



GE VERNOVA

B90

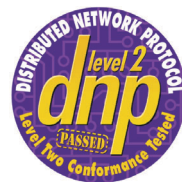
Low Impedance Bus Differential System



Instruction Manual

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B90 Low Impedance Bus Differential System

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B90 Low Impedance Bus Differential System

Chapter 1: Introduction

This chapter outlines safety and technical support information.

1.1 Safety symbols and definitions

Before attempting to install or use the device, review all safety indicators in this document to help prevent injury, equipment damage, or downtime.

The following safety and equipment symbols are used in this document.



Indicates a hazardous situation which, if not avoided, will result in death or serious injury.



Indicates a hazardous situation which, if not avoided, could result in death or serious injury.



Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.



Indicates practices not related to personal injury.

1.1.1 General cautions and warnings

The following general safety precautions and warnings apply.



Ensure that all connections to the product are correct so as to avoid accidental risk of shock and/or fire, for example such as can arise from high voltage connected to low voltage terminals.

Follow the requirements of this manual, including adequate wiring size and type, terminal torque settings, voltage, current magnitudes applied, and adequate isolation/clearance in external wiring from high to low voltage circuits.

Use the device only for its intended purpose and application.

Ensure that all ground paths are uncompromised for safety purposes during device operation and service.

Ensure that the control power applied to the device, the AC current, and voltage input match the ratings specified on the relay nameplate. Do not apply current or voltage in excess of the specified limits.

1

Only qualified personnel are to operate the device. Such personnel must be thoroughly familiar with all safety cautions and warnings in this manual and with applicable country, regional, utility, and plant safety regulations. Hazardous voltages can exist in the power supply and at the device connection to current transformers, voltage transformers, control, and test circuit terminals. Make sure all sources of such voltages are isolated prior to attempting work on the device.

Hazardous voltages can exist when opening the secondary circuits of live current transformers. Make sure that current transformer secondary circuits are shorted out before making or removing any connection to the current transformer (CT) input terminals of the device.

For tests with secondary test equipment, ensure that no other sources of voltages or currents are connected to such equipment and that trip and close commands to the circuit breakers or other switching apparatus are isolated, unless this is required by the test procedure and is specified by appropriate utility/plant procedure.

When the device is used to control primary equipment, such as circuit breakers, isolators, and other switching apparatus, all control circuits from the device to the primary equipment must be isolated while personnel are working on or around this primary equipment to prevent any inadvertent command from this device.

Use an external disconnect to isolate the mains voltage supply.

Personal safety can be affected if the product is physically modified by the end user. Modifications to the product outside of recommended wiring configuration, hardware, or programming boundaries is not recommended end-use practice. Product disassembly and repairs are not permitted. All service needs to be conducted by the factory.



LED transmitters are classified as IEC 60825-1 Accessible Emission Limit (AEL) Class 1M. Class 1M devices are considered safe to the unaided eye. Do not view directly with optical instruments.

NOTICE

This product is rated to Class A emissions levels and is to be used in Utility, Substation Industrial environments. Not to be used near electronic devices rated for Class B levels.

1.2 For further assistance

For product support, contact the information and call center as follows:

GE Grid Solutions
650 Markland Street
Markham, Ontario
Canada L6C 0M1
Worldwide telephone: +1 905 927 7070
Europe/Middle East/Africa telephone: +34 94 485 88 54
North America toll-free: 1 800 547 8629
Fax: +1 905 927 5098
Worldwide e-mail: multilin.tech@ge.com
Europe e-mail: multilin.tech.euro@ge.com
Website: <http://www.gegridsolutions.com/multilin>

B90 Low Impedance Bus Differential System

Chapter 2: Product description

This chapter outlines the product, order codes, and specifications.

2.1 Product description

2.1.1 Overview

The B90 Low Impedance Bus Differential System is a microprocessor-based architecture that provides protection and metering for busbars with up to 24 feeders. The B90 protection system is a centralized architecture built on one B90 IED as per requirements of a particular application. The IED is a full-featured B90 and as such can be accessed and programmed individually. Protection and supervisory functions of the B90 include:

- Multi-zone differential protection with both restrained (percent, biased) and unrestrained (unbiased, instantaneous) functions incorporated. Differential protection is fast (typical response time: $\frac{3}{4}$ of a power cycle; maximum response time: 1 power cycle) and secure. Security is achieved by using fast and reliable CT saturation detection algorithm and a second, phase comparison operating principle.
- Check-zone functionality is provided by programming one of the differential zones to enclose the entire bus
- Dynamic bus replica functionality and multi-zone protection allowing application of the B90 to multi-section re-configurable busbars
- Isolator monitoring feature monitors up to 48 isolators from the B90 IED
- End fault protection (dead zone protection) is provided for up to 24 breakers
- CT trouble monitoring function is provided for each zone of differential protection
- Breaker fail function is provided for up to 24 breakers
- An instantaneous overcurrent function is available per each current input of the B90 system
- A time overcurrent function is available per each current input of the B90 system for backup protection
- An undervoltage function is provided per each voltage input of the B90 system for supervision purposes

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

Diagnostic features include an event recorder capable of storing 1024 time-tagged events and oscillography capable of storing up to 64 records with programmable trigger, content, and sampling rate. The internal clock used for time-tagging can be synchronized with an IRIG-B signal, using the Simple Network Time Protocol (SNTP) over the Ethernet port, or using the Precision Time Protocol (PTP). This precise time stamping allows the sequence of events to be determined between the

B90 IEDs and throughout the system. Events can also be programmed (via FlexLogic™ equations) to trigger oscillography data capture that can be set to record the measured parameters before and after the event for viewing on a computer. These tools significantly reduce troubleshooting time and simplify report generation in the event of a system fault.

Several options are available for communication. A faceplate RS232 port can be used to connect to a computer for the programming of settings and the monitoring of actual values. The rear RS485 port allows independent access by operating and engineering staff. It can be connected to system computers with baud rates up to 115.2 kbps. All serial ports use the Modbus RTU protocol. The IEC 60870-5-103 protocol is supported on the RS485 interface. IEC 60870-5-103, DNP, and Modbus cannot be enabled simultaneously on this interface. Also only one of the DNP, IEC 60870-5-103, and IEC 60870-5-104 protocols can be enabled at any time on the relay. When the IEC 60870-5-103 protocol is chosen, the RS485 port has a fixed even parity and the baud rate can be either 9.6 kbps or 19.2 kbps. The 100Base-FX or 100Base-TX Ethernet interface provides fast, reliable communications in noisy environments. The Ethernet port supports IEC 61850, Modbus/TCP, TFTP, and PTP (according to IEEE Std. 1588-2008 or IEC 61588), and it allows access to the relay via any standard web browser (B90 web pages). The IEC 60870-5-104 protocol is supported on the Ethernet port. The Ethernet port also supports the Parallel Redundancy Protocol (PRP) of IEC 62439-3 (clause 4, 2012) when purchased as an option.

Settings and actual values can be accessed from the front panel or EnerVista software.

The B90 uses flash memory technology that allows field upgrading as new features are added. Firmware and software are upgradable.

The following single-line diagram illustrates the relay functionality using American National Standards Institute (ANSI) device numbers.

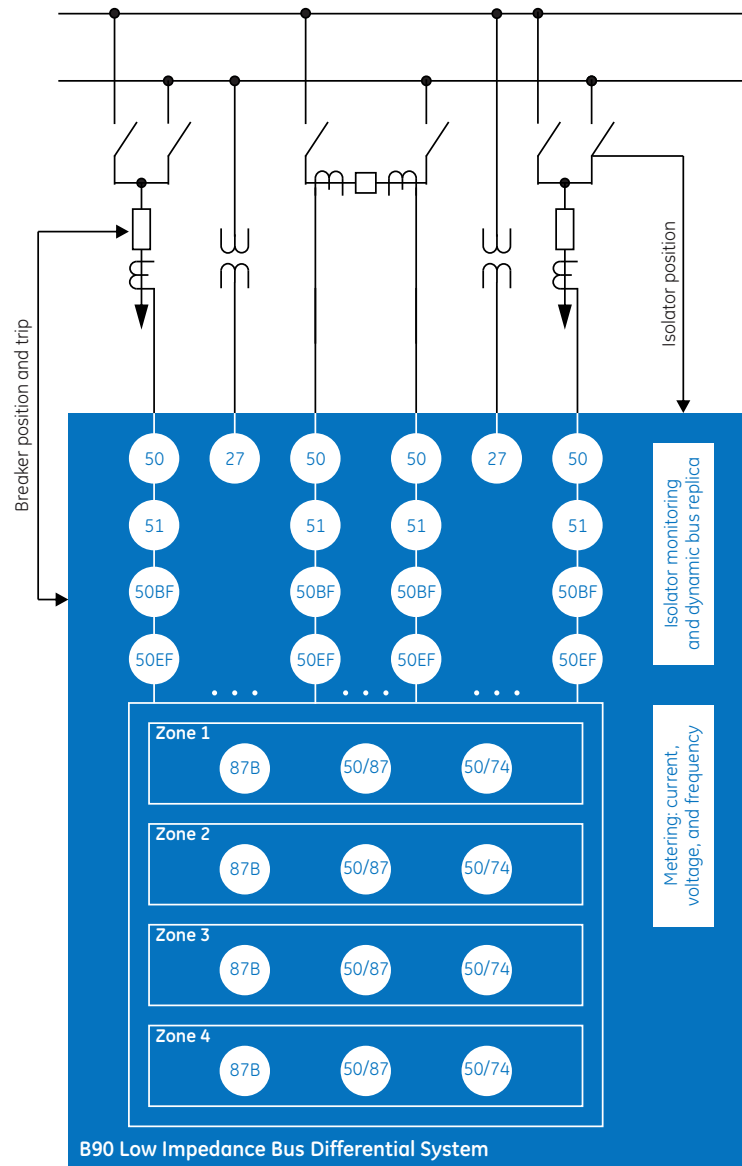


The available zones of differential protection and their size (maximum number of inputs) are optional and controlled by the software option portion of the order code. The breaker failure function is also optional. See the ordering section for information on the maximum number of zones and inputs for a given model. In addition, different applications can require differing numbers of B90s with different hardware configurations.

Table 2-1: ANSI device numbers and functions supported

Device number	Function	Device number	Function
27	Undervoltage	51	Time overcurrent
50	Instantaneous overcurrent	50BF	Breaker failure
50/74	CT trouble	50EF	End fault protection
50/87	Unrestrained bus differential		

Figure 2-1: Single-line diagram



836752A5.CDR

Table 2-2: Other device functions

Function	Function
Contact inputs (up to 96 per IED)	Modbus communications
Contact outputs (up to 64 per IED)	Modbus user map
Control pushbuttons	Non-volatile latches
CyberSentry™ security	Oscillography
Digital elements (48 per IED)	Setting groups (6)
Direct inputs and outputs (96)	Time synchronization over IRIG-B or IEEE 1588
DNP 3.0 or IEC 60870-5-104 communications	Time synchronization over SNTP
Dynamic bus replica	User definable displays
End fault protection	User-programmable fault reports
Event recorder	User-programmable LEDs

Function
IEC 60870-5-103 communications
FlexLogic equations
IEC 61850 communications
Metering: current, voltage, frequency

Function
User-programmable pushbuttons
User-programmable self-tests
Virtual inputs (64 per IED)
Virtual outputs (96 per IED)

2

2.2 Security

The following security features are available:

- Password security — Basic security present by default
- EnerVista security — Role-based access to various EnerVista software screens and configuration elements. The feature is present by default in the EnerVista software.
- CyberSentry security — Advanced security available as a software option. When purchased, the options are automatically enabled, and the default Password security and EnerVista security are disabled.

2.2.0.1 EnerVista security

The EnerVista security management system is a role-based access control (RBAC) system that allows an administrator to manage the privileges of multiple users. This allows for access control of UR devices by multiple personnel within a substation and conforms to the principles of RBAC as defined in ANSI INCITS 359-2004. The EnerVista security management system is disabled by default to allow the administrator direct access to the EnerVista software after installation. It is recommended that security be enabled before placing the device in service.

Basic password or enhanced CyberSentry security applies, depending on purchase.

2.2.0.2 Password security

Password security is a basic security feature present by default.

Two levels of password security are provided: command and setting. Use of a password for each level controls whether users can enter commands and/or change settings.

The B90 supports password entry from a local or remote connection. Local access is defined as any access to settings or commands via the faceplate interface. This includes both keypad entry and the through the faceplate RS232 port. Remote access is defined as any access to settings or commands via any rear communications port. This includes both Ethernet and RS485 connections. Any changes to the local or remote passwords enables this functionality.

When entering a settings or command password via EnerVista or any serial interface, the user must enter the corresponding connection password. If the connection is to the back of the B90, the remote password must be used. If the connection is to the RS232 port of the faceplate, the local password applies.

Password access events are logged in the Event Recorder.

2.2.0.3 CyberSentry security

CyberSentry embedded security is a software option that provides advanced security services. When this option is purchased, the basic password security is disabled automatically.

CyberSentry provides security through the following features:

- An Authentication, Authorization, Accounting (AAA) Remote Authentication Dial-In User Service (RADIUS) client that is centrally managed, enables user attribution, provides accounting of all user activities, and uses secure standards-based strong cryptography for authentication and credential protection
- A Role-Based Access Control (RBAC) system that provides a permission model that allows access to UR device operations and configurations based on specific roles and individual user accounts configured on the AAA server (that is, Administrator, Supervisor, Engineer, Operator, Observer roles)
- Security event reporting through the Syslog protocol for supporting Security Information Event Management (SIEM) systems for centralized cybersecurity monitoring

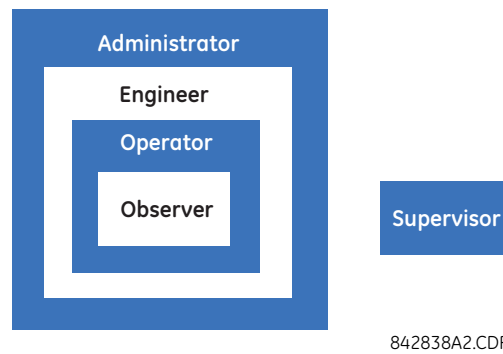
- Strong encryption of all access and configuration network messages between the EnerVista software and UR devices using the Secure Shell (SSH) protocol, the Advanced Encryption Standard (AES), and 128-bit keys in Galois Counter Mode (GCM) as specified in the U.S. National Security Agency Suite B extension for SSH and approved by the National Institute of Standards and Technology (NIST) FIPS-140-2 standards for cryptographic systems

CyberSentry user roles

CyberSentry user roles (Administrator, Engineer, Operator, Supervisor, Observer) limit the levels of access to various UR device functions. This means that the EnerVista software allows for access to functionality based on the user's logged in role.

Example: Administrative functions can be segmented away from common operator functions, or engineering type access, all of which are defined by separate roles (see figure) so that access of UR devices by multiple personnel within a substation is allowed.

Figure 2-2: CyberSentry user roles



The table lists user roles and their corresponding capabilities.

Table 2-3: Permissions by user role for CyberSentry

Roles	Administrator	Engineer	Operator	Supervisor	Observer
	Complete access	Complete access except for CyberSentry Security	Command menu	Authorizes writing	Default role
Device Definition	R	R	R	R	R
Settings					
----- Product Setup					
----- Security (CyberSentry)	RW	R	R	R	R
----- Supervisory	See table notes	R	R	See table notes	R
----- Display Properties	RW	RW	R	R	R
----- Clear Relay Records (settings)	RW	RW	R	R	R
----- Communications	RW	RW	R	R	R
----- Modbus User Map	RW	RW	R	R	R
----- Real Time Clock	RW	RW	R	R	R
----- Oscillography	RW	RW	R	R	R
----- Data Logger	RW	RW	R	R	R
----- Demand	RW	RW	R	R	R
----- User-Programmable LEDs	RW	RW	R	R	R

Roles	Administrator	Engineer	Operator	Supervisor	Observer
----- User-Programmable Self Tests	RW	RW	R	R	R
----- Control Pushbuttons	RW	RW	R	R	R
----- User-Programmable Pushbuttons	RW	RW	R	R	R
----- Flex state Parameters	RW	RW	R	R	R
----- User-Definable Displays	RW	RW	R	R	R
----- Direct I/O	RW	RW	R	R	R
----- Teleprotection	RW	RW	R	R	R
----- Installation	RW	RW	R	R	R
----- System Setup	RW	RW	R	R	R
----- FlexLogic	RW	RW	R	R	R
----- Grouped Elements	RW	RW	R	R	R
----- Control Elements	RW	RW	R	R	R
----- Inputs / Outputs	RW	RW	R	R	R
----- Contact Inputs	RW	RW	R	R	R
----- Contact Input threshold	RW	RW	R	R	R
----- Virtual Inputs	RW	RW	R	R	R
----- Contact Outputs	RW	RW	R	R	R
----- Virtual Outputs	RW	RW	R	R	R
----- Resetting	RW	RW	R	R	R
----- Direct Inputs	RW	RW	R	R	R
----- Direct Outputs	RW	RW	R	R	R
----- Teleprotection	RW	RW	R	R	R
----- Direct Analogs	RW	RW	R	R	R
----- Direct Integers	RW	RW	R	R	R
----- Transducer I/O	RW	RW	R	R	R
----- Testing	RW	RW	R	R	R
----- Front Panel Labels Designer	NA	NA	NA	NA	NA
----- Protection Summary	NA	NA	NA	NA	NA
Commands	RW	RW	RW	R	R
----- Virtual Inputs	RW	RW	RW	R	R
----- Clear Records	RW	RW	RW	R	R
----- Set Date and Time	RW	RW	RW	R	R
User Displays	R	R	R	R	R
Targets	R	R	R	R	R
Actual Values	R	R	R	R	R
----- Front panel labels designer	R	R	R	R	R
----- Status	R	R	R	R	R
----- Metering	R	R	R	R	R
----- Transducer I/O	R	R	R	R	R
----- Records	R	R	R	R	R
----- Product Info	R	R	R	R	R
Maintenance	RW	RW	R	R	R
----- Modbus analyzer	NA	NA	NA	NA	NA

Roles	Administrator	Engineer	Operator	Supervisor	Observer
----- Change front panel	RW	RW	RW	R	R
----- Update firmware	Yes	No	No	No	No
----- Retrieve file	Yes	No	No	No	No

Table Notes:

RW = read and write access

R = read access

Supervisor = RW (default), Administrator = R (default), Administrator = RW (only if Supervisor role is disabled)

NA = the permission is not enforced by CyberSentry security

CyberSentry user authentication

The following types of authentication are supported by CyberSentry to access the UR device:

- Device Authentication (local UR device authenticates)
- Server Authentication (RADIUS server authenticates)

The EnerVista software allows access to functionality that is determined by the user role, which comes either from the local UR device or the RADIUS server.

The EnerVista software has a device authentication option on the login screen for accessing the UR device. When the "Device" button is selected, the UR uses its local authentication database and not the RADIUS server to authenticate the user. In this case, it uses its built-in roles (Administrator, Engineer, Supervisor, Observer, Operator, or Administrator and Supervisor when Device Authentication is disabled) as login names and the associated passwords are stored on the UR device. As such, when using the local accounts, access is not user-attributable.

In cases where user-attributable access is required especially to facilitate auditable processes for compliance reasons, use RADIUS authentication only.

When the "Server" Authentication Type option is selected, the UR uses the RADIUS server and not its local authentication database to authenticate the user.

No password or security information is displayed in plain text by the EnerVista software or UR device, nor is such information ever transmitted without cryptographic protection.

CyberSentry server authentication

The UR has been designed to direct automatically the authentication requests based on user names. In this respect, local account names on the UR are considered as reserved and not used on a RADIUS server.

The UR detects automatically whether an authentication request is to be handled remotely or locally. As there are five local accounts possible on the UR, if the user ID credential does not match one of the five local accounts, the UR forwards automatically the request to a RADIUS server when one is provided.

If a RADIUS server is provided, but is unreachable over the network, server authentication requests are denied. In this situation, use local UR accounts to gain access to the UR system.

2.3 Order codes

A B90 protection system consists of several UR-series B90 IEDs as per user needs and system configuration. At least three IEDs are required to provide differential and other protection functions for phases A, B, and C of the busbar. The fourth IED is required for breaker failure functionality and isolator status monitoring as well as extra input and output capability. A fifth IED is sometimes required for additional input and output capability.

Before ordering the B90 system, an analysis of the required protection and monitoring functions is required. Also, detailed analyses of required AC inputs and input/output contacts must be performed to select appropriate hardware configurations for each of the B90 IEDs.



The B90 is provided with an option of protecting 8, 16, or 24-feeder busbars. When ordered as an eight-feeder protection system, the B90 is configurable for up to eight-input bus differential, regardless of the number of physical current inputs available in the B90 IEDs.

The relay is available as a 19-inch rack horizontal mount unit and consists of the following modules: power supply, CPU, CTs and VTs, contact inputs and outputs, and inter-relay communications. Each of these modules can be supplied in a number of configurations specified at the time of ordering. The information required to completely specify the relay is provided in the following tables (see chapter 3 for full details of relay modules).

Order codes are subject to change without notice. See the web page for the product for the latest options.

Table 2-4: B90 order codes

BASE CPU	B90 - * ** - H * * - F ** - H ** - L ** - N ** - S ** - U ** - W/X **																								Full Size Horizontal Mount Base Unit		
	T	U																									
SOFTWARE OPTIONS	V																										RS485 with 3 100Base-FX Ethernet, multimode, SFP with LC multimode, SFP with LC RS485 with 1 100Base-TX Ethernet, SFP RJ-45 +2 100Base-FX Ethernet, multimode, SFP with LC RS485 with 3 100Base-TX Ethernet, SFP with RJ-45
	00																										Six-zone 8-feeder bus protection
	01																										Six-zone 16-feeder bus protection
	02																										Six-zone 24-feeder bus protection
	03																										Single-zone 24-feeder bus protection
	04																										Six-zone 8-feeder bus protection + IEC 61850
	05																										Six-zone 16-feeder bus protection + IEC 61850
	06																										Six-zone 24-feeder bus protection + IEC 61850
	07																										Single-zone 24-feeder bus protection + IEC 61850
	10																										Six-zone 8-feeder bus protection + breaker failure
	11																										Six-zone 16-feeder bus protection + breaker failure
	12																										Six-zone 24-feeder bus protection + breaker failure
	13																										Single-zone 24-feeder bus protection + breaker failure
	14																										Six-zone 8-feeder bus protection + IEC 61850 + breaker failure
	15																										Six-zone 16-feeder bus protection + IEC 61850 + breaker failure
	16																										Six-zone 24-feeder bus protection + IEC 61850 + breaker failure
	17																										Single-zone 24-feeder bus protection + IEC 61850 + breaker failure
	A0																										Six-zone 8-feeder bus protection + CyberSentry Lvl 1
	A1																										Six-zone 16-feeder bus protection + CyberSentry Lvl 1
	A2																										Six-zone 24-feeder bus protection + CyberSentry Lvl 1
	A3																										Single-zone 24-feeder bus protection + CyberSentry Lvl 1
	A4																										Six-zone 8-feeder bus protection + IEC 61850 + CyberSentry Lvl 1
	A5																										Six-zone 16-feeder bus protection + IEC 61850 + CyberSentry Lvl 1
	A6																										Six-zone 24-feeder bus protection + IEC 61850 + CyberSentry Lvl 1
	A7																										Single-zone 24-feeder bus protection + IEC 61850 + CyberSentry Lvl 1
	A8																										Six-zone 8-feeder bus protection + breaker failure + CyberSentry Lvl 1
	A9																										Six-zone 16-feeder bus protection + breaker failure + CyberSentry Lvl 1
	AA																										Six-zone 24-feeder bus protection + breaker failure + CyberSentry Lvl 1
	AB																										Single-zone 24-feeder bus protection + breaker failure + CyberSentry Lvl 1
	AC																										Six-zone 8-feeder bus protection + IEC 61850 + breaker failure + CyberSentry Lvl 1
		AD																									Six-zone 16-feeder bus protection + IEC 61850 + breaker failure + CyberSentry Lvl 1
		AE																									Six-zone 24-feeder bus protection + IEC 61850 + breaker failure + CyberSentry Lvl 1
		AF																									Single-zone 24-feeder bus protection + IEC 61850 + breaker failure + CyberSentry Lvl 1
		B0																									Six-zone 8-feeder bus protection + IEEE 1588
		B1																									Six-zone 16-feeder bus protection + IEEE 1588
		B2																									Six-zone 24-feeder bus protection + IEEE 1588
		B3																									Single-zone 24-feeder bus protection + IEEE 1588
		B4																									Six-zone 8-feeder bus protection + IEC 61850 + IEEE 1588
		B5																									Six-zone 16-feeder bus protection + IEC 61850 + IEEE 1588
		B6																									Six-zone 24-feeder bus protection + IEC 61850 + IEEE 1588
	B7																									Single-zone 24-feeder bus protection + IEC 61850 + IEEE 1588	
	B8																									Six-zone 8-feeder bus protection + breaker failure + IEEE 1588	
	B9																									Six-zone 16-feeder bus protection + breaker failure + IEEE 1588	
	BA																									Six-zone 24-feeder bus protection + breaker failure + IEEE 1588	
	BB																									Single-zone 24-feeder bus protection + breaker failure + IEEE 1588	
	BC																									Six-zone 8-feeder bus protection + IEC 61850 + breaker failure + IEEE 1588	
	BD																									Six-zone 16-feeder bus protection + IEC 61850 + breaker failure + IEEE 1588	
	BE																									Six-zone 24-feeder bus protection + IEC 61850 + breaker failure + IEEE 1588	
	BF																									Single-zone 24-feeder bus protection + IEC 61850 + breaker failure + IEEE 1588	
	C0																									Parallel Redundancy Protocol (PRP) + six-zone 8-feeder bus protection	
	C1																									PRP + six-zone 16-feeder bus protection	
	C2																									PRP + six-zone 24-feeder bus protection	
	C3																									PRP + single-zone 24-feeder bus protection	
	C4																									PRP + six-zone 8-feeder bus protection + IEC 61850	
	C5																									PRP + six-zone 16-feeder bus protection + IEC 61850	
	C6																									PRP + six-zone 24-feeder bus protection + IEC 61850	
	C7																									PRP + single-zone 24-feeder bus protection + IEC 61850	
	C8																									PRP + six-zone 8-feeder bus protection + breaker failure	
	C9																									PRP + six-zone 16-feeder bus protection + breaker failure	
	CA																									PRP + six-zone 24-feeder bus protection + breaker failure	
	CB																									PRP + single-zone 24-feeder bus protection + breaker failure	
	CC																									PRP + six-zone 8-feeder bus protection + breaker failure + IEC 61850	
	CD																									PRP + six-zone 16-feeder bus protection + breaker failure + IEC 61850	
	CE																									PRP + six-zone 24-feeder bus protection + breaker failure + IEC 61850	
	CF																									PRP + single-zone 24-feeder bus protection + breaker failure + IEC 61850	
	D0																									Six-zone 8-feeder bus protection + IEEE 1588 + CyberSentry Lvl 1	
	D1																									Six-zone 16-feeder bus protection + IEEE 1588 + CyberSentry Lvl 1	
	D2																									Six-zone 24-feeder bus protection + IEEE 1588 + CyberSentry Lvl 1	
	D3																									Single-zone 24-feeder bus protection + IEEE 1588 + CyberSentry Lvl 1	
	D4																									Six-zone 8-feeder bus protection + IEC 61850 + IEEE 1588 + CyberSentry Lvl 1	
	D5																									Six-zone 16-feeder bus protection + IEC 61850 + IEEE 1588 + CyberSentry Lvl 1	

B90	- *	**	- H *	* - F **	- H **	- L **	- N **	- S **	- U **	- W/X **	
D6											Full Size Horizontal Mount
D7											Six-zone 24-feeder bus protection + IEC 61850 + IEEE 1588 + CyberSentry Lvl 1
D8											Single-zone 24-feeder bus protection + IEC 61850 + IEEE 1588 + CyberSentry Lvl 1
D9											Six-zone 8-feeder bus protection + breaker failure + IEEE 1588 + CyberSentry Lvl 1
DA											Six-zone 16-feeder bus protection + breaker failure + IEEE 1588 + CyberSentry Lvl 1
DB											Six-zone 24-feeder bus protection + breaker failure + IEEE 1588 + CyberSentry Lvl 1
DC											Single-zone 24-feeder bus protection + breaker failure + IEEE 1588 + CyberSentry Lvl 1
DD											Six-zone 8-feeder bus protection + IEC 61850 + breaker failure + IEEE 1588 + CyberSentry Lvl 1
DE											Six-zone 16-feeder bus protection + IEC 61850 + breaker failure + IEEE 1588 + CyberSentry Lvl 1
DF											Six-zone 24-feeder bus protection + IEC 61850 + breaker failure + IEEE 1588 + CyberSentry Lvl 1
E0											Single-zone 24-feeder bus protection + IEC 61850 + breaker failure + IEEE 1588 + CyberSentry Lvl 1
E1											IEEE 1588 + PRP + six-zone 8-feeder bus protection
E2											IEEE 1588 + PRP + six-zone 16-feeder bus protection
E3											IEEE 1588 + PRP + six-zone 24-feeder bus protection
E4											IEEE 1588 + PRP + single-zone 24-feeder bus protection
E5											IEEE 1588 + PRP + six-zone 8-feeder bus protection + IEC 61850
E6											IEEE 1588 + PRP + six-zone 16-feeder bus protection + IEC 61850
E7											IEEE 1588 + PRP + six-zone 24-feeder bus protection + IEC 61850
E8											IEEE 1588 + PRP + single-zone 24-feeder bus protection + IEC 61850
E9											IEEE 1588 + PRP + six-zone 8-feeder bus protection + breaker failure
EA											IEEE 1588 + PRP + six-zone 16-feeder bus protection + breaker failure
EB											IEEE 1588 + PRP + six-zone 24-feeder bus protection + breaker failure
EC											IEEE 1588 + PRP + single-zone 24-feeder bus protection + breaker failure
ED											IEEE 1588 + PRP + six-zone 8-feeder bus protection + breaker failure + IEC 61850
EE											IEEE 1588 + PRP + six-zone 16-feeder bus protection + breaker failure + IEC 61850
EF											IEEE 1588 + PRP + six-zone 24-feeder bus protection + breaker failure + IEC 61850
F0											IEEE 1588 + PRP + single-zone 24-feeder bus protection + breaker failure + IEC 61850
F1											PRP + CyberSentry Lvl 1 + six-zone 8-feeder bus protection
F2											PRP + CyberSentry Lvl 1 + six-zone 16-feeder bus protection
F3											PRP + CyberSentry Lvl 1 + six-zone 24-feeder bus protection
F4											PRP + CyberSentry Lvl 1 + single-zone 24-feeder bus protection
F5											PRP + CyberSentry Lvl 1 + six-zone 8-feeder bus protection + IEC 61850
F6											PRP + CyberSentry Lvl 1 + six-zone 16-feeder bus protection + IEC 61850
F7											PRP + CyberSentry Lvl 1 + six-zone 24-feeder bus protection + IEC 61850
F8											PRP + CyberSentry Lvl 1 + single-zone 24-feeder bus protection + IEC 61850
F9											PRP + CyberSentry Lvl 1 + six-zone 8-feeder bus protection + breaker failure
FA											PRP + CyberSentry Lvl 1 + six-zone 16-feeder bus protection + breaker failure
FB											PRP + CyberSentry Lvl 1 + six-zone 24-feeder bus protection + breaker failure
FC											PRP + CyberSentry Lvl 1 + single-zone 24-feeder bus protection + breaker failure
FD											PRP + CyberSentry Lvl 1 + six-zone 8-feeder bus protection + breaker failure + IEC 61850
FE											PRP + CyberSentry Lvl 1 + six-zone 16-feeder bus protection + breaker failure + IEC 61850
FF											PRP + CyberSentry Lvl 1 + six-zone 24-feeder bus protection + breaker failure + IEC 61850
G0											PRP + CyberSentry Lvl 1 + single-zone 24-feeder bus protection + breaker failure + IEC 61850
G1											IEEE 1588 + PRP + CyberSentry Lvl 1 + six-zone 8-feeder bus protection
G2											IEEE 1588 + PRP + CyberSentry Lvl 1 + six-zone 16-feeder bus protection
G3											IEEE 1588 + PRP + CyberSentry Lvl 1 + six-zone 24-feeder bus protection
G4											IEEE 1588 + PRP + CyberSentry Lvl 1 + single-zone 24-feeder bus protection
G5											IEEE 1588 + PRP + CyberSentry Lvl 1 + six-zone 8-feeder bus protection + IEC 61850
G6											IEEE 1588 + PRP + CyberSentry Lvl 1 + six-zone 16-feeder bus protection + IEC 61850
G7											IEEE 1588 + PRP + CyberSentry Lvl 1 + six-zone 24-feeder bus protection + IEC 61850
G8											IEEE 1588 + PRP + CyberSentry Lvl 1 + single-zone 24-feeder bus protection + IEC 61850
G9											IEEE 1588 + PRP + CyberSentry Lvl 1 + six-zone 8-feeder bus protection + breaker failure
GA											IEEE 1588 + PRP + CyberSentry Lvl 1 + six-zone 16-feeder bus protection + breaker failure
GB											IEEE 1588 + PRP + CyberSentry Lvl 1 + six-zone 24-feeder bus protection + breaker failure
GC											IEEE 1588 + PRP + CyberSentry Lvl 1 + single-zone 24-feeder bus protection + breaker failure
GD											IEEE 1588 + PRP + CyberSentry Lvl 1 + six-zone 8-feeder bus protection + breaker failure + IEC 61850
GE											IEEE 1588 + PRP + CyberSentry Lvl 1 + six-zone 16-feeder bus protection + breaker failure + IEC 61850
GF											IEEE 1588 + PRP + CyberSentry Lvl 1 + six-zone 24-feeder bus protection + breaker failure + IEC 61850
J0											IEEE 1588 + PRP + CyberSentry Lvl 1 + single-zone 24-feeder bus protection + breaker failure + IEC 61850
J1											IEC 60870-5-103 + six-zone 8-feeder bus protection
J2											IEC 60870-5-103 + six-zone 16-feeder bus protection
J3											IEC 60870-5-103 + six-zone 24-feeder bus protection
J4											IEC 60870-5-103 + single-zone 24-feeder bus protection
J5											IEC 60870-5-103 + six-zone 8-feeder bus protection + IEC 61850
J6											IEC 60870-5-103 + six-zone 16-feeder bus protection + IEC 61850
J7											IEC 60870-5-103 + six-zone 24-feeder bus protection + IEC 61850
J8											IEC 60870-5-103 + single-zone 24-feeder bus protection + IEC 61850
J9											IEC 60870-5-103 + six-zone 8-feeder bus protection + breaker failure
JA											IEC 60870-5-103 + six-zone 16-feeder bus protection + breaker failure
JB											IEC 60870-5-103 + six-zone 24-feeder bus protection + breaker failure
JC											IEC 60870-5-103 + single-zone 24-feeder bus protection + breaker failure
											IEC 60870-5-103 + six-zone 8-feeder bus protection + breaker failure + IEC 61850

