possible to be used in the UR, based on the product order code. For example, Signal Source data from source numbers that cannot be used is not included. 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 UR is not restarted, but the DNP process is restarted.

E.2.1 BINARY INPUTS

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 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**

Table E-3: BINARY INPUTS (Sheet 1 of 10)

POINT INDEX	NAME/DESCRIPTION	CHANGE EVENT CLASS (1/2/3/NONE)
0	Virtual Input 1	2
1	Virtual Input 2	2
2	Virtual Input 3	2
3	Virtual Input 4	2
4	Virtual Input 5	2
5	Virtual Input 6	2
6	Virtual Input 7	2
7	Virtual Input 8	2
8	Virtual Input 9	2
9	Virtual Input 10	2
10	Virtual Input 11	2
11	Virtual Input 12	2
12	Virtual Input 13	2
13	Virtual Input 14	2
14	Virtual Input 15	2
15	Virtual Input 16	2
16	Virtual Input 17	2
17	Virtual Input 18	2
18	Virtual Input 19	2
19	Virtual Input 20	2
20	Virtual Input 21	2
21	Virtual Input 22	2
22	Virtual Input 23	2
23	Virtual Input 24	2
24	Virtual Input 25	2
25	Virtual Input 26	2
26	Virtual Input 27	2
27	Virtual Input 28	2
28	Virtual Input 29	2
29	Virtual Input 30	2
30	Virtual Input 31	2
31	Virtual Input 32	2

Table E-3: BINARY INPUTS (Sheet 2 of 10)

POINT INDEX	NAME/DESCRIPTION	CHANGE EVENT CLASS (1/2/3/NONE)
32	Virtual Output 1	2
33	Virtual Output 2	2
34	Virtual Output 3	2
35	Virtual Output 4	2
36	Virtual Output 5	2
37	Virtual Output 6	2
38	Virtual Output 7	2
39	Virtual Output 8	2
40	Virtual Output 9	2
41	Virtual Output 10	2
42	Virtual Output 11	2
43	Virtual Output 12	2
44	Virtual Output 13	2
45	Virtual Output 14	2
46	Virtual Output 15	2
47	Virtual Output 16	2
48	Virtual Output 17	2
49	Virtual Output 18	2
50	Virtual Output 19	2
51	Virtual Output 20	2
52	Virtual Output 21	2
53	Virtual Output 22	2
54	Virtual Output 23	2
55	Virtual Output 24	2
56	Virtual Output 25	2
57	Virtual Output 26	2
58	Virtual Output 27	2
59	Virtual Output 28	2
60	Virtual Output 29	2
61	Virtual Output 30	2
62	Virtual Output 31	2
63	Virtual Output 32	2

Table E-3: BINARY INPUTS (Sheet 3 of 10)

POINT INDEX	NAME/DESCRIPTION	CHANGE EVENT CLASS (1/2/3/NONE)
64	Virtual Output 33	2
65	Virtual Output 34	2
66	Virtual Output 35	2
67	Virtual Output 36	2
68	Virtual Output 37	2
69	Virtual Output 38	2
70	Virtual Output 39	2
71	Virtual Output 40	2
72	Virtual Output 41	2
73	Virtual Output 42	2
74	Virtual Output 43	2
75	Virtual Output 44	2
76	Virtual Output 45	2
77	Virtual Output 46	2
78	Virtual Output 47	2
79	Virtual Output 48	2
80	Virtual Output 49	2
81	Virtual Output 50	2
82	Virtual Output 51	2
83	Virtual Output 52	2
84	Virtual Output 53	2
85	Virtual Output 54	2
86	Virtual Output 55	2
87	Virtual Output 56	2
88	Virtual Output 57	2
89	Virtual Output 58	2
90	Virtual Output 59	2
91	Virtual Output 60	2
92	Virtual Output 61	2
93	Virtual Output 62	2
94	Virtual Output 63	2
95	Virtual Output 64	2
96	Contact Input 1	1
97	Contact Input 2	1
98	Contact Input 3	1
99	Contact Input 4	1
100	Contact Input 5	1
101	Contact Input 6	1
102	Contact Input 7	1
103	Contact Input 8	1
104	Contact Input 9	1
105	Contact Input 10	1
106	Contact Input 11	1
107	Contact Input 12	1
108	Contact Input 13	1
109	Contact Input 14	1
110	Contact Input 15	1
111	Contact Input 16	1
112	Contact Input 17	1

Table E-3: BINARY INPUTS (Sheet 4 of 10)

POINT INDEX	NAME/DESCRIPTION	CHANGE EVENT CLASS (1/2/3/NONE)
113	Contact Input 18	1
114	Contact Input 19	1
115	Contact Input 20	1
116	Contact Input 21	1
117	Contact Input 22	1
118	Contact Input 23	1
119	Contact Input 24	1
120	Contact Input 25	1
121	Contact Input 26	1
122	Contact Input 27	1
123	Contact Input 28	1
124	Contact Input 29	1
125	Contact Input 30	1
126	Contact Input 31	1
127	Contact Input 32	1
128	Contact Input 33	1
129	Contact Input 34	1
130	Contact Input 35	1
131	Contact Input 36	1
132	Contact Input 37	1
133	Contact Input 38	1
134	Contact Input 39	1
135	Contact Input 40	1
136	Contact Input 41	1
137	Contact Input 42	1
138	Contact Input 43	1
139	Contact Input 44	1
140	Contact Input 45	1
141	Contact Input 46	1
142	Contact Input 47	1
143	Contact Input 48	1
144	Contact Input 49	1
145	Contact Input 50	1
146	Contact Input 51	1
147	Contact Input 52	1
148	Contact Input 53	1
149	Contact Input 54	1
150	Contact Input 55	1
151	Contact Input 56	1
152	Contact Input 57	1
153	Contact Input 58	1
154	Contact Input 59	1
155	Contact Input 60	1
156	Contact Input 61	1
157	Contact Input 62	1
158	Contact Input 63	1
159	Contact Input 64	1
160	Contact Input 65	1
161	Contact Input 66	1

Table E-3: BINARY INPUTS (Sheet 5 of 10)

POINT INDEX	NAME/DESCRIPTION	CHANGE EVENT CLASS (1/2/3/NONE)
162	Contact Input 67	1
163	Contact Input 68	1
164	Contact Input 69	1
165	Contact Input 70	1
166	Contact Input 71	1
167	Contact Input 72	1
168	Contact Input 73	1
169	Contact Input 74	1
170	Contact Input 75	1
171	Contact Input 76	1
172	Contact Input 77	1
173	Contact Input 78	1
174	Contact Input 79	1
175	Contact Input 80	1
176	Contact Input 81	1
177	Contact Input 82	1
178	Contact Input 83	1
179	Contact Input 84	1
180	Contact Input 85	1
181	Contact Input 86	1
182	Contact Input 87	1
183	Contact Input 88	1
184	Contact Input 89	1
185	Contact Input 90	1
186	Contact Input 91	1
187	Contact Input 92	1
188	Contact Input 93	1
189	Contact Input 94	1
190	Contact Input 95	1
191	Contact Input 96	1
192	Contact Output 1	1
193	Contact Output 2	1
194	Contact Output 3	1
195	Contact Output 4	1
196	Contact Output 5	1
197	Contact Output 6	1
198	Contact Output 7	1
199	Contact Output 8	1
200	Contact Output 9	1
201	Contact Output 10	1
202	Contact Output 11	1
203	Contact Output 12	1
204	Contact Output 13	1
205	Contact Output 14	1
206	Contact Output 15	1
207	Contact Output 16	1
208	Contact Output 17	1
209	Contact Output 18	1
210	Contact Output 19	1

Table E-3: BINARY INPUTS (Sheet 6 of 10)

POINT INDEX	NAME/DESCRIPTION	CHANGE EVENT CLASS (1/2/3/NONE)
211	Contact Output 20	1
212	Contact Output 21	1
213	Contact Output 22	1
214	Contact Output 23	1
215	Contact Output 24	1
216	Contact Output 25	1
217	Contact Output 26	1
218	Contact Output 27	1
219	Contact Output 28	1
220	Contact Output 29	1
221	Contact Output 30	1
222	Contact Output 31	1
223	Contact Output 32	1
224	Contact Output 33	1
225	Contact Output 34	1
226	Contact Output 35	1
227	Contact Output 36	1
228	Contact Output 37	1
229	Contact Output 38	1
230	Contact Output 39	1
231	Contact Output 40	1
232	Contact Output 41	1
233	Contact Output 42	1
234	Contact Output 43	1
235	Contact Output 44	1
236	Contact Output 45	1
237	Contact Output 46	1
238	Contact Output 47	1
239	Contact Output 48	1
240	Contact Output 49	1
241	Contact Output 50	1
242	Contact Output 51	1
243	Contact Output 52	1
244	Contact Output 53	1
245	Contact Output 54	1
246	Contact Output 55	1
247	Contact Output 56	1
248	Contact Output 57	1
249	Contact Output 58	1
250	Contact Output 59	1
251	Contact Output 60	1
252	Contact Output 61	1
253	Contact Output 62	1
254	Contact Output 63	1
255	Contact Output 64	1
256	Remote Input 1	1
257	Remote Input 2	1
258	Remote Input 3	1
259	Remote Input 4	1

Table E-3: BINARY INPUTS (Sheet 7 of 10)