B90	- *	- *	- H *	- F **	- H **	- L **	- N **	- S **	- U **	- W/X **		Full Size Horizontal Mount
JD												IEC 60870-5-103 + six-zone 16-feeder bus protection + breaker failure + IEC 61850
JE												IEC 60870-5-103 + six-zone 24-feeder bus protection + breaker failure + IEC 61850
JF												IEC 60870-5-103 + single-zone 24-feeder bus protection + breaker failure + IEC 61850
K0												IEC 60870-5-103 + IEEE 1588 + PRP + six-zone 8-feeder bus protection
K1												IEC 60870-5-103 + IEEE 1588 + PRP + six-zone 16-feeder bus protection
K2												IEC 60870-5-103 + IEEE 1588 + PRP + six-zone 24-feeder bus protection
K3												IEC 60870-5-103 + IEEE 1588 + PRP + single-zone 24-feeder bus protection
K4												IEC 60870-5-103 + IEEE 1588 + PRP + six-zone 8-feeder bus protection + IEC 61850
K5												IEC 60870-5-103 + IEEE 1588 + PRP + six-zone 16-feeder bus protection + IEC 61850
K6												IEC 60870-5-103 + IEEE 1588 + PRP + six-zone 24-feeder bus protection + IEC 61850
K7												IEC 60870-5-103 + IEEE 1588 + PRP + single-zone 24-feeder bus protection + IEC 61850
K8												IEC 60870-5-103 + IEEE 1588 + PRP + six-zone 8-feeder bus protection + breaker failure
K9												IEC 60870-5-103 + IEEE 1588 + PRP + six-zone 16-feeder bus protection + breaker failure
KA												IEC 60870-5-103 + IEEE 1588 + PRP + six-zone 24-feeder bus protection + breaker failure
KB												IEC 60870-5-103 + IEEE 1588 + PRP + single-zone 24-feeder bus protection + breaker failure
KC												IEC 60870-5-103 + IEEE 1588 + PRP + six-zone 8-feeder bus protection + breaker failure + IEC 61850
KD												IEC 60870-5-103 + IEEE 1588 + PRP + six-zone 16-feeder bus protection + breaker failure + IEC 61850
KE												IEC 60870-5-103 + IEEE 1588 + PRP + six-zone 24-feeder bus protection + breaker failure + IEC 61850
KF												IEC 60870-5-103 + IEEE 1588 + PRP + single-zone 24-feeder bus protection + breaker failure + IEC 61850
L0												IEC 60870-5-103 + IEEE 1588 + PRP + CyberSentry Lvl 1 + six-zone 8-feeder bus protection
L1												IEC 60870-5-103 + IEEE 1588 + PRP + CyberSentry Lvl 1 + six-zone 16-feeder bus protection
L2												IEC 60870-5-103 + IEEE 1588 + PRP + CyberSentry Lvl 1 + six-zone 24-feeder bus protection
L3												IEC 60870-5-103 + IEEE 1588 + PRP + CyberSentry Lvl 1 + single-zone 24-feeder bus protection
L4												IEC 60870-5-103 + IEEE 1588 + PRP + CyberSentry Lvl 1 + six-zone 8-feeder bus protection + IEC 61850
L5												IEC 60870-5-103 + IEEE 1588 + PRP + CyberSentry Lvl 1 + six-zone 16-feeder bus protection + IEC 61850
L6												IEC 60870-5-103 + IEEE 1588 + PRP + CyberSentry Lvl 1 + six-zone 24-feeder bus protection + IEC 61850
L7												IEC 60870-5-103 + IEEE 1588 + PRP + CyberSentry Lvl 1 + single-zone 24-feeder bus protection + IEC 61850
L8												IEC 60870-5-103 + IEEE 1588 + PRP + CyberSentry Lvl 1 + six-zone 8-feeder bus protection + breaker failure
L9												IEC 60870-5-103 + IEEE 1588 + PRP + CyberSentry Lvl 1 + six-zone 16-feeder bus protection + breaker failure
LA												IEC 60870-5-103 + IEEE 1588 + PRP + CyberSentry Lvl 1 + six-zone 24-feeder bus protection + breaker failure
LB												IEC 60870-5-103 + IEEE 1588 + PRP + CyberSentry Lvl 1 + single-zone 24-feeder bus protection + breaker failure
LC												IEC 60870-5-103 + IEEE 1588 + PRP + CyberSentry Lvl 1 + six-zone 8-feeder bus protection + breaker failure + IEC 61850
LD												IEC 60870-5-103 + IEEE 1588 + PRP + CyberSentry Lvl 1 + six-zone 16-feeder bus protection + breaker failure + IEC 61850
LE												IEC 60870-5-103 + IEEE 1588 + PRP + CyberSentry Lvl 1 + six-zone 24-feeder bus protection + breaker failure + IEC 61850
LF												IEC 60870-5-103 + IEEE 1588 + PRP + CyberSentry Lvl 1 + single-zone 24-feeder bus protection + breaker failure + IEC 61850
MOUNTING	H	A										Horizontal (19" rack)
FACEPLATE/DISPLAY	C	D										Horizontal (19" rack) with harsh-environmental coating
	R	P										English display
	G	L										French display
	S	K										Russian display
	M	Q										English display with 4 small and 12 large programmable pushbuttons
	U	L										French display with 4 small and 12 large programmable pushbuttons
	N	T										Russian display with 4 small and 12 large programmable pushbuttons
	V											Enhanced front panel with English display
	W											Enhanced front panel with French display
	Y											Enhanced front panel with Russian display
	I											Enhanced front panel with Chinese display
	J											Enhanced front panel with English display and user-programmable pushbuttons
												Enhanced front panel with French display and user-programmable pushbuttons
												Enhanced front panel with Russian display and user-programmable pushbuttons
												Enhanced front panel with Chinese display and user-programmable pushbuttons
POWER SUPPLY (redundant power supply must be same type as main power supply) CT/VT DSP	H	L										125 / 250 V AC/DC
												125 / 250 V AC/DC with redundant 125 / 250 V AC/DC power supply
												24 to 48 V (DC only)
												24 to 48 V (DC only) with redundant 24 to 48 V DC power supply
												None
												Standard 4CT/4VT with enhanced diagnostics
												Standard 8CT with enhanced diagnostics
												Standard 7CT/1VT with enhanced diagnostics
CONTACT INPUTS/OUTPUTS												No Module
												4 Solid state (no monitoring) MOSFET outputs
												4 Solid state (voltage with optional current) MOSFET outputs
												4 Solid state (current with optional voltage) MOSFET outputs

B90	- *	**	- H *	* - F **	- H **	- L **	- N **	- S **	- U **	- W/X **	
4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	4D	Full Size Horizontal Mount
4L	4L	4L	4L	4L	4L	4L	4L	4L	4L	4L	16 Contact inputs with auto-burnish
6A	6A	6A	6A	6A	6A	6A	6A	6A	6A	6A	14 Form-A (no monitoring) latching outputs
6B	6B	6B	6B	6B	6B	6B	6B	6B	6B	6B	2 Form-A (voltage with optional current) and 2 Form-C outputs, 8 contact inputs
6C	6C	6C	6C	6C	6C	6C	6C	6C	6C	6C	2 Form-A (voltage with optional current) and 4 Form-C outputs, 4 contact inputs
6D	6D	6D	6D	6D	6D	6D	6D	6D	6D	6D	8 Form-C outputs
6E	6E	6E	6E	6E	6E	6E	6E	6E	6E	6E	16 Contact inputs
6F	6F	6F	6F	6F	6F	6F	6F	6F	6F	6F	4 Form-C outputs, 8 contact inputs
6G	6G	6G	6G	6G	6G	6G	6G	6G	6G	6G	8 Fast Form-C outputs
6H	6H	6H	6H	6H	6H	6H	6H	6H	6H	6H	4 Form-A (voltage with optional current) outputs, 8 contact inputs
6K	6K	6K	6K	6K	6K	6K	6K	6K	6K	6K	6 Form-A (voltage with optional current) outputs, 4 contact inputs
6L	6L	6L	6L	6L	6L	6L	6L	6L	6L	6L	4 Form-C and 4 Fast Form-C outputs
6M	6M	6M	6M	6M	6M	6M	6M	6M	6M	6M	2 Form-A (current with optional voltage) and 2 Form-C outputs, 8 contact inputs
6N	6N	6N	6N	6N	6N	6N	6N	6N	6N	6N	2 Form-A (current with optional voltage) and 4 Form-C outputs, 4 contact inputs
6P	6P	6P	6P	6P	6P	6P	6P	6P	6P	6P	4 Form-A (current with optional voltage) outputs, 8 contact inputs
6R	6R	6R	6R	6R	6R	6R	6R	6R	6R	6R	6 Form-A (current with optional voltage) outputs, 4 contact inputs
6S	6S	6S	6S	6S	6S	6S	6S	6S	6S	6S	2 Form-A (no monitoring) and 2 Form-C outputs, 8 contact inputs
6T	6T	6T	6T	6T	6T	6T	6T	6T	6T	6T	2 Form-A (no monitoring) and 4 Form-C outputs, 4 contact inputs
6U	6U	6U	6U	6U	6U	6U	6U	6U	6U	6U	4 Form-A (no monitoring) outputs, 8 contact inputs
67	67	67	67	67	67	67	67	67	67	67	6 Form-A (no monitoring) outputs, 4 contact inputs
											8 Form-A (no monitoring) outputs
INTER-RELAY											XX No Module
COMMUNICATIONS											2A C37.94SM, 1300 nm single-mode, ELED, 1 channel single-mode
(select a maximum of 1 per unit)											2B C37.94SM, 1300 nm single-mode, ELED, 2 channel single-mode
											2H IEEE C37.94, 820 nm, 128 kbps, multimode, LED, 2 Channels
											2I Channel 1 - IEEE C37.94, MM, 64/128 kbps; Channel 2 - 1300 nm, single-mode, Laser
											2J Channel 1 - IEEE C37.94, MM, 64/128 kbps; Channel 2 - 1550 nm, single-mode, Laser
											72 1550 nm, single-mode, Laser, 1 Channel
											73 1550 nm, single-mode, Laser, 2 Channel
											76 IEEE C37.94, 820 nm, 64 kbps, multimode, LED, 1 Channel
											77 IEEE C37.94, 820 nm, 64 kbps, multimode, LED, 2 Channels
											7A 820 nm, multimode, LED, 1 Channel
											7B 1300 nm, multimode, LED, 1 Channel
											7C 1300 nm, single-mode, ELED, 1 Channel
											7D 1300 nm, single-mode, Laser, 1 Channel
											7F Channel 1 - G.703; Channel 2 - 1300 nm, multimode
											7G Channel 1 - G.703; Channel 2 - 1300 nm, single-mode ELED
											7H 820 nm, multimode, LED, 2 Channels
											7I 1300 nm, multimode, LED, 2 Channels
											7J 1300 nm, single-mode, ELED, 2 Channels
											7K 1300 nm, single-mode, Laser, 2 Channels
											7M Channel 1 - RS422; Channel 2 - 1300 nm, multimode, LED
											7N Channel 1 - RS422; Channel 2 - 1300 nm, single-mode, ELED
											7P Channel 1 - RS422; Channel 2 - 1300 nm, single-mode, Laser
											7Q Channel 1 - G.703; Channel 2 - 1300 nm, single-mode Laser
											7R G.703, 1 Channel
											7S G.703, 2 Channels
											7T RS422, 1 Channel
											7W RS422, 2 Channels

2.3.1 Replacement modules

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

Not all replacement modules apply to the B90 relay. The modules specified in the order codes for the B90 are available as replacement modules for the B90.

The order codes shown here are subject to change without notice. See the web page for the product for the latest options.

Table 2-5: UR order codes for replacement modules, horizontal units

UR	- *	- *
POWER SUPPLY	SH	A
redundant supply only available in horizontal units and must be same type as main supply, for example must swap both power supplies when switching from RH to SH	SL	A
CPU	T	RS485 with 3 100Base-FX Ethernet, multimode, SFP with LC
	U	RS485 with 1 100Base-TX Ethernet, SFP RJ-45 + 2 100Base-FX Ethernet, multimode, SFP with LC
	V	RS485 with 3 100Base-TX Ethernet, SFP with RJ-45
FACEPLATE/DISPLAY	3C	Horizontal faceplate with keypad and English display
	3D	Horizontal faceplate with keypad and French display
	3R	Horizontal faceplate with keypad and Russian display
	3A	Horizontal faceplate with keypad and Chinese display
	3P	Horizontal faceplate with keypad, user-programmable pushbuttons, and English display
	3G	Horizontal faceplate with keypad, user-programmable pushbuttons, and French display
	3S	Horizontal faceplate with keypad, user-programmable pushbuttons, and Russian display
	3B	Horizontal faceplate with keypad, user-programmable pushbuttons, and Chinese display
	3K	Enhanced front panel with English display
	3M	Enhanced front panel with French display
	3Q	Enhanced front panel with Russian display
	3U	Enhanced front panel with Chinese display
	3L	Enhanced front panel with English display and user-programmable pushbuttons
	3N	Enhanced front panel with French display and user-programmable pushbuttons
	3T	Enhanced front panel with Russian display and user-programmable pushbuttons
	3V	Enhanced front panel with Chinese display and user-programmable pushbuttons
	3W	Enhanced front panel with Turkish display
	3Y	Enhanced front panel with Turkish display and user-programmable pushbuttons
	3I	Enhanced front panel with German display
	3J	Enhanced front panel with German display and user-programmable pushbuttons

CONTACT INPUTS AND OUTPUTS

UR	-	**	-	*
4A	4	Solid-State (no monitoring) MOSFET outputs		
4B	4	Solid-State (voltage with optional current) MOSFET outputs		
4C	4	Solid-State (current with optional voltage) MOSFET outputs		
4D	16	Contact inputs with Auto-Burnishing		
4L	14	Form-A (no monitoring) Latching outputs		
67	8	Form-A (no monitoring) outputs		
6A	2	Form-A (voltage with optional current) and 2 Form-C outputs, 8 contact inputs		
6B	2	Form-A (voltage with optional current) and 4 Form-C outputs, 4 contact inputs		
6C	8	Form-C outputs		
6D	16	Contact inputs		
6E	4	Form-C outputs, 8 contact inputs		
6F	8	Fast Form-C outputs		
6G	4	Form-A (voltage with optional current) outputs, 8 contact inputs		
6H	6	Form-A (voltage with optional current) outputs, 4 contact inputs		
6K	4	Form-C and 4 Fast Form-C outputs		
6L	2	Form-A (current with optional voltage) and 2 Form-C outputs, 8 contact inputs		
6M	2	Form-A (current with optional voltage) and 4 Form-C outputs, 4 contact inputs		
6N	4	Form-A (current with optional voltage) outputs, 8 contact inputs		
6P	6	Form-A (current with optional voltage) outputs, 4 contact inputs		
6R	2	Form-A (no monitoring) and 2 Form-C outputs, 8 contact inputs		
6S	2	Form-A (no monitoring) and 4 Form-C outputs, 4 contact inputs		
6T	4	Form-A (no monitoring) outputs, 8 contact inputs		
6U	6	Form-A (no monitoring) outputs, 4 contact inputs		
6V	2	Form-A outputs, 1 Form-C output, 2 Form-A (no monitoring) latching outputs, 8 contact inputs		
8L	Standard	4CT/4VT with enhanced diagnostics		
8N	Standard	8CT with enhanced diagnostics		
CT/VT MODULES (not available for the C30)				
INTER-RELAY COMMUNICATIONS				
2A	C37.94SM, 1300 nm	single-mode, ELED, 1 channel	single-mode	
2B	C37.94SM, 1300 nm	single-mode, ELED, 2 channel	single-mode	
2H	IEEE C37.94, 820 nm, 128 kbps, multimode, LED, 2 Channels			
2I	Channel 1 - IEEE C37.94, multimode, 64/128 kbps; Channel 2 - 1300 nm, single-mode, Laser			
2J	Channel 1 - IEEE C37.94, multimode, 64/128 kbps; Channel 2 - 1550 nm, single-mode, Laser			
72	1550 nm, single-mode, Laser, 1 Channel			
73	1550 nm, single-mode, Laser, 2 Channel			
76	IEEE C37.94, 820 nm, multimode, LED, 1 Channel			
77	IEEE C37.94, 820 nm, multimode, LED, 2 Channels			
7A	820 nm, multimode, LED, 1 Channel			
7B	1300 nm, multimode, LED, 1 Channel			
7C	1300 nm, single-mode, ELED, 1 Channel			
7D	1300 nm, single-mode, Laser, 1 Channel			
7F	Channel 1 - G.703; Channel 2 - 1300 nm, multimode			
7G	Channel 1 - G.703; Channel 2 - 1300 nm, single-mode ELED			
7H	820 nm, multimode, LED, 2 Channels			
7I	1300 nm, multimode, LED, 2 Channels			
7J	1300 nm, single-mode, ELED, 2 Channels			
7K	1300 nm, single-mode, Laser, 2 Channels			
7M	Channel 1 - RS422; Channel 2 - 1300 nm, multimode, LED			
7N	Channel 1 - RS422; Channel 2 - 1300 nm, single-mode, ELED			
7P	Channel 1 - RS422; Channel 2 - 1300 nm, single-mode, Laser			
7Q	Channel 1 - G.703; Channel 2 - 1300 nm, single-mode Laser			
7R	G.703, 1 Channel			
7S	G.703, 2 Channels			
7T	RS422, 1 Channel			
7W	RS422, 2 Channels			

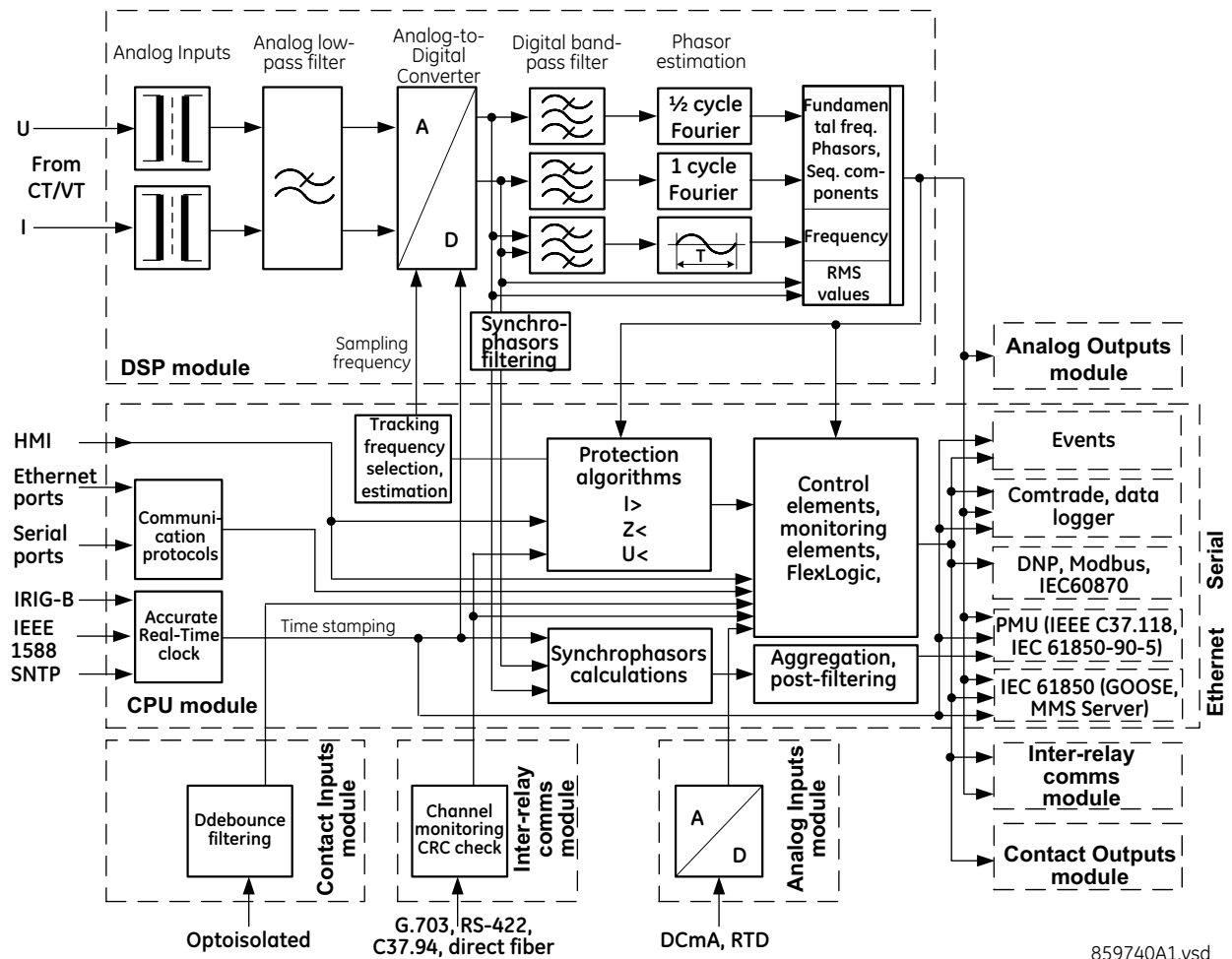
2.4 Signal processing

2.4.1 UR signal processing

The UR series relays are microprocessor-based protective relays that are designed to measure power system conditions directly via CT and VT inputs and via other sources of information, such as analog inputs, communications inputs and contact inputs. The following figure shows the overall signal processing in URs.

An analog low pass anti-aliasing filter with a 3 dB corner frequency is set at 2.4 kHz and is used for current and voltage analog filtering as well as signal conditioning. The same filtering is applied for phase, ground currents, phase-to-phase (when applicable), and auxiliary voltages. The 2.4 kHz cut-off frequency applies to both 50 Hz and 60 Hz applications and fixed in the hardware, and thus is not dependent on the system nominal frequency setting.

Figure 2-3: UR signal processing



The UR samples its AC signals at 64 samples per cycle, that is, at 3840 Hz in 60 Hz systems, and 3200 Hz in 50 Hz systems. The sampling rate is dynamically adjusted to the actual system frequency by an accurate and fast frequency tracking system.

The A/D converter has the following ranges of AC signals:

Voltages:

$$\pm \sqrt{2} \cdot 260(\text{V}) \quad \text{Eq. 2-1}$$

Currents:

$$\pm \sqrt{2} \cdot 46 \text{ rated}(\text{A}) \quad \text{Eq. 2-2}$$

Current harmonics are estimated based on raw samples with the use of the full-cycle Fourier filter. Harmonics 2nd through 25th are estimated.

True RMS value for the current is calculated on a per-phase basis. The true RMS can be used for demand recording or as an input signal to Time Overcurrent function, if the latter is intended for thermal protection. The true RMS is calculated as per the widely accepted definition:

$$I_{\text{RMS}(t)} = \sqrt{\frac{1}{T} \int_{(t-T)}^t i^2(t) dt} \quad \text{Eq. 2-3}$$

RMS values include harmonics, inter-harmonics, DC components, and so on, along with fundamental frequency values. The true RMS value reflects thermal effects of the current and is used for the thermal related monitoring and protection functions.

Protection and control functions respond to phasors of the fundamental and/or harmonic frequency components (magnitudes and angles), with an exception for some functions that have an option for RMS or fundamental measurements, or some function responding to RMS only. This type of response is explained typically in each element's section in the instruction manual.

Currents are pre-filtered using a Finite Impulse Response (FIR) digital filter. The filter is designed to reject DC components and low-frequency distortions, without amplifying high-frequency noise. This filter is referred to as a modified MIMIC filter, which provides excellent filtering and overall balance between speed and accuracy of filtering. The filter is cascaded with the full-cycle Fourier filter for the current phasor estimation.

Voltages are pre-filtered using a patented Finite Impulse Response (FIR) digital filter. The filter has been optimized to reject voltage transformers specific distortions, such as Capacitive Voltage Transformer (CVT) noise and high-frequency oscillatory components. The filter is cascaded with the half-cycle Fourier filter for the voltage phasor estimation.

The URs measure power system frequency using the Clarke transformation by estimating the period of the waveform from two consecutive zero-crossings in the same direction (negative-to-positive). Voltage or current samples are pre-filtered using a Finite Impulse Response (FIR) digital filter to remove high frequency noise contained in the signal. The period is used after several security conditions are met, such as true RMS signal must be above 6% nominal for a certain time and others. If these security conditions are not met, the last valid measurement is used for a specific time after which the UR reverts to nominal system frequency.

Synchrophasors are calculated using a patented convolution integral algorithm. This algorithm allows use of the same time stamped samples, which are used for protection and taken at the same sampling frequency. This allows URs to use one sampling clock for both protection algorithms and synchrophasors.

Synchrophasors on firmware versions 7.23 and up have been tested and certified to meet IEEE C37.118-2011 and C37.118.1a-2014 standards for both metering and protection classes with outputs available up to 60 synchrophasors per second for the metering class and 120 synchrophasors per second for the protection class. Synchrophasors measurement are also available via IEC 61850-90-5 protocol.

Contact inputs threshold is settable in the firmware with 17, 33, 84, 166 VDC settings available. Inputs are scanned every 0.5 ms and can be conditioned for the critical applications, using debounce time timer, settable from 0.0 ms to 16.0 ms. Contact inputs with auto-burnishing are available as well, when external contacts are exposed to the contamination in a harsh industrial environment.

All measured values are available in the UR metering section on the front panel and via communications protocols. Measured analog values and binary signals can be captured in COMTRADE format with sampling rates from 8 to 64 samples per power cycle. Analog values can be captured with Data Logger, allowing much slower rates extended over long period of time.

Other advanced UR order code options are available to support IEC 61850 Ed2.0 (including fast GOOSE, MMS server, 61850 services, ICD/CID/IID files, and so on), IEEE 1588 (IEEE C37.238 power profile) based time synchronization, CyberSentry (advanced cyber security), the Parallel Redundancy Protocol (PRP), IEC 60870-5-103, and so on.

2.5 Specifications

Specifications are subject to change without notice.

2.5.1 Protection elements

The operating times 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. Take this into account when using FlexLogic to interconnect with other protection or control elements of the relay, building FlexLogic equations, or interfacing with other intelligent electronic devices (IEDs) or power system devices via communications or different output contacts. If not specified, the operate times

given here are for a 60 Hz system at nominal system frequency. Operate times for a 50 Hz system are 1.2 times longer. Timer Accuracy is specified as a percentage of the total operating time that is the sum of the Operate Time and settable Pickup Delay.

BUS DIFFERENTIAL (87B)

Pickup level:	0.050 to 6.000 pu in steps of 0.001
Low slope:	15 to 100% in steps of 1
High slope:	50 to 100% in steps of 1
Low breakpoint:	1.00 to 30.00 pu in steps of 0.01
High breakpoint:	1.00 to 30.00 pu in steps of 0.01
High set level:	0.10 to 99.99 pu in steps of 0.01
Dropout level:	97 to 98% of pickup
Characteristic accuracy:	±3% of the maximum circuit current or ±2% of rated (whichever is greater)
Operating time:	12.5 ms (typical) at 3x pickup at 60 Hz 9 ms (typical) at 10x pickup at 60 Hz
Number of zones:	1 or 6 (option)
Max number of inputs:	8, 16, or 24 (option)

CT TROUBLE

Responding to:	Differential current
Pickup level:	0.020 to 2.000 pu in steps of 0.001
Pickup delay:	1.0 to 60.0 sec. in steps of 0.1
Timer accuracy:	±3% of operate time or ±1/4 cycle (whichever is greater)
Availability:	one per zone of protection

ISOLATOR MONITORING

Responding to:	Both normally-open and normally-closed auxiliary contacts
Asserting:	Isolator Position, Isolator Alarm, Block Switching
Alarm pickup delay:	0.00 to 120.00 s in steps of 0.05
Timer accuracy:	±3% of operate time or ±1/4 cycle (whichever is greater)

TIME OVERCURRENT

Pickup level:	0.000 to 30.000 pu in steps of 0.001
Dropout level:	97% of pickup
Level accuracy:	0.5% of reading or 1% of nominal (whichever is greater) 1.5% of reading
Timing characteristics:	IEEE Moderately/Very/Extremely Inverse; IEC (and BS) A/B/C and Short Inverse; GE IAC Inverse, Short/Very/Extremely Inverse; I^2t ; FlexCurve™ (programmable); (Curve multiplier = 0.00 to 600.00 in steps of 0.01 s); Definite Time (Time delay = 0.00 to 600.00 in steps of 0.01 s)
Reset type:	Instantaneous or Timed (per IEEE)
Curve timing accuracy at 1.03 to 20 x pickup:	±3.5% of operate time or ±1/2 cycle (whichever is greater) from pickup to operate

INSTANTANEOUS OVERCURRENT

Pickup level:	0.000 to 30.000 pu in steps of 0.001
Dropout level:	97% of pickup
Level accuracy:	0.5% of reading or 1% of nominal (whichever is greater) 1.5% of reading
Pickup delay:	0 to 65.535 s in steps of 0.001
Reset delay:	0 to 65.535 s in steps of 0.001
Timer accuracy:	±3% of operate time or ±1/4 cycle (whichever is greater)
Operate time:	<16 ms at 3x pickup at 60 Hz

UNDERVOLTAGE

Pickup level:	0.000 to 3.000 pu in steps of 0.001
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Dropout level:	102 to 103% of pickup
Level accuracy:	±0.5% of reading from 10 to 208 V
Pickup delay:	0 to 65.535 s in steps of 0.001
Reset delay:	0 to 65.535 s in steps of 0.001
Timer accuracy:	±3% of operate time or ±1/4 cycle (whichever is greater)
Operate time:	<16 ms at <0.9 × pickup at 60 Hz

END FAULT PROTECTION

IOC pickup level:	0.000 to 30.000 pu in steps of 0.001
IOC dropout level:	97 to 98% of pickup
Level accuracy	
at 0.1 to 2.0 × CT:	0.5% of reading or 1% of nominal (whichever is greater)
above 2.0 × CT:	1.5% of reading
CB open pickup timer:	0 to 65.535 s in steps of 0.001
End Fault pickup timer:	0 to 65.535 s in steps of 0.001
Timer accuracy:	±3% of operate time or ±8 ms, whichever is greater

BREAKER FAILURE

Mode:	3-pole
Current supervision:	phase current
Current supv. pickup:	0.001 to 30.000 pu in steps of 0.001
Current supv. dropout:	97% of pickup
Current supv. accuracy:	
0.1 to 2.0 × CT rating:	±0.75% of reading or ±2% of rated (whichever is greater)
above 2 × CT rating:	±2.5% of reading
Timer accuracy:	±3% of operate time or ±1/4 cycle (whichever is greater)

TRIP BUS (TRIP WITHOUT FLEXLOGIC)

Number of elements:	6
Number of inputs:	16
Operate time:	<2 ms at 60 Hz
Timer accuracy:	±3% or 10 ms, whichever is greater

2.5.2 User-programmable elements

FLEXLOGIC

Programming language:	Reverse Polish Notation with graphical visualization (keypad programmable)
Lines of code:	512
Internal variables:	64
Supported operations:	NOT, XOR, OR (2 to 16 inputs), AND (2 to 16 inputs), NOR (2 to 16 inputs), NAND (2 to 16 inputs), latch (reset-dominant), edge detectors, timers
Inputs:	any logical variable, contact, or virtual input
Number of timers:	32
Pickup delay:	0 to 60000 (ms, sec., min.) in steps of 1
Dropout delay:	0 to 60000 (ms, sec., min.) in steps of 1
Timer accuracy:	±0.1% of operate time or ±1/8 cycle, whichever is greater

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

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 contact input or user-programmable condition
Number of tests:	3, interruptible at any time
Duration of full test:	approximately 3 minutes
Test sequence 1:	all LEDs on
Test sequence 2:	all LEDs off, one LED at a time on for 1 s
Test sequence 3:	all LEDs on, one LED at a time off for 1 s

USER-DEFINABLE DISPLAYS

Number of displays:	16
Lines of display:	2 × 20 alphanumeric characters
Parameters:	up to 5, any Modbus register addresses
Invoking and scrolling:	keypad, or any user-programmable condition, including pushbuttons

CONTROL PUSHBUTTONS

Number of pushbuttons:	7
Operation:	drive FlexLogic operands

USER-PROGRAMMABLE PUSHBUTTONS (OPTIONAL)

Number of pushbuttons:	12 on basic front panel 16 on enhanced horizontal front panel 6 on enhanced vertical front panel
Mode:	self-reset, latched
Display message:	2 lines of 20 characters each
Drop-out timer:	0.00 to 60.00 s in steps of 0.05
Autoreset timer:	0.2 to 600.0 s in steps of 0.1
Hold timer:	0.0 to 10.0 s in steps of 0.1

DIGITAL ELEMENTS

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

2.5.3 Monitoring

OSCILLOGRAPHY

Number of records:	3 to 64, configurable
Sampling rate:	8, 16, 32, or 64 samples per power cycle, configurable
Triggers:	any FlexLogic operand, configurable
Trigger position:	0 to 100%, configurable
Recorded data:	raw AC input channels up to 64 configured digital channels, representing any FlexLogic operand up to 16 configured analog channels, representing any measured analog value
Data storage:	in non-volatile memory

Format: COMTRADE IEEE C37.111 (1999 or 2013)

EVENT RECORDER

Capacity: 1024 events
 Time-tag: to 1 microsecond
 Triggers: any FlexLogic operand, configurable
 Data storage: in non-volatile memory

USER-PROGRAMMABLE FAULT REPORT

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

2.5.4 Metering

CURRENT METERING

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

VOLTAGE

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

FREQUENCY

Accuracy for 20 to 65 Hz input at
 V = 0.8 to 1.2 pu: ±0.001 Hz (when voltage signal is used for frequency measurement)
 I = 0.1 to 0.25 pu: ±0.02 Hz (when current signal is used for frequency measurement)
 I > 0.25 pu: ±0.005 Hz (when current signal is used for frequency measurement)

2.5.5 Inputs

AC CURRENT

CT rated primary: 1 to 50000 A
 CT rated secondary: 1 A or 5 A by connection
 Relay burden: < 0.2 VA at rated secondary
 Conversion range: 0.02 to 46 × CT rating RMS symmetrical
 Current withstand: 20 ms at 250 times rated
 1 sec at 100 times rated
 continuous 4×Inom
 URs equipped with 24 CT inputs have a maximum operating temperature of 50°C
 Short circuit rating: 150000 RMS symmetrical amperes, 250 V maximum (primary current to external CT)

AC VOLTAGE

VT rated secondary: 25.0 to 240.0 V
 VT ratio: 1.00 to 24000.00
 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

FREQUENCY

Nominal frequency setting: 25 to 60 Hz
 Sampling frequency: 64 samples per power cycle
 Tracking frequency range: 20 to 70 Hz

CONTACT INPUTS

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

CONTACT INPUTS WITH AUTO-BURNISHING

Dry contacts:	1000 Ω maximum
Wet contacts:	300 V DC maximum
Selectable thresholds:	17 V, 33 V, 84 V, 166 V
Tolerance:	$\pm 10\%$
Contacts per common return:	2
Recognition time:	< 1 ms
Debounce time:	0.0 to 16.0 ms in steps of 0.5
Continuous current draw:	4 mA (when energized)
Auto-burnish impulse current:	50 to 70 mA
Duration of auto-burnish impulse:	25 to 50 ms

IRIG-B INPUT

IRIG formats accepted:	B000...B007, B120...B127
IRIG control bits:	IEEE Std C37.118.1-2011
Amplitude modulation:	1 to 10 V pk-pk
DC shift:	TTL-Compatible
Input impedance:	50 k Ω
Isolation:	2 kV

DIRECT INPUTS

Input points:	96
Remote devices:	16
Default states on loss of comms.:	On, Off, Latest/Off, Latest/On
Ring configuration:	Yes, No
Data rate:	64 or 128 kbps
CRC:	32-bit
CRC alarm:	
Responding to:	Rate of messages failing the CRC
Monitoring message count:	10 to 10000 in steps of 1
Alarm threshold:	1 to 1000 in steps of 1
Unreturned message alarm:	
Responding to:	Rate of unreturned messages in the ring configuration
Monitoring message count:	10 to 10000 in steps of 1
Alarm threshold:	1 to 1000 in steps of 1

2.5.6 Power supply

LOW RANGE

Nominal DC voltage:	24 to 48 V
Minimum DC voltage:	20 V
Maximum DC voltage:	60 V for RL power supply module (obsolete), 75 V for SL power supply module
Voltage loss hold-up:	200 ms duration at maximum load
NOTE: Low range is DC only.	

HIGH RANGE

Nominal DC voltage:	125 to 250 V
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Minimum DC voltage:	88 V
Maximum DC voltage:	300 V
Nominal AC voltage:	100 to 240 V at 50/60 Hz
Minimum AC voltage:	88 V at 25 to 100 Hz
Maximum AC voltage:	265 V at 25 to 100 Hz
Voltage loss hold-up:	200 ms duration at maximum load

ALL RANGES

Volt withstand:	2 × Highest Nominal Voltage for 10 ms
Power consumption:	typical = 15 to 20 W/VA maximum = 45 W/VA contact factory for exact order code consumption

INTERNAL FUSE

Ratings:	
Low range power supply:	8 A / 250 V
High range power supply:	4 A / 250 V
Interrupting capacity:	
AC:	100 000 A RMS symmetrical
DC:	10 000 A

2.5.7 Outputs**FORM-A RELAY**

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

Voltage	Current
24 V	1 A
48 V	0.5 A
125 V	0.3 A
250 V	0.2 A

Operate time:	< 4 ms
Contact material:	silver alloy

LATCHING RELAY

Make and carry for 0.2 s:	30 A as per ANSI C37.90
Carry continuous:	6 A as per IEEE C37.90
Break (DC resistive as per IEC 61810-1):	

Voltage	Current
24 V	6 A
48 V	1.6 A
125 V	0.4 A
250 V	0.2 A

Operate time:	< 4 ms
Contact material:	silver alloy
Control:	separate operate and reset inputs
Control mode:	operate-dominant or reset-dominant

FORM-A VOLTAGE MONITOR

Applicable voltage:	approx. 15 to 250 V DC
Trickle current:	approx. 1 to 2.5 mA

FORM-A CURRENT MONITOR

Threshold current: approx. 80 to 100 mA

FORM-C AND CRITICAL FAILURE RELAY

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

Carry continuous: 8 A

Break (DC inductive, L/R = 40 ms):

Voltage	Current
24 V	1 A
48 V	0.5 A
125 V	0.3 A
250 V	0.2 A

Operate time: < 8 ms

Contact material: silver alloy

FAST FORM-C RELAY

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

Minimum load impedance:

Input voltage	Impedance	
	2 W Resistor	1 W Resistor
250 V DC	20 K Ω	50 K Ω
120 V DC	5 K Ω	2 K Ω
48 V DC	2 K Ω	2 K Ω
24 V DC	2 K Ω	2 K Ω

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

Operate time: < 0.6 ms

Internal Limiting Resistor: 100 Ω , 2 W

SOLID-STATE OUTPUT RELAY

Operate and release time: <100 μ s

Maximum voltage: 265 V DC

Maximum leakage current in off state

(excluding voltage monitor circuit current): 100 μ A

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

Make and carry:

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

for 0.03 s: 300 A

Breaking capacity:

	UL 508	Utility application (autoreclose scheme)	Industrial application
Operations/ interval	5000 ops / 1 s-On, 9 s-Off	5 ops / 0.2 s-On, 0.2 s-Off within 1 minute	10000 ops /0.2 s-On, 30 s-Off
	1000 ops / 0.5 s-On, 0.5 s-Off		
Break capability (0 to 250 V DC)	3.2 A L/R = 10 ms	10 A L/R = 40 ms	10 A L/R = 40 ms
	1.6 A L/R = 20 ms		
	0.8 A L/R = 40 ms		

CONTROL POWER EXTERNAL OUTPUT (FOR DRY CONTACT INPUT)

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

DIRECT OUTPUTS

Output points: 96

2.5.8 Communications**IEC 61850**

IEC 61850: Supports IEC 61850 Edition 2.0. See the UR Series Communications Guide and its conformance statements.

RS232

Front port: 19.2 or 115.2 kbps, Modbus RTU

RS485

1 rear port: up to 115 kbps, Modbus RTU, DNP 3, IEC 60870-5-103
 Typical distance: 1200 m
 Isolation: 2 kV, isolated together at 36 Vpk

FIBER ETHERNET PORT

Operates with 50/125 μ m and 62.5/125 μ m multimode fiber

Parameter	Fiber type
	100 Mb multimode
Wavelength	1310 nm
Connector	LC
Transmit power	-20 dBm
Receiver sensitivity	-30 dBm
Power budget	10 dB
Maximum input power	-14 dBm
Typical distance	2 km
Full duplex	yes
Redundancy	yes

ETHERNET (10/100 MB TWISTED PAIR)

Modes: 10 Mb, 10/100 Mb (auto-detect)
 Connector: RJ45

SIMPLE NETWORK TIME PROTOCOL (SNTP)

Clock synchronization error: <10 ms (typical)

PRECISION TIME PROTOCOL (PTP)

PTP IEEE Std 1588-2008 (version 2)
 Power Profile (PP) per IEEE Standard PC37.238-2011
 Slave-only ordinary clock
 Peer delay measurement mechanism

**PARALLEL REDUNDANCY PROTOCOL (PRP)
(IEC 62439-3 CLAUSE 4, 2012)**

Ethernet ports used: 2 and 3
 Networks supported: 10/100 Mb Ethernet

OTHER

TFTP, SFTP, HTTP, IEC 60870-5-104, Ethernet Global Data (EGD), IEEE C37.118

2.5.9 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 AND MAXIMUM OPTICAL INPUT POWER

The following specifications apply to filter interface modules manufactured from January 2012.

Emitter, fiber type	Cable type	Transmit power	Received sensitivity	Power budget	Maximum optical input power
820 nm, Multimode	62.5/125 μ m	-16 dBm	-32 dBm	16 dBm	-8 dBm
	50/125 μ m	-20 dBm		12 dBm	
1300 nm, Multimode	62.5/125 μ m	-16 dBm	-32 dBm	16 dBm	-8 dBm
	50/125 μ m	-20 dBm		12 dBm	
1300 nm, Single mode	9/125 μ m	-15 dBm	-32 dBm	17 dBm	-8 dBm
1300 nm Laser, Single mode	9/125 μ m	0 dBm	-34 dBm	34 dBm	-8 dBm
1550 nm Laser, Single mode	9/125 μ m	5 dBm	-34 dBm	39 dBm	-10 dBm

The following specifications apply to filter interface modules implemented before January 2012.

Emitter, fiber type	Transmit power	Received sensitivity	Power budget	Maximum optical input power
820 nm LED, Multimode	-20 dBm	-30 dBm	10 dB	-7.6 dBm
1300 nm LED, Multimode	-21 dBm	-30 dBm	9 dB	-11 dBm
1300 nm ELED, Single mode	-23 dBm	-32 dBm	9 dB	-14 dBm
1300 nm Laser, Single mode	-1 dBm	-30 dBm	29 dB	-14 dBm
1550 nm Laser, Single mode	+5 dBm	-30 dBm	35 dB	-14 dBm



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

The power budgets for the 1300 nm ELED are calculated from the manufacturer's transmitter power and receiver sensitivity at ambient temperature. At extreme temperatures these values deviate based on component tolerance. On average, the output power decreases as the temperature is increased by a factor of 1 dB / 5 °C.

TYPICAL LINK DISTANCE

Emitter, fiber type	Cable type	Connector type	Typical distance	
			Before January 2012	From January 2012
820 nm LED, multimode	62.5/125 μm	ST	1.65 km	2 km
	50/125 μm	ST	1.65 km	2 km
1300 nm LED, multimode	62.5/125 μm	ST	4 km	5 km
	50/125 μm	ST	4 km	5 km
1300 nm ELED, single mode	9/125 μm	ST	11.4 km	20 km
1300 nm Laser, single mode	9/125 μm	ST	64 km	65 km
1550 nm Laser, single mode	9/125 μm	ST	105 km	125 km



NOTE

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

CONNECTOR LOSSES (TOTAL OF BOTH ENDS)

ST connector: 0.7 dB (each)

FIBER LOSSES

820 nm multimode: 3 dB/km

1300 nm multimode: 1 dB/km

1300 nm single mode: 0.35 dB/km

1550 nm single mode: 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

2.5.10 Environmental**AMBIENT TEMPERATURES**

Maximum operating range: -40 to 85°C

Continuous operating range: -40 to 60°C¹

¹ Based on IEC 60068-2-1 and IEC 60068-2-2, Variant Bd and Ad for 16 hrs. The UR can operate up to a surrounding ambient of 85°C, however operating outside the recommended continuous temperature range for extended periods can result in MTBF degradation and decrease the response time of the LCD.

HUMIDITY

Humidity: operating up to 95% (non-condensing) at 55°C (as per IEC60068-2-30 variant 1, 6 days)

OTHER

Altitude: 2000 m (maximum)

Pollution degree: II

Overvoltage category: II

Ingress protection: IP20 front, IP10 back (basic front panel and Rev. 1 enhanced front panel)

IP40 front, IP10 back (Rev. 2 enhanced front panel)

IP54 front with IP54 mounting collar accessory (Rev. 2 enhanced front panel)

Noise: 0 dB

2.5.11 Type tests

B90 TYPE TESTS

Test	Reference standard	Test level
Dielectric voltage withstand	EN 60255-5 ¹	2.2 kV
Impulse voltage withstand	EN 60255-5 ¹	5 kV
Damped oscillatory	IEC 61000-4-18 / IEC 60255-22-1	2.5 kV CM, 1 kV DM
Electrostatic discharge	EN 61000-4-2 / IEC 60255-22-2	Level 3
RF immunity	EN 61000-4-3 / IEC 60255-22-3	Level 3
Fast transient disturbance	EN 61000-4-4 / IEC 60255-22-4	Class A and B
Surge immunity	EN 61000-4-5 / IEC 60255-22-5	Level 3 and 4
Conducted RF immunity	EN 61000-4-6 / IEC 60255-22-6	Level 3
Power frequency immunity	EN 61000-4-7 ¹ / IEC 60255-22-7	Class A and B
Voltage interruption and ripple DC	IEC 60255-11	12% ripple, 200 ms interrupts
Radiated and conducted emissions	CISPR11 / CISPR22 / IEC 60255-25	Class A
Sinusoidal vibration	IEC 60255-21-1	Class 1
Shock and bump	IEC 60255-21-2	Class 1
Seismic	IEC 60255-21-3	Class 1
Power magnetic immunity	IEC 61000-4-8	Level 5
Pulse magnetic immunity	IEC 61000-4-9	Level 4
Damped magnetic immunity	IEC 61000-4-10	Level 4
Voltage dip and interruption	IEC 61000-4-11	0, 40, 70, 80% dips; 250 / 300 cycle interrupts
Damped oscillatory	IEC 61000-4-12 ¹	2.5 kV CM, 1 kV DM
Conducted RF immunity, 0 to 150 kHz	IEC 61000-4-16	Level 4
Voltage ripple	IEC 61000-4-17	15% ripple
Ingress protection	IEC 60529 ¹	IP20 front, IP10 back
Cold	IEC 60068-2-1	-40°C for 16 hours
Hot	IEC 60068-2-2	85°C for 16 hours
Humidity	IEC 60068-2-30	6 days, variant 1
Damped oscillatory	IEEE/ANSI C37.90.1	2.5 kV, 1 MHz
RF immunity	IEEE/ANSI C37.90.2	20 V/m, 80 MHz to 1 GHz
Safety	UL 508	e83849 NKCR
Safety	UL C22.2-14	e83849 NKCR7
Safety	UL 1053	e83849 NKCR
Safety	IEC 60255-27	Insulation: class 1, Pollution degree: 2, Over voltage cat II

¹ Not tested by third party.

2.5.12 Production tests

THERMAL

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

2.5.13 Approvals

APPROVALS

Compliance	Applicable council directive	According to
CE	Low voltage directive	EN 60255-5
	EMC directive	EN 60255-26 / EN 50263
		EN 61000-6-5
C-UL-US	---	UL 508
		UL 1053
		C22.2 No. 14

2.5.14 Maintenance

MOUNTING

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

CLEANING

Normally, cleaning is not required. When dust has accumulated on the faceplate display, wipe with a dry cloth.

NOTICE

To avoid deterioration of electrolytic capacitors, power up units that are stored in a de-energized state once per year, for one hour continuously.

B90 Low Impedance Bus Differential System

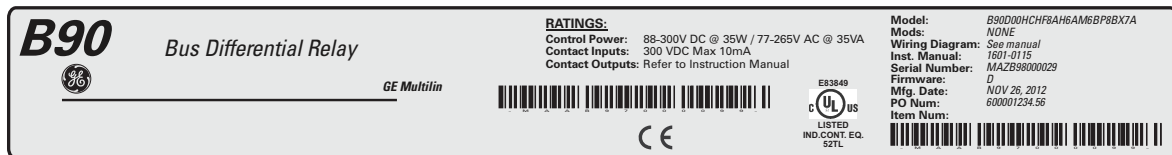
Chapter 3: Installation

This chapter outlines installation of hardware and software. You unpack, check, mount, and wire the unit, then install the software and configure settings.

3.1 Unpack and inspect

Use this procedure to unpack and inspect the unit.

1. Open the relay package and check that the following items have been delivered:
 - B90
 - Mounting screws
 - GE EnerVista™ DVD (software and documentation)
 - B90 Instruction Manual (soft copy on DVD; printed copy if ordered)
 - UR Series Communications Guide (soft copy on DVD; printed copy if Instruction Manual ordered)
 - Certificate of Calibration
 - Test Report
 - EC Declaration of Conformity
 - Front panel label templates and tool
2. Inspect the unit for physical damage.
3. View the rear nameplate and verify that the correct model has been delivered. The model number is at the top right.



4. For any issues, contact GE Grid Solutions as outlined in the For Further Assistance section in chapter 1.
5. Check that you have the latest copy of the B90 Instruction Manual and the UR Series Communications Guide, for the applicable firmware version, at <http://www.gegridsolutions.com/multilin/manuals/index.htm>

The Instruction Manual outlines how to install, configure, and use the unit. The Communications Guide is for advanced use with communication protocols. The warranty is included at the end of this instruction manual and on the GE Grid Solutions website.

3.2 Panel cutouts

Install the relay in an indoor environment within the environmental specifications. The relay complies with Pollution Category II, which means installation in an office, laboratory, or testing environment.

The B90 is available as a 19-inch rack horizontal mount unit with a removable faceplate. The faceplate can be specified as either basic or enhanced at the time of ordering. The enhanced faceplate contains additional user-programmable pushbuttons and LED indicators.

The modular design allows the relay to be upgraded and repaired by qualified service personnel. The faceplate is hinged to allow access to the removable modules, and is itself removable to allow mounting on doors with limited rear depth.

In November 2017, GE began transitioning to Rev. 2 of the enhanced horizontal front panel. This panel can be identified by the use of a screw instead of a knob to close the panel. It can conform to an IP54 rating with the IP54 mounting collar purchased separately. The IP54 mounting collar can be used in panel-mount installations, not 19-inch rack-mount installations. The IP54 mounting collar cannot be used with Rev. 1 enhanced front panels.

The case dimensions are shown in the following figure, 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: Horizontal dimensions (Rev. 1 enhanced front panel)

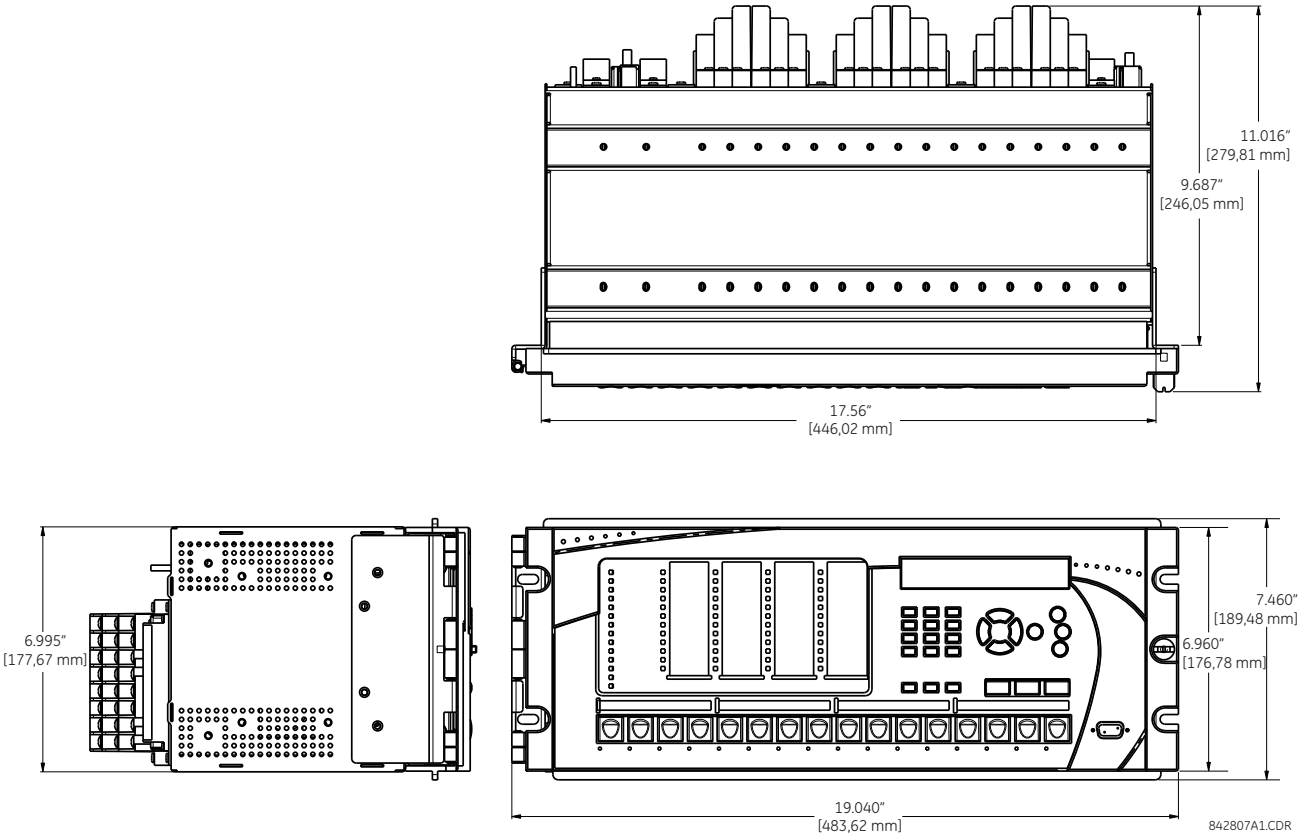


Figure 3-2: Horizontal dimensions (Rev. 2 enhanced front panel)

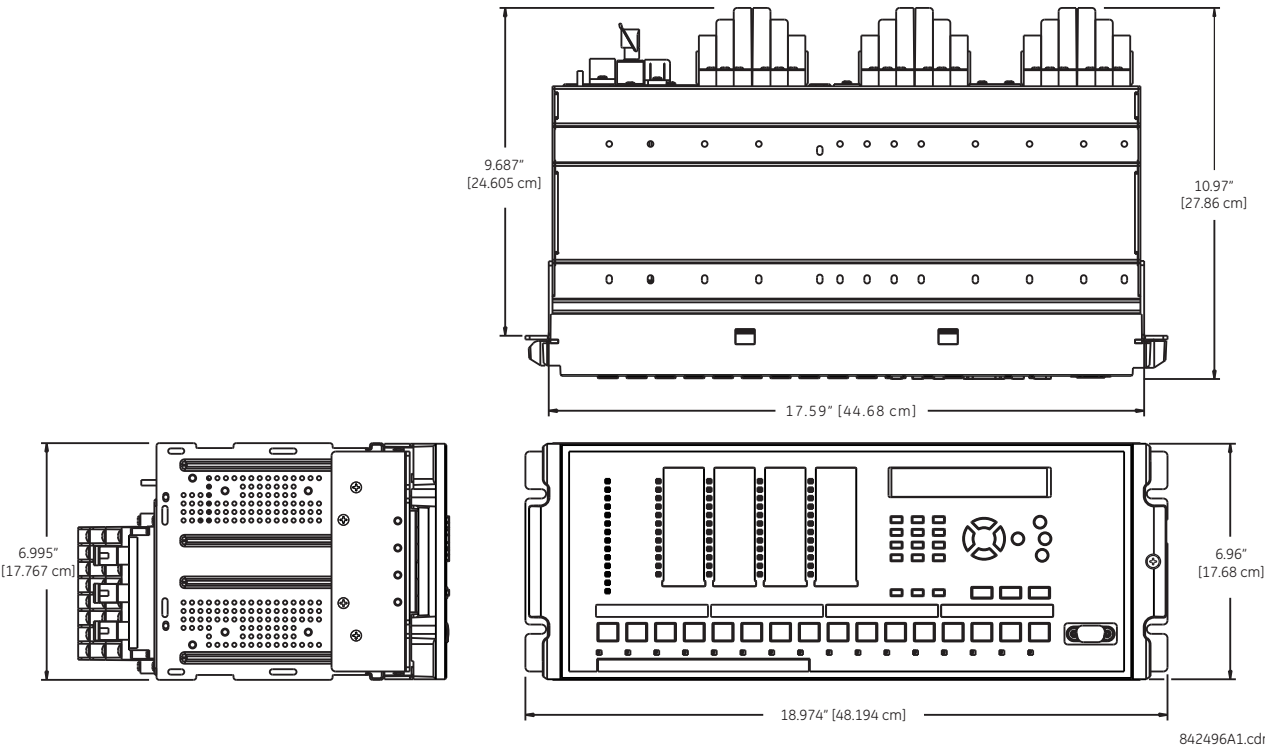


Figure 3-3: Horizontal mounting (enhanced front panel)

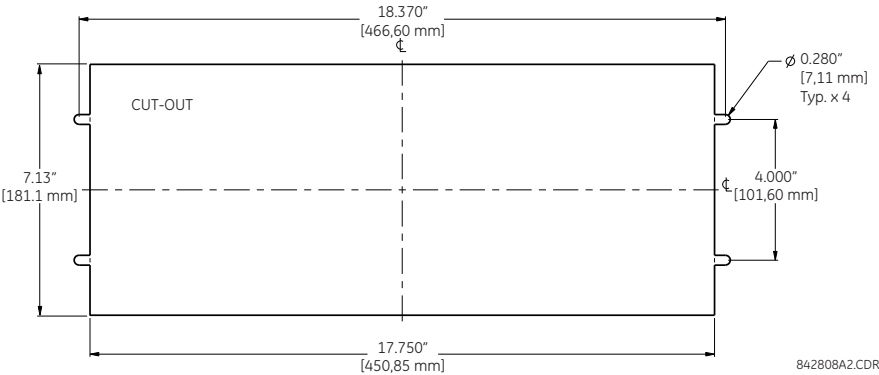


Figure 3-4: Horizontal mounting and dimensions (basic front panel)

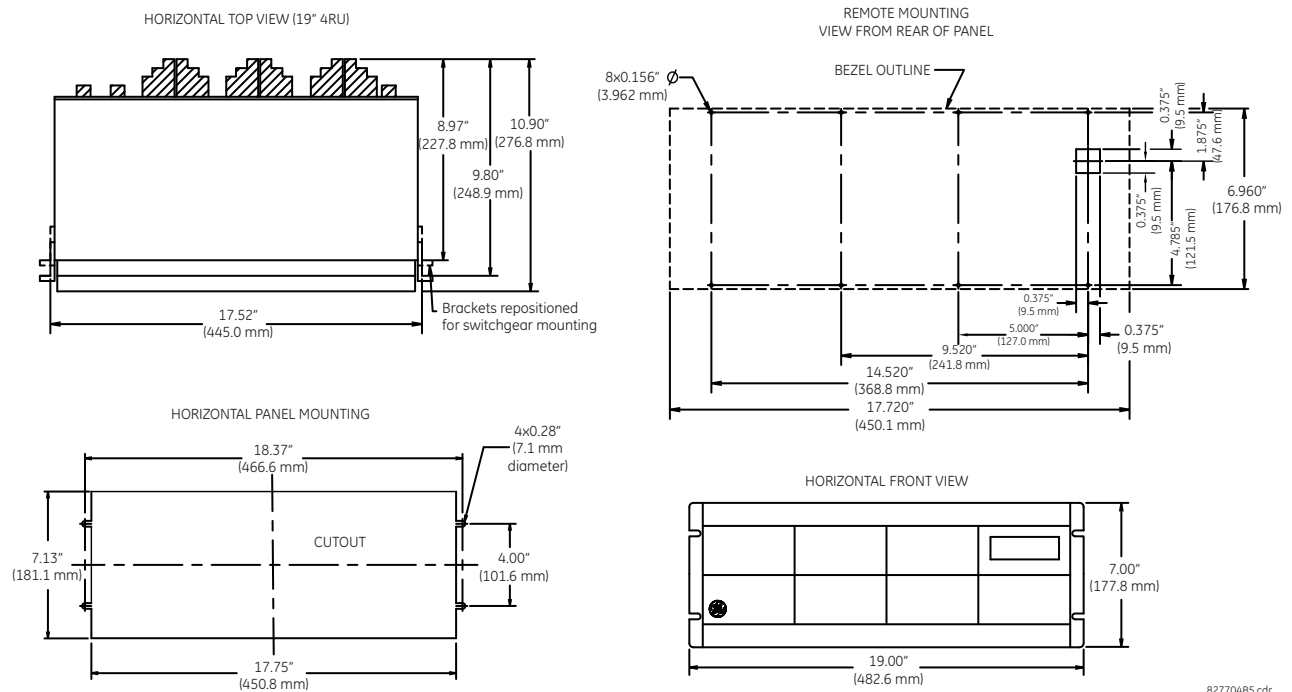
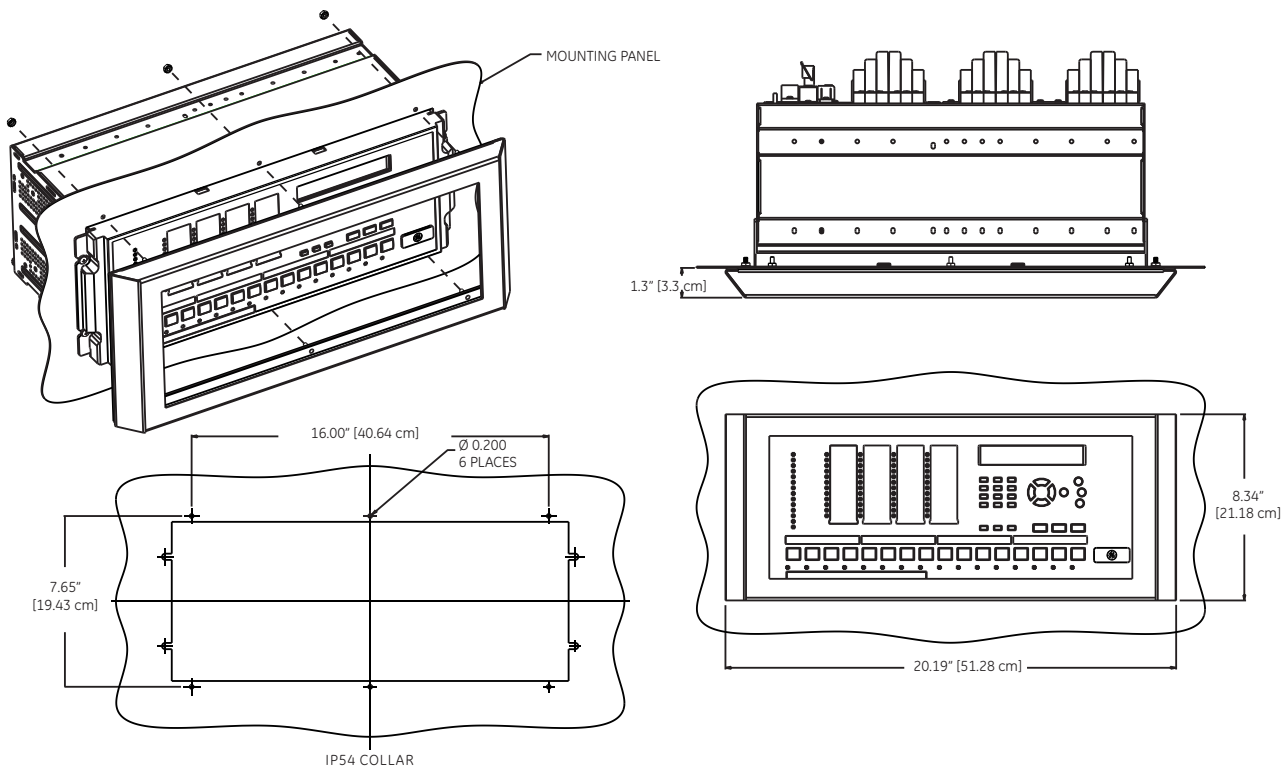


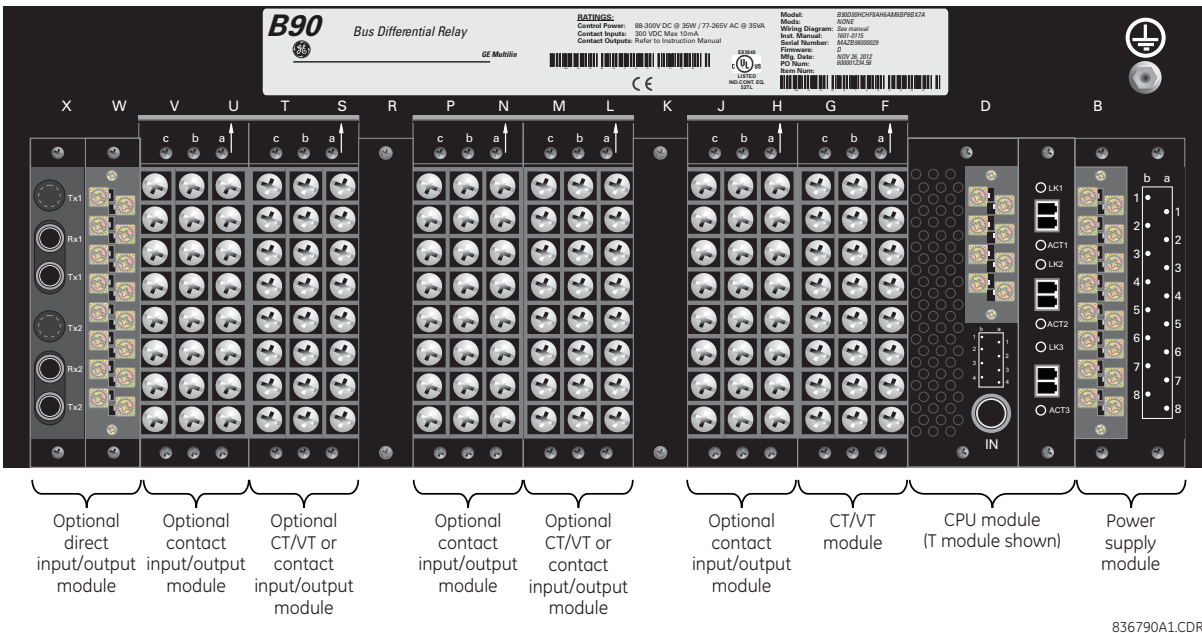
Figure 3-5: Horizontal dimensions (IP54 mounting collar)



- NOTES
- 1. INSPECT THE COLLAR BEFORE INSTALLATION, VERIFY GASKET IS ADHERED TO THE METAL ON ALL SIDES
 - 2. MAKE SURE THE RELAY IS POSITIONED CENTER TO THE CUT OUT
 - 3. INSTALL IP-54 COLLAR, CONFIRM THE GASKET PROPERLY MATES WITH THE PANEL ON ALL SIDES
SECURE USING #8-32 HEX NUT AT 6 PLACES.

842497A1.cdr

Rear terminal layout



836790A1.CDR



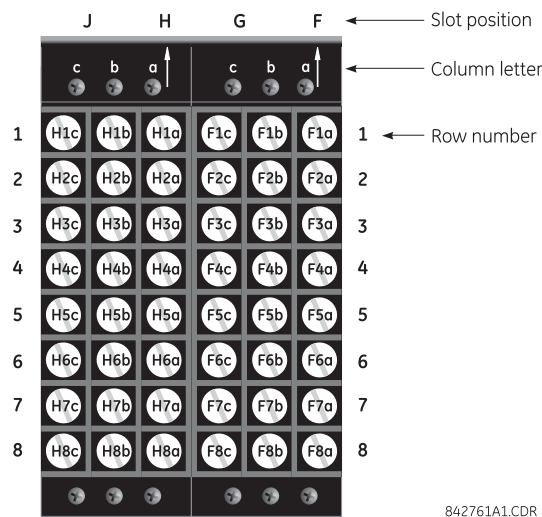
WARNING Do not touch any rear terminals while the relay is energized, else death or serious injury can result from electrical shock.



NOTICE The small form-factor pluggable ports (SFPs) are pluggable transceivers. Do not use non-validated transceivers or install validated transceivers in the wrong Ethernet slot, else damage can occur.

The relay follows a convention with respect to terminal number assignments, which are three characters long and assigned 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), indicated by an arrow marker on the terminal block. The figure shows an example of rear terminal assignments.

Figure 3-6: Example of modules in F and H slots

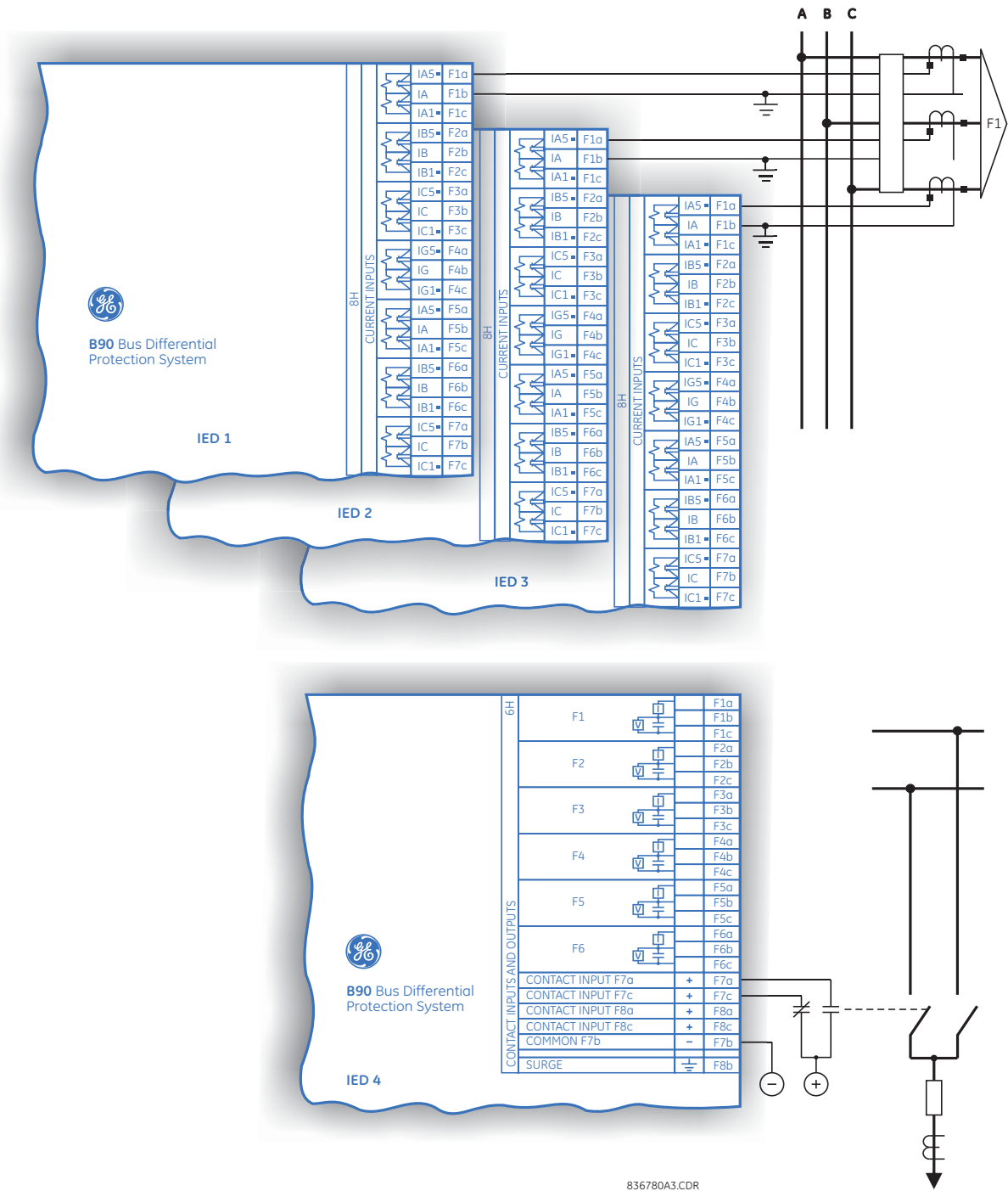


The torque used to connect the terminal blocks to the back of the relay chassis (screws a, b, c shown) is 9 inch-pounds. For the connections to the terminal blocks (rows 1 to 8), use a minimum of 17 inch-pounds. During manufacturing, the power supply and CPU modules are installed in slots B and D of the chassis with 13 inch-pounds of torque on the screws at the top and bottom of the modules.

3.3 Wiring

3.3.1 Typical wiring

Figure 3-7: B90 is a multi-IED protection system



NOTICE

The wiring diagrams on the next four pages are based on the following order code:
B90-H02-HCL-F8H-H6H-L8H-N6A-S8H-U6H-W7H.

The purpose of these diagrams is to provide examples of how the B90 is typically wired, not specifically how to wire your own relay. See the sections following the wiring diagrams for examples on connecting your relay correctly based on your relay configuration and order code.