POINT INDEX	NAME/DESCRIPTION	CHANGE EVENT CLASS (1/2/3/NONE)
260	Remote Input 5	1
261	Remote Input 6	1
262	Remote Input 7	1
263	Remote Input 8	1
264	Remote Input 9	1
265	Remote Input 10	1
266	Remote Input 11	1
267	Remote Input 12	1
268	Remote Input 13	1
269	Remote Input 14	1
270	Remote Input 15	1
271	Remote Input 16	1
272	Remote Input 17	1
273	Remote Input 18	1
274	Remote Input 19	1
275	Remote Input 20	1
276	Remote Input 21	1
277	Remote Input 22	1
278	Remote Input 23	1
279	Remote Input 24	1
280	Remote Input 25	1
281	Remote Input 26	1
282	Remote Input 27	1
283	Remote Input 28	1
284	Remote Input 29	1
285	Remote Input 30	1
286	Remote Input 31	1
287	Remote Input 32	1
288	Remote Device 1	1
289	Remote Device 2	1
290	Remote Device 3	1
291	Remote Device 4	1
292	Remote Device 5	1
293	Remote Device 6	1
294	Remote Device 7	1
295	Remote Device 8	1
296	Remote Device 9	1
297	Remote Device 10	1
298	Remote Device 11	1
299	Remote Device 12	1
300	Remote Device 13	1
301	Remote Device 14	1
302	Remote Device 15	1
303	Remote Device 16	1
304	PHASE IOC1 Element OP	1
305	PHASE IOC2 Element OP	1
320	PHASE TOC1 Element OP	1
321	PHASE TOC2 Element OP	1
328	PH DIR1 Element OP	1

Table E-3: BINARY INPUTS (Sheet 8 of 10)

POINT INDEX	NAME/DESCRIPTION	CHANGE EVENT CLASS (1/2/3/NONE)
329	PH DIR2 Element OP	1
336	NEUTRAL IOC1 Element OP	1
337	NEUTRAL IOC2 Element OP	1
352	NEUTRAL TOC1 Element OP	1
353	NEUTRAL TOC2 Element OP	1
360	NTRL DIR OC1 Element OP	1
361	NTRL DIR OC2 Element OP	1
364	NEG SEQ DIR OC1 Elem. OP	1
365	NEG SEQ DIR OC2 Elem OP	1
368	GROUND IOC1 Element OP	1
369	GROUND IOC2 Element OP	1
384	GROUND TOC1 Element OP	1
385	GROUND TOC2 Element OP	1
400	NEG SEQ IOC1 Element OP	1
401	NEG SEQ IOC2 Element OP	1
416	NEG SEQ TOC1 Element OP	1
417	NEG SEQ TOC2 Element OP	1
424	NEG SEQ OV Element OP	1
432	HI-Z Element OP	1
444	AUX UV1 Element OP	1
448	PHASE UV1 Element OP	1
449	PHASE UV2 Element OP	1
452	AUX OV1 Element OP	1
456	PHASE OV1 Element OP	1
460	NEUTRAL OV1 Element OP	1
484	LOAD ENCHR Element OP	1
518	DIR POWER1 Element OP	1
519	DIR POWER2 Element OP	1
528	SRC1 VT FUSE FAIL Elem OP	1
529	SRC2 VT FUSE FAIL Elem OP	1
530	SRC3 VT FUSE FAIL Elem OP	1
531	SRC4 VT FUSE FAIL Elem OP	1
532	SRC5 VT FUSE FAIL Elem OP	1
533	SRC6 VT FUSE FAIL Elem OP	1
536	SRC1 50DD Element OP	1
537	SRC2 50DD Element OP	1
538	SRC3 50DD Element OP	1
539	SRC4 50DD Element OP	1
540	SRC5 50DD Element OP	1
541	SRC6 50DD Element OP	1
548	50DD Element OP	1
576	BREAKER 1 Element OP	1
577	BREAKER 2 Element OP	1
584	BKR FAIL 1 Element OP	1
585	BKR FAIL 2 Element OP	1
592	BKR ARC 1 Element OP	1
593	BKR ARC 2 Element OP	1
608	AR 1 Element OP	1
609	AR 2 Element OP	1

Table E-3: BINARY INPUTS (Sheet 9 of 10)

POINT INDEX	NAME/DESCRIPTION	CHANGE EVENT CLASS (1/2/3/NONE)
610	AR 3 Element OP	1
611	AR 4 Element OP	1
612	AR 5 Element OP	1
613	AR 6 Element OP	1
616	SYNC 1 Element OP	1
617	SYNC 2 Element OP	1
624	COLD LOAD 1 Element OP	1
625	COLD LOAD 2 Element OP	1
640	SETTING GROUP Element OP	1
641	RESET Element OP	1
648	OVERFREQ1 Element OP	1
649	OVERFREQ2 Element OP	1
650	OVERFREQ3 Element OP	1
651	OVERFREQ4 Element OP	1
655	OVERFREQ Element OP	1
656	UNDERFREQ 1 Element OP	1
657	UNDERFREQ 2 Element OP	1
658	UNDERFREQ 3 Element OP	1
659	UNDERFREQ 4 Element OP	1
660	UNDERFREQ 5 Element OP	1
661	UNDERFREQ 6 Element OP	1
704	FLEXELEMENT 1 Element OP	1
705	FLEXELEMENT 2 Element OP	1
706	FLEXELEMENT 3 Element OP	1
707	FLEXELEMENT 4 Element OP	1
708	FLEXELEMENT 5 Element OP	1
709	FLEXELEMENT 6 Element OP	1
710	FLEXELEMENT 7 Element OP	1
711	FLEXELEMENT 8 Element OP	1
816	DIG ELEM 1 Element OP	1
817	DIG ELEM 2 Element OP	1
818	DIG ELEM 3 Element OP	1
819	DIG ELEM 4 Element OP	1
820	DIG ELEM 5 Element OP	1
821	DIG ELEM 6 Element OP	1
822	DIG ELEM 7 Element OP	1
823	DIG ELEM 8 Element OP	1
824	DIG ELEM 9 Element OP	1
825	DIG ELEM 10 Element OP	1
826	DIG ELEM 11 Element OP	1
827	DIG ELEM 12 Element OP	1
828	DIG ELEM 13 Element OP	1
829	DIG ELEM 14 Element OP	1
830	DIG ELEM 15 Element OP	1
831	DIG ELEM 16 Element OP	1
848	COUNTER 1 Element OP	1
849	COUNTER 2 Element OP	1
850	COUNTER 3 Element OP	1
851	COUNTER 4 Element OP	1

Table E-3: BINARY INPUTS (Sheet 10 of 10)

POINT INDEX	NAME/DESCRIPTION	CHANGE EVENT CLASS (1/2/3/NONE)
852	COUNTER 5 Element OP	1
853	COUNTER 6 Element OP	1
854	COUNTER 7 Element OP	1
855	COUNTER 8 Element OP	1
864	LED State 1 (IN SERVICE)	1
865	LED State 2 (TROUBLE)	1
866	LED State 3 (TEST MODE)	1
867	LED State 4 (TRIP)	1
868	LED State 5 (ALARM)	1
869	LED State 6(PICKUP)	1
880	LED State 9 (VOLTAGE)	1
881	LED State 10 (CURRENT)	1
882	LED State 11 (FREQUENCY)	1
883	LED State 12 (OTHER)	1
884	LED State 13 (PHASE A)	1
885	LED State 14 (PHASE B)	1
886	LED State 15 (PHASE C)	1
887	LED State 16 (NTL/GROUND)	1
898	SNTP FAILURE	1
899	BATTERY FAIL	1
900	PRI ETHERNET FAIL	1
901	SEC ETHERNET FAIL	1
902	EEPROM DATA ERROR	1
903	SRAM DATA ERROR	1
904	PROGRAM MEMORY	1
905	WATCHDOG ERROR	1
906	LOW ON MEMORY	1
907	REMOTE DEVICE OFF	1
908	DIRECT DEVICE OFF	
909	DIRECT RING BREAK	
910	ANY MINOR ERROR	1
911	ANY MAJOR ERROR	1
912	ANY SELF-TESTS	1
913	IRIG-B FAILURE	1
914	DSP ERROR	1
916	NO DSP INTERRUPTS	1
917	UNIT NOT CALIBRATED	1
921	PROTOTYPE FIRMWARE	1
922	FLEXLOGIC ERR TOKEN	1
923	EQUIPMENT MISMATCH	1
925	UNIT NOT PROGRAMMED	1
926	SYSTEM EXCEPTION	1
927	LATCHING OUT ERROR	1

E.2.2 BINARY AND CONTROL RELAY OUTPUTS

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-4: BINARY/CONTROL OUTPUTS

POINT	NAME/DESCRIPTION
0	Virtual Input 1
1	Virtual Input 2
2	Virtual Input 3
3	Virtual Input 4
4	Virtual Input 5
5	Virtual Input 6
6	Virtual Input 7
7	Virtual Input 8
8	Virtual Input 9
9	Virtual Input 10
10	Virtual Input 11
11	Virtual Input 12
12	Virtual Input 13
13	Virtual Input 14
14	Virtual Input 15
15	Virtual Input 16
16	Virtual Input 17
17	Virtual Input 18
18	Virtual Input 19
19	Virtual Input 20
20	Virtual Input 21
21	Virtual Input 22
22	Virtual Input 23
23	Virtual Input 24
24	Virtual Input 25
25	Virtual Input 26
26	Virtual Input 27
27	Virtual Input 28
28	Virtual Input 29
29	Virtual Input 30
30	Virtual Input 31
31	Virtual Input 32

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-5: BINARY AND FROZEN COUNTERS

POINT INDEX	NAME/DESCRIPTION
0	Digital Counter 1
1	Digital Counter 2
2	Digital Counter 3
3	Digital Counter 4
4	Digital Counter 5
5	Digital Counter 6
6	Digital Counter 7
7	Digital Counter 8
8	Oscillography Trigger Count
9	Events Since Last Clear

A counter freeze command has no meaning for counters 8 and 9. 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 following table lists Analog Inputs (Object 30). It is important to note that 16-bit and 32-bit variations of analog inputs are transmitted through DNP as signed numbers. Even for analog input points that are not valid as negative values, the maximum positive representation is 32767 for 16-bit values and 2147483647 for 32-bit values. This is a DNP requirement.