Figure 3-8: Typical wiring diagram (Phase A; T module shown for CPU)

NOTE: This diagram is based on the following order code:
B90-T02-HCL-F8H-H6H-L8H-N6A-S8H-U6H-W7H
This diagram provides an example of how the device is wired, not specifically how to wire the device. Please refer to the Instruction Manual for additional details on wiring based on various configurations.

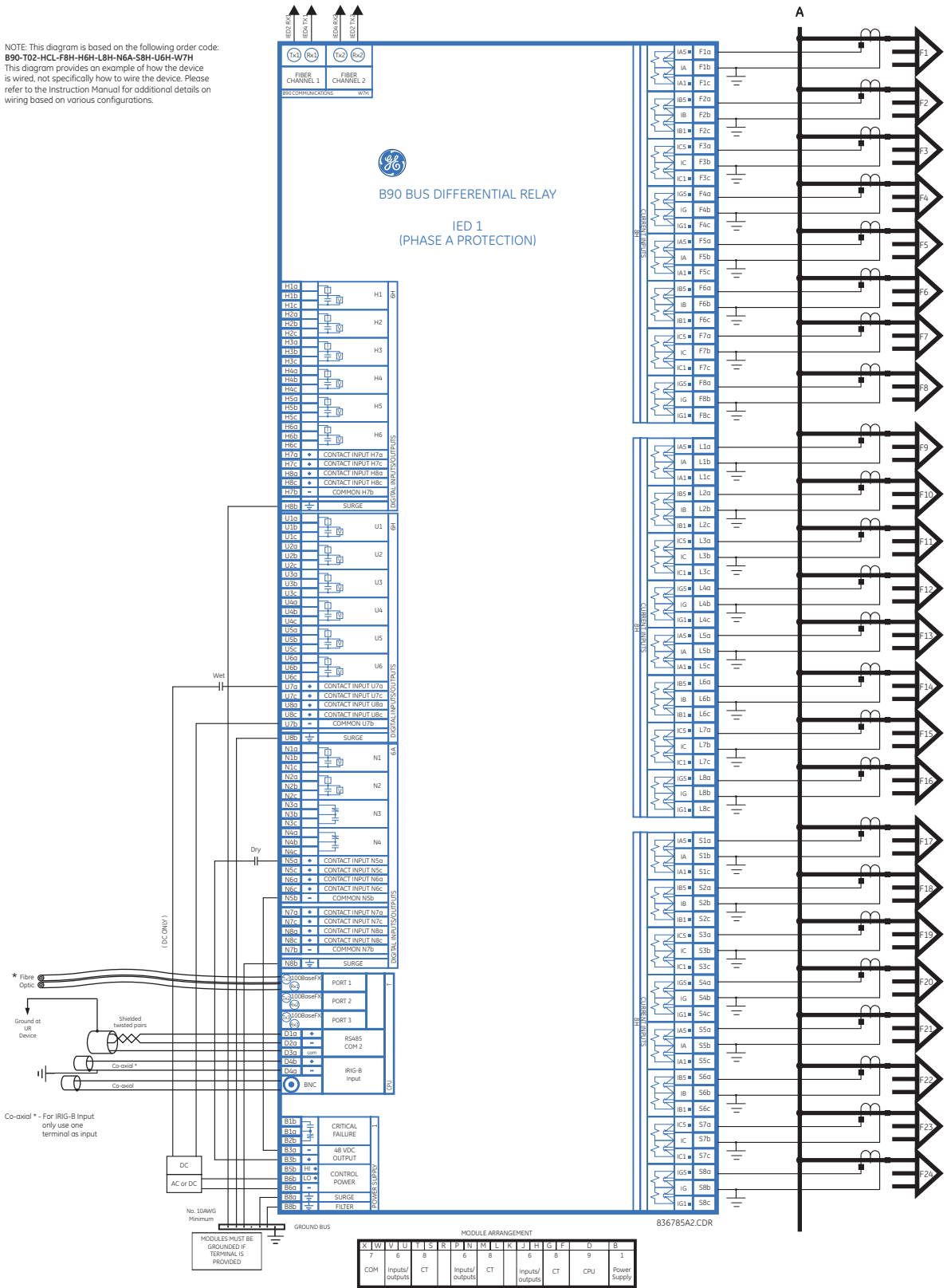


Figure 3-9: Typical wiring diagram (Phase B; T module shown for CPU)

NOTE: This diagram is based on the following order code:
B90-T02-HCL-F8H-H6H-L8H-N6A-S8H-U6H-W7H
 This diagram provides an example of how the device is wired, not specifically how to wire the device. Please refer to the Instruction Manual for additional details on wiring based on various configurations.

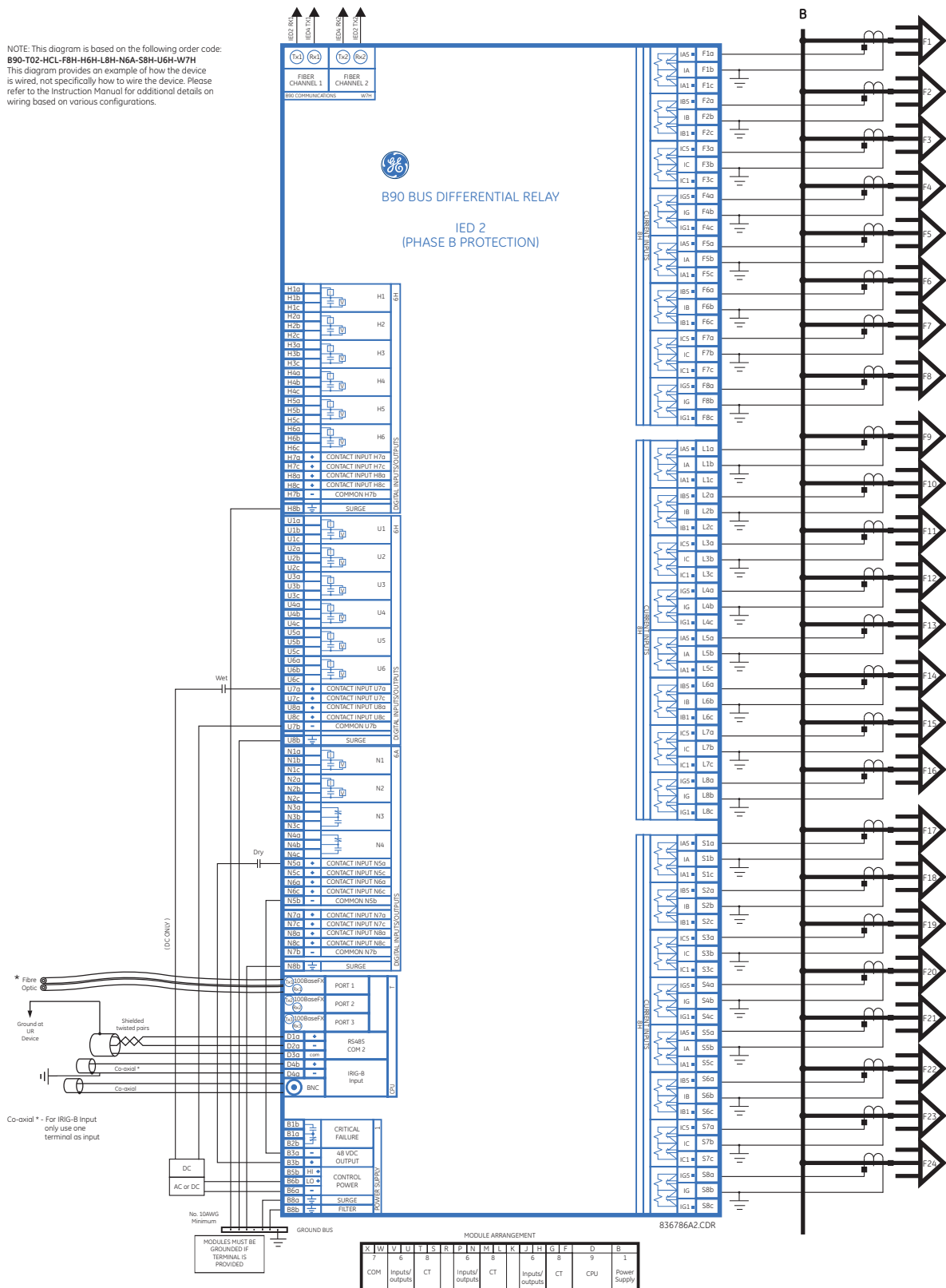


Figure 3-10: Typical wiring diagram (Phase C; T module shown for CPU)

NOTE: This diagram is based on the following order code:
B90-T02-HCL-F8H-H6H-L8H-N6A-S8H-U6H-W7H
This diagram provides an example of how the device is wired, not specifically how to wire the device. Please refer to the Instruction Manual for additional details on wiring based on various configurations.

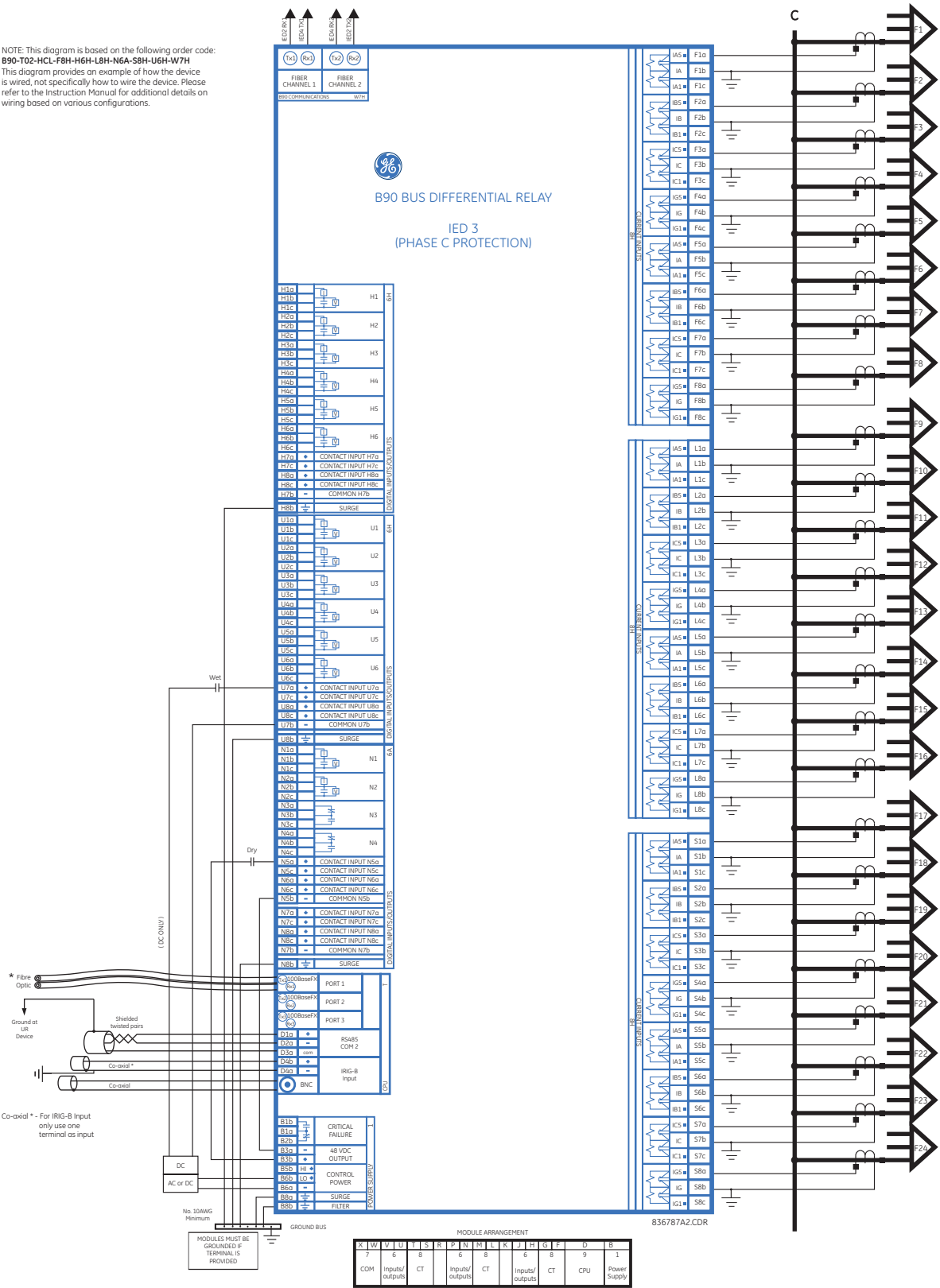
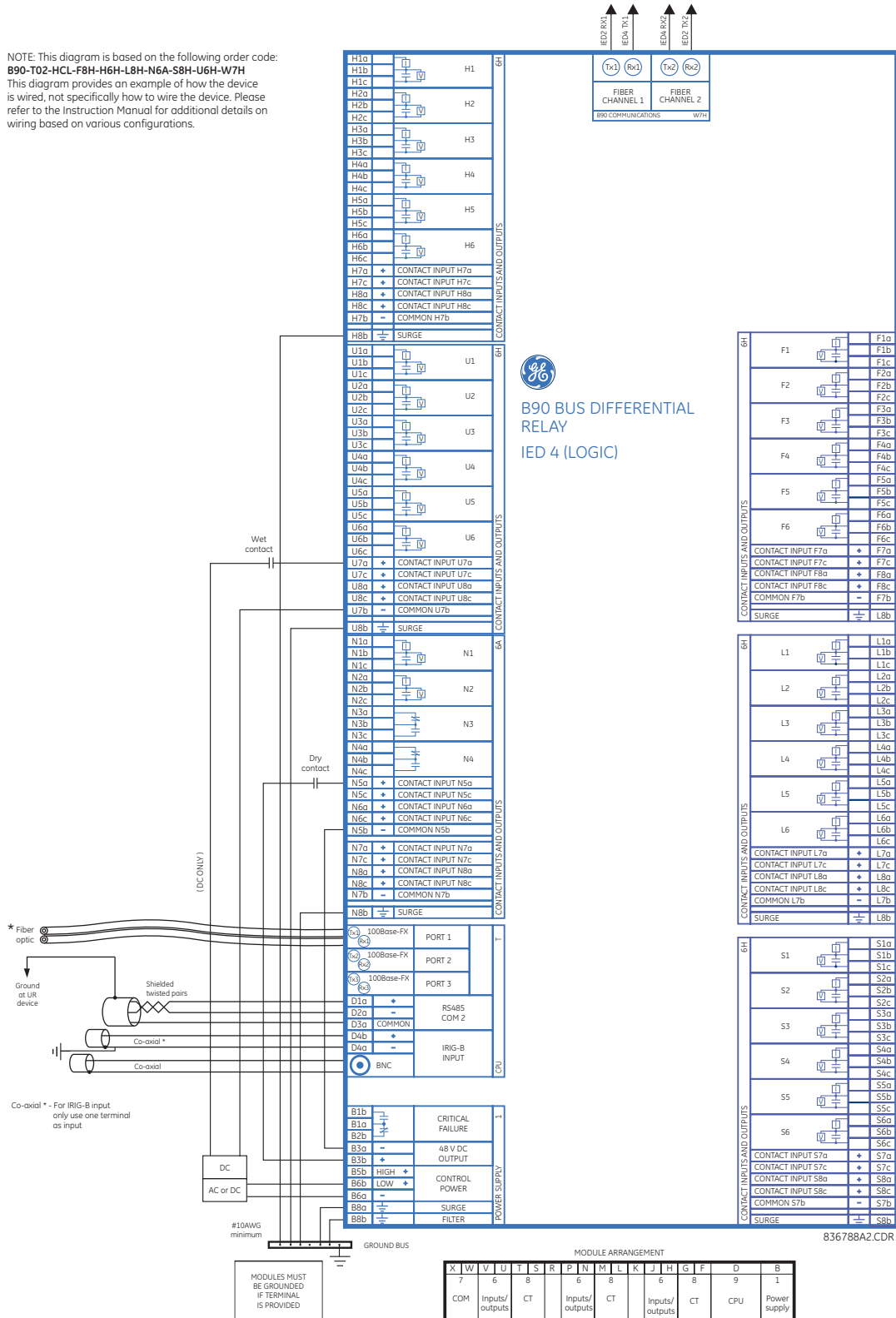


Figure 3-11: Typical wiring diagram (breaker fail and isolator monitoring; T module shown)

NOTE: This diagram is based on the following order code:
B90-T02-HCL-F8H-H6H-L8H-N6A-S8H-U6H-W7H
 This diagram provides an example of how the device is wired, not specifically how to wire the device. Please refer to the Instruction Manual for additional details on wiring based on various configurations.



3.3.2 Dielectric strength

Dielectric strength is the maximum electric strength that can be sustained without breakdown. It is measured in volts. The table shows the dielectric strength of the UR-series module hardware.

Table 3-1: Dielectric strength of UR series modules

Module type	Module function	Terminals		Dielectric strength
		From	To	
1	Power supply	High (+); Low (+); (-)	Chassis	2000 V AC for 1 minute
1	Power supply	48 V DC (+) and (-)	Chassis	2000 V AC for 1 minute
1	Power supply	Relay terminals except terminals 8a and 8b	Chassis	2000 V AC for 1 minute
2	Reserved	N/A	N/A	N/A
3	Reserved	N/A	N/A	N/A
4	Digital contact inputs/outputs	All	Chassis	2000 V AC for 1 minute
5	Analog inputs/outputs	All except 8b	Chassis	< 50 V DC
6	Digital contact inputs/outputs	All	Chassis	2000 V AC for 1 minute
7	G.703	All except 2b, 3a, 7b, 8a	Chassis	2000 V AC for 1 minute
	RS422	All except 6a, 7b, 8a	Chassis	< 50 V DC
8	CT/VT	All	Chassis	2000 V AC for 1 minute
9	CPU	All	Chassis	2000 V AC for 1 minute

NOTICE

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

3.3.3 Control power

NOTICE

Control power supplied to the relay must be connected to the matching power supply range of the relay. If voltage is applied to the wrong terminals, damage can occur.

The B90, like almost all electronic relays, contains electrolytic capacitors. These capacitors are well-known to deteriorate over time if voltage is not applied periodically. Deterioration can be avoided by powering up the relay at least once a year.

The power supply module can be ordered for two possible voltage ranges, and the B90 can be ordered with or without a redundant power supply module option. Each range has a dedicated input connection for proper operation. The ranges are as follows (see the Specifications section of chapter 2 for details):

- Low (LO) range — 24 to 48 V (DC only) nominal
- High (HI) range — 125 to 250 V nominal

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

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

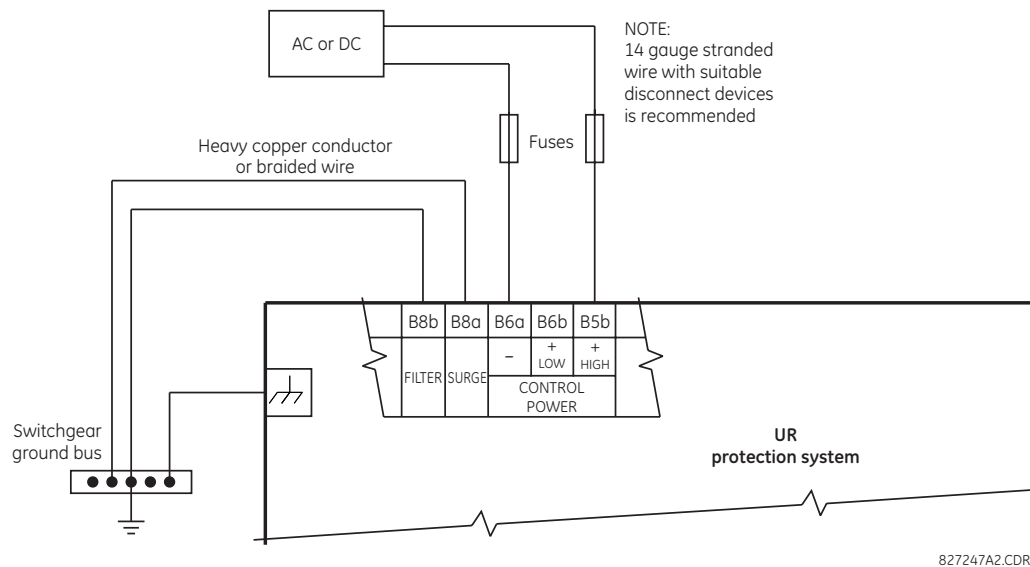
For high-reliability systems, the B90 has a redundant option in which two B90 power supplies are placed in parallel on the bus. If one of the power supplies becomes faulted, the second power supply assumes the full load of the relay without any interruptions. Each power supply has a green LED on the front of the module to indicate that it is functional. The critical fail relay of the module also indicates a faulted power supply.

An LED on the front of the control power module shows the status of the power supply, as outlined in the table.

Table 3-2: Power supply LED on front panel

LED indication	Power supply
Continuous on	OK
On/off cycling	Failure
Off	Failure or no power

Figure 3-12: Control power connection



3.3.3.1 Non-volatile data storage

Non-volatile data is temporary data required after a power cycle for relay state, such as latch status before reboot. The relay saves this data in non-volatile storage every two minutes or when a state change occurs.

If a state change occurs just before a power down (less than two minutes) and the relay power is cycled, some temporary data can be saved and the prior state is retained at power up. Otherwise, a two-minute powered on period after a state change ensures that all temporary state changes required after reboot have been saved. A command also is available to initiate saving of data in the compact flash memory using **Commands > Relay Maintenance > Save Volatile Data**.

3.3.4 CT and VT modules

Information on the CT and VT modules for the B90 relay is shown here.

NOTICE

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.

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.

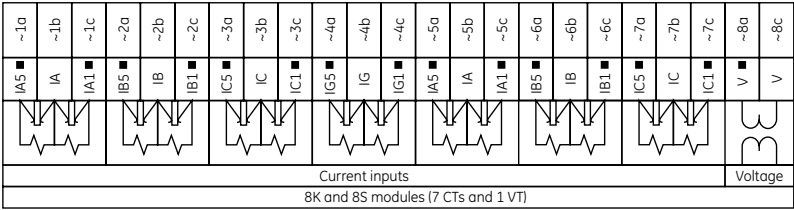
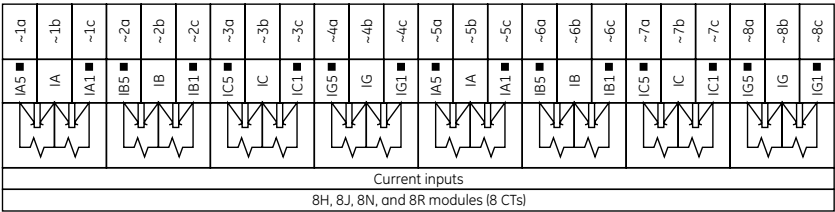
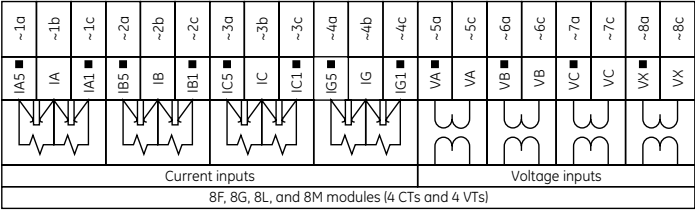
Each B90 voltage input is intended for monitoring a single-phase voltage. The may include phase voltages or neutral voltage from the open-delta VT.

All CT and VT modules are available with enhanced diagnostics. These modules can automatically detect CT/VT hardware failure and take the relay out of service.



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

Figure 3-13: CT/VT module wiring



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3.3.5 Contact inputs and outputs

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

The contact inputs are grouped with a common return. The input/output modules have two versions of grouping: four inputs per common return and two inputs per common return. When a contact input/output module is ordered, four inputs per common is used. If the inputs must be isolated per row, then two inputs per common return are selected (4D module).

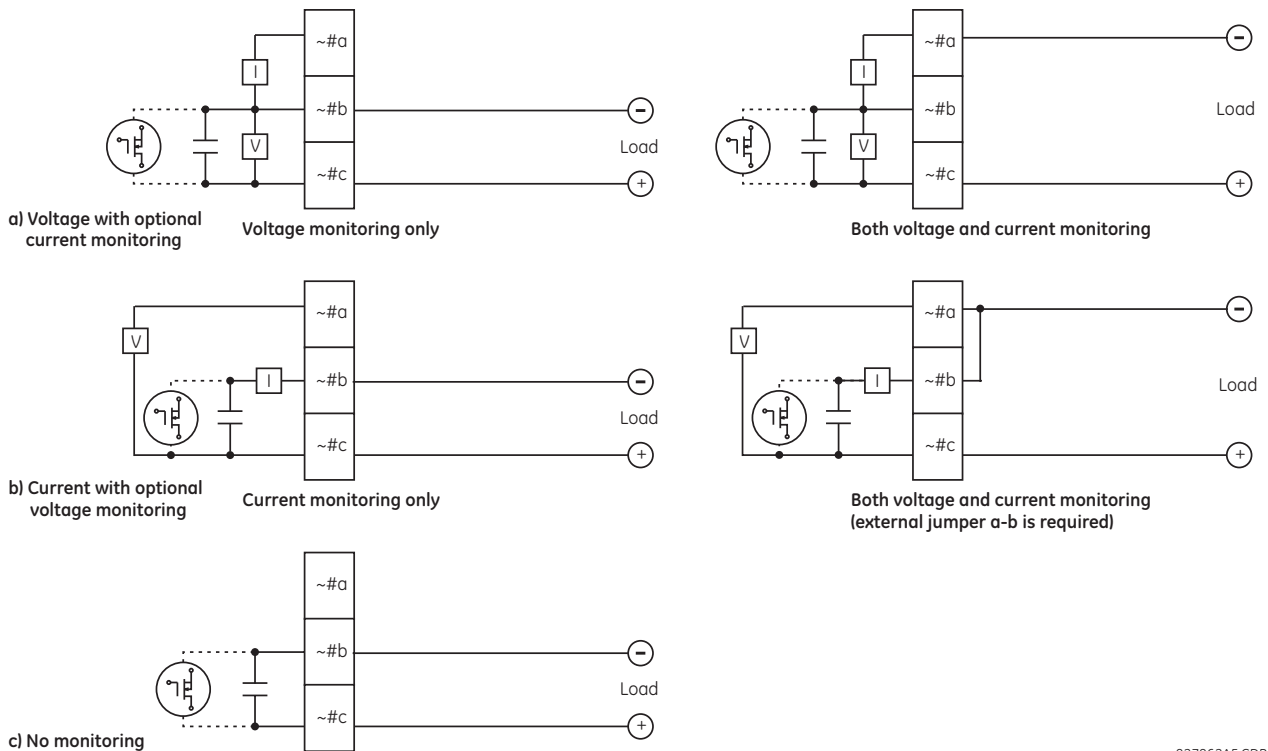
The tables and diagrams on the following pages illustrate the module types (6A and so on) and contact arrangements that can be ordered for the relay. Since an entire row is used for a single contact output, the name is assigned using the module slot position and row number. However, since there are two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

Some form-A / solid-state relay outputs include circuits to monitor the DC voltage across the output contact when it is open, and the DC current through the output contact when it is closed. Each of the monitors contains a level detector whose output is set to logic “On” when the current in the circuit is above the threshold setting. The voltage monitor is set to “On” when there is a voltage across open contact (the detector allows a current of about 1 to 2.5 mA), and the current monitor is set to “On” when the current flowing through the closed contact 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. 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.

Block diagrams are shown as follows for form-A and solid-state relay outputs with optional voltage monitor, optional current monitor, and with no monitoring. The actual values shown for contact output 1 are the same for all contact outputs. Form-A contact output with or without a current or voltage monitoring option is not polarity sensitive. The polarity shown in the figure is required for solid-state contact output connection.

Figure 3-14: Form-A and solid-state contact outputs with voltage and current monitoring



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The operation of voltage and current monitors is reflected with the corresponding FlexLogic operands ([CONT OP # VON](#), [CONT OP # VOFF](#), and [CONT OP # ION](#)) that 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.

See the Digital Elements section of chapter 5 for an example of how form-A and solid-state relay contacts can be applied for breaker trip circuit integrity monitoring.



Consider relay contacts unsafe to touch when the unit is energized. Death or serious injury can result from touching live relay contacts.



USE OF FORM-A AND SOLID-STATE RELAY OUTPUTS IN HIGH-IMPEDANCE CIRCUITS

For form-A and solid-state relay output contacts internally equipped with a voltage measuring circuit across the contact, the circuit has an impedance that can cause a problem when used in conjunction with external high-input impedance monitoring equipment such as modern relay test set trigger circuits. These monitoring circuits can continue to read the form-A contact as being closed after it has closed and subsequently opened, when measured as an impedance.

The solution 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.

3



Where a tilde “~” symbol appears, substitute the slot position of the module. Where a number sign “#” appears, substitute the contact number.

NOTICE

When current monitoring is used to seal-in the form-A and solid-state relay contact outputs, give the FlexLogic operand driving the contact output 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 3-3: Contact input and output module assignments

~6A module		~6B module		~6C module		~6D module	
Terminal assignment	Output or input	Terminal assignment	Output or input	Terminal assignment	Output	Terminal assignment	Output
~1	Form-A	~1	Form-A	~1	Form-C	~1a, ~1c	2 Inputs
~2	Form-A	~2	Form-A	~2	Form-C	~2a, ~2c	2 Inputs
~3	Form-C	~3	Form-C	~3	Form-C	~3a, ~3c	2 Inputs
~4	Form-C	~4	Form-C	~4	Form-C	~4a, ~4c	2 Inputs
~5a, ~5c	2 Inputs	~5	Form-C	~5	Form-C	~5a, ~5c	2 Inputs
~6a, ~6c	2 Inputs	~6	Form-C	~6	Form-C	~6a, ~6c	2 Inputs
~7a, ~7c	2 Inputs	~7a, ~7c	2 Inputs	~7	Form-C	~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs	~8a, ~8c	2 Inputs	~8	Form-C	~8a, ~8c	2 Inputs

~6E module		~6F module		~6G module		~6H module	
Terminal assignment	Output or input	Terminal assignment	Output	Terminal assignment	Output or input	Terminal assignment	Output or input
~1	Form-C	~1	Fast Form-C	~1	Form-A	~1	Form-A
~2	Form-C	~2	Fast Form-C	~2	Form-A	~2	Form-A
~3	Form-C	~3	Fast Form-C	~3	Form-A	~3	Form-A
~4	Form-C	~4	Fast Form-C	~4	Form-A	~4	Form-A
~5a, ~5c	2 Inputs	~5	Fast Form-C	~5a, ~5c	2 Inputs	~5	Form-A
~6a, ~6c	2 Inputs	~6	Fast Form-C	~6a, ~6c	2 Inputs	~6	Form-A
~7a, ~7c	2 Inputs	~7	Fast Form-C	~7a, ~7c	2 Inputs	~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs	~8	Fast Form-C	~8a, ~8c	2 Inputs	~8a, ~8c	2 Inputs

~6K module	
Terminal assignment	Output
~1	Form-C
~2	Form-C
~3	Form-C
~4	Form-C
~5	Fast Form-C
~6	Fast Form-C
~7	Fast Form-C
~8	Fast Form-C

~6L module	
Terminal assignment	Output or input
~1	Form-A
~2	Form-A
~3	Form-C
~4	Form-C
~5a, ~5c	2 Inputs
~6a, ~6c	2 Inputs
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs

~6M module	
Terminal assignment	Output or input
~1	Form-A
~2	Form-A
~3	Form-C
~4	Form-C
~5	Form-C
~6	Form-C
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs

~6N module	
Terminal assignment	Output or input
~1	Form-A
~2	Form-A
~3	Form-A
~4	Form-A
~5a, ~5c	2 Inputs
~6a, ~6c	2 Inputs
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs

~6P module	
Terminal assignment	Output or input
~1	Form-A
~2	Form-A
~3	Form-A
~4	Form-A
~5	Form-A
~6	Form-A
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs

~6R module	
Terminal assignment	Output or input
~1	Form-A
~2	Form-A
~3	Form-C
~4	Form-C
~5a, ~5c	2 Inputs
~6a, ~6c	2 Inputs
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs

~6S module	
Terminal assignment	Output or input
~1	Form-A
~2	Form-A
~3	Form-C
~4	Form-C
~5	Form-C
~6	Form-C
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs

~6T module	
Terminal assignment	Output or input
~1	Form-A
~2	Form-A
~3	Form-A
~4	Form-A
~5a, ~5c	2 Inputs
~6a, ~6c	2 Inputs
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs

~6U module	
Terminal assignment	Output or input
~1	Form-A
~2	Form-A
~3	Form-A
~4	Form-A
~5	Form-A
~6	Form-A
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs

~6V module	
Terminal assignment	Output or input
~1	Form-A
~2	Form-A
~3	Form-C
~4	2 Outputs
~5a, ~5c	2 Inputs
~6a, ~6c	2 Inputs
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs

~67 module	
Terminal assignment	Output
~1	Form-A
~2	Form-A
~3	Form-A
~4	Form-A
~5	Form-A
~6	Form-A
~7	Form-A
~8	Form-A

~4A module	
Terminal assignment	Output
~1	Not Used
~2	Solid-State
~3	Not Used
~4	Solid-State
~5	Not Used
~6	Solid-State
~7	Not Used
~8	Solid-State

~4B module	
Terminal assignment	Output
~1	Not Used
~2	Solid-State
~3	Not Used
~4	Solid-State
~5	Not Used
~6	Solid-State

~4C module	
Terminal assignment	Output
~1	Not Used
~2	Solid-State
~3	Not Used
~4	Solid-State
~5	Not Used
~6	Solid-State

~4D module	
Terminal assignment	Output
~1a, ~1c	2 Inputs
~2a, ~2c	2 Inputs
~3a, ~3c	2 Inputs
~4a, ~4c	2 Inputs
~5a, ~5c	2 Inputs
~6a, ~6c	2 Inputs

~4L module	
Terminal assignment	Output
~1	2 Outputs
~2	2 Outputs
~3	2 Outputs
~4	2 Outputs
~5	2 Outputs
~6	2 Outputs

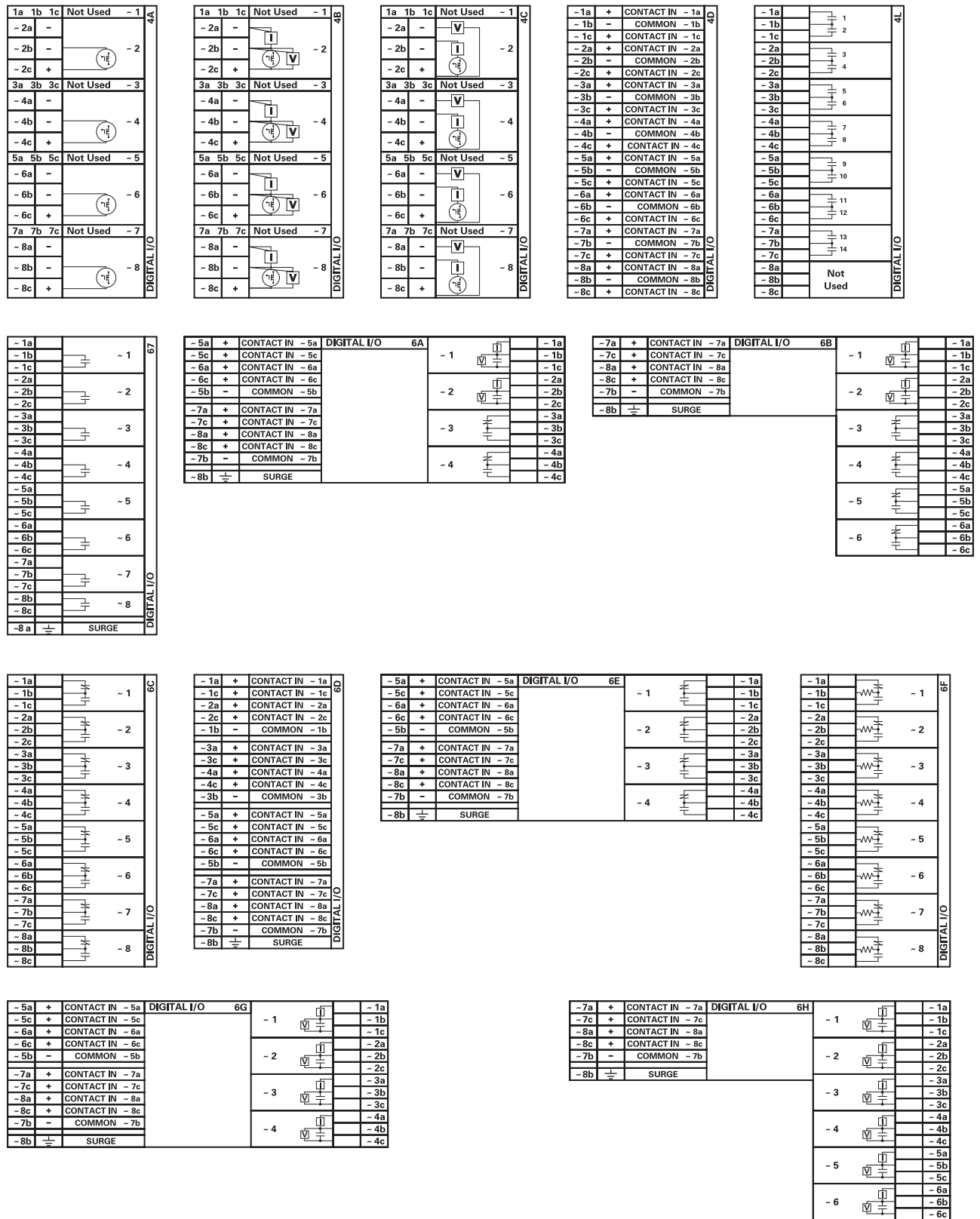
~4B module	
Terminal assignment	Output
~7	Not Used
~8	Solid-State