The deadbands for all Analog Input points are in the same units as the Analog Input quantity. For example, an Analog Input quantity measured in volts has a corresponding deadband in units of volts. This is in conformance with DNP Technical Bulletin 9809-001 Analog Input Reporting Deadband. Relay settings are available to set default deadband values according to data type. Deadbands for individual Analog Input Points can be set using DNP Object 34.

When using the F60 in DNP systems with limited memory, the Analog Input Points below may be replaced with a user-definable list. This user-definable list uses the same settings as the Modbus User Map and can be configured with the Modbus User Map settings. When used with DNP, each entry in the Modbus User Map represents the starting Modbus address of a data item available as a DNP Analog Input point. To enable use of the Modbus User Map for DNP Analog Input points, set the **USER MAP FOR DNP ANALOGS** setting to Enabled (this setting is in the **PRODUCT SETUP** ⇨ **COMMUNICATIONS** ⇨ **DNP PROTOCOL** menu). The new DNP Analog points list can be checked via the “DNP Analog Input Points List” webpage, accessible from the “Device Information menu” webpage.



After changing the **USER MAP FOR DNP ANALOGS** setting, the relay must be powered off and then back on for the setting to take effect.

Only Source 1 data points are shown in the following table. If the **NUMBER OF SOURCES IN ANALOG LIST** setting is increased, data points for subsequent sources will be added to the list immediately following the Source 1 data points.

Units for Analog Input points are as follows:

- | | | | |
|-------------------|----------------------------------|--------------|----------------------|
| • Current: | A (amps) | • Frequency: | Hz (hertz) |
| • Voltage: | V (volts) | • Angle: | degrees |
| • Real Power: | W (watts) | • Ohm Input: | ohms |
| • Reactive Power: | var (vars) | • RTD Input: | °C (degrees Celsius) |
| • Apparent Power: | VA (volt-amps) | | |
| • Energy | Wh, varh (watt-hours, var-hours) | | |

Static (Steady-State) Object Number: **30**
 Change Event Object Number: **32**
 Request Function Codes supported: **1 (read), 2 (write, deadbands only), 22 (assign class)**
 Static Variation reported when variation 0 requested: **1 (32-Bit Analog Input)**
 Change Event Variation reported when variation 0 requested: **1 (Analog Change Event without Time)**
 Change Event Scan Rate: defaults to **500 ms**
 Change Event Buffer Size: **800**
 Default Class for all Points: **1**

Table E-6: ANALOG INPUT POINTS (Sheet 1 of 6)

POINT	DESCRIPTION
0	SRC 1 Phase A Current RMS
1	SRC 1 Phase B Current RMS
2	SRC 1 Phase C Current RMS
3	SRC 1 Neutral Current RMS
4	SRC 1 Phase A Current Magnitude
5	SRC 1 Phase A Current Angle
6	SRC 1 Phase B Current Magnitude
7	SRC 1 Phase B Current Angle
8	SRC 1 Phase C Current Magnitude
9	SRC 1 Phase C Current Angle
10	SRC 1 Neutral Current Magnitude
11	SRC 1 Neutral Current Angle
12	SRC 1 Ground Current RMS
13	SRC 1 Ground Current Magnitude
14	SRC 1 Ground Current Angle
15	SRC 1 Zero Sequence Current Magnitude
16	SRC 1 Zero Sequence Current Angle
17	SRC 1 Positive Sequence Current Magnitude
18	SRC 1 Positive Sequence Current Angle
19	SRC 1 Negative Sequence Current Magnitude
20	SRC 1 Negative Sequence Current Angle
21	SRC 1 Differential Ground Current Magnitude
22	SRC 1 Differential Ground Current Angle
23	SRC 1 Phase AG Voltage RMS
24	SRC 1 Phase BG Voltage RMS
25	SRC 1 Phase CG Voltage RMS
26	SRC 1 Phase AG Voltage Magnitude
27	SRC 1 Phase AG Voltage Angle
28	SRC 1 Phase BG Voltage Magnitude
29	SRC 1 Phase BG Voltage Angle
30	SRC 1 Phase CG Voltage Magnitude
31	SRC 1 Phase CG Voltage Angle
32	SRC 1 Phase AB Voltage RMS
33	SRC 1 Phase BC Voltage RMS
34	SRC 1 Phase CA Voltage RMS
35	SRC 1 Phase AB Voltage Magnitude
36	SRC 1 Phase AB Voltage Angle
37	SRC 1 Phase BC Voltage Magnitude
38	SRC 1 Phase BC Voltage Angle
39	SRC 1 Phase CA Voltage Magnitude
40	SRC 1 Phase CA Voltage Angle
41	SRC 1 Auxiliary Voltage RMS
42	SRC 1 Auxiliary Voltage Magnitude
43	SRC 1 Auxiliary Voltage Angle
44	SRC 1 Zero Sequence Voltage Magnitude
45	SRC 1 Zero Sequence Voltage Angle
46	SRC 1 Positive Sequence Voltage Magnitude
47	SRC 1 Positive Sequence Voltage Angle
48	SRC 1 Negative Sequence Voltage Magnitude
49	SRC 1 Negative Sequence Voltage Angle
50	SRC 1 Three Phase Real Power

Table E-6: ANALOG INPUT POINTS (Sheet 2 of 6)

POINT	DESCRIPTION
51	SRC 1 Phase A Real Power
52	SRC 1 Phase B Real Power
53	SRC 1 Phase C Real Power
54	SRC 1 Three Phase Reactive Power
55	SRC 1 Phase A Reactive Power
56	SRC 1 Phase B Reactive Power
57	SRC 1 Phase C Reactive Power
58	SRC 1 Three Phase Apparent Power
59	SRC 1 Phase A Apparent Power
60	SRC 1 Phase B Apparent Power
61	SRC 1 Phase C Apparent Power
62	SRC 1 Three Phase Power Factor
63	SRC 1 Phase A Power Factor
64	SRC 1 Phase B Power Factor
65	SRC 1 Phase C Power Factor
66	SRC 1 Positive Watthour
67	SRC 1 Negative Watthour
68	SRC 1 Positive Varhour
69	SRC 1 Negative Varhour
70	SRC 1 Frequency
71	SRC 1 Demand Ia
72	SRC 1 Demand Ib
73	SRC 1 Demand Ic
74	SRC 1 Demand Watt
75	SRC 1 Demand Var
76	SRC 1 Demand Va
77	SRC 1 Va THD
78	SRC 1 Va Harmonics[0]
79	SRC 1 Va Harmonics[1]
80	SRC 1 Va Harmonics[2]
81	SRC 1 Va Harmonics[3]
82	SRC 1 Va Harmonics[4]
83	SRC 1 Va Harmonics[5]
84	SRC 1 Va Harmonics[6]
85	SRC 1 Va Harmonics[7]
86	SRC 1 Va Harmonics[8]
87	SRC 1 Va Harmonics[9]
88	SRC 1 Va Harmonics[10]
89	SRC 1 Va Harmonics[11]
90	SRC 1 Va Harmonics[12]
91	SRC 1 Va Harmonics[13]
92	SRC 1 Va Harmonics[14]
93	SRC 1 Va Harmonics[15]
94	SRC 1 Va Harmonics[16]
95	SRC 1 Va Harmonics[17]
96	SRC 1 Va Harmonics[18]
97	SRC 1 Va Harmonics[19]
98	SRC 1 Va Harmonics[20]
99	SRC 1 Va Harmonics[21]
100	SRC 1 Va Harmonics[22]
101	SRC 1 Va Harmonics[23]

Table E-6: ANALOG INPUT POINTS (Sheet 3 of 6)

POINT	DESCRIPTION
102	SRC 1 Vb THD
103	SRC 1 Vb Harmonics[0]
104	SRC 1 Vb Harmonics[1]
105	SRC 1 Vb Harmonics[2]
106	SRC 1 Vb Harmonics[3]
107	SRC 1 Vb Harmonics[4]
108	SRC 1 Vb Harmonics[5]
109	SRC 1 Vb Harmonics[6]
110	SRC 1 Vb Harmonics[7]
111	SRC 1 Vb Harmonics[8]
112	SRC 1 Vb Harmonics[9]
113	SRC 1 Vb Harmonics[10]
114	SRC 1 Vb Harmonics[11]
115	SRC 1 Vb Harmonics[12]
116	SRC 1 Vb Harmonics[13]
117	SRC 1 Vb Harmonics[14]
118	SRC 1 Vb Harmonics[15]
119	SRC 1 Vb Harmonics[16]
120	SRC 1 Vb Harmonics[17]
121	SRC 1 Vb Harmonics[18]
122	SRC 1 Vb Harmonics[19]
123	SRC 1 Vb Harmonics[20]
124	SRC 1 Vb Harmonics[21]
125	SRC 1 Vb Harmonics[22]
126	SRC 1 Vb Harmonics[23]
127	SRC 1 Vc THD
128	SRC 1 Vc Harmonics[0]
129	SRC 1 Vc Harmonics[1]
130	SRC 1 Vc Harmonics[2]
131	SRC 1 Vc Harmonics[3]
132	SRC 1 Vc Harmonics[4]
133	SRC 1 Vc Harmonics[5]
134	SRC 1 Vc Harmonics[6]
135	SRC 1 Vc Harmonics[7]
136	SRC 1 Vc Harmonics[8]
137	SRC 1 Vc Harmonics[9]
138	SRC 1 Vc Harmonics[10]
139	SRC 1 Vc Harmonics[11]
140	SRC 1 Vc Harmonics[12]
141	SRC 1 Vc Harmonics[13]
142	SRC 1 Vc Harmonics[14]
143	SRC 1 Vc Harmonics[15]
144	SRC 1 Vc Harmonics[16]
145	SRC 1 Vc Harmonics[17]
146	SRC 1 Vc Harmonics[18]
147	SRC 1 Vc Harmonics[19]
148	SRC 1 Vc Harmonics[20]
149	SRC 1 Vc Harmonics[21]
150	SRC 1 Vc Harmonics[22]
151	SRC 1 Vc Harmonics[23]
152	SRC 1 Ia THD