~4C module	
Terminal assignment	Output
~7	Not Used
~8	Solid-State

~4D module	
Terminal assignment	Output
~7a, ~7c	2 Inputs
~8a, ~8c	2 Inputs

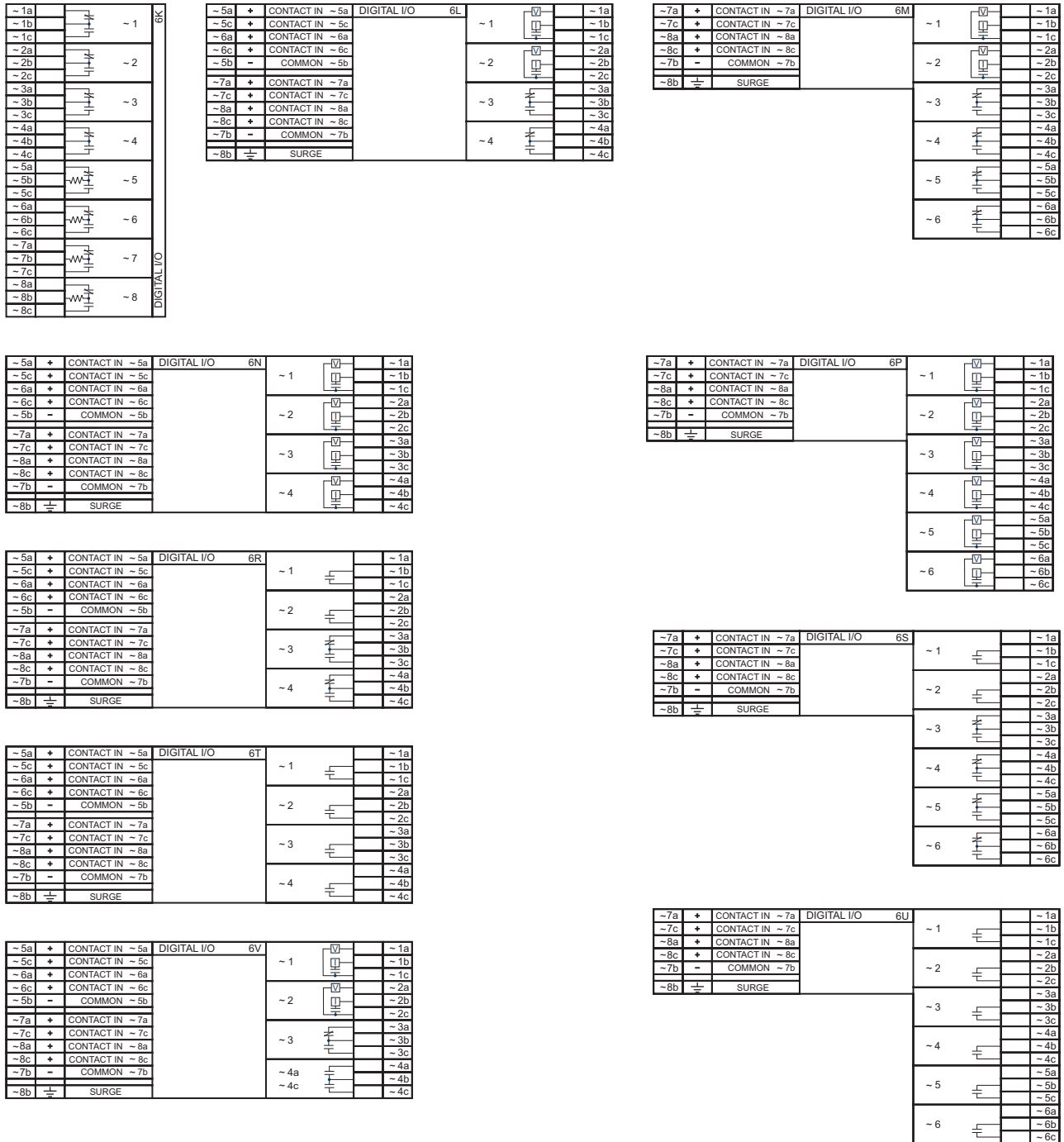
~4L module	
Terminal assignment	Output
~7	2 Outputs
~8	Not Used

Figure 3-15: Contact input and output module wiring (Sheet 1 of 2)



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Figure 3-16: Contact input and output module wiring (Sheet 2 of 2)



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NOTICE

For proper functionality, observe the polarity shown in the figures for all contact input and output connections.

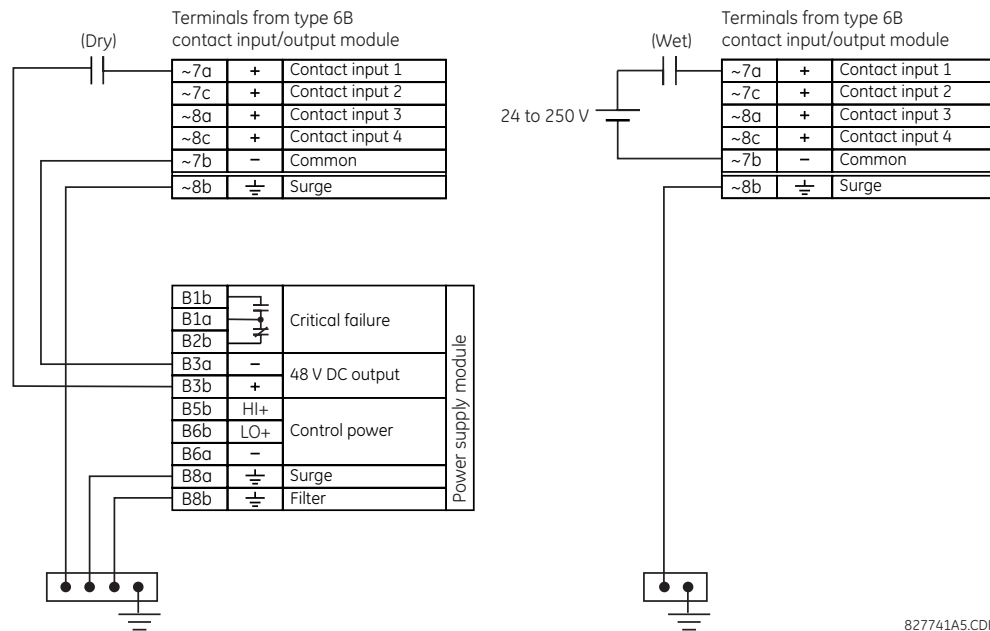
3.3.5.1 Contact inputs

A dry contact has one side connected to terminal B3b. This is the positive 48 V DC voltage rail supplied by the power supply module. The other side of the dry contact is connected to the required contact input terminal. Each contact input group has its own common (negative) terminal that 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 flows through the associated circuit.

A wet contact has one side connected to the positive terminal of an external DC power supply. The other side of this contact is connected to the required contact input terminal. If a wet contact is used, then the negative side of the external source must be connected to the relay common (negative) terminal of each contact group. The maximum external source voltage for this arrangement is 300 V DC.

The voltage threshold at which each group of four contact inputs detects 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 3-17: Dry and wet contact input connections



Where a tilde “~” symbol appears, substitute the slot position of the module.

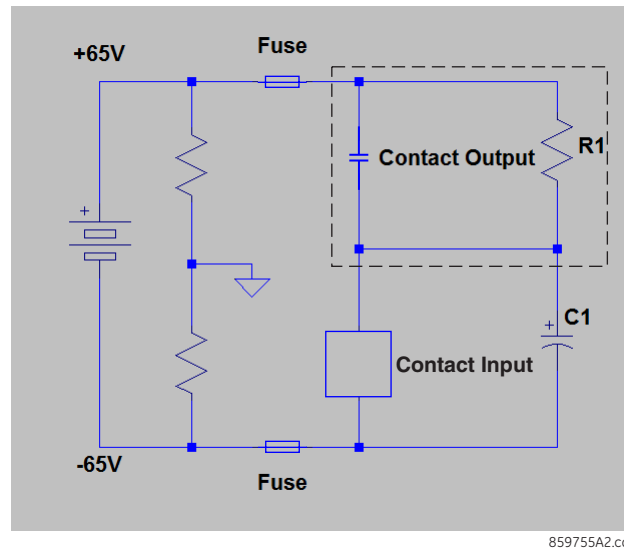
There is no provision in the relay to detect a DC ground fault on 48 V DC control power external output. We recommend using an external DC supply.

3.3.5.2 General application considerations

Contacts outputs of protective relays, auxiliary contacts from breakers, disconnectors and other devices, are generally connected to contacts inputs of protective relays. In some situations, the contact outputs of some protective relays can have high impedance connected across it. When such a contact output is connected across a B90 contact input, it can spuriously operate the B90 input even when the output is open, if there is a substantial distributed capacitance (represented by C1) present in the wiring between the output and the B90 input and the debounce time setting in the B90 relay is low enough. This false assertion of the contact input, when there is inadvertent ground present at the DC positive terminal, can be prevented by inserting a resistor across the B90 input.

The following figure shows a typical DC circuit, with battery ground detection, of contact input. The contact output has parallel impedance across it (represented by R1).

Figure 3-18: Typical contact input DC circuit



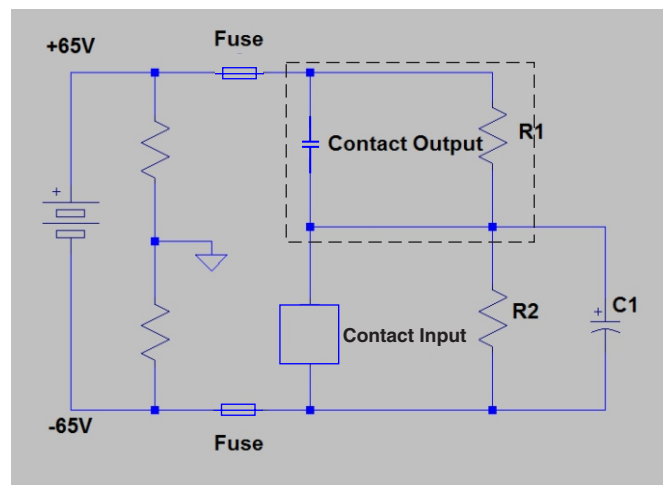
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The presence of the impedance path (R1) across the contact output allows the stray (distributed) capacitance C1 to charge as shown, thus developing a voltage across the contact input enough to momentarily operate the input while the capacitance discharges in the presence of DC ground on the positive terminal of the battery.

The duration of the discharge depends on the value of the distributed capacitance, the initial voltage of the distributed capacitance, and the input impedance of the contact input. If the duration is greater than the debounce time setting, then the contact input operates.

The application example that follows describes how to mitigate this problem by connecting a resistor across the contact input, as shown in the next figure, or by adjusting the debounce time setting to a value greater than the discharge time to prevent spurious operation of the contact input only if the voltage (with output open) across the contact input due to trickle current is less than the threshold voltage. This operation of contact inputs also can be prevented by using the Auto-Burnish contact inputs or contact inputs with active impedance.

Figure 3-19: Contact input connected to a contact output with resistor (R2) across the input



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Application example

This example is for illustrative purposes only and the calculations present the worst-case scenario. In practice, the value of debounce time can be lower.

Contact input ON state impedance used in the calculation of the discharge period is based on the following table.

Table 3-4: Discharge period

Battery voltage (V)	Input impedance (kΩ)
130	50
250	97

Debounce time setting = 2 ms

Assume a stray capacitance of 0.1 μF.

Assume an initial voltage across the stray capacitance "Vinitial" = 19 V (Vthreshold - 65 V), where Vthreshold = 84 V. The initial voltage Vinitial depends on values of impedance of R1 and contact inputs when the contact input is OFF (non-activated state).

Therefore, discharge time constant (τ) = 50 kΩ * 0.1 μF = 5 ms.

Discharge period t is calculated from the following equation:

$$V_{\text{threshold}} = (V_{\text{batt}} - V_{\text{initial}}) * e^{(-t/\tau)}$$

$$84 = -149 * e^{(t/0.005)}$$

$$T = -0.005 * \ln(84/149) = 0.0029 \text{ s}$$

Eq. 3-1

Therefore, in this example the contact inputs operate.

To prevent this operation, the debounce time must be increased to 4 ms (set debounce time as per the following table) or insert a resistor less than or equal to "R" as calculated later.

Table 3-5: Typical debounce time setting

Stray capacitance (μF)	Battery voltage (V)	Debounce time (ms)
0.05	130	2
0.1	130	4
0.2	130	6
0.05	250	3
0.1	250	6
0.2	250	11

The value of this resistor "R" is calculated as follows:

1. Determine the minimum voltage (V threshold) required to turn on the input. This is determined by direct measurement or referenced in the input specifications.
2. Calculate the resistance necessary to limit the voltage to 1/3 V threshold (when the contact is OFF, the non-activated state) as follows:

$$R = (V_{\text{threshold}} / 3) / (2 \text{ mA})$$

Eq. 3-2

The 2 mA current is used in case the contact input is connected across the GE Form A contact output with voltage monitoring. Otherwise use the amperage of the active circuit connected to the contact input when its contact output is open and the voltage across the contact input is third trigger threshold to calculate the resistor value.

3. When the contact is ON (operate state), the battery voltage appears across the resistor. The wattage rating of the resistor is then:

$$PR = 1.3 * (V_{\text{batt}})^2 / R \text{ Watts}$$

Eq. 3-3

4. Applying the following equation to our example:

$$R = 84 \text{ V} / 3 * (1 / 2 \text{ mA}) = 14 \text{ k}\Omega$$

$$PR = 1.57 \text{ Watts}$$

Eq. 3-4

5. Calculating the voltage across the contact input with the Burden Resistor, Voltage across the contact Input:

$$V_{\text{resistor}} = 2 \text{ mA} * 14 \text{ k}\Omega = 28 \text{ V}$$

$$V_{\text{resistor}} < \text{contact input threshold (84 V)}$$

Eq. 3-5

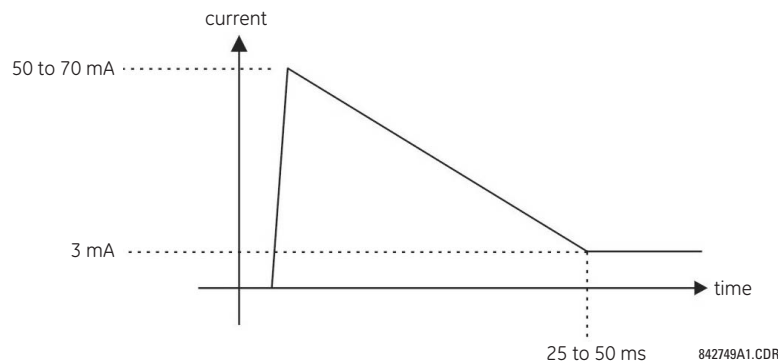
In conclusion, in this example, the contact input does NOT operate falsely with the Burden Resistor across its input AND when a battery ground is present.

3.3.5.3 Use of contact inputs with auto-burnishing

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

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

Figure 3-20: Current through contact inputs with auto-burnishing

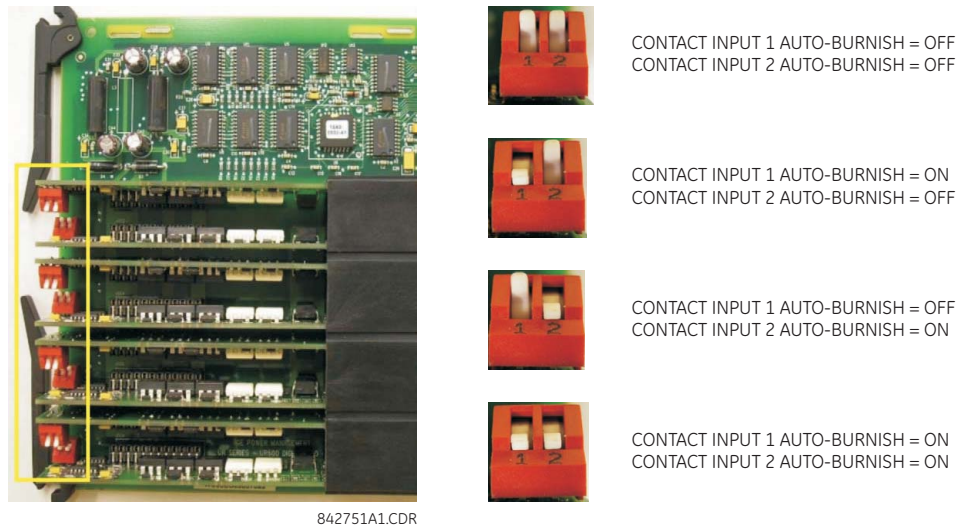


Regular contact inputs limit current to less than 3 mA to reduce station battery burden. In contrast, contact inputs with auto-burnishing allow currents up to 50 to 70 mA at the first instance when the change of state was sensed. Then, within 25 to 50 ms, this current is slowly reduced to 3 mA as indicated.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

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

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

Figure 3-21: Auto-burnish DIP switches



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

3.3.5.4 Use of contact inputs with active impedance

Contact inputs susceptible to parasitic capacitance caused by long cable runs affected by switching surges from external circuits can result in inadvertent activation of contact inputs with the external contact open. In this case, GE recommends using the contact I/O module with active impedance circuit.

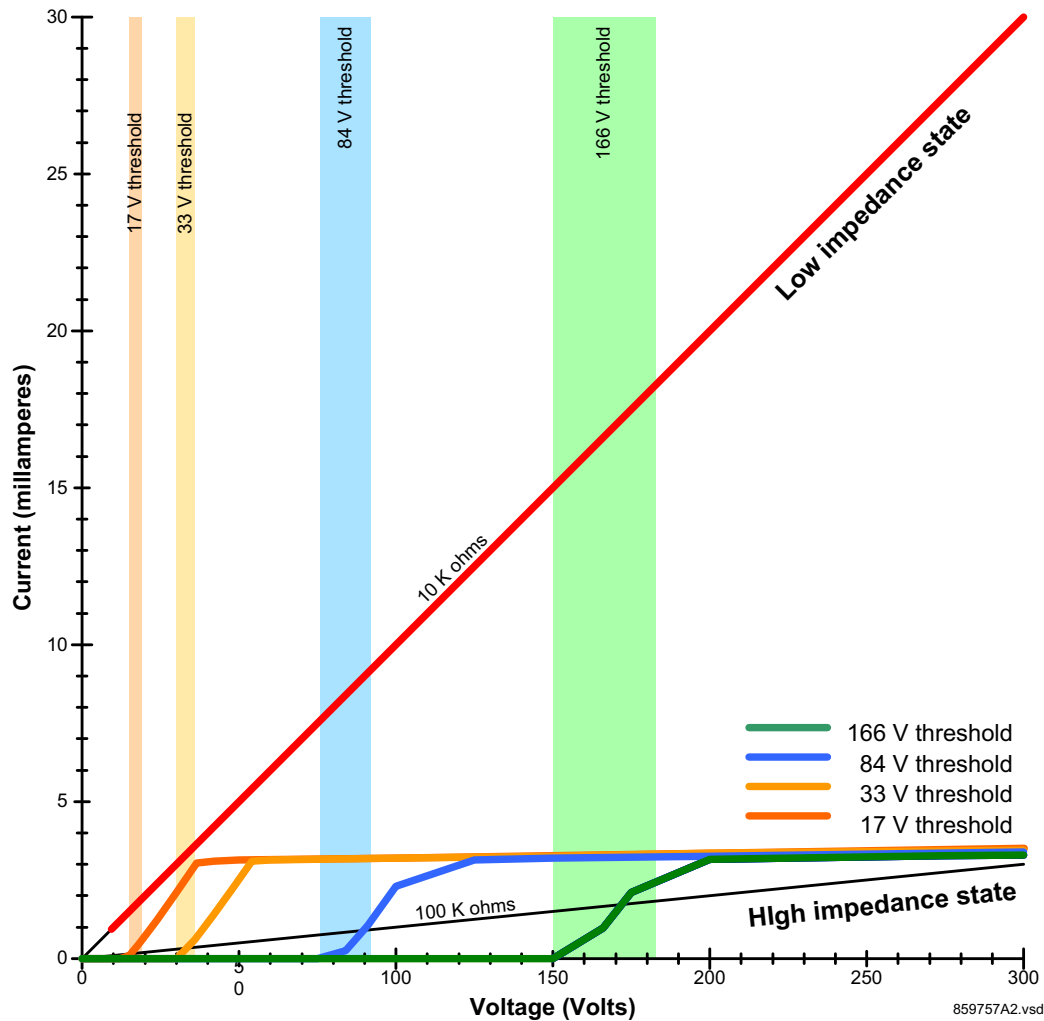
Active impedance contact input can tolerate external cable capacitance of up to 0.2 μF , without entering the ON state for more than 2 ms. The contact input debounce time can still be set above 2 ms for added security to prevent contact input activations caused by external transient ON states.

An active impedance contact input is normally in Low impedance mode during OFF contact state (non-activated condition). During Low impedance state contact input impedance is maintained at 10 K Ohms impedance to allow fast discharge of the stray capacitance of the long cables.

When the contact input voltage exceeds the set threshold, active impedance maintains 10 K Ohms impedance value. If voltage starts rapidly decreasing, this indicates that stray capacitance is being discharged through the contact input. If, however, voltage stabilizes above the set threshold, the input impedance is switched to High impedance mode of 100 K Ohms. This value reduces the input current to <3 mA, and contact input switched to the ON state (operated state).

The figure shows the active impedance contact input V-I characteristic. Different thresholds with their corresponding characteristics are shown by color. The contact input is in the ON (operated) state if the input voltage is to the right of the colored threshold band (+/-10% tolerance), and the contact input is in the OFF (non-activated) state when input voltage is to the left of the band. A contact input is in LOW state during non-operated system condition, and actively switches to HIGH state upon detection of input voltage above the settable threshold.

Figure 3-22: Active impedance contact input V-I characteristic

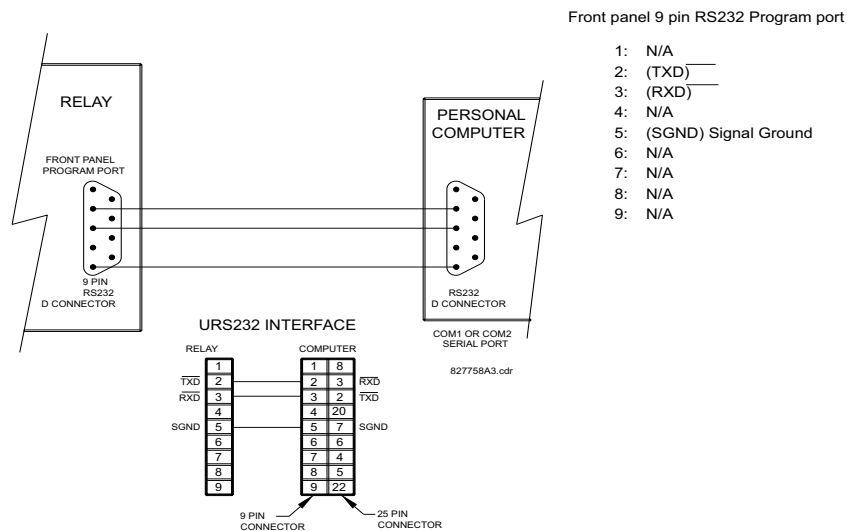


3.3.6 RS232C faceplate port

A nine-pin RS232C serial port is located on the faceplate for programming with a computer. All that is required to use this interface is a computer running the EnerVista UR Setup software provided with the relay. Cabling for the RS232 port is shown in the following figure for both 9-pin and 25-pin connectors.

The baud rate for this port can be set, with a default of 115200 bps.

Figure 3-23: RS232 faceplate port connection

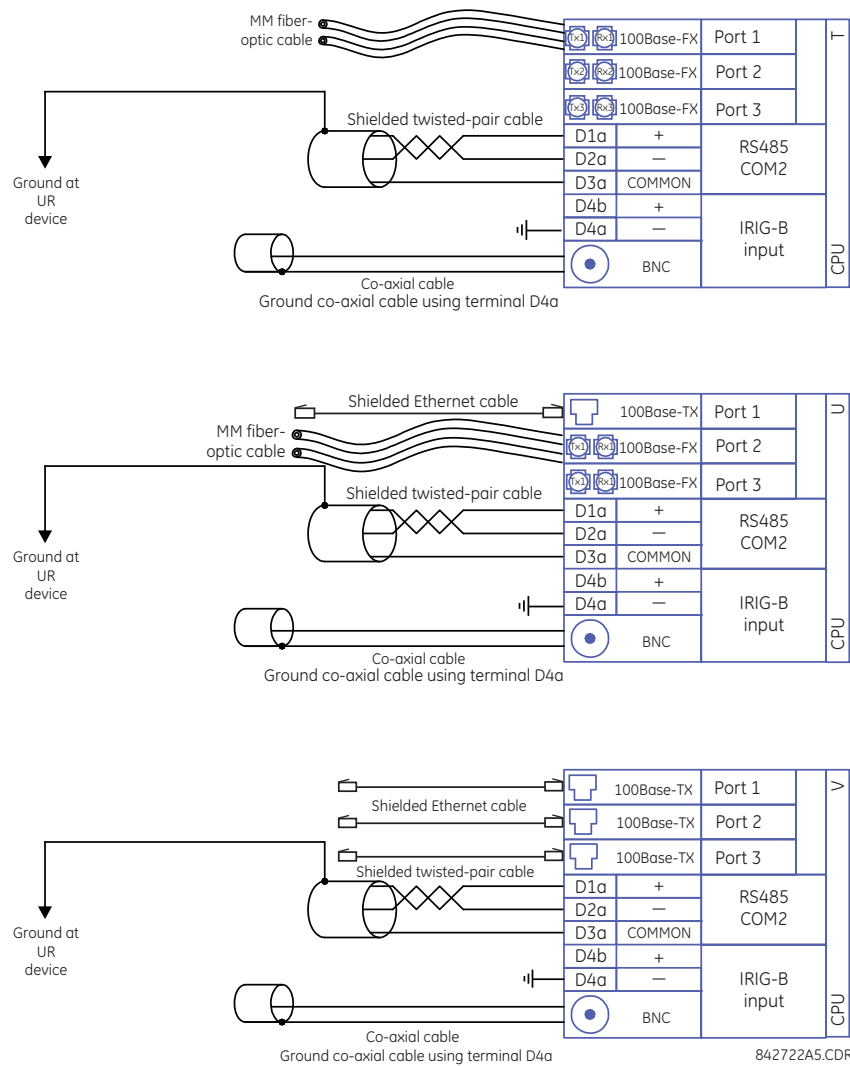


3.3.7 CPU communication ports

3.3.7.1 Overview

In addition to the faceplate RS232 port, there is a rear RS485 communication port. The CPU modules do not require a surge ground connection.

Figure 3-24: CPU module communications wiring



3.3.7.2 RS485 port

RS485 data transmission and reception are accomplished over a single twisted-pair wire with transmit and receive data alternating over the same two wires. Through the use of the port, continuous monitoring and control from a remote computer, SCADA system, or Power Line Carrier (PLC) is possible.

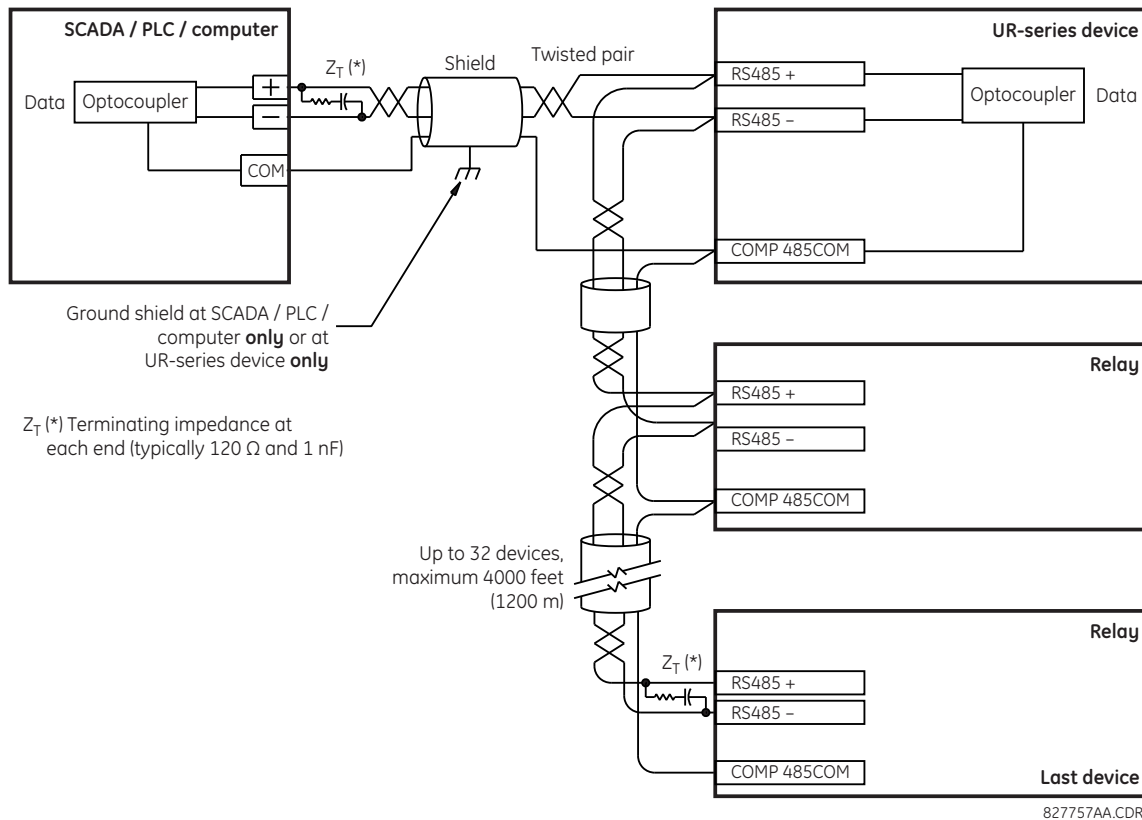
To minimize errors from noise, the use of shielded twisted-pair wire is recommended. Correct polarity must be observed. For instance, the relays must be connected with all RS485 “+” terminals connected together, and all RS485 “-” terminals connected together. Though data is transmitted over a two-wire twisted pair, all RS485 devices require a shared reference, or common voltage. This common voltage is implied to be a power supply common. Some systems allow the shield (drain wire) to be used as common wire and to connect directly to the B90 COM terminal (#3); others function correctly only if the common wire is connected to the B90 COM terminal, but insulated from the shield.

To avoid loop currents, ground the shield at only one point. If other system considerations require the shield to be grounded at more than one point, install resistors (typically 100 ohms) between the shield and ground at each grounding point. Each relay needs to be daisy-chained to the next one in the link. A maximum of 32 relays can be connected in this manner without exceeding driver capability. For larger systems, additional serial channels must be added. It is also possible to use commercially available repeaters to have more than 32 relays on a single channel. Avoid star or stub connections 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 provided internally at both communication ports. An isolated power supply with an optocoupled data interface also acts to reduce noise coupling. To ensure maximum reliability, ensure that all equipment has similar transient protection devices installed.

Terminate both ends of the RS485 circuit with an impedance as shown in the figure.

Figure 3-25: RS485 serial connection



3.3.7.3 100Base-FX fiber optic ports

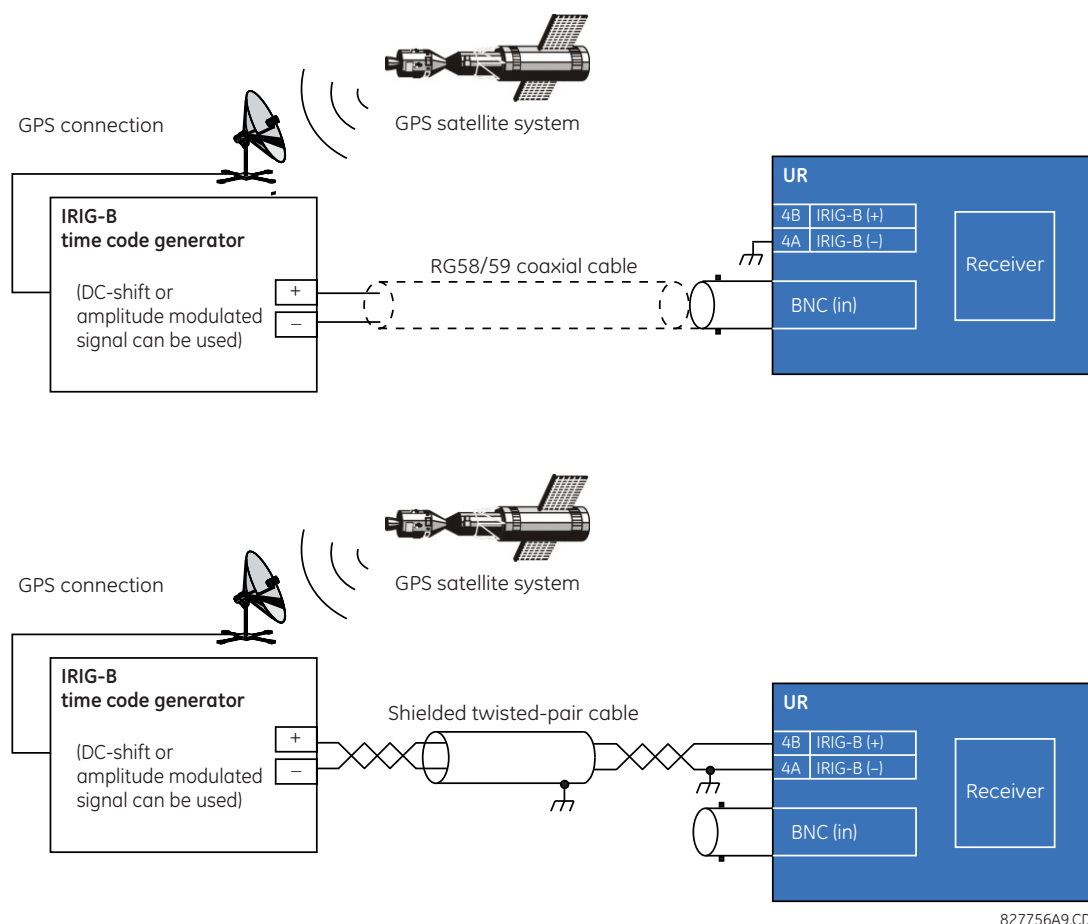
The fiber optic communication ports allow for fast and efficient communications between relays at 100 Mbps. Optical fiber can be connected to the relay supporting a wavelength of 1310 nm in multimode.

Ensure that 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.

3.3.8 IRIG-B

IRIG-B is a standard time code format that allows stamping of events to be synchronized among connected devices. The IRIG-B code allows time accuracies of up to 100 ns. Using the IRIG-B input, the B90 operates an internal oscillator with 1 μ s resolution and accuracy. The IRIG time code formats are serial, pulse width-modulated codes that can be either DC level shifted or amplitude modulated (AM). The GE MultiSync 100 1588 GPS Clock as well as third-party equipment are available for generating the IRIG-B signal; this equipment can use a global positioning system (GPS) satellite system to obtain the time reference so that devices at different geographic locations can be synchronized.

Figure 3-26: Options for the IRIG-B connection



Using an amplitude-modulated receiver causes errors up to 1 ms in event time-stamping.

The B90 is intended for use with external clocks that set the IRIG-B control bits according to IEEE Std C37.118.1-2011. When used with a source that sets the IRIG-B control bits according to IEEE Std 1344-1995, the source must have the sign of its local time offset setting reversed, and if daylight savings time (DST) is used, the source's DST start and DST stop date settings must be interchanged.

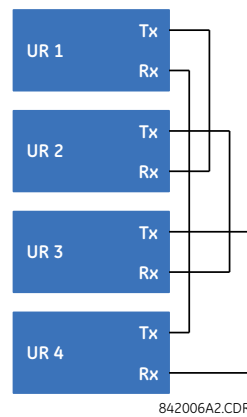
3.4 Direct input and output communications

3.4.1 Description

The direct inputs and outputs feature makes use of the type 7 series of communications modules and allows direct messaging between UR devices. The communications modules are outlined in the table later in this section.

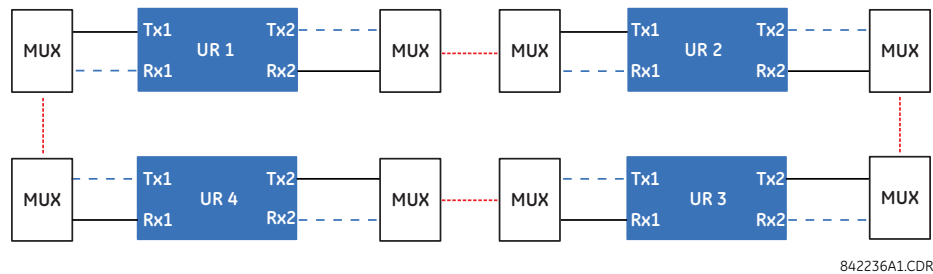
The communications channels are normally connected in a ring configuration, as shown in the following figure. The transmitter of one module is connected to the receiver of the next module. The transmitter of this second module is then connected to the receiver of the next module in the ring. This is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

Figure 3-27: Direct input and output single-channel connection



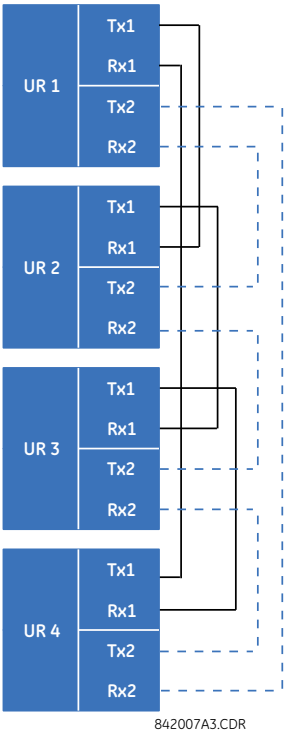
IRC modules with protocol C37.94 and G.703 are designed for back-to-back communication connections, so the ring configuration shown in the previous figure does not apply. To establish inter-relay communication in more than two URs, you need to have two channel IRC module and enable DIRECT I/O CHANNEL CROSSOVER function in all relays, as shown in the next figure. This configuration can be expanded to 16 URs, and this configuration does not provide redundancy ring since both channels are made into single ring by the channel crossover function. As per the figure Typical Pin Interconnection between Two G.703 Interfaces later in this chapter, the clock is supplied typically by multiplexer (MUX) and all URs are in Loop Timing Mode. If there is no MUX, then UR1 and UR3 can be in Internal Timing Mode and UR2 and UR4 can be in Loop Timing Mode. That is, connected channels must have opposite timing modes.

Figure 3-28: Ring configuration for C37.94 module (concept also applies to G.703)



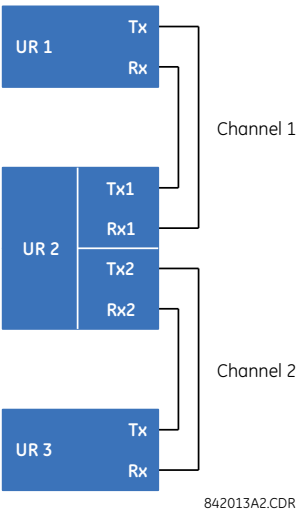
The interconnection for dual-channel type 7 communications modules is shown as follows. Two-channel modules allow for a redundant ring configuration. That is, two rings can be created to provide an additional independent data path. The required connections are: UR1-Tx1 to UR2-Rx1, UR2-Tx1 to UR3-Rx1,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

Figure 3-29: Direct input and output dual-channel connection



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

Figure 3-30: Direct input and output single/dual channel combination connection

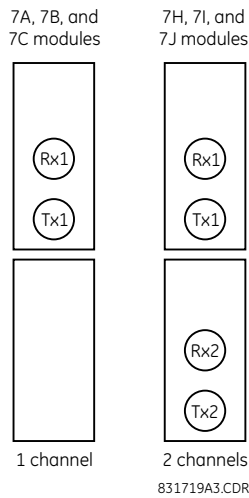


The inter-relay communications modules are available with several interfaces and some are outlined here in more detail. Those that apply depend on options purchased. The options are outlined in the Inter-Relay Communications section of the Order Code tables in Chapter 2. All of the fiber modules use ST type connectors.

3.4.2 Fiber: LED and ELED transmitters

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

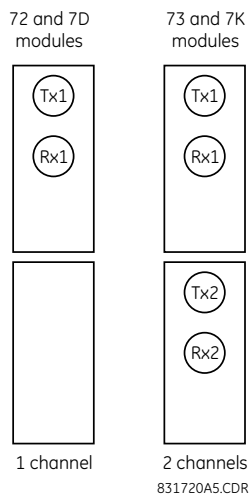
Figure 3-31: LED and ELED fiber modules



3.4.3 Fiber laser transmitters

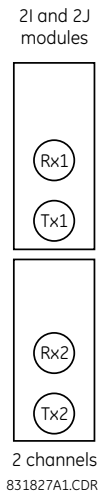
The following figure shows the configuration for the 72, 73, 7D, and 7K fiber-laser modules.

Figure 3-32: 7x Laser fiber modules



The following figure shows configuration for the 2I and 2J fiber-laser modules.

Figure 3-33: 2I and 2J laser fiber modules



CAUTION Observing any fiber transmitter output can injure the eye.

NOTICE When using a laser Interface, attenuators can be necessary to ensure that you do not exceed the maximum optical input power to the receiver.

3.4.4 G.703 interface

3.4.4.1 Description

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

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

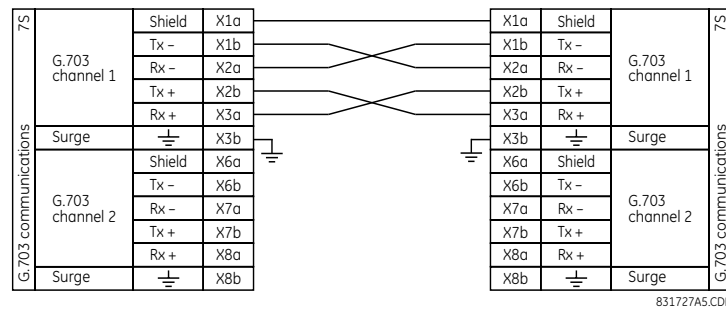
AWG 24 twisted shielded pair is recommended for external connections, with the shield grounded only at one end. Connecting the shield to pin X1a or X6a grounds the shield since these pins are connected internally to ground. Thus, if pin X1a or X6a is used to ground the shield at one end, do not ground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

Figure 3-34: G.703 interface configuration

75 G.703 communications	G.703 channel 1	Shield	~1a
		Tx -	~1b
		Rx -	~2a
		Tx +	~2b
		Rx +	~3a
		Surge	~3b
	G.703 channel 2	Shield	~6a
		Tx -	~6b
		Rx -	~7a
		Tx +	~7b
		Rx +	~8a
		Surge	~8b

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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 Layout section earlier in this chapter. All pin interconnections are to be maintained for a connection to a multiplexer.

Figure 3-35: Typical pin interconnection between two G.703 interfaces

Pin nomenclature differs from one manufacturer to another. It is not uncommon to see pinouts numbered TxA, TxB, RxA, and RxB. In such cases, assume that "A" is equivalent to "+" and "B" is equivalent to "-."

3.4.4.2 G.703 selection switch procedures

1. With the power to the relay off, remove the G.703 module (7R or 7S) as follows. Record the original location of the module to help ensure that the same or replacement module is inserted into the correct slot.
2. Simultaneously pull the ejector/insert clips located at the top and at the bottom of each module in order to release the module for removal. (For more information on accessing modules, see the Maintenance chapter.)
3. Remove the module cover screw.
4. Remove the top cover by sliding it towards the rear and then lift it upwards.
5. Set the timing selection switches (channels 1 and 2) to the required timing modes.
6. Replace the top cover and the cover screw.
7. Re-insert the G.703 module. Take care to ensure that the correct module type is inserted into the correct slot position. The ejector/insert clips located at the top and bottom of each module must be in the disengaged position as the module is inserted smoothly 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 is inserted fully.

Figure 3-36: G.703 timing selection switch setting

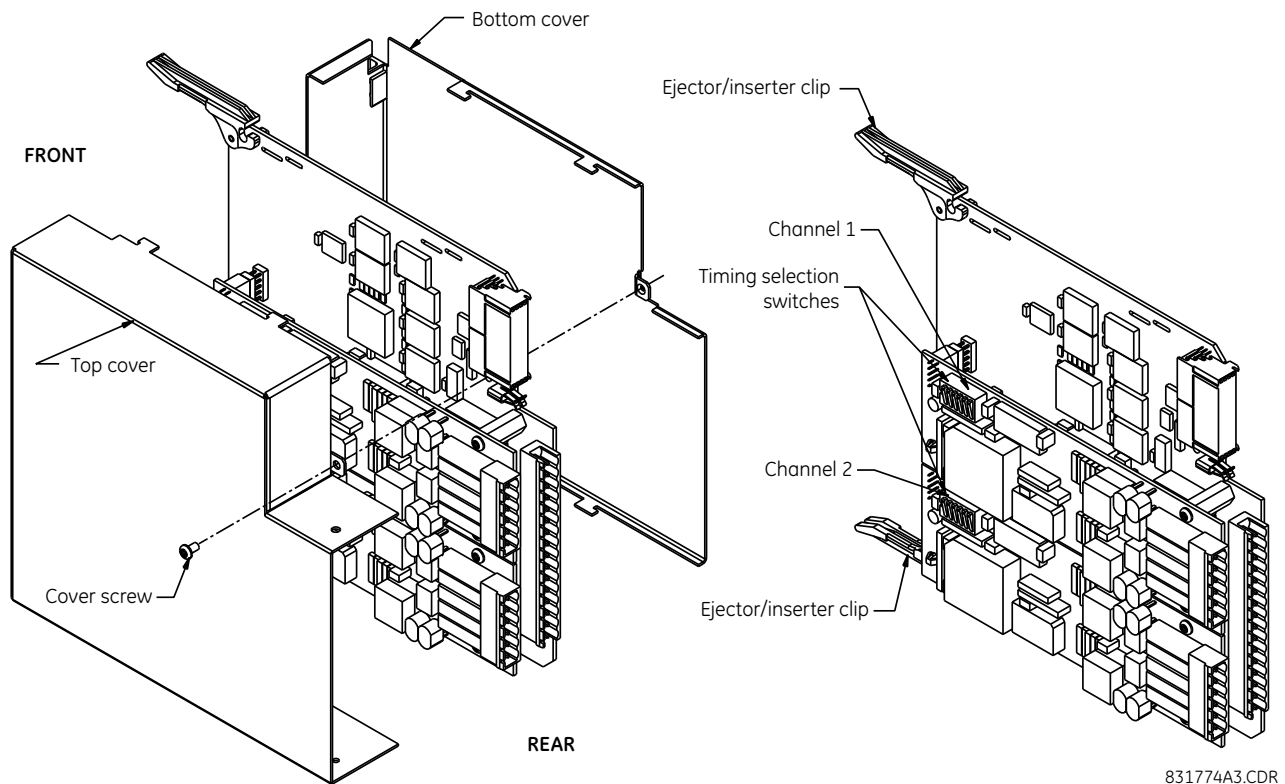


Table 3-6: G.703 timing selections

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

3.4.4.3 G.703 octet timing

If octet timing is enabled (ON), this 8 kHz signal is asserted during the violation of bit 8 (LSB) necessary for connecting to higher order systems. When B90s are connected back-to-back, octet timing is disabled (OFF).

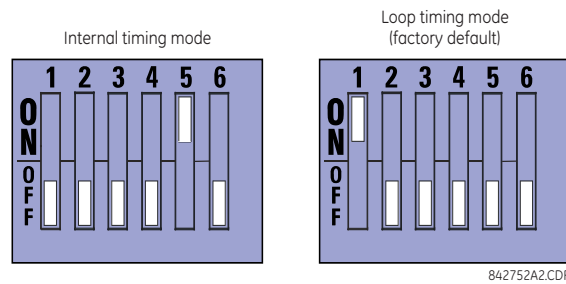
3.4.4.4 G.703 timing modes

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

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

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

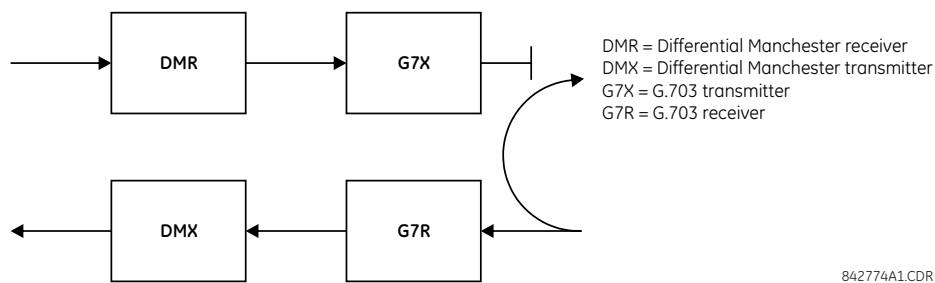
Figure 3-37: Switches



3.4.4.5 G.703 test modes

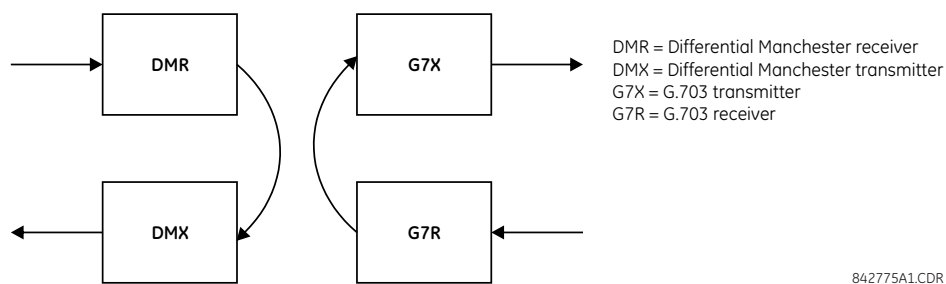
In *minimum remote loopback mode*, the multiplexer is enabled to return the data from the external interface without any processing to assist in diagnosing G.703 line-side problems irrespective of clock rate. Data enters from the G.703 inputs, passes through the data stabilization latch that also restores the proper signal polarity, passes through the multiplexer and then returns to the transmitter. The differential received data is processed and passed to the G.703 transmitter module after which point the data is discarded. The G.703 receiver module is fully functional and continues to process data and passes it to the differential Manchester transmitter module. Since timing is returned as it is received, the timing source is expected to be from the G.703 line side of the interface.

Figure 3-38: G.703 minimum remote loopback mode



In *dual loopback mode*, the multiplexers are active and the functions of the circuit are divided into two with each receiver/transmitter pair linked together to deconstruct and then reconstruct their respective signals. Differential Manchester data enters the Differential Manchester receiver module and then is returned to the differential Manchester transmitter module. Likewise, G.703 data enters the G.703 receiver module and is passed through to the G.703 transmitter module to be returned as G.703 data. Because of the complete split in the communications path and because, in each case, the clocks are extracted and reconstructed with the outgoing data, in this mode there must be two independent sources of timing. One source lies on the G.703 line side of the interface while the other lies on the differential Manchester side of the interface.

Figure 3-39: G.703 dual loopback mode



3.4.5 RS422 interface

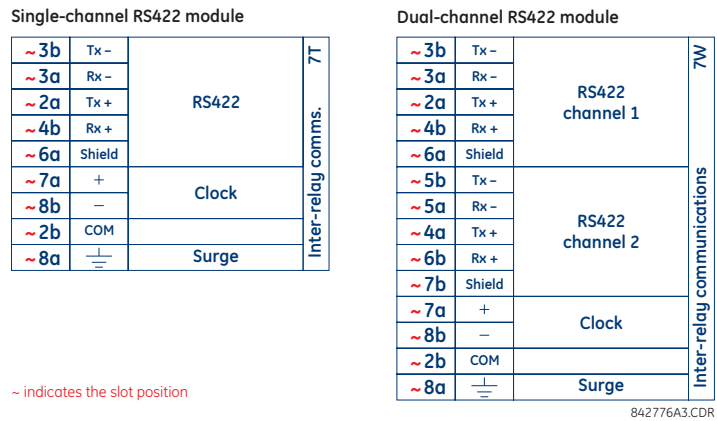
3.4.5.1 Description

There are two RS422 inter-relay communications modules available: single-channel RS422 (module 7T) and dual-channel RS422 (module 7W). The modules can be configured to run at 64 kbps or 128 kbps. AWG 20-24 twisted shielded pair cable is recommended for external connections. These modules are protected by optically-isolated surge suppression devices. The shield pins (6a and 7b) are connected internally to the ground pin (8a). Proper shield termination is as follows:

- Site 1 — Terminate shield to pins 6a or 7b or both
- Site 2 — Terminate shield to COM pin 2b

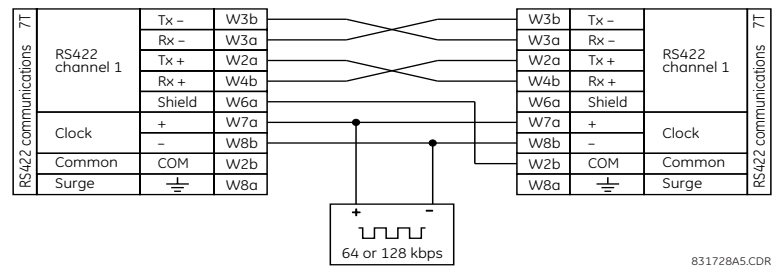
Match the clock terminating impedance with the impedance of the line.

Figure 3-40: RS422 interface connections



The following figure shows the typical pin interconnection between two single-channel RS422 interfaces installed in slot W. All pin interconnections are to be maintained for a connection to a multiplexer.

Figure 3-41: Typical pin interconnect between two RS422 interfaces

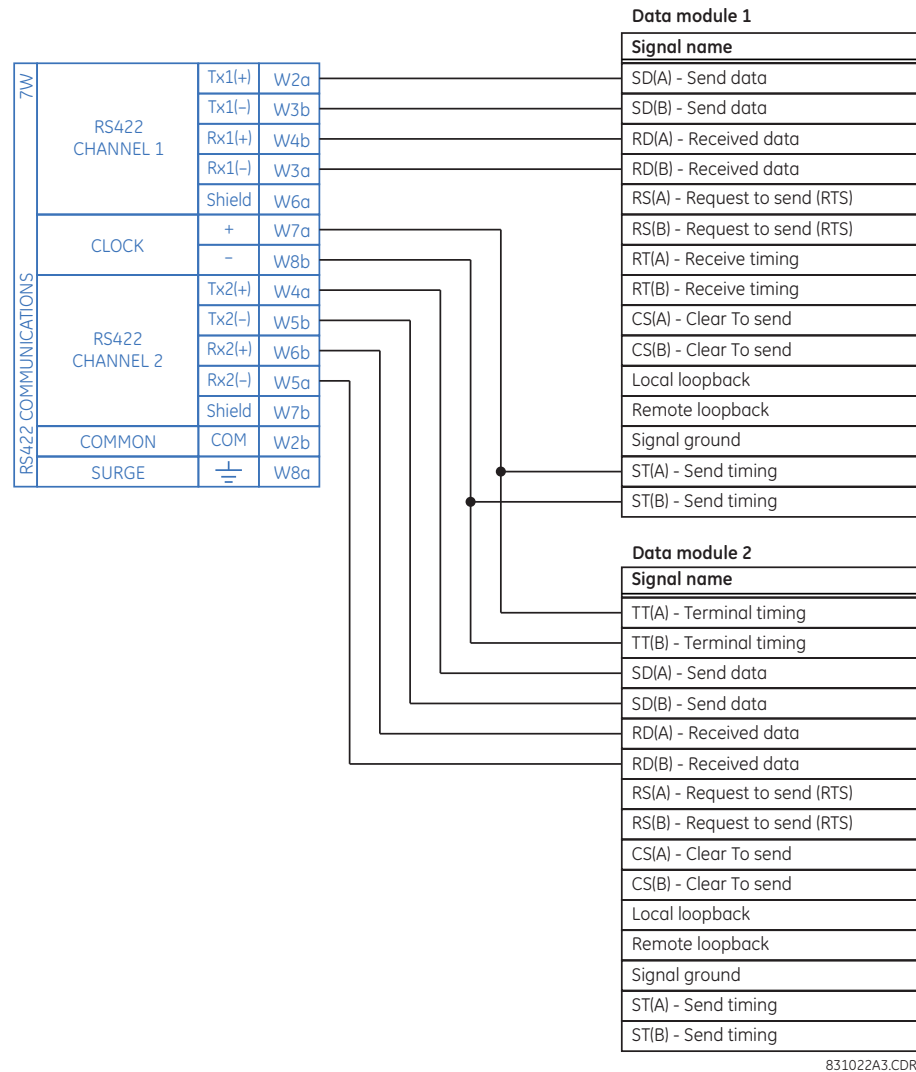


3.4.5.2 Two-channel application via multiplexers

The RS422 interface can be used for single-channel or two-channel applications over SONET/SDH or multiplexed systems. When used in single-channel applications, the RS422 interface links to higher-order systems in a typical way, observing transmit (Tx), receive (Rx), and send timing (ST) connections. However, when used in two-channel applications, certain criteria must be followed since there is one clock input for the two RS422 channels. The system functions correctly when the following connections are observed and your data module has a terminal timing feature. Terminal timing is a common feature to most synchronous data units that allows the module to accept timing from an external source. Using the terminal timing feature, two-channel applications can be achieved if these connections are followed: the send timing outputs from the multiplexer (data module 1) connects to the clock inputs of the UR RS422 interface in the usual way. In addition, the send timing outputs of data module 1 are also 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 are derived from a single clock

source. As a result, data sampling for both of the UR RS422 channels is synchronized via the send timing leads on data module 1, shown as follows. If the terminal timing feature is not available or this type of connection is not wanted, the G.703 interface is a viable option that does not impose timing restrictions.

Figure 3-42: Timing configuration for RS422 two-channel, three-terminal application

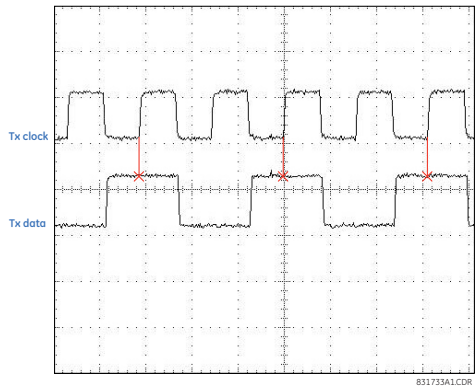


Data module 1 provides timing to the B90 RS422 interface via the ST(A) and ST(B) outputs. Data module 1 also provides timing to data module 2 TT(A) and TT(B) inputs via the ST(A) and AT(B) outputs. The data module pin numbers have been omitted in the figure because they vary by manufacturer.

3.4.5.3 Transmit timing

The RS422 interface accepts one clock input for transmit timing. It is important that the rising edge of the 64 kHz transmit timing clock of the multiplexer interface is sampling the data in the center of the transmit data window. Therefore, it is important to confirm clock and data transitions to ensure proper system operation. For example, the following figure shows the positive edge of the Tx clock in the center of the Tx data bit.

Figure 3-43: Clock and data transitions



3.4.5.4 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 digital phase lock loop (DPLL) circuit is utilized. The DPLL is driven by an internal clock, which is 16-times over-sampled, and uses this clock along with the data-stream to generate a data clock that can be used as the serial communication controller (SCC) receive clock.

3.4.6 RS422 and fiber interface

The following figure shows the combined RS422 plus fiberoptic interface configuration at 64 K baud. The 7L, 7M, 7N, 7P, and 74 modules are used in two-terminal with a redundant channel or three-terminal configurations where channel 1 is employed via the RS422 interface (possibly with a multiplexer) and channel 2 via direct fiber. AWG 20-24 twisted shielded pair is recommended for external RS422 connections and ground the shield only at one end. For the direct fiber channel, address power budget issues properly.

NOTICE When using a laser interface, attenuators can be necessary to ensure that you do not exceed maximum optical input power to the receiver.

Figure 3-44: RS422 and fiber interface connection

7L, 7M, 7N, 7P, and 74 RS422 communications	Clock channel 1	+	~1a
		-	~1b
	Common	COM	~2b
	RS422 channel 1	Tx -	~3b
		Rx -	~3a
		Tx +	~2a
		Rx +	~4b
		Shield	~6a
	Fiber channel 2		
	Surge		~8a

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The connections shown in the figure are for multiplexers configured as data communications equipment (DCE) units.

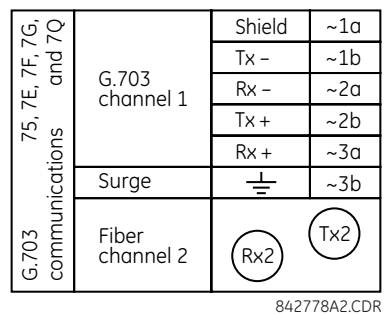
3.4.7 G.703 and fiber interface

The following figure shows the combined G.703 plus fiberoptic interface configuration at 64 kbps. The 7E, 7F, 7G, 7Q, and 75 modules are used in configurations where channel 1 is employed via the G.703 interface (possibly with a multiplexer) and channel 2 via direct fiber. AWG 24 twisted shielded pair is recommended for external G.703 connections connecting the shield to pin 1a at one end only. For the direct fiber channel, address power budget issues properly. See previous sections for details on the G.703 and fiber interfaces.

NOTICE

When using a laser interface, attenuators can be necessary to ensure that you do not exceed the maximum optical input power to the receiver.

Figure 3-45: G.703 and fiber interface connection



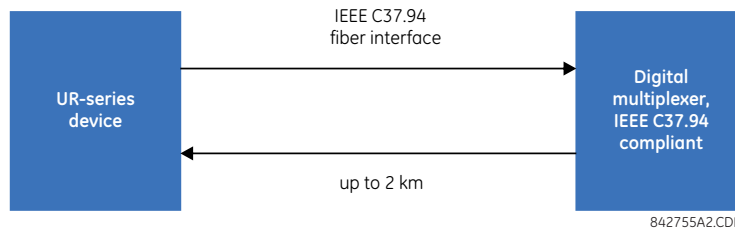
3.4.8 IEEE C37.94 interface

The UR-series IEEE C37.94 communication modules (module types 2G, 2H, 2I, 2J, 76, and 77) are designed to interface with IEEE C37.94 compliant digital multiplexers or an IEEE C37.94 compliant interface converter for use with direct input and output applications. 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,..., 12. The UR-series C37.94 communication modules are either 64 kbps (with n fixed at 1) or 128 kbps (with n fixed at 2). The frame is a valid International Telecommunications Union (ITU-T) recommended G.704 pattern from the standpoint of framing and data rate. The frame is 256 bits and is repeated at a frame rate of 8000 Hz, with a resultant bit rate of 2048 kbps.

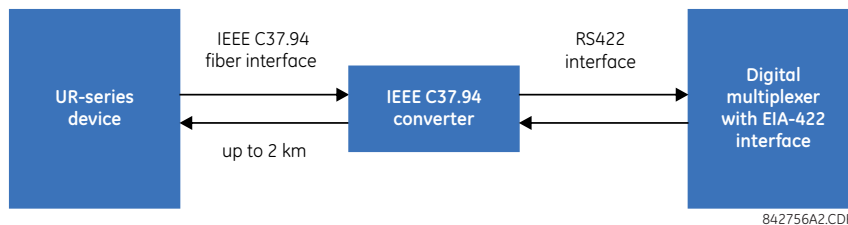
The specifications for the module are as follows:

- IEEE standard — C37.94 for 1 × 128 kbps optical fiber interface (for 2G and 2H modules) or C37.94 for 2 × 64 kbps optical fiber interface (for 76 and 77 modules)
- Fiber optic cable type — 50 nm or 62.5 μm core diameter optical fiber
- Fiber optic mode — multimode
- Fiber optic cable length — up to 2 km
- Fiber optic connector — type ST
- Wavelength — 820 ±40 nm
- Connection — as per all fiber optic connections, a Tx-to-Rx connection is required

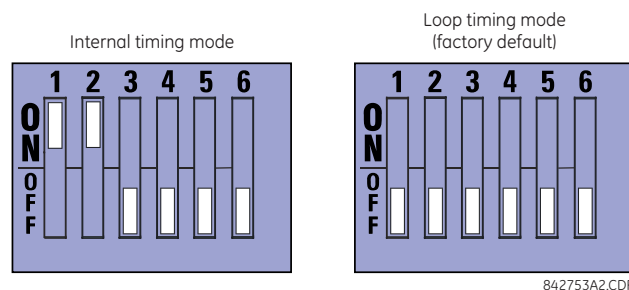
The UR-series C37.94 communication module can be connected directly to any compliant digital multiplexer that supports the IEEE C37.94 standard. The figure shows the concept.

Figure 3-46: IEEE C37.94 connection to compliant digital multiplexer

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. The following figure shows the concept.

Figure 3-47: IEEE C37.94 connection to non-compliant digital multiplexer

In 2008, GE Grid Solutions released revised modules 76 and 77 for C37.94 communication to enable multi-ended fault location functionality with firmware 5.60 release and higher. All modules 76 and 77 shipped since the change support this feature and are fully backward compatible with firmware releases below 5.60. For customers using firmware release 5.60 and higher, the module can be identified with "Rev D" printed on the module and is to be used on all ends of B90 communication for two and three terminal applications. Failure to use it at all ends results in intermittent communication alarms. For customers using firmware revisions below 5.60, it is not required to match the revision of the modules installed. The UR-series C37.94 communication module has six switches to set the clock configuration. The following figure shows the functions of these control switches.

Figure 3-48: Switches

For the internal timing mode, the system clock is generated internally. Therefore, set the timing switch selection to internal timing for relay 1 and loop timed for relay 2. There must be only one timing source configured.

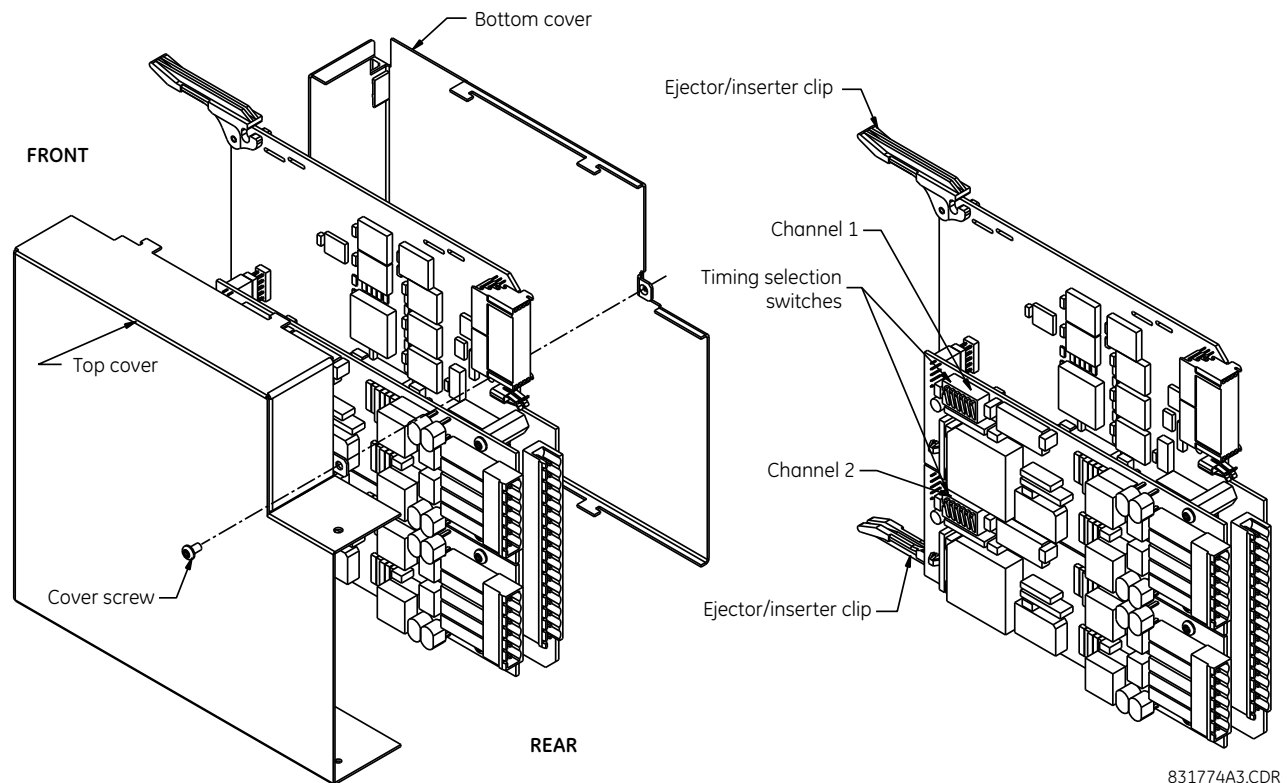
For the looped timing mode, the system clock is derived from the received line signal. Therefore, set the timing selection to loop timing mode for connections to higher order systems.

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

1. With power to the relay off, remove the IEEE C37.94 module (type 2G, 2H, 2I, 2J, 76, or 77 module) as follows. Record the original location of the module to help ensure that the same or replacement module is inserted into the correct slot.
2. Simultaneously pull the ejector/insert clips located at the top and bottom of each module in order to release the module for removal.

3. Remove the module cover screw.
4. Remove the top cover by sliding it towards the rear and then lift it upwards.
5. Set the timing selection switches (channels 1 and 2) to the required timing modes (see description earlier).
6. Replace the top cover and the cover screw.
7. Re-insert the IEEE C37.94 module. Take care to ensure that the **correct** module type is inserted into the **correct** slot position. The ejector/inserter clips located at the top and at the bottom of each module must be in the disengaged position as the module is inserted smoothly 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 is inserted fully.

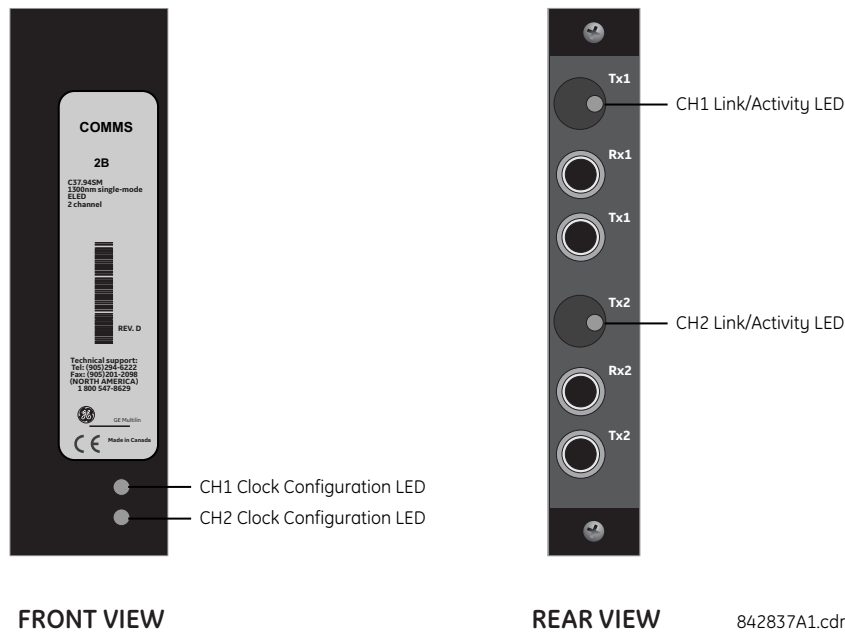
Figure 3-49: IEEE C37.94 timing selection switch setting



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Modules shipped since January 2012 have status LEDs that indicate the status of the DIP switches, as shown in the following figure.