Table E-6: ANALOG INPUT POINTS (Sheet 4 of 6)

POINT	DESCRIPTION
153	SRC 1 Ia Harmonics[0]
154	SRC 1 Ia Harmonics[1]
155	SRC 1 Ia Harmonics[2]
156	SRC 1 Ia Harmonics[3]
157	SRC 1 Ia Harmonics[4]
158	SRC 1 Ia Harmonics[5]
159	SRC 1 Ia Harmonics[6]
160	SRC 1 Ia Harmonics[7]
161	SRC 1 Ia Harmonics[8]
162	SRC 1 Ia Harmonics[9]
163	SRC 1 Ia Harmonics[10]
164	SRC 1 Ia Harmonics[11]
165	SRC 1 Ia Harmonics[12]
166	SRC 1 Ia Harmonics[13]
167	SRC 1 Ia Harmonics[14]
168	SRC 1 Ia Harmonics[15]
169	SRC 1 Ia Harmonics[16]
170	SRC 1 Ia Harmonics[17]
171	SRC 1 Ia Harmonics[18]
172	SRC 1 Ia Harmonics[19]
173	SRC 1 Ia Harmonics[20]
174	SRC 1 Ia Harmonics[21]
175	SRC 1 Ia Harmonics[22]
176	SRC 1 Ia Harmonics[23]
177	SRC 1 Ib THD
178	SRC 1 Ib Harmonics[0]
179	SRC 1 Ib Harmonics[1]
180	SRC 1 Ib Harmonics[2]
181	SRC 1 Ib Harmonics[3]
182	SRC 1 Ib Harmonics[4]
183	SRC 1 Ib Harmonics[5]
184	SRC 1 Ib Harmonics[6]
185	SRC 1 Ib Harmonics[7]
186	SRC 1 Ib Harmonics[8]
187	SRC 1 Ib Harmonics[9]
188	SRC 1 Ib Harmonics[10]
189	SRC 1 Ib Harmonics[11]
190	SRC 1 Ib Harmonics[12]
191	SRC 1 Ib Harmonics[13]
192	SRC 1 Ib Harmonics[14]
193	SRC 1 Ib Harmonics[15]
194	SRC 1 Ib Harmonics[16]
195	SRC 1 Ib Harmonics[17]
196	SRC 1 Ib Harmonics[18]
197	SRC 1 Ib Harmonics[19]
198	SRC 1 Ib Harmonics[20]
199	SRC 1 Ib Harmonics[21]
200	SRC 1 Ib Harmonics[22]
201	SRC 1 Ib Harmonics[23]
202	SRC 1 Ic THD
203	SRC 1 Ic Harmonics[0]

Table E-6: ANALOG INPUT POINTS (Sheet 5 of 6)

POINT	DESCRIPTION
204	SRC 1 Ic Harmonics[1]
205	SRC 1 Ic Harmonics[2]
206	SRC 1 Ic Harmonics[3]
207	SRC 1 Ic Harmonics[4]
208	SRC 1 Ic Harmonics[5]
209	SRC 1 Ic Harmonics[6]
210	SRC 1 Ic Harmonics[7]
211	SRC 1 Ic Harmonics[8]
212	SRC 1 Ic Harmonics[9]
213	SRC 1 Ic Harmonics[10]
214	SRC 1 Ic Harmonics[11]
215	SRC 1 Ic Harmonics[12]
216	SRC 1 Ic Harmonics[13]
217	SRC 1 Ic Harmonics[14]
218	SRC 1 Ic Harmonics[15]
219	SRC 1 Ic Harmonics[16]
220	SRC 1 Ic Harmonics[17]
221	SRC 1 Ic Harmonics[18]
222	SRC 1 Ic Harmonics[19]
223	SRC 1 Ic Harmonics[20]
224	SRC 1 Ic Harmonics[21]
225	SRC 1 Ic Harmonics[22]
226	SRC 1 Ic Harmonics[23]
1362	Sens Dir Power 1 Actual
1363	Sens Dir Power 2 Actual
1364	Breaker 1 Arcing Amp Phase A
1365	Breaker 1 Arcing Amp Phase B
1366	Breaker 1 Arcing Amp Phase C
1367	Breaker 2 Arcing Amp Phase A
1368	Breaker 2 Arcing Amp Phase B
1369	Breaker 2 Arcing Amp Phase C
1370	HIZ Phase A Arc Confidence
1371	HIZ Phase B Arc Confidence
1372	HIZ Phase C Arc Confidence
1373	HIZ Neutral Arc Confidence
1374	Synchrocheck 1 Delta Voltage
1375	Synchrocheck 1 Delta Frequency
1376	Synchrocheck 1 Delta Phase
1377	Synchrocheck 2 Delta Voltage
1378	Synchrocheck 2 Delta Frequency
1379	Synchrocheck 2 Delta Phase
1380	Tracking Frequency
1381	FlexElement 1 Actual
1382	FlexElement 2 Actual
1383	FlexElement 3 Actual
1384	FlexElement 4 Actual
1385	FlexElement 5 Actual
1386	FlexElement 6 Actual
1387	FlexElement 7 Actual
1388	FlexElement 8 Actual
1389	FlexElement 9 Actual

Table E-6: ANALOG INPUT POINTS (Sheet 6 of 6)

POINT	DESCRIPTION
1390	FlexElement 10 Actual
1391	FlexElement 11 Actual
1392	FlexElement 12 Actual
1393	FlexElement 13 Actual
1394	FlexElement 14 Actual
1395	FlexElement 15 Actual
1396	FlexElement 16 Actual
1397	Current Setting Group

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-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-E1	3.3x	01 May 2003	URX-080
1601-0093-E2	3.3x	29 May 2003	URX-083

F.1.2 CHANGES TO F60 MANUAL

F

Table F-1: MAJOR UPDATES FOR F60 MANUAL REVISION E2

PAGE (E1)	PAGE (E2)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0100-E2.
4-4	4-4	Update	Updated UR VERTICAL FACEPLATE PANELS figure to remove incorrect reference to User-Programmable Pushbuttons.

Table F–2: MAJOR UPDATES FOR F60 MANUAL REVISION E1

PAGE (D1)	PAGE (E1)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0093-E1.
2-5	2-5	Update	Added specifications for SELECTOR SWITCH, CONTROL PUSHBUTTONS, USER-DEFINABLE DISPLAYS, DIRECT INPUTS, DIRECT OUTPUTS, LATCHING OUTPUTS, and LED TEST.
3-13	3-13	Update	Updated DIGITAL I/O MODULE ASSIGNMENTS table to add the 4A, 4B, 4C, and 4L modules.
3-15	3-15	Update	Updated the DIGITAL I/O MODULE WIRING diagram to 827719CX.
3-32	3-31	Add	Added section for IEEE C37.94 Direct I/O communications.
5-9	5-9	Add	Added CLEAR RELAY RECORDS section.
5-21	5-22	Update	Updated USER-PROGRAMMABLE LEDs section to include LED Test feature.
5-22	5-25	Add	Added CONTROL PUSHBUTTONS section.
5-24	5-28	Update	Updated USER-DEFINABLE DISPLAYS section.
5-26	5-30	Update	Updated DIRECT I/O section to include CRC Alarm and Unreturned Messages Alarm features.
5-112	5-118	Add	Added SELECTOR SWITCH section.
5-145	5-156	Add	Added LATCHING OUTPUTS section.
5-155	5-168	Update	Updated TESTING section.
7-3	7-3	Update	Updated RELAY SELF-TESTS section.
B-8	B-8	Update	Updated MODBUS MEMORY MAP to reflect new firmware 3.3x features.

Table F–3: MAJOR UPDATES FOR F60 MANUAL REVISION D1

PAGE (C6)	PAGE (D1)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0093-D1.
1-6	1-6	Update	Updated CONNECTING URPC WITH THE F60 section to reflect new URPC software.
2-1	2-1	Update	Updated ANSI DEVICE NUMBERS AND FUNCTIONS table to include Frequency Rate of Change
2-2	2-2	Update	Updated OTHER DEVICE FUNCTIONS table to include User-Programmable Self Tests.
2-7	2-7	Add	Added specifications for RATE OF CHANGE OF FREQUENCY element.
3-6	3-6	Update	Updated TYPICAL WIRING DIAGRAM to 830710B6 and TYPICAL WIRING DIAGRAM WITH HI-Z to 830751A2
5-13	5-13	Update	Updated UCA/MMS PROTOCOL sub-section to include two new settings.
5-22	5-22	Add	Added USER-PROGRAMMABLE SELF-TESTS section.
5-49	5-47	Update	Updated FLEXLOGIC™ OPERANDS table to include firmware revision 3.2x features.
5-116	5-114	Add	Added FREQUENCY RATE OF CHANGE settings section.
5-117	5-116	Update	Updated SYNCHROCHECK description and logic diagrams to reflect new operands.
5-141	5-139	Update	Updated VT FUSE FAIL SCHEME LOGIC diagram to 827093AD
6-15	6-15	Add	Added FREQUENCY RATE OF CHANGE actual values section.
7-3	7-3	Update	Updated RELAY SELF-TESTS section.
B-9	B-8	Update	Updated MODBUS MEMORY MAP to reflect new firmware 3.2x features.

Table F–4: MAJOR UPDATES FOR F60 MANUAL REVISION C6

PAGE (C4)	PAGE (C6)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0093-C6.
2-3	2-3	Update	Updated ORDER CODES table to add the 67 Digital I/O option.
2-4	2-4	Update	Updated ORDER CODES FOR REPLACEMENT MODULES table to add the 67 Module option.
3-13	3-13	Update	Updated DIGITAL I/O MODULE ASSIGNMENTS table to add the 67 module.
3-15	3-15	Update	Updated the DIGITAL I/O MODULE WIRING diagram to 827719CV.

Table F–5: MAJOR UPDATES FOR F60 MANUAL REVISION C5

PAGE (C3)	PAGE (C5)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0093-C5.
2-3	2-3	Update	Updated ORDER CODES table to add the 67 Digital I/O option.
2-4	2-4	Update	Updated ORDER CODES FOR REPLACEMENT MODULES table to add the 67 Module option.
3-13	3-13	Update	Updated DIGITAL I/O MODULE ASSIGNMENTS table to add the 67 module.
3-15	3-15	Update	Updated the DIGITAL I/O MODULE WIRING diagram to 827719CV.

Table F–6: MAJOR UPDATES FOR F60 MANUAL REVISION C4

PAGE (C2)	PAGE (C4)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0093-C4.
2-3	2-3	Update	Updated ORDER CODES table to remove the 63 and 64 Digital I/O options.
2-4	2-4	Update	Updated ORDER CODES FOR REPLACEMENT MODULES table to remove the 63 and 64 Digital I/O options.
3-13	3-13	Update	Updated DIGITAL I/O MODULE ASSIGNMENTS table to remove the 63 and 64 modules.
3-15	3-15	Update	Updated the DIGITAL I/O MODULE WIRING diagram to 827719CT.
5-134	5-134	Update	Updated VTFF LOGIC diagram to version 827093AD.
F-3	--	Remove	Removed List of Tables and List of Figures section

Table F–7: MAJOR UPDATES FOR F60 MANUAL REVISION C3

PAGE (C1)	PAGE (C3)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0093-C3.
2-3	2-3	Update	Updated ORDER CODES table to remove the 63 and 64 Digital I/O options.
2-4	2-4	Update	Updated ORDER CODES FOR REPLACEMENT MODULES table to remove the 63 and 64 Digital I/O options.
3-13	3-13	Update	Updated DIGITAL I/O MODULE ASSIGNMENTS table to remove the 63 and 64 modules.
3-15	3-15	Update	Updated the DIGITAL I/O MODULE WIRING diagram to 827719CT.
9-1	---	Remove	Removed COMMISSIONING chapter; setpoints tables are available from URPC or can be downloaded from the GE Multilin website.

F.2.1 STANDARD ABBREVIATIONS

A.....	Ampere	FREQ.....	Frequency
AC.....	Alternating Current	FSK.....	Frequency-Shift Keying
A/D.....	Analog to Digital	FTP.....	File Transfer Protocol
AE.....	Accidental Energization, Application Entity	FxE.....	FlexElement™
AMP.....	Ampere	FWD.....	Forward
ANG.....	Angle		
ANSI.....	American National Standards Institute	G.....	Generator
AR.....	Automatic Reclosure	GE.....	General Electric
ASDU.....	Application-layer Service Data Unit	GND.....	Ground
ASYM.....	Asymmetry	GNTR.....	Generator
AUTO.....	Automatic	GOOSE.....	General Object Oriented Substation Event
AUX.....	Auxiliary	GPS.....	Global Positioning System
AVG.....	Average		
		HARM.....	Harmonic / Harmonics
BER.....	Bit Error Rate	HCT.....	High Current Time
BF.....	Breaker Fail	HGF.....	High-Impedance Ground Fault (CT)
BFI.....	Breaker Failure Initiate	HIZ.....	High-Impedance and Arcing Ground
BKR.....	Breaker	HMI.....	Human-Machine Interface
BLK.....	Block	HTTP.....	Hyper Text Transfer Protocol
BLKG.....	Blocking	HYB.....	Hybrid
BPNT.....	Breakpoint of a characteristic		
BRKR.....	Breaker	I.....	Instantaneous
		I ₀	Zero Sequence current
CAP.....	Capacitor	I ₁	Positive Sequence current
CC.....	Coupling Capacitor	I ₂	Negative Sequence current
CCVT.....	Coupling Capacitor Voltage Transformer	IA.....	Phase A current
CFG.....	Configure / Configurable	IAB.....	Phase A minus B current
.CFG.....	Filename extension for oscillography files	IB.....	Phase B current
CHK.....	Check	IBC.....	Phase B minus C current
CHNL.....	Channel	IC.....	Phase C current
CLS.....	Close	ICA.....	Phase C minus A current
CLSD.....	Closed	ID.....	Identification
CMND.....	Command	IED.....	Intelligent Electronic Device
CMPSN.....	Comparison	IEC.....	International Electrotechnical Commission
CO.....	Contact Output	IEEE.....	Institute of Electrical and Electronic Engineers
COM.....	Communication	IG.....	Ground (not residual) current
COMM.....	Communications	Igd.....	Differential Ground current
COMP.....	Compensated, Comparison	IN.....	CT Residual Current (3Io) or Input
CONN.....	Connection	INC SEQ.....	Incomplete Sequence
CONT.....	Continuous, Contact	INIT.....	Initiate
CO-ORD.....	Coordination	INST.....	Instantaneous
CPU.....	Central Processing Unit	INV.....	Inverse
CRC.....	Cyclic Redundancy Code	I/O.....	Input/Output
CRT, CRNT.....	Current	IOC.....	Instantaneous Overcurrent
CSA.....	Canadian Standards Association	IOV.....	Instantaneous Overvoltage
CT.....	Current Transformer	IRIG.....	Inter-Range Instrumentation Group
CVT.....	Capacitive Voltage Transformer	ISO.....	International Standards Organization
		IUV.....	Instantaneous Undervoltage
D/A.....	Digital to Analog		
DC (dc).....	Direct Current	K0.....	Zero Sequence Current Compensation
DD.....	Disturbance Detector	kA.....	kiloAmpere
DFLT.....	Default	kV.....	kiloVolt
DGNST.....	Diagnostics		
DI.....	Digital Input	LED.....	Light Emitting Diode
DIFF.....	Differential	LEO.....	Line End Open
DIR.....	Directional	LFT BLD.....	Left Blinder
DISCREP.....	Discrepancy	LOOP.....	Loopback
DIST.....	Distance	LPU.....	Line Pickup
DMD.....	Demand	LRA.....	Locked-Rotor Current
DNP.....	Distributed Network Protocol	LTC.....	Load Tap-Changer
DPO.....	Dropout		
DSP.....	Digital Signal Processor	M.....	Machine
dt.....	Rate of Change	mA.....	MilliAmpere
DTT.....	Direct Transfer Trip	MAG.....	Magnitude
DUTT.....	Direct Under-reaching Transfer Trip	MAN.....	Manual / Manually
		MAX.....	Maximum
ENCRMNT.....	Encroachment	MIC.....	Model Implementation Conformance
EPRI.....	Electric Power Research Institute	MIN.....	Minimum, Minutes
.EVT.....	Filename extension for event recorder files	MMI.....	Man Machine Interface
EXT.....	Extension, External	MMS.....	Manufacturing Message Specification
		MRT.....	Minimum Response Time
F.....	Field	MSG.....	Message
FAIL.....	Failure	MTA.....	Maximum Torque Angle
FD.....	Fault Detector	MTR.....	Motor
FDH.....	Fault Detector high-set	MVA.....	MegaVolt-Ampere (total 3-phase)
FDL.....	Fault Detector low-set	MVA_A.....	MegaVolt-Ampere (phase A)
FLA.....	Full Load Current	MVA_B.....	MegaVolt-Ampere (phase B)
FO.....	Fiber Optic	MVA_C.....	MegaVolt-Ampere (phase C)