Figure 3-50: Status LEDs



The clock configuration LED status is as follows:

- Flashing green — loop timing mode while receiving a valid data packet
- Flashing yellow — internal mode while receiving a valid data packet
- Solid red — (switch to) internal timing mode while not receiving a valid data packet

The link/activity LED status is as follows:

- Flashing green — FPGA is receiving a valid data packet
- Solid yellow — FPGA is receiving a "yellow bit" and remains yellow for each "yellow bit"
- Solid red — FPGA is not receiving a valid packet or the packet received is invalid

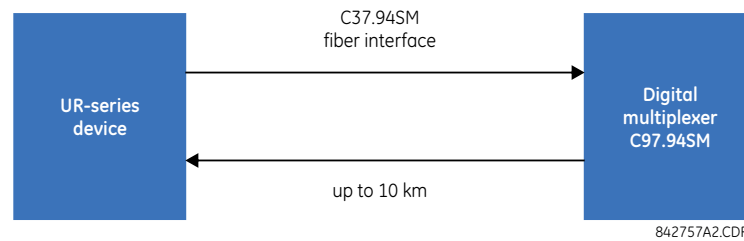
3.4.9 C37.94SM interface

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

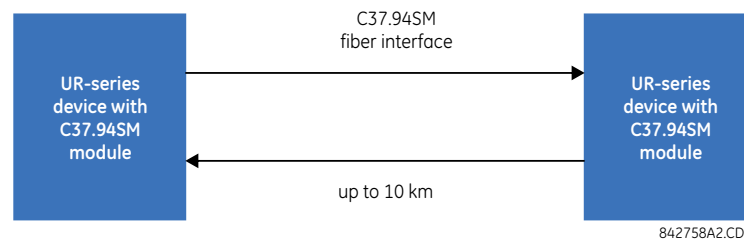
The specifications for the module are as follows:

- Emulated IEEE standard — Emulates C37.94 for 1×64 kbps optical fiber interface (modules set to $n = 1$ or 64 kbps)
- Fiber optic cable type — $9/125 \mu\text{m}$ core diameter optical fiber
- Fiber optic mode — Single-mode, ELED compatible with HP HFBR-1315T transmitter and HP HFBR-2316T receiver
- Fiber optic cable length — Up to 11.4 km
- Fiber optic connector — Type ST
- Wavelength — $1300 \pm 40 \text{ nm}$
- Connection — As per all fiber optic connections, a Tx-to-Rx connection is required

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

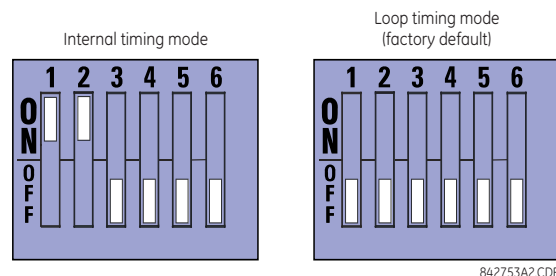


It also can be connected directly to any other UR-series relay with a C37.94SM module, as shown.



In 2008, GE Grid Solutions released revised modules 2A and 2B for C37.94SM communication to enable multi-ended fault location functionality with firmware 5.60 release and higher. All modules 2A and 2B shipped since the change support this feature and are fully backward compatible with firmware releases below 5.60. For customers using firmware release 5.60 and higher, the module can be identified with "Rev D" printed on the module and is to be used on all ends of B90 communication for two and three terminal applications. Failure to use it at all ends results in intermittent communication alarms. For customers using firmware revisions below 5.60, it is not required to match the revision of the modules installed. The UR-series C37.94SM communication module has six switches that are used to set the clock configuration. The following figure shows the functions of these control switches.

Figure 3-51: Switches



For the internal timing mode, the system clock is generated internally. Therefore, set the timing switch selection to internal timing for relay 1 and loop timed for relay 2. There must be only one timing source configured.

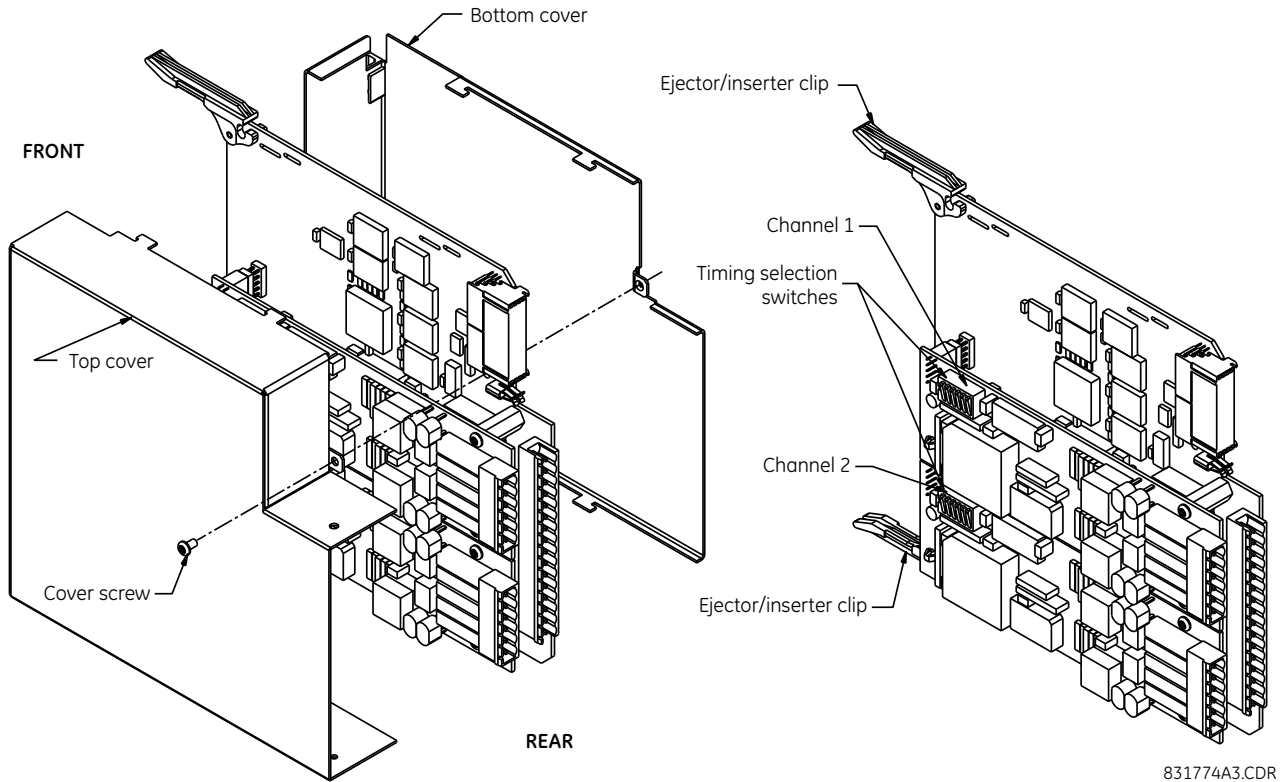
For the looped timing mode, the system clock is derived from the received line signal. Therefore, set the timing selection to loop timing mode for connections to higher-order systems.

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

1. With power to the relay off, remove the C37.94SM module (module 2A or 2B) as follows. Record the original location of the module to help ensure that the same or replacement module is inserted into the correct slot.
2. Simultaneously pull the ejector/insertor clips located at the top and at the bottom of each module in order to release the module for removal.
3. Remove the module cover screw.
4. Remove the top cover by sliding it towards the rear and then lift it upwards.

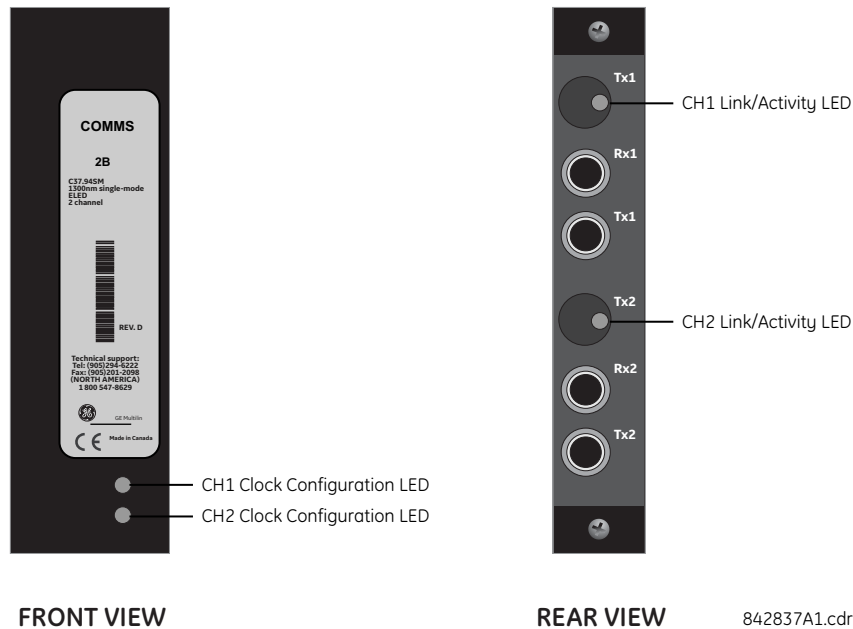
5. Set the timing selection switches (channels 1 and 2) to the required timing modes (see description earlier).
6. Replace the top cover and the cover screw.
7. Re-insert the C37.94SM module. Take care to ensure that the **correct** module type is inserted into the **correct** slot position. The ejector/inserter clips located at the top and at the bottom of each module must be in the disengaged position as the module is inserted smoothly 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 is inserted fully.

Figure 3-52: C37.94SM timing selection switch setting



Modules shipped since January 2012 have status LEDs that indicate the status of the DIP switches, as shown in the following figure.

Figure 3-53: Status LEDs



The clock configuration LED status is as follows:

- Flashing green — loop timing mode while receiving a valid data packet
- Flashing yellow — internal mode while receiving a valid data packet
- Solid red — (switch to) internal timing mode while not receiving a valid data packet

The link/activity LED status is as follows:

- Flashing green — FPGA is receiving a valid data packet
- Solid yellow — FPGA is receiving a "yellow bit" and remains yellow for each "yellow bit"
- Solid red — FPGA is not receiving a valid packet or the packet received is invalid

3.5 Activate relay

The relay is in the default "Not Programmed" state when it leaves the factory. When powered up successfully, the "Trouble" LED is on and the "In Service" LED is off. The relay in the "Not Programmed" state blocks signaling of any output relay. These conditions remain until the relay is explicitly put in the "Programmed" state.

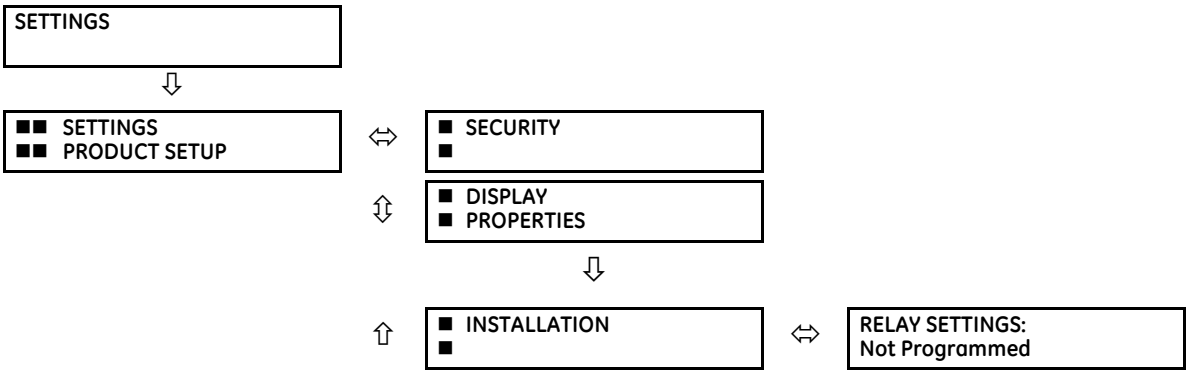
RELAY SETTINGS: Not Programmed

When the relay is powered up, the "Trouble LED" is on, the "In Service" LED is off, and this message displays, indicating that 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.

The relay can be activated on the front panel or in the EnerVista software.

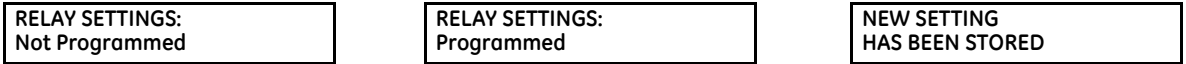
To activate the relay using the front panel:

1. Press the **MENU** key until the **SETTINGS** header flashes momentarily and the **PRODUCT SETUP** message displays.
2. Press the **MESSAGE** right arrow until the **SECURITY** message displays.
3. Press the **MESSAGE** down arrow until the **INSTALLATION** message displays.
4. Press the **MESSAGE** right arrow until the **RELAY SETTINGS: Not Programmed** message displays.



3

5. After the **RELAY SETTINGS: Not Programmed** message displays, press a **VALUE** key to change the selection to "Programmed."
6. Press the **ENTER** key to save the change.



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

To activate the relay using EnerVista software:

1. Navigate to **Settings > Product Setup > Installation** and change the **Relay Settings** field to "Programmed."
2. Save the change.

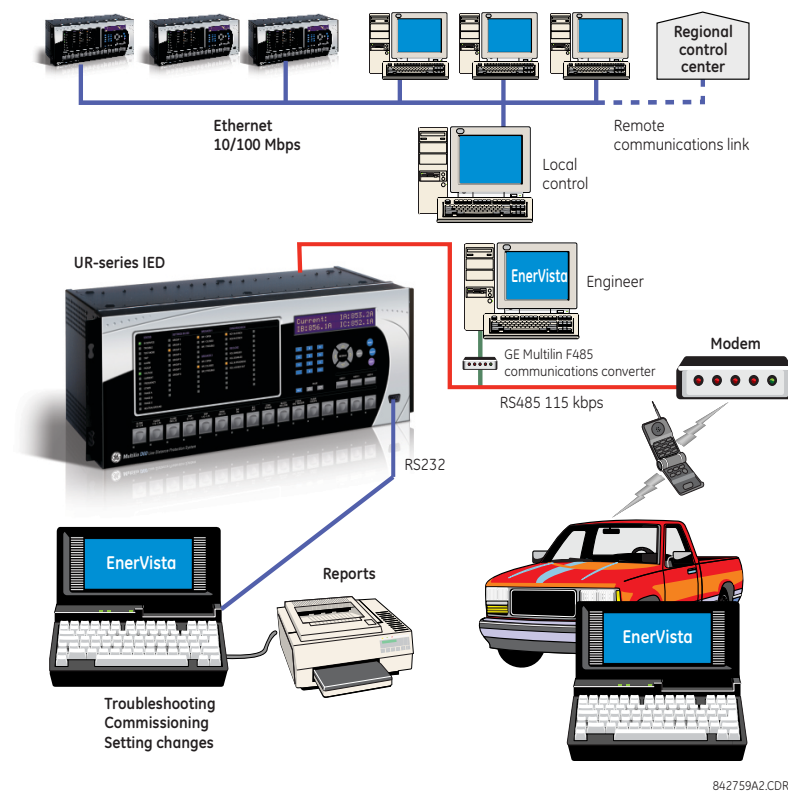
3.6 Install software

3.6.1 EnerVista communication overview

The EnerVista UR Setup software communicates to the relay via the faceplate RS232 port or the rear panel RS485 / Ethernet ports.

To communicate via the faceplate RS232 port, use a standard straight-through serial cable. Connect the DB-9 male end to the relay and the DB-9 or DB-25 female end to the computer COM2 port as described in the CPU Communication Ports section earlier in this chapter.

Figure 3-54: Relay communication options



To communicate through the B90 rear RS485 port from a computer RS232 port, the GE Grid Solutions 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 B90 rear communications port. The converter terminals (+, -, GND) are connected to the B90 communication module (+, -, COM) terminals. See the CPU Communication Ports section in chapter 3 for details. The line is terminated with an R-C network (that is, 120 Ω , 1 nF) as described in this chapter.

3.6.2 System requirements

The relay front panel or the EnerVista UR Setup software can be used to communicate with the relay. The software interface is the preferred method to edit settings and view actual values because the computer monitor can display more information.

The minimum system requirements for the EnerVista software are as follows:

- Pentium 4 (Core Duo recommended)
- Windows XP with Service Pack 2 (Service Pack 3 recommended) or Windows 7, or Windows Server 2008 Release 2 64-bit, in the required EnerVista language
- 1 GB of RAM (2 GB recommended)
- 500 MB free hard drive space (1 GB recommended)
- 1024 x 768 display (1280 x 800 recommended)
- Serial port
- Ethernet port of the same type as one of the UR CPU ports or a LAN connection to the UR
- Internet access or a DVD drive

The following qualified modems have been tested to be compatible with the B90 and the EnerVista software:

- US Robotics external 56K FaxModem 5686

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

3.6.3 Install software

After ensuring that the requirements for using EnerVista UR Setup software are met, install the software from the DVD, or download EnerVista Launchpad software from <http://www.gegridsolutions.com/multilin> and install it.

Install on a computer that has an operating system in the required language, for example a German operating system for use with EnerVista software in German.

To install the UR EnerVista software from the DVD:

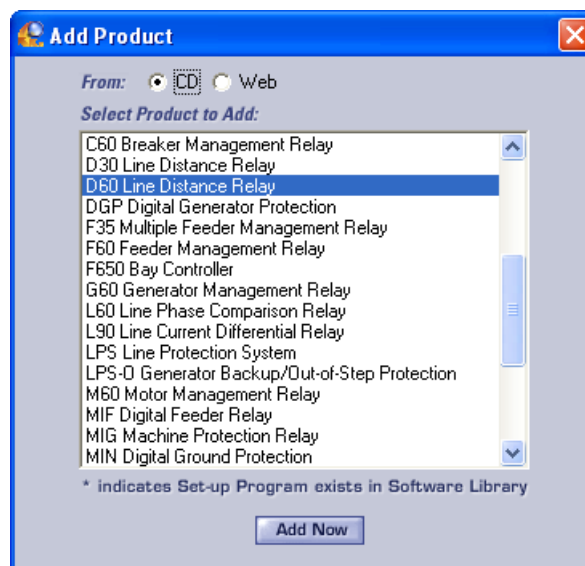
1. Insert the DVD into the DVD drive of your computer.
2. Click the **Install Now** button and follow the instructions.
3. When installation is complete, start the EnerVista Launchpad application.
4. Click the **IED Setup** section of the **Launch Pad** window.

Figure 3-55: Adding a UR device in Launchpad window



5. In the EnerVista Launch Pad window, click the **Add Product** button and select the appropriate product as follows. Select the **Web** option to ensure the most recent software release, or select **CD** if you do not have an Internet connection, then click the **Add Now** button to list software items for the product. EnerVista Launchpad obtains the software from the Internet or DVD and automatically starts the installation program.

Figure 3-56: Identifying the UR device type



6. Select the complete path, including the new directory name, where the EnerVista UR Setup software is to be installed.
7. Click the **Next** button to begin the installation. The files are installed in the directory indicated, and the installation program automatically creates icons and adds an entry to the Windows start menu.

8. Click **Finish** to complete the installation. The UR device is added to the list of installed intelligent electronic devices (IEDs) in the EnerVista Launchpad window, as shown.

Figure 3-57: UR device added to Launchpad window



3.7 Configure the B90 for software access

You connect remotely to the B90 through the rear RS485 or Ethernet port with a computer running the EnerVista UR Setup software. The B90 also can be accessed locally with a computer through the front panel RS232 port or the rear Ethernet port using the Quick Connect feature.

- To configure the B90 for remote access via the rear RS485 port, see the next section.
- To configure the B90 for remote access via the rear Ethernet port, see the Configure Ethernet Communication section.
- To configure the B90 for local access with a computer through either the front RS232 port or rear Ethernet port, see the Connect to the B90 section.
- To discover automatically UR devices and configure the software for them, see the Automatic Discovery of UR Devices section.

The devices are listed alphabetically in the main software window, for example B30, B90, T35. Use the **Device Name** to order them as required, for example B30 Odessa, B30 Truro, B90, T35.

Devices are listed in the order entered in the Device Setup window.

You cannot import a file to add a device to the software. You can import settings as outlined at the end of the chapter.

Implement IP addresses for the computer and a B90 device as follows.

The UR family supports the use of subnetworks as documented in RFC 950, which divides class-based networks into subnetworks (non-CIDR). The classes and IP address ranges are defined as follows.

Table 3-7: IP address classes

Classes	IP address range	Default subnet mask address	UR devices
A	1.0.0.0 to 127.255.255.255	255.0.0.0	65,535 or more
B	128.0.0.0 to 191.255.255.255	255.255.0.0	255 to 65,534
C	192.0.0.0 to 223.255.255.255	255.255.255.0	0 to 254
D	224.0.0.0 to 239.255.255.255	(Reserved for multicasting)	
E	240.0.0.0 to 255.255.255.255	(Reserved)	

Both network and subnet addresses are contained within a range. The number of hosts determines the class and addresses as follows:

- Class A 255.0.0.0 — The first octet (255) specifies the network, the second to fourth octets (0) specify the subnet and host. Use this class when you have more than 65,535 hosts (UR devices).
- Class B 255.255.0.0 — The first two octets (255) specify the network, the third octet (0) specifies the subnet, and the fourth octet (0) specifies the host. Use this class when you have 255 to 65,534 hosts (UR devices).

- Class C 255.255.255.0 — The first three octets (255) specify the network and the last octet (0) specifies the subnet and host. Use this class when you have up to 254 hosts (UR devices).

An example of implementation is one computer and one UR device. Because there is one UR device, class C addressing is required. So we use UR 192.167.2.x with subnet mask 255.255.255.0 and computer 192.167.3.x with subnet mask 255.255.255.0.

For older, non-CIDR routing protocols, such as RIP version 1, follow these restrictions:

- Identical subnet masks — Use a single mask for all subnets within a network
- Contiguous subnets — The subnets must be contiguous and not split among networks. The subnets cannot pass traffic through other networks.

3.7.1 Configure serial communication

3

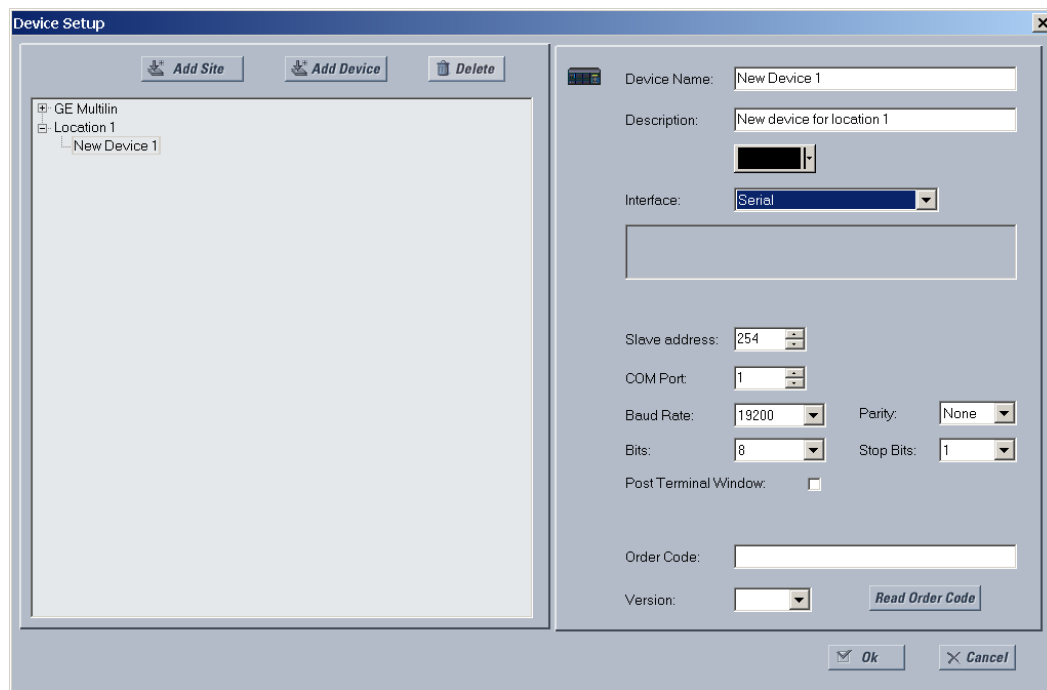
Two options are possible: local connection between computer and front RS232 port, and remote connection using the rear RS485 port.

For the RS232 connection, a computer with an RS232 port and a serial cable are required.

To use the RS485 port at the back of the relay, a GE Grid Solutions F485 converter (or compatible RS232-to-RS485 converter) is required. See the F485 instruction manual for details.

1. Connect the computer to the F485 and the F485 to the RS485 terminal on the back of the UR device, or connect the computer to the RS232 port on the front of the relay.
2. In the EnerVista Launchpad software on the computer, select the UR device to start the software.
3. Click the **Device Setup** button to open the Device Setup window, and click the **Add Site** button to define a new site.
4. Enter a site name in the **Site Name** field. Optionally add a short description of the site along with the display order of devices defined for the site. This example uses "Location 1" as the site name. When done, click the **OK** button. The new site appears in the upper-left list in the EnerVista UR Setup window.
5. Click the **Device Setup** button, then select the new site to re-open the Device Setup window.
6. Click the **Add Device** button to define the new device.
7. Enter a name in the **Device Name** field and a description (optional) of the site.
8. Select "Serial" from the **Interface** drop-down list. This displays a number of interface parameters that must be entered for serial communications.

Figure 3-58: Configuring serial communication



9. Enter the COM port used by the computer, the baud rate, and parity settings from the front panel **SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ SERIAL PORTS** menu, and the relay slave address setting from the front panel **SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ MODBUS PROTOCOL ⇒ MODBUS SLAVE ADDRESS** menu in their respective fields.

Baud Rate — Typically 19200 for RS232 and higher for RS485

Parity — Set to None if unsure

Bits — Set to 8 if unsure

Stop Bits — Set to 1 if unsure

10. Click the **Read Order Code** button to connect to the B90 and upload the order code to the software. If a communications error occurs, ensure that the EnerVista UR Setup serial communications values entered in the previous step correspond to the relay setting values.
11. Click the **OK** button when the relay order code has been received. The new device is added to the Site List window (or Online window) located in the top left corner of the main EnerVista UR Setup window.

The device has now been configured for RS232 communications. Proceed to the Connect to the B90 section to begin communication.

3.7.2 Configure Ethernet communication

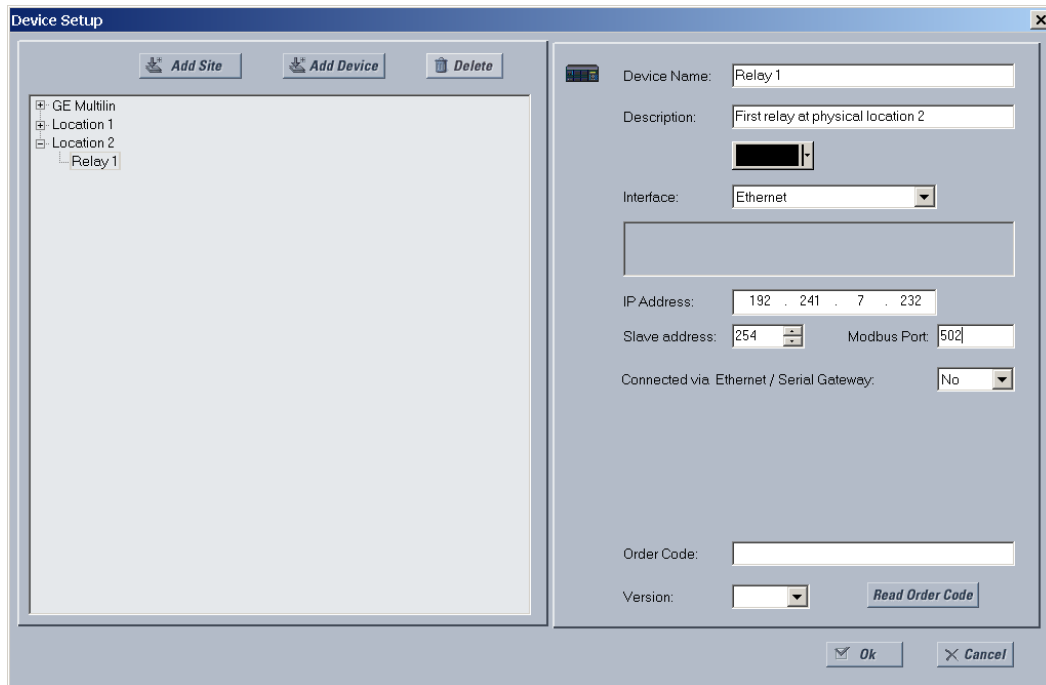
You connect the cable, define a site in the software, then add the relay as a device for the site. The computer and UR device must be on the same subnet.

1. Connect the Ethernet network cable to the Ethernet port on the back of the device.
2. On the computer, select the UR device from the EnerVista Launchpad to start EnerVista UR Setup.
3. Click the **Device Setup** button to open the Device Setup window, then click the **Add Site** button to define a new site.
4. Enter a site name in the "Site Name" field. If wanted, a short description of site can also be entered along with the display order of devices defined for the site. In this example, we use "Location 2" as the site name. Click the **OK** button when complete.

The new site appears in the upper-left list in the EnerVista UR Setup window.

5. Click the **Device Setup** button then select the new site to re-open the Device Setup window.
6. Click the **Add Device** button to define the new device.
7. Enter a name in the “Device Name” field and a description (optional) of the site.
8. Select “Ethernet” from the **Interface** drop-down list. This displays a number of interface parameters that must be entered for proper Ethernet functionality.

Figure 3-59: Configuring Ethernet communication



9. Enter the relay IP address specified in the front panel **SETTINGS** ⇒ **PRODUCT SETUP** ⇄ **COMMUNICATIONS** ⇄ **NETWORK** ⇒ **IP ADDRESS** in the **IP Address** field.
10. Enter the relay slave address and Modbus port address values from the respective settings in the front panel **SETTINGS** ⇒ **PRODUCT SETUP** ⇄ **COMMUNICATIONS** ⇄ **MODBUS PROTOCOL** menu.
11. Click the **Read Order Code** button to connect to the B90 device and upload the order code. If an communications error occurs, ensure that the three EnerVista UR Setup values entered in the previous steps correspond to the relay setting values.
12. Click **OK** when the relay order code has been received. The new device is added to the Site List window (or Online window) located in the top left corner of the main EnerVista UR Setup window.

The Site Device has now been configured for Ethernet communications. Proceed to the Connect to the B90 section to begin communications.

3.7.3 Automatic discovery of UR devices

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

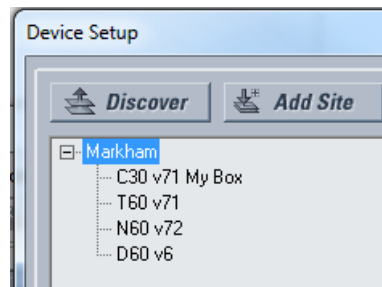
Using the **Discover** button in the **Device Setup** window, a single click of the mouse triggers the software to detect automatically any UR-series relays located on the network. The EnerVista UR Setup software then proceeds to configure all settings and order code options in the window. This feature allows the user to identify and interrogate all UR-series devices at a location.

To discover UR devices:

1. In EnerVista, click the **Device Setup** button.

2. In the window that opens, click the **Discover** button. If the required device is not found, add it manually as outlined earlier.

Figure 3-60: Discover button to detect UR devices in network



3.8 Connect to the B90

There are four ways to the connect to the device, as follows:

- RS232 port (outlined here)
- RS485 port
- Ethernet port (outlined here)
- LAN

When unable to connect because of an "ACCESS VIOLATION," access **Device Setup** and refresh the order code for the device.



When multiple computers are connected to a B90 device, EnerVista settings windows are not updated automatically. They are refreshed when re-opened. If a user changes a setting on one computer, the other users need to refresh the display by closing and opening the settings window to see the change. To ensure that current settings are always viewed, close settings windows when not in use so that they are up-to-date when next accessed.

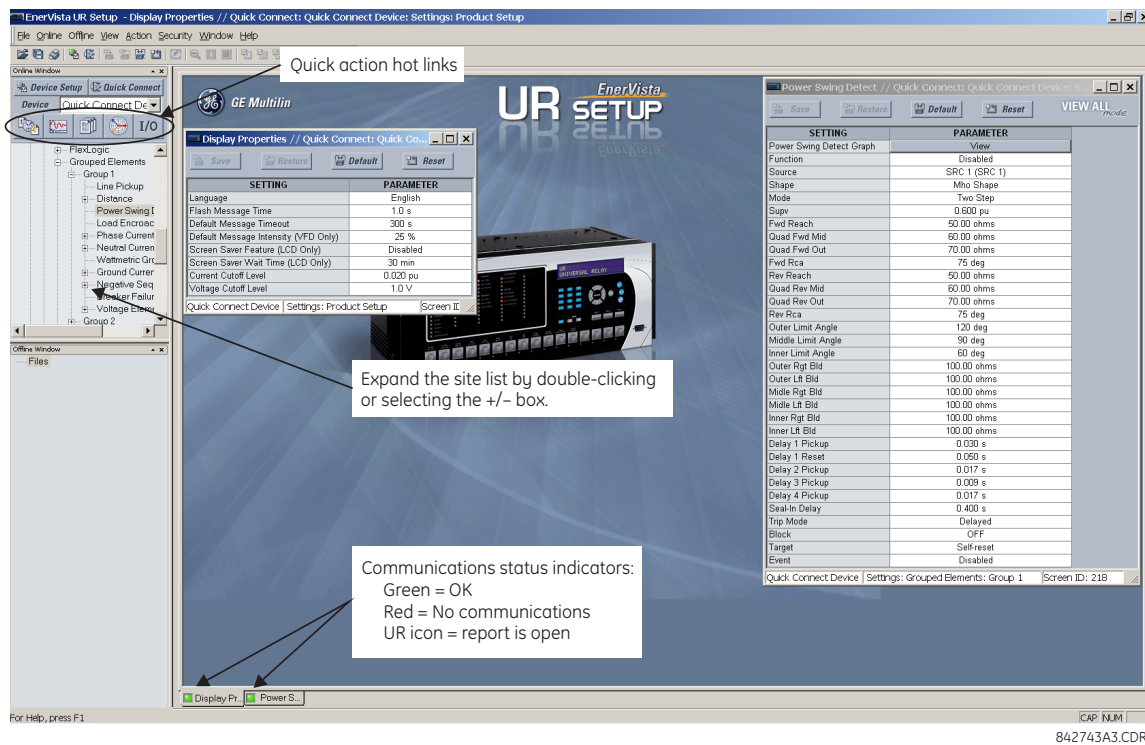
3.8.1 Connect to the B90 in EnerVista

For information on using the EnerVista software, see the Interfaces chapter.

To access the relay in EnerVista:

1. Open the **Settings > Product Setup > Display Properties** window as shown. The window opens with a status indicator on the lower left of the EnerVista UR Setup window.

Figure 3-61: EnerVista window



2. 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 set up for communications (steps A and B earlier).
3. If a relay icon appears in place of the status indicator, then a report (such as an oscillography or event record) is open. Close the report to re-display the green status indicator.
4. The Display Properties settings can now be viewed, edited, or printed.