MVAR	MegaVar (total 3-phase)	SAT	CT Saturation
MVAR_A	MegaVar (phase A)	SBO	Select Before Operate
MVAR_B	MegaVar (phase B)	SCADA	Supervisory Control and Data Acquisition
MVAR_C	MegaVar (phase C)	SEC	Secondary
MVARH	MegaVar-Hour	SEL	Select / Selector / Selection
MW	MegaWatt (total 3-phase)	SENS	Sensitive
MW_A	MegaWatt (phase A)	SEQ	Sequence
MW_B	MegaWatt (phase B)	SIR	Source Impedance Ratio
MW_C	MegaWatt (phase C)	SNTP	Simple Network Time Protocol
MWH	MegaWatt-Hour	SRC	Source
N	Neutral	SSB	Single Side Band
N/A, n/a	Not Applicable	SSEL	Session Selector
NEG	Negative	STATS	Statistics
NMPLT	Nameplate	SUPN	Supervision
NOM	Nominal	SUPV	Supervise / Supervision
NSAP	Network Service Access Protocol	SV	Supervision, Service
NTR	Neutral	SYNC	Synchrocheck
O	Over	SYNCHCHK	Synchrocheck
OC, O/C	Overcurrent	T	Time, transformer
O/P, Op	Output	TC	Thermal Capacity
OP	Operate	TCP	Transmission Control Protocol
OPER	Operate	TCU	Thermal Capacity Used
OPERATG	Operating	TD MULT	Time Dial Multiplier
O/S	Operating System	TEMP	Temperature
OSI	Open Systems Interconnect	TFTP	Trivial File Transfer Protocol
OSB	Out-of-Step Blocking	THD	Total Harmonic Distortion
OUT	Output	TMR	Timer
OV	Overvoltage	TOC	Time Overcurrent
OVERFREQ	Overfrequency	TOV	Time Overvoltage
OVLDT	Overload	TRANS	Transient
P	Phase	TRANSF	Transfer
PC	Phase Comparison, Personal Computer	TSEL	Transport Selector
PCNT	Percent	TUC	Time Undercurrent
PF	Power Factor (total 3-phase)	TUV	Time Undervoltage
PF_A	Power Factor (phase A)	TX (Tx)	Transmit, Transmitter
PF_B	Power Factor (phase B)	U	Under
PF_C	Power Factor (phase C)	UC	Undercurrent
PFL	Phase and Frequency Lock Loop	UCA	Utility Communications Architecture
PHS	Phase	UDP	User Datagram Protocol
PICS	Protocol Implementation & Conformance Statement	UL	Underwriters Laboratories
PKP	Pickup	UNBAL	Unbalance
PLC	Power Line Carrier	UR	Universal Relay
POS	Positive	URC	Universal Recloser Control
POTT	Permissive Over-reaching Transfer Trip	.URS	Filename extension for settings files
PRESS	Pressure	UV	Undervoltage
PRI	Primary	V/Hz	Volts per Hertz
PROT	Protection	V_0	Zero Sequence voltage
PSEL	Presentation Selector	V_1	Positive Sequence voltage
pu	Per Unit	V_2	Negative Sequence voltage
PUIB	Pickup Current Block	VA	Phase A voltage
PUIT	Pickup Current Trip	VAB	Phase A to B voltage
PUSHBTN	Pushbutton	VAG	Phase A to Ground voltage
PUTT	Permissive Under-reaching Transfer Trip	VARH	Var-hour voltage
PWM	Pulse Width Modulated	VB	Phase B voltage
PWR	Power	VBA	Phase B to A voltage
QUAD	Quadrilateral	VBG	Phase B to Ground voltage
R	Rate, Reverse	VC	Phase C voltage
RCA	Reach Characteristic Angle	VCA	Phase C to A voltage
REF	Reference	VCG	Phase C to Ground voltage
REM	Remote	VF	Variable Frequency
REV	Reverse	VIBR	Vibration
RI	Reclose Initiate	VT	Voltage Transformer
RIP	Reclose In Progress	VTFF	Voltage Transformer Fuse Failure
RGT BLD	Right Blinder	VTLOS	Voltage Transformer Loss Of Signal
ROD	Remote Open Detector	WDG	Winding
RST	Reset	WH	Watt-hour
RSTR	Restrained	w/ opt	With Option
RTD	Resistance Temperature Detector	WRT	With Respect To
RTU	Remote Terminal Unit	X	Reactance
RX (Rx)	Receive, Receiver	XDUCER	Transducer
s	second	XFMR	Transformer
S	Sensitive	Z	Impedance, Zone

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

10BASE-F	
communications options	3-19
description	3-21
interface	3-30
redundant option	3-19
settings	5-11
specifications	2-12

A

ABBREVIATIONS	F-4
AC CURRENT INPUTS	2-10, 3-10, 5-36
AC VOLTAGE INPUTS	2-10, 3-10
ACTIVATING THE RELAY	1-10, 4-12
ACTIVE SETTING GROUP	5-70
ACTUAL VALUES	
maintenance	6-21
metering	6-8
product information	6-22
records	6-18
status	6-3
ALARM LEDs	5-24
ALTITUDE	2-13
ANSI DEVICE NUMBERS	2-1
APPARENT POWER	2-9, 6-13
APPLICATION EXAMPLES	
breaker trip circuit integrity	5-139
contact inputs	5-154
sensitive directional power	5-115
APPROVALS	2-13
AR	
see entry for AUTORECLOSE	
ARC BURST PATTERN ANALYSIS ALGORITHM	8-3
ARC DETECTION ALGORITHM	8-2
ARCHITECTURE	5-51
ARCING CURRENT	5-148
ARCING SUSPECTED ALGORITHM	8-3
AUTORECLOSE	
actual values	6-4
FlexLogic™ operands	5-53
logic	5-134, 5-135
settings	5-131, 5-133
single shot sequence	5-136
specifications	2-7
AUXILIARY OVERVOLTAGE	
FlexLogic™ operands	5-53
logic	5-113
settings	5-113
specifications	2-6
AUXILIARY UNDERVOLTAGE	
FlexLogic™ operands	5-53
logic	5-112
settings	5-112
specifications	2-6
AUXILIARY VOLTAGE CHANNEL	3-10
AUXILIARY VOLTAGE METERING	6-12

B

BANKS	5-6, 5-36, 5-37
BATTERY FAIL	7-4

BATTERY TAB	1-10
BINARY INPUT POINTS	E-8
BINARY OUTPUT POINTS	E-13
BLOCK DIAGRAM	1-3
BLOCK SETTING	5-4
BREAKER ARCING	
FlexLogic™ operands	5-53
BREAKER ARCING CURRENT	
clearing	5-9, 7-2
logic	5-149
measurement	5-149
settings	5-148
BREAKER CONTROL	
actual values	6-21
control of 2 breakers	4-9
description	4-8
dual breaker logic	5-43
FlexLogic™ operands	5-53
settings	5-41
BREAKER FAILURE	
description	5-99
determination	5-100
FlexLogic™ operands	5-53
logic	5-103, 5-104, 5-105, 5-106
main path sequence	5-100
settings	5-98, 5-101
specifications	2-7
BREAKER-AND-A-HALF SCHEME	5-6
BRIGHTNESS	5-8

C

C37.94 COMMUNICATIONS	3-31, 3-32
CE APPROVALS	2-13
CHANGES TO F60 MANUAL	F-1
CHANGES TO MANUAL	F-1, F-2, F-3
CHANNEL COMMUNICATION	3-23
CHANNELS	
banks	5-36, 5-37
CIRCUIT MONITORING APPLICATIONS	5-137
CLEANING	2-13
CLEAR RECORDS	5-9, 7-1, B-41
CLOCK	
setting date and time	7-2
settings	5-16
COLD LOAD PICKUP	
characteristic	5-151
FlexLogic™ operands	5-53
logic	5-152
settings	5-151
COMMANDS MENU	7-1
COMMUNICATIONS	
10BASE-F	3-19, 3-21, 5-11
channel	3-23
connecting to the UR	1-6, 1-7
CRC-16 error checking	B-2
dnp	5-12, 5-16, E-1
G.703	3-26
half duplex	B-1
HTTP	5-14
IEC 60870-5-104 protocol	5-15
inter-relay communications	2-12
Modbus	5-11, 5-16, B-1, B-3
network	5-11
overview	1-8

RS232	3-19
RS485	3-19, 3-20, 5-10
settings	5-11, 5-12, 5-14, 5-15, 5-16
specifications	2-12
UCA/MMS	5-14, 5-41, 5-155, 5-159, 5-160, 5-161, C-1
web server	5-14
COMTRADE	B-6, B-7
CONDUCTED RFI	2-13
CONTACT INFORMATION	1-1
CONTACT INPUTS	
actual values	6-3
dry connections	3-17
FlexLogic™ operands	5-57
Modbus registers	B-9
module assignments	3-13
settings	5-153
specifications	2-10
thresholds	5-153
wet connections	3-17
wiring	3-15
CONTACT OUTPUTS	
actual values	6-4
FlexLogic™ operands	5-57
Modbus registers	B-9
module assignments	3-13
settings	5-156
wiring	3-15
CONTROL ELEMENTS	5-117
CONTROL POWER	
description	3-9
specifications	2-11
CONTROL PUSHBUTTONS	
FlexLogic™ operands	5-53
Modbus registers	B-41
settings	5-25
specifications	2-8
COUNTERS	
actual values	6-5
settings	5-140
CRC ALARM	5-34
CRC-16 ALGORITHM	B-2
CRITICAL FAILURE RELAY	2-11, 3-9
CSA APPROVAL	2-13
CT BANKS	
settings	5-36
CT INPUTS	3-10, 5-6, 5-36
CT WIRING	3-11
CURRENT BANK	5-36
CURRENT DEMAND	5-20
CURRENT HARMONICS	2-9, 6-14
CURRENT METERING	
actual values	6-11
Modbus registers	B-10
specifications	2-9
CURVES	
definite time	5-77, 5-107
FlexCurves™	5-44, 5-77
I2T	5-77
IAC	5-76
IEC	5-75
IEEE	5-74
inverse time undervoltage	5-107
types	5-73

D

DATA FORMATS, MODBUS	B-48
----------------------------	------

DATA LOGGER	
clearing	5-9, 7-1
Modbus	B-6, B-7
Modbus registers	B-10
settings	5-20
specifications	2-9
DATE	7-2
DCMA INPUTS	6-17
settings	5-166
specifications	2-10
DEFINITE TIME CURVE	5-77, 5-107
DEMAND METERING	
actual values	6-13
Modbus registers	B-12, B-13
settings	5-20
specifications	2-10
DEMAND RECORDS	
clearing	5-9, 7-2
DESIGN	1-3
DEVICE ID	5-159
DEVICE PROFILE DOCUMENT	E-1
DIELECTRIC STRENGTH	2-13, 3-8
DIGITAL COUNTER	
FlexLogic™ operands	5-54
DIGITAL COUNTERS	
actual values	6-5
logic	5-141
Modbus registers	B-9
settings	5-140
DIGITAL ELEMENT	
FlexLogic™ operands	5-54
DIGITAL ELEMENTS	
application example	5-138
logic	5-137
settings	5-137
DIGITAL INPUTS	
see entry for CONTACT INPUTS	
DIGITAL OUTPUTS	
see entry for CONTACT OUTPUTS	
DIMENSIONS	3-1
DIRECT DEVICES	
actual values	6-7
DIRECT I/O	
see also DIRECT INPUTS and DIRECT OUTPUTS	
application example	5-163, 5-164
configuration examples	5-22, 5-30, 5-34, 5-35
settings	5-22, 5-30, 5-34, 5-35, 5-162
DIRECT INPUTS	
actual values	6-6
application example	5-163, 5-164
clearing counters	7-2
settings	5-162
specifications	2-10
DIRECT OUTPUTS	
application example	5-163, 5-164
clearing counters	7-2
settings	5-163
DIRECTIONAL OVERCURRENT	
see PHASE, GROUND, and NEUTRAL DIRECTIONAL entries	
DIRECTIONAL POLARIZATION	5-82
DIRECTIONAL POWER	
see entry for SENSITIVE DIRECTIONAL POWER	
DISPLAY	1-8, 4-8, 5-8
DISTURBANCE DETECTOR	
FlexLogic™ operands	5-54
internal	5-39
DNA-1 BIT PAIR	5-161
DNP COMMUNICATIONS	

INDEX

iii

G

G.703	3-25, 3-26, 3-27, 3-30
GE TYPE IAC CURVES	5-76
GOMSFE	C-1
GOOSE	5-14, 5-159, 5-160, 5-161, 5-162, 5-163, 6-5
GROUND CURRENT METERING	6-11
GROUND IOC	
FlexLogic™ operands	5-54
logic	5-91
settings	5-91
GROUND TIME OVERCURRENT	
see entry for GROUND TOC	
GROUND TOC	
FlexLogic™ operands	5-54
logic	5-90
settings	5-90
specifications	2-5
GROUPED ELEMENTS	5-70

H

HALF-DUPLEX	B-1
HARMONIC CONTENT	6-14
HARMONICS	
actual values	6-15
HARMONICS METERING	
specifications	2-9
HI-Z	
actual values	6-6, 6-21
arc burst pattern analysis	8-3
arcing suspected algorithm	8-3
CT/VT module	3-11
data collection	5-143
energy algorithm	8-1
even harmonic restraint	8-3
expert arc detection algorithm	8-2
load analysis algorithm	8-3
load event detector algorithm	8-2
logic	5-147
overcurrent disturbance monitoring	8-3
randomness algorithm	8-2
settings	5-142, 5-145, 5-146
specifications	2-9
spectral analysis algorithm	8-2
theory of operation	8-1
voltage supervision algorithm	8-4
wiring diagram	3-7
HTTP PROTOCOL	5-14
HUMIDITY	2-13

I

I2T CURVES	5-77
IAC CURVES	5-76
IEC 60870-5-104 PROTOCOL	
interoperability document	D-1
settings	5-15
IEC CURVES	5-75
IED	1-2
IEEE C37.94 COMMUNICATIONS	3-31, 3-32
IEEE CURVES	5-74
IMPORTANT CONCEPTS	1-4

IN SERVICE INDICATOR	1-10, 7-3
INPUTS	
AC current	2-10, 5-36
AC voltage	2-10, 5-37
contact inputs	2-10, 3-15, 5-153, 5-168
dcmA inputs	2-10, 3-18, 5-166
direct inputs	2-10
IRIG-B	2-10, 3-21
remote inputs	2-10, 5-159, 5-160
RTD inputs	2-10, 3-18, 5-167
virtual	5-155
INSPECTION CHECKLIST	1-1
INSTALLATION	
communications	3-19
contact inputs/outputs	3-13, 3-15, 3-16
CT inputs	3-10
RS485	3-20
settings	5-35
VT inputs	3-10
INSTANTANEOUS OVERCURRENT	
see PHASE, GROUND, and NEUTRAL IOC entries	
INSULATION RESISTANCE	2-13
INTELLIGENT ELECTRONIC DEVICE	1-2
INTER-RELAY COMMUNICATIONS	2-12
INTRODUCTION	1-2
INVERSE TIME UNDERVOLTAGE	5-107
IOC	
see PHASE, GROUND, and NEUTRAL IOC entries	
IP ADDRESS	5-11
IRIG-B	
connection	3-21
settings	5-16
specifications	2-10
ISO-9000 REGISTRATION	2-13

K

KEYPAD	1-9, 4-8
--------------	----------

L

LAMPTEST	7-2
LASER MODULE	3-24
LATCHING OUTPUTS	
application example	5-157, 5-158
settings	5-156
specifications	2-11
LED INDICATORS	4-5, 4-6, 4-7, 5-24, B-8
LED TEST	
FlexLogic™ operand	5-57
settings	5-22
specifications	2-8
LINE	
settings	5-40
LINE LENGTH	5-40
LINK POWER BUDGET	2-12
LOAD ANALYSIS ALGORITHM	8-3
LOAD ENCROACHMENT	
FlexLogic™ operands	5-55
settings	5-71, 5-72
specifications	2-7
LOAD EVENT DETECTOR ALGORITHM	8-2
LOGIC GATES	5-59
LOST PASSWORD	5-7

M

MAINTENANCE COMMANDS	7-2
MANUFACTURING DATE	6-22
MEMORY MAP DATA FORMATS	B-48
MENU HEIRARCHY	1-9, 4-10
MENU NAVIGATION	1-9, 4-9, 4-10
METERING	
conventions	6-8, 6-9
current	2-9
demand	2-10
frequency	2-10
harmonics	2-9
power	2-9
THD	2-9
voltage	2-9
METERING CONVENTIONS	6-9
MIC	C-3
MMS	
see entry for UCA/MMS	
MODBUS	
data logger	B-6, B-7
event recorder	B-7
exception responses	B-5
execute operation	B-4
fault report	B-7
flex state parameters	5-28
function code 03/04h	B-3
function code 05h	B-4
function code 06h	B-4
function code 10h	B-5
introduction	B-1
memory map data formats	B-48
obtaining files	B-6
oscillography	B-6
passwords	B-7
read/write settings/actual values	B-3
settings	5-11, 5-16
store multiple settings	B-5
store single setting	B-4
supported function codes	B-3
user map	5-16
user map Modbus registers	B-9
MODEL INFORMATION	6-22
MODIFICATION FILE NUMBER	6-22
MODULES	
communications	3-19
contact inputs/outputs	3-13, 3-15, 3-16
CT	3-11
CT/VT	3-10, 5-6
direct inputs/outputs	3-24
Hi-Z	3-11
insertion	3-4
order codes	2-4
ordering	2-4
power supply	3-9
transducer I/O	3-18
VT	3-11
withdrawal	3-4
MONITORING ELEMENTS	5-142
MOUNTING	3-1

N

NAMEPLATE	1-1
NEGATIVE SEQUENCE DIRECTIONAL OVERCURRENT	

characteristics	5-96
FlexLogic™ operands	5-55
logic	5-97
settings	5-95, 5-97
specifications	2-6
NEGATIVE SEQUENCE IOC	
FlexLogic™ operands	5-55
logic	5-94
settings	5-94
specifications	2-5
NEGATIVE SEQUENCE OVERVOLTAGE	
FlexLogic™ operands	5-55
logic	5-111
settings	5-111
specifications	2-6
NEGATIVE SEQUENCE TOC	
FlexLogic™ operands	5-55
logic	5-93
settings	5-93
specifications	2-5
NEUTRAL DIRECTIONAL OVERCURRENT	
FlexLogic™ operands	5-55
logic	5-89
polarization	5-88
settings	5-86
specifications	2-6
NEUTRAL INSTANTANEOUS OVERCURRENT	
see entry for NEUTRAL IOC	
NEUTRAL IOC	
FlexLogic™ operands	5-55
logic	5-85
settings	5-85
specifications	2-5
NEUTRAL OVERVOLTAGE	
FlexLogic™ operands	5-55
logic	5-110
settings	5-110
specifications	2-6
NEUTRAL TIME OVERCURRENT	
see entry for NEUTRAL TOC	
NEUTRAL TOC	
FlexLogic™ operands	5-55
logic	5-84
settings	5-84
specifications	2-5
NON-VOLATILE LATCHES	
FlexLogic™ operands	5-55
settings	5-69
specifications	2-8

O

ONE SHOTS	5-59
OPERATING TEMPERATURE	2-13
OPERATING TIMES	2-5
ORDER CODES	2-3, 6-22, 7-2
ORDER CODES, UPDATING	7-2
ORDERING	2-3, 2-4
OSCILLATORY TRANSIENT TESTING	2-13
OSCILLOGRAPHY	
actual values	6-20
clearing	5-9, 7-1
Modbus	B-6
settings	5-18
specifications	2-9
with URPC	4-2
OUTPUTS	

contact outputs	3-13, 3-15, 5-156
control power	2-11
critical failure relay	2-11
Fast Form-C relay	2-11
Form-A relay	2-11, 3-12, 3-13, 3-17
Form-C relay	2-11, 3-12, 3-17
latching outputs	2-11, 5-156
remote outputs	5-161, 5-162
virtual outputs	5-158
OVERCURRENT CURVE TYPES	5-73
OVERCURRENT CURVES	
definite time	5-77
FlexCurves™	5-77
I2T	5-77
IAC	5-76
IEC	5-75
IEEE	5-74
OVERCURRENT DISTURBANCE MONITORING	8-3
OVERFREQUENCY	
FlexLogic™ operands	5-55
logic	5-124
settings	5-124
specifications	2-7
OVERVOLTAGE	
auxiliary	2-6, 5-113
negative sequence	5-111
negative-sequence	2-6
neutral	2-6, 5-110
phase	2-6, 5-109

P

PANEL CUTOUT	3-1
PASSWORD SECURITY	5-7
PASSWORDS	
changing	4-13
lost password	4-13, 5-7
Modbus	B-7
overview	1-10
security	5-7
settings	5-7
PC SOFTWARE	
see entry for URPC	
PERMISSIVE FUNCTIONS	5-107
PER-UNIT QUANTITY	5-4
PHASE ANGLE METERING	6-9
PHASE CURRENT METERING	6-11
PHASE DIRECTIONAL OVERCURRENT	
FlexLogic™ operands	5-55
logic	5-83
phase A polarization	5-81
settings	5-81, 5-82
specifications	2-5
PHASE INSTANTANEOUS OVERCURRENT	
see entry for PHASE IOC	
PHASE IOC	
FlexLogic™ operands	5-55
logic	5-80
specifications	2-5
PHASE OVERVOLTAGE	
FlexLogic™ operands	5-56
logic	5-109
settings	5-109
specifications	2-6
PHASE ROTATION	5-38
PHASE TIME OVERCURRENT	
see entry for PHASE TOC	

PHASE TOC	
FlexLogic™ operands	5-56
logic	5-79
settings	5-78
specifications	2-5
PHASE UNDERVOLTAGE	
FlexLogic™ operands	5-56
logic	5-108
settings	5-108
specifications	2-6
PHONE NUMBERS	1-1
PICS	C-2
POWER METERING	
Modbus registers	B-11
specifications	2-9
values	6-12
POWER SUPPLY	
description	3-9
low range	2-11
specifications	2-11
PRODUCT INFORMATION	6-22
Modbus registers	B-8
PRODUCT SETUP	5-7
PRODUCTION TESTS	2-13
PROTECTION ELEMENTS	5-4
PU QUANTITY	5-4
PUSHBUTTONS, USER-PROGRAMMABLE	
see USER-PROGRAMMABLE PUSHBUTTONS	

R

RANDOMNESS ALGORITHM FOR HI-Z	8-2
REACTIVE POWER	2-9, 6-12
REAL POWER	2-9, 6-12
REAL TIME CLOCK	5-16
REAR TERMINAL ASSIGNMENTS	3-5
RECLOSER CURVES	5-47, 5-77
REDUNDANT 10BASE-F	3-19
RELAY ACTIVATION	4-12
RELAY ARCHITECTURE	5-51
RELAY MAINTENANCE	7-2
RELAY NAME	5-35
RELAY NOT PROGRAMMED	1-10
REMOTE DEVICES	
actual values	6-4
device ID	5-159
FlexLogic™ operands	5-57
Modbus registers	B-9
settings	5-159
statistics	6-5
REMOTE INPUTS	
actual values	6-3
FlexLogic™ operands	5-57
settings	5-160
specifications	2-10
REMOTE OUTPUTS	
DNA-1 bit pair	5-161
UserSt-1 bit pair	5-162, 5-163
REPLACEMENT MODULES	2-4
RESETTING	5-57, 5-162
REVISION HISTORY	F-1
RFI SUSCEPTIBILITY	2-13
RFI, CONDUCTED	2-13
RMS CURRENT	2-9
RMS VOLTAGE	2-9
ROLLING DEMAND	5-21
RS232	

configuration	1-6
specifications	2-12
wiring	3-19
RS422	
configuration	3-27
timing	3-29
two-channel application	3-28
with fiber interface	3-30
RS485	
communications	3-19
description	3-20
specifications	2-12
RTD INPUTS	
actual values	6-17
settings	5-167
specifications	2-10

S

SALES OFFICE	1-1
SCAN OPERATION	1-4
SELECTOR SWITCH	
actual values	6-5
application example	5-122
FlexLogic™ operands	5-56
logic	5-122
settings	5-118
specifications	2-8
timing	5-120, 5-121
SELF-TESTS	
description	7-3
error messages	7-4
FlexLogic™ operands	5-58
Modbus registers	B-8
SENSITIVE DIRECTIONAL POWER	
actual values	6-15
FlexLogic™ operands	5-54
logic	5-116
Modbus registers	B-10
settings	5-114, 5-116
specifications	2-6
SENSITIVE DIRECTIONAL POWER	
characteristic	5-115
SERIAL NUMBER	6-22
SERIAL PORTS	5-10
SETTING GROUPS	5-56, 5-70, 5-117
SETTINGS, CHANGING	4-11
SIGNAL SOURCES	
description	5-5
metering	6-11
settings	5-39
SIGNAL TYPES	1-3
SINGLE LINE DIAGRAM	2-1, 2-2
SITE LIST, CREATING	4-1
SNTP PROTOCOL	
settings	5-16
SOFTWARE	
see entry for URPC	
SOFTWARE ARCHITECTURE	1-4
SOFTWARE, PC	
see entry for URPC	
SOURCE TRANSFER SCHEMES	5-107
SOURCES	
description	5-5
metering	6-11
Modbus registers	B-10
settings	5-38, 5-39

SPECIFICATIONS	2-5
SPECTRAL ANALYSIS ALGORITHM FOR HI-Z	8-2
ST TYPE CONNECTORS	3-21
STANDARD ABBREVIATIONS	F-4
STATUS INDICATORS	4-5
SURGE IMMUNITY	2-13
SYMMETRICAL COMPONENTS METERING	6-9
SYNCHROCHECK	
actual values	6-16
FlexLogic™ operands	5-56
logic	5-130
settings	5-127, 5-128
specifications	2-7
SYSTEM FREQUENCY	5-37
SYSTEM SETUP	5-36

T

TARGET MESSAGES	7-3
TARGET SETTING	5-4
TARGETS MENU	7-3
TCP PORT NUMBER	5-14
TEMPERATURE, OPERATING	2-13
TERMINALS	3-5
TESTING	
force contact inputs	5-168
force contact outputs	5-169
lamp test	7-2
self-test error messages	7-3
THD METERING	2-9, 6-14
analog channel correspondence	5-19
THEORY OF OPERATION	8-1
THERMAL DEMAND CHARACTERISTIC	5-21
TIME	7-2
TIME OVERCURRENT	
see PHASE, NEUTRAL, and GROUND TOC entries	
TIMERS	5-64
TOC	
ground	5-90
neutral	5-84
phase	5-78
specifications	2-5
TRACKING FREQUENCY	6-16
TRANSDUCER I/O	
actual values	6-17
settings	5-166, 5-167
specifications	2-10
wiring	3-18
TRIP LEDs	5-24
TROUBLE INDICATOR	1-10, 7-3
TYPE TESTS	2-13
TYPICAL WIRING DIAGRAM	3-6, 3-7

U

UCA SBO TIMER	
for breaker control	5-41
for virtual inputs	5-155
UCA/MMS	
device ID	5-159
DNA2 assignments	5-161
MIC	C-3
overview	C-1
PICS	C-2
remote device settings	5-159

remote inputs	5-160
reporting.....	C-6
SBO timeout	5-41, 5-155
settings	5-14
UserSt-1 bit pair	5-162, 5-163
UL APPROVAL.....	2-13
UNAUTHORIZED ACCESS	
resetting	5-9, 7-2
UNDERFREQUENCY	
FlexLogic™ operands	5-56
logic	5-123
settings	5-123
specifications.....	2-6
UNDERVOLTAGE	
auxiliary	2-6
phase	2-6, 5-108
UNDERVOLTAGE CHARACTERISTICS	5-107
UNIT NOT PROGRAMMED.....	5-35
UNPACKING THE RELAY.....	1-1
UNRETURNED MESSAGES ALARM	5-35
UPDATING ORDER CODE	7-2
URPC	
creating a site list	4-1
event recorder	4-2
firmware upgrades	4-2
installation.....	1-5
introduction	4-1
oscillography	4-2
overview.....	4-1
requirements	1-5
USER-DEFINABLE DISPLAYS	
example	5-30
invoking and scrolling	5-28
Modbus registers	B-9
settings	5-28, 5-30
specifications.....	2-8
USER-PROGRAMMABLE LEDs	
custom labeling	4-7
defaults	4-6
description.....	4-6
settings	5-24
specifications.....	2-8
USER-PROGRAMMABLE PUSHBUTTONS	
FlexLogic™ operands	5-58
settings	5-26
specifications.....	2-8
USER-PROGRAMMABLE SELF TESTS	
settings	5-25
USERST-1 BIT PAIR	5-162, 5-163

V

VAR-HOURS	2-9, 6-13
VIBRATION TESTING	2-13
VIRTUAL INPUTS	
actual values.....	6-3
commands	7-1
FlexLogic™ operands	5-57
logic	5-155
Modbus registers.....	B-8, B-9
settings	5-155
VIRTUAL OUTPUTS	
actual values.....	6-4
FlexLogic™ operands	5-57
settings	5-158
VOLTAGE BANKS	5-37
VOLTAGE DEVIATIONS	2-13
VOLTAGE ELEMENTS	5-107
VOLTAGE HARMONICS	6-14
VOLTAGE METERING	
Modbus registers.....	B-11
specifications	2-9
values	6-11
VOLTAGE RESTRAINT CHARACTERISTIC	5-78
VT FUSE FAILURE	
logic	5-150
settings	5-150
VT INPUTS	3-10, 5-6, 5-37
VT WIRING	3-11
VTFF	
FlexLogic™ operands	5-57
see VT FUSE FAILURE	

W

WARRANTY	F-6
WATT-HOURS	2-9, 6-13
WEB SERVER PROTOCOL	5-14
WEBSITE	1-1
WIRING DIAGRAM	3-6, 3-7

Z

ZERO SEQUENCE CORE BALANCE	3-10
----------------------------------	------