3.8.1.1 Quick action hot links

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

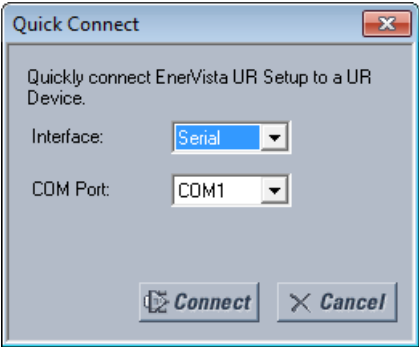
- View the event record
- View the last recorded oscillography record
- View the status of all B90 inputs and outputs
- View all of the B90 metering values
- View the B90 protection summary
- Generate a service report

3.8.2 Use Quick Connect via the front panel RS232 port

To connect to the UR from a computer using a serial cable:

1. Connect an RS232 serial cable to the computer and the front panel RS232 port.
2. Select the UR device from the EnerVista Launchpad to start EnerVista UR Setup.
3. Click the **Quick Connect** button to open the window.

Figure 3-62: Quick Connect window to access a device



- 4. Select the **Serial** interface and the correct COM Port, then click **Connect**.
- 5. The EnerVista UR Setup software creates a site named “Quick Connect” with a corresponding device also named “Quick Connect” and displays them on the left side of the screen. Expand the sections to view data directly from the B90 device. Use the **Device Setup** button to change the site names.

Each time that the EnerVista UR Setup software is initialized, click the **Quick Connect** button to establish direct communications to the B90. This ensures that configuration of the EnerVista UR Setup software matches the B90 model number.

3.8.3 Use Quick Connect via a rear Ethernet port

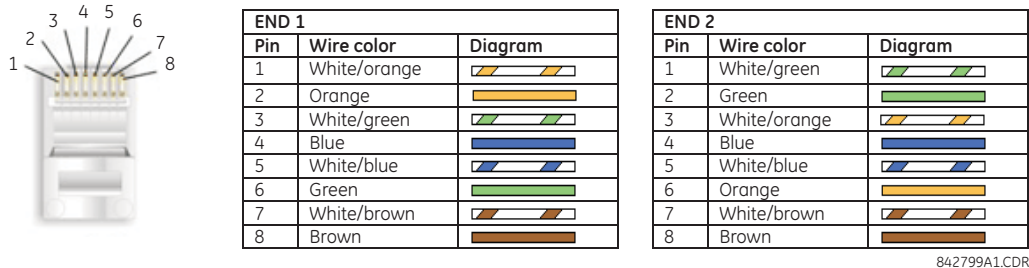
To use the Quick Connect feature to access the B90 from a computer through Ethernet, first assign an IP address to the relay using the front panel keyboard.

- 1. Press the **MENU** key until the **Settings** menu displays.
- 2. Navigate to **Settings** ⇒ **Product Setup** ⇅ **Communications** ⇅ **Network** ⇒ **IP Address Setting**.
- 3. Enter an IP address, for example “1.1.1.1,” and press the **ENTER** key to save the value.
- 4. In the same menu, select the **Subnet IP Mask** setting.
- 5. Enter a subnet IP address, for example “255.0.0.0,” and press the **ENTER** key to save the value.

If using a blue or grey Ethernet cable, skip the rest of the this section. If using an orange cross-over Ethernet cable, the computer needs to be set up as follows.

- 1. Use an orange Ethernet cross-over cable to connect the computer to the rear Ethernet port. In case you need it, the following figure shows the pinout for an Ethernet cross-over cable.

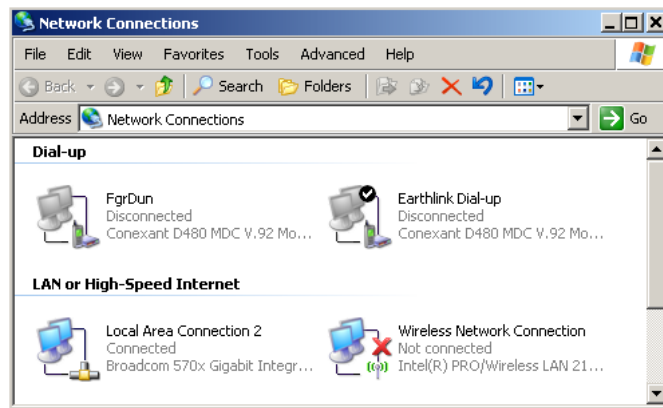
Figure 3-63: Ethernet cross-over cable PIN layout



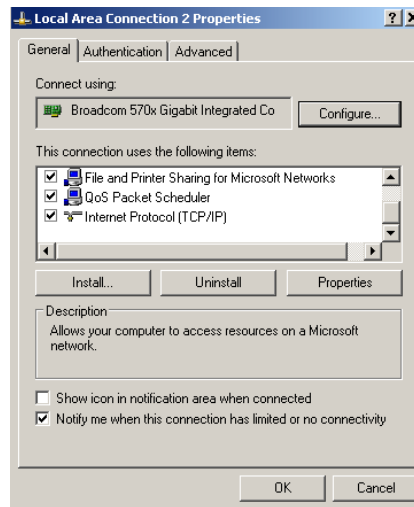
Next, assign the computer an IP address compatible with the relay’s IP address.

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

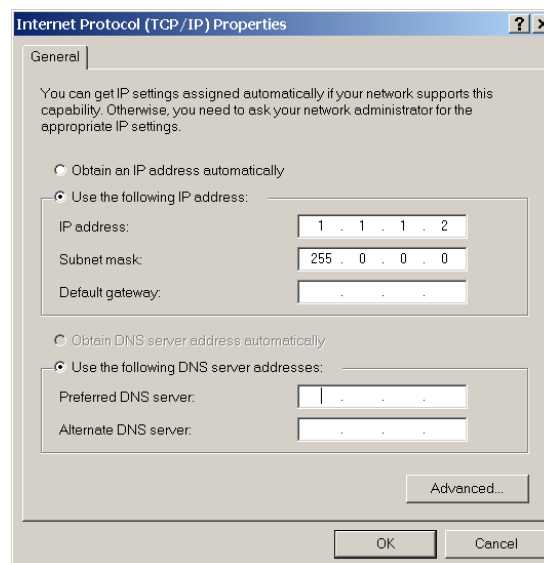
connections window. Or in Windows 7, access the **Network and Sharing Center** in the Control Panel.



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



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



4. Click the "Use the following IP address" box.
5. Enter an **IP address** with the first three numbers the same as the IP address of the B90 relay and the last number different (in this example, 1.1.1.2).
6. Enter a subnet mask equal to the one set in the B90 (in this example, 255.0.0.0).
7. Click the **OK** button to save the values.

Before continuing, test the Ethernet connection.

1. Open a Windows console window, for example by selecting **Start > Run** from the Windows **Start** menu and typing "cmd" or clicking the **Start** button and entering "cmd".
2. Type the following command, substituting the IP address of 1.1.1.1 with yours:

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

3. If the connection is successful, the system returns four replies similar to the following:

```
Pinging 1.1.1.1 with 32 bytes of data:
Reply from 1.1.1.1: bytes=32 time<10ms TTL=255
Reply from 1.1.1.1: bytes=32 time<10ms TTL=255
Reply from 1.1.1.1: bytes=32 time<10ms TTL=255
Reply from 1.1.1.1: bytes=32 time<10ms TTL=255
Ping statistics for 1.1.1.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip time in milliseconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0 ms
```

4. Note that the values for **time** and **TTL** vary depending on local network configuration.
5. If the following sequence of messages appears when entering the C:\WINNT>ping 1.1.1.1 command:

```
Pinging 1.1.1.1 with 32 bytes of data:
Request timed out.
Request timed out.
Request timed out.
Request timed out.
Ping statistics for 1.1.1.1:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
    Approximate round trip time in milliseconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0 ms
Pinging 1.1.1.1 with 32 bytes of data:
```

verify the physical connection between the B90 and the computer, and double-check the programmed IP address in the **Product Setup** ⇒ **Communications** ⇒ **Network** ⇒ **IP Address** setting, then repeat step 2.

6. If the following sequence of messages appears when entering the C:\WINNT>ping 1.1.1.1 command:

```
Pinging 1.1.1.1 with 32 bytes of data:
Hardware error.
Hardware error.
Hardware error.
Hardware error.
Ping statistics for 1.1.1.1:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
    Approximate round trip time in milliseconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0 ms
Pinging 1.1.1.1 with 32 bytes of data:
```

verify the physical connection between the B90 and the computer, and double-check the programmed IP address in the **PRODUCT SETUP** ⇒ **COMMUNICATIONS** ⇒ **NETWORK** ⇒ **IP ADDRESS** setting, then repeat step 2.

7. If the following sequence of messages appears when entering the C:\WINNT>ping 1.1.1.1 command:

```
Pinging 1.1.1.1 with 32 bytes of data:
Destination host unreachable.
Destination host unreachable.
Destination host unreachable.
Destination host unreachable.
```

```

Ping statistics for 1.1.1.1:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
    Approximate round trip time in milliseconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0 ms
    Pinging 1.1.1.1 with 32 bytes of data:

```

verify the IP address is programmed in the local computer by entering the ipconfig command in the command window.

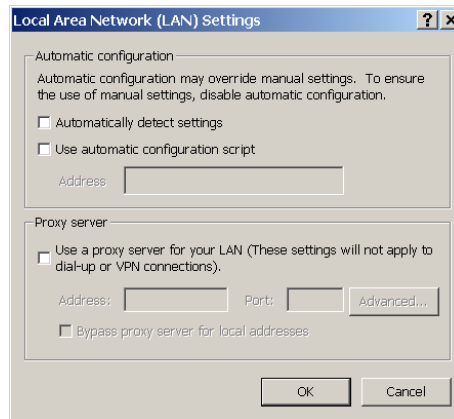
```

C:\WINNT>ipconfig
Windows IP Configuration
Ethernet adapter <F4FE223E-5EB6-4BFB-9E34-1BD7BE7F59FF>:
    Connection-specific DNS suffix. . . :
    IP Address. . . . . : 0.0.0.0
    Subnet Mask . . . . . : 0.0.0.0
    Default Gateway . . . . . :
Ethernet adapter Local Area Connection:
    Connection-specific DNS suffix . . :
    IP Address. . . . . : 1.1.1.2
    Subnet Mask . . . . . : 255.0.0.0
    Default Gateway . . . . . :
C:\WINNT>

```

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

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

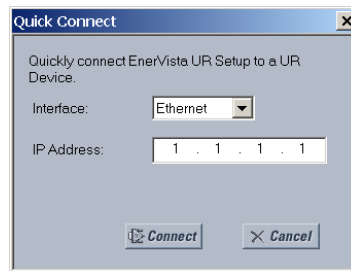


4. Ensure that the "Use a proxy server for your LAN" box is not checked.

If this computer is used to connect to the Internet, re-enable any proxy server settings after the computer has been disconnected from the B90 relay.

1. Start the Internet Explorer software.
2. Select the UR device from the EnerVista Launchpad to start EnerVista UR Setup.

- Click the **Quick Connect** button to open the window.

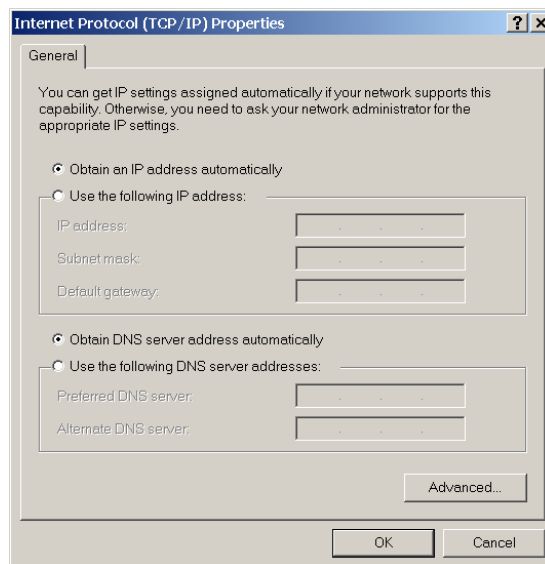


- Select the **Ethernet** interface and enter the IP address assigned to the B90, then click the **Connect** button. The EnerVista UR Setup software creates a site named "Quick Connect" with a corresponding device also named "Quick Connect" and displays them on the left side of the screen.
- Expand the sections to view data directly from the B90 device.

Each time that the EnerVista UR Setup software is initialized, click the **Quick Connect** button to establish direct communications to the B90. This ensures that configuration of the EnerVista UR Setup software matches the B90 model number.

When direct communications with the B90 via Ethernet is complete, make the following changes:

- From the Windows desktop, right-click the **My Network Places** icon and select **Properties** to open the network connections window.
- Right-click the **Local Area Connection** icon and select the **Properties** item.
- Select the **Internet Protocol (TCP/IP)** item from the list provided and click the **Properties** button.
- Set the computer to "Obtain a relay address automatically" as shown.



If the computer is used to connect to the Internet, re-enable any proxy server settings after the computer has been disconnected from the B90 relay.

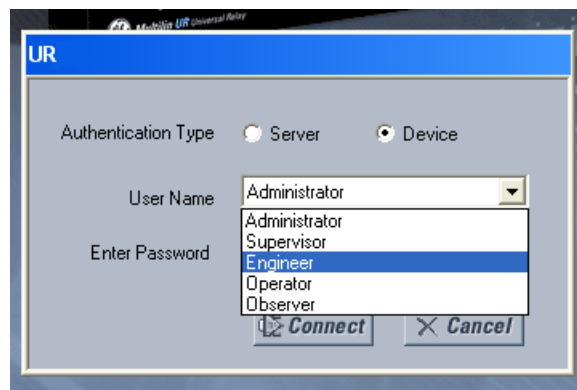
3.9 Set up CyberSentry and change default password

If and when first using CyberSentry security, use the following procedure for set up.

1. Log in to the relay as Administrator by using the **VALUE** keys on the front panel or through EnerVista connected serially (so that no IP address is required). If logging in through EnerVista choose Device authentication (see figure). Enter the default password "ChangeMe1#". Note that the "Lock relay" setting needs to be disabled in the **Security > Supervisory** menu. When this setting is disabled, configuration and firmware upgrade are possible. By default, this setting is disabled.
2. Enable the Supervisor role if you have a need for it.
3. Make any required changes in configuration, such as setting a valid IP address for communication over Ethernet.
4. Log out of the Administrator account by choosing None.

Next, device or server authentication can be chosen on the login screen, but the choice is available only in EnerVista. Use Device authentication to log in using the five pre-configured roles (Administrator, Supervisor, Engineer, Operator, Observer, or Administrator and Supervisor when Device authentication is disabled). When using a serial connection, only Device authentication is supported. When Server authentication is required, characteristics for communication with a RADIUS server must be configured on the UR. This is possible only through the EnerVista software. The RADIUS server itself also must be configured. At the end of this instruction manual, the appendix called RADIUS Server Configuration gives an example of how to set up a simple RADIUS server. Once both the RADIUS server and the parameters for connecting the UR to the server have been configured, you can choose Server authentication on the login screen of EnerVista.

Figure 3-64: Login screen for CyberSentry



During the commissioning phase, you have the option to bypass the use of passwords. Do so by enabling the **Bypass Access** setting under **Settings > Product Setup > Security > Supervisory**. Be sure to disable this bypass setting after commissioning the device.

You can change the password for any role either from the front panel or through EnerVista. If using EnerVista, navigate to **Settings > Product Setup > Security**. Change the **Local Administrator Password**, for example. It is strongly recommended that the password for the Administrator be changed from the default. Changing the passwords for the other three roles is optional.

B90 Low Impedance Bus Differential System

Chapter 4: Interfaces

This chapter explains the EnerVista software interface, the front panel interface, and logic diagrams.

4.1 EnerVista software interface

4.1.1 Introduction

The EnerVista UR Setup software provides a single facility to configure, monitor, maintain, and troubleshoot relay functions, connected over local or wide-area networks. It can be used while disconnected (offline) or connected (online) to a UR device. In offline mode, settings files can be created for eventual downloading to the device. In online mode, communication with the device is real-time.

The EnerVista UR Setup software is provided with every B90. This chapter outlines the EnerVista software interface features. The EnerVista UR Setup help file in the software also provides details for getting started and using the software interface.

4.1.2 Settings files

The EnerVista software supports the following three ways of handling changes to relay settings:

- In offline mode (relay disconnected) to create or edit relay settings files for later download to relays
- While connected to a relay to modify relay settings, and then save the settings to the relay
- Create/edit settings files and then write them to the relay while 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
- Remote resources

- Testing
- Factory default values are supplied and can be restored after any changes.

The following communications settings are not transferred to the B90 with settings files:

- Modbus Slave Address
- Modbus TCP Port Number
- RS485 COM2 Baud Rate
- RS485 COM2 Parity
- COM2 Minimum Response Time
- COM2 Selection
- RRTD Slave Address
- RRTD Baud Rate
- IP Address
- IP Subnet Mask
- IP Routing

When a settings file is loaded to a B90 that is in-service, the following sequence occurs:

1. The B90 takes itself out of service.
2. The B90 issues a UNIT NOT PROGRAMMED major self-test error.
3. The B90 closes the critical fail contact.

The Maintenance chapter outlines how to use a settings file in the .urs format for backup and restore.

4.1.3 Event viewing

While the interface is in online or offline mode, you can view and analyze data generated by triggered parameters as follows:

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

Event records are viewable at software and device-specific levels. Access the former under **Admin > Event Log > View**. Access the latter under **Actual Values > Records > Event Record**.

Event record entries for CyberSentry are explained in the next chapter. The following table outlines some software-level entries.

Table 4-1: Event record descriptions

Event	Description
EnerVista UR Setup SESSION STARTED	The EnerVista software was launched
Language was changed.	The user changed the software language using the View > Language menu item
DEFAULT USERS CREATED	The user management window was launched using the Admin > User Management menu item
: Successful upload of firmware END Firmware verified Firmware uploaded Firmware erased START: Upload new firmware	The firmware on a device was upgraded
EnerVista UR Setup EVENT LOG CLEARED	The event record was cleared. All event records were deleted using the Admin > Event Log > Clear menu item.

4.1.4 File support

The following support applies, where the Settings List is at the bottom left and the Site List is at the top left of the EnerVista window:

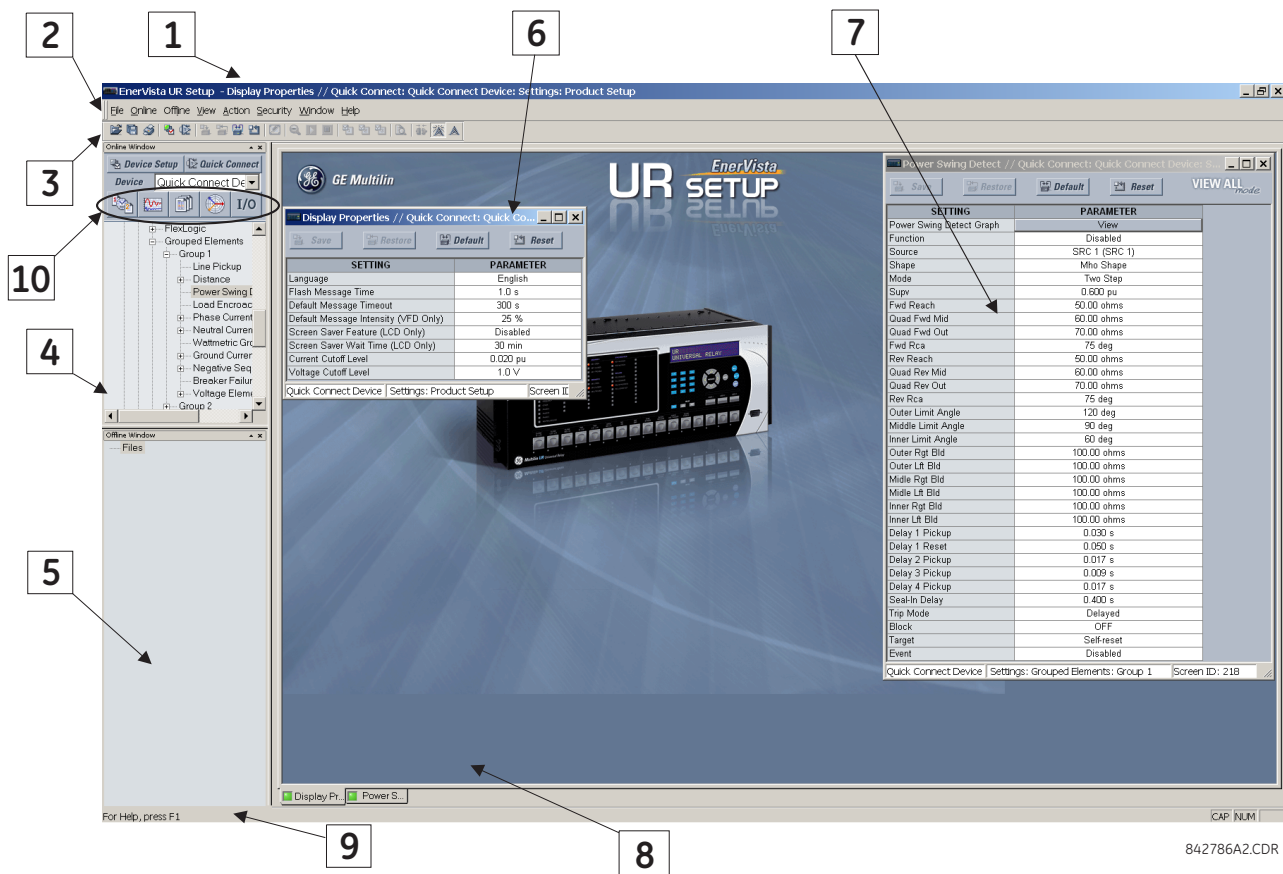
- **Execution** — Any EnerVista UR Setup file that is opened launches the application or provides focus to the already opened application. If the file was a settings file (has a .urs extension) that had been removed from the Settings List navigation menu, it is added back to the menu.
- **Drag and Drop** — The device settings and individual settings can be dragged and dropped between the Online and Offline Window areas. Also, any Windows Explorer directory folder is a file drag source and drop target.
New files that are dropped into the Offline Window are added to the tree, which is automatically sorted alphabetically with respect to settings file names. In the Online Window, files or individual menu items that are dropped in the selected device menu are sent automatically to the online device.

4.1.5 EnerVista main window

The EnerVista UR Setup software window has the following components:

1. Title bar that shows the pathname of the active data view or the name of the software
2. Main window menu bar
3. Main window tool bar
4. Site list / online window area
5. Settings list / offline window area
6. Software windows, with common tool bar
7. Settings file data view windows, with common tool bar
8. Workspace area with data view tabs
9. Status bar
10. Quick action hot links

Figure 4-1: EnerVista UR Setup software window



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4.1.6 Settings templates

Settings file templates simplify the configuration and commissioning of multiple relays that protect similar assets. An example is a substation that has 10 similar feeders protected by 10 UR F60 relays.

In these situations, typically 90% or greater of the settings are identical among devices. The templates allow engineers to configure and test these common settings, then lock them so that they are not available to users. For example, locked settings can be hidden from view for field engineers, allowing them to quickly identify and concentrate on specific settings.

The remaining settings (typically 10% or less) can be specified as editable and made available to field engineers installing the devices. These are settings such as protection element pickup values and CT and VT ratios.

The settings template mode allows the user to define which settings are visible in the software. Settings templates can be applied to both settings files (settings file templates) and online devices (online settings templates). The functionality is identical for both purposes.



Template mode is available in English only.

NOTE

Settings file conversion from previous firmware versions is supported.

4.1.6.1 Enable the settings template

The settings file template feature is disabled by default. It can be enabled in offline or online mode.

The procedure outlines how to enable in offline mode the settings template for UR settings files.

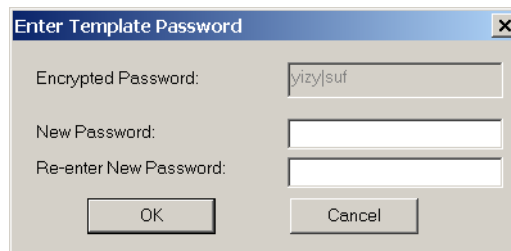
1. Locate the settings file from the Offline Window area of the EnerVista UR Setup software. If not there, a file can be added from an online device by right-clicking it and selecting the **Add Device to Offline Window** option.
2. In the Offline Window area, right-click the selected device or settings file and select the **Template Mode > Create Template** option.

The settings file template is now enabled and the file menus display in light blue. A message displays. The settings file is now in template editing mode. To undo the action, select **Template Mode > Remove Template**.

Alternatively, the settings template can be applied to online settings, as follows.

1. Locate the device in the Online Window area of the EnerVista UR Setup software.
2. Right-click the device and select the **Template Mode > Create Template** option. The software prompts for a template password. This password is required to use the template feature and must be at least four characters in length.

Figure 4-2: Entering a settings file password



3. Enter and re-enter the new password, then click **OK** to continue.
The online settings template is now enabled. The device is now in template editing mode.

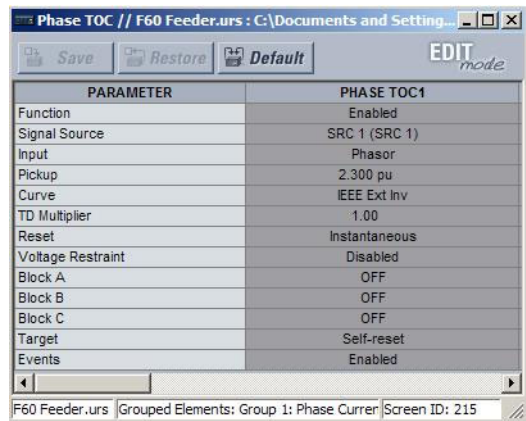
4.1.6.2 Edit the settings template

The settings template editing feature allows the user to specify which settings are available for viewing and modification in EnerVista UR Setup. By default, all settings except the FlexLogic equation editor settings are locked.

1. With the template already enabled, locate the device or settings file in the Online or Offline Window area in the software.
2. Right-click the device or file and select the **Template Mode > Edit Template** option to place the device in template editing mode. If prompted, enter the template password then click **OK**.
3. Open the relevant settings window that contains settings to be specified as viewable.

By default, all settings are specified as locked and displayed against a grey background. The icon on the upper right of the settings window also indicates that the EnerVista software is in **EDIT mode**. The following example shows the phase time overcurrent settings window in edit mode.

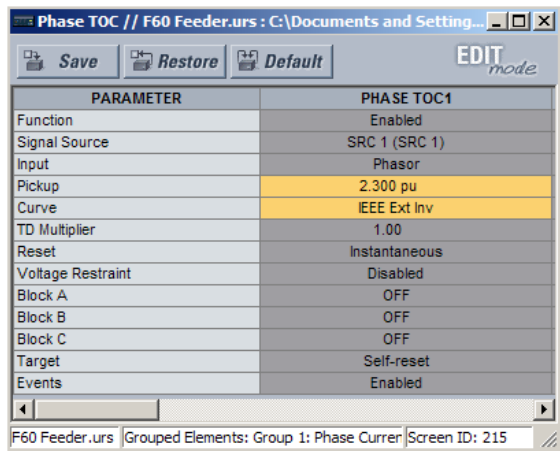
Figure 4-3: Settings template with all settings specified as locked



- 4
4.

Specify the settings to make viewable by clicking them.
A setting available to view is displayed against a yellow background.

Figure 4-4: Settings template with two settings specified as editable



5.

Click the **Save** button to save changes to the settings template.
6.

Continue through any other settings window to specify all viewable settings.
The next time that the device/settings are accessed, only those specified as viewable/editable display in the menu hierarchy.

4.1.6.3 Add password protection to a template

GE recommends that templates be saved with password protection to maximize security.



NOTE

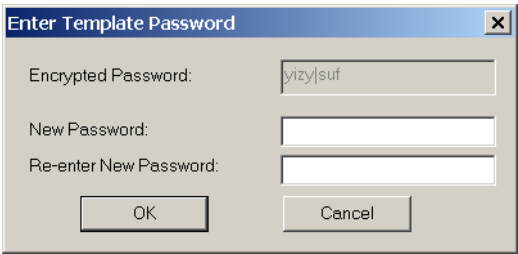
When templates are created for online settings, the password is added during the initial template creation step. It does not need to be added after the template is created.

To add password protection to a settings file template:

1.

In the Offline Window area, right-click the device and select the **Template Mode > Password Protect Template** option.

The software prompts for a template password. This password must be at least four characters in length.



- 2. Enter and re-enter the new password, then click **OK** to continue.
- The settings file template is now secured with password protection.

4.1.6.4 View the settings template

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

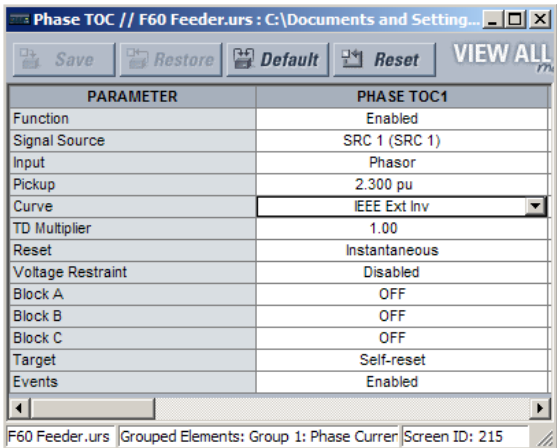
- Display only those settings available for editing
- Display all settings, with settings not available for editing greyed-out

To display only the settings available for editing:

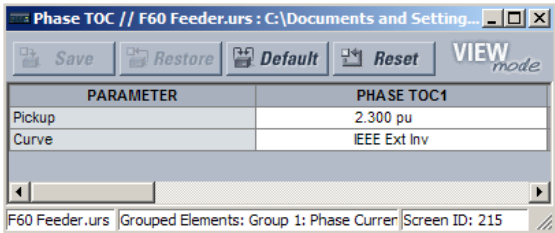
1. Right-click the device in the Online or Offline Window area and apply the template by selecting the **Template Mode > View In Template Mode** option.
2. Enter the template password then click **OK** to apply the template.

Once the template has been applied, users are limited to view and edit the settings specified by the template. The effect of applying the template to the phase time overcurrent settings is shown.

Figure 4-5: Applying templates using the View in Template Mode command



Phase time overcurrent settings window without template applied.

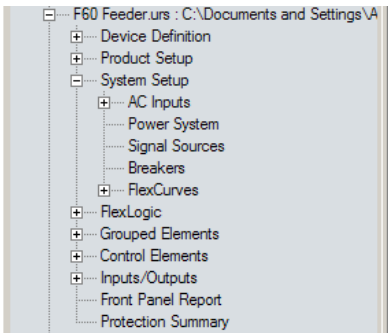


Phase time overcurrent window with template applied via the **Template Mode > View In Template Mode** command. The template specifies that only the **Pickup** and **Curve** settings be available.

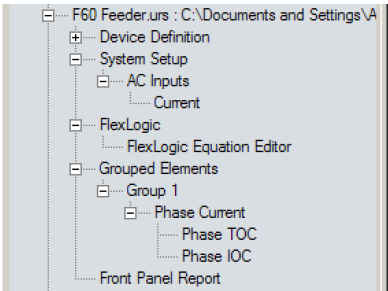
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Viewing the settings in template mode also modifies the settings menu, showing only the settings categories that contain editable settings. The effect of applying the template to a typical settings menu is shown as follows.

Figure 4-6: Applying templates using the View in Template Mode settings command



Typical settings tree view without template applied.



Typical settings tree view with template applied via the **Template Mode > View In Template Mode** command.

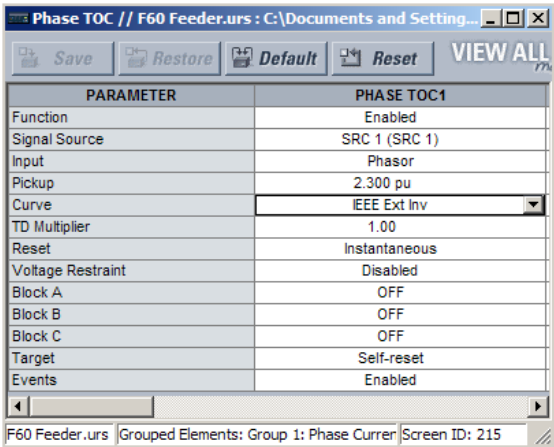
842860A1.CDR

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

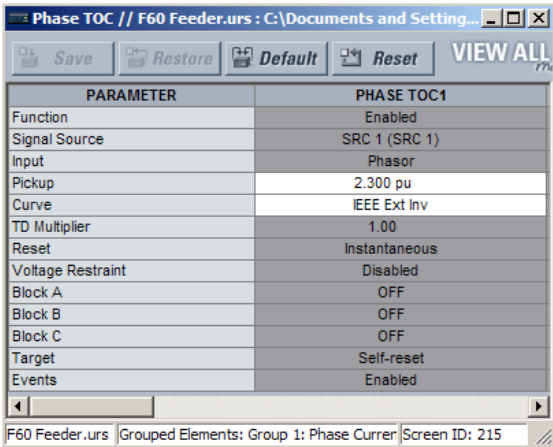
1. Right-click the device in the Online or Offline Window area and apply the template by selecting the **Template Mode > View All Settings** option.
2. Enter the template password then click **OK** to apply the template.

Once the template has been applied, users are limited to edit the settings specified by the template, but all settings are shown. The effect of applying the template to the phase time overcurrent settings is shown as follows.

Figure 4-7: Applying templates using the View All Settings command



Phase time overcurrent settings window without template applied.



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

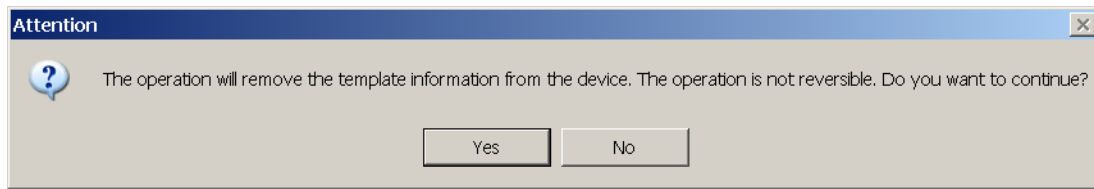
842859A1.CDR

4.1.6.5 Remove the settings template

Once a settings template is removed, it cannot be reapplied and a new settings template needs to be defined before use.

1. Right-click the device in the Online or Offline Window area and select the **Template Mode > Remove Template** option.
2. Enter the template password and click **OK** to continue.

- Confirm that you want to remove the template by clicking **Yes**.



The EnerVista software removes all template information and all settings are available.

4.1.7 Secure and lock FlexLogic equations

The UR allows users to secure parts or all of a FlexLogic equation, preventing unauthorized viewing or modification of critical FlexLogic applications. This is accomplished using the settings template feature to lock individual entries within FlexLogic equations.

Secured FlexLogic equations remain secure when files are sent to and retrieved from any UR-series device.

Locking can be tied to the serial number too.

4.1.7.1 Lock FlexLogic equations

To lock individual entries of a FlexLogic equation:

- Right-click the settings file or online device and select the **Template Mode > Create Template** item to enable the settings template feature.
- If prompted, enter the template password.
- Select the **FlexLogic > FlexLogic Equation Editor** settings menu item.

By default, all FlexLogic entries are specified as viewable and displayed against a yellow background. The icon on the upper right of the window also indicates that EnerVista UR Setup is in **EDIT mode**.

- Specify the entries to lock by clicking them.

The locked entries display against a grey background as shown in the example.

Figure 4-8: Locking FlexLogic equation entries in Edit Mode

FLEXLOGIC ENTRY	TYPE	SYNTAX
View Graphic	View	View
FlexLogic Entry 1	Virtual Inputs On	Close HMI On (V11)
FlexLogic Entry 2	Virtual Inputs On	Close SCADA On (V12)
FlexLogic Entry 3	Contact Inputs On	Manual Close On(HSA)
FlexLogic Entry 4	OR	3 Input
FlexLogic Entry 5	Assign Virtual Output	= Close 52-1 (V01)
FlexLogic Entry 6	Contact Inputs On	52-1 Closed On(H5C)
FlexLogic Entry 7	Contact Inputs On	52-1 Rack In On(H6A)
FlexLogic Entry 8	AND	2 Input
FlexLogic Entry 9	Protection Element	PHASE IOC1 OP
FlexLogic Entry 10	Protection Element	PHASE TOC1 OP
FlexLogic Entry 11	Protection Element	GROUND IOC1 OP
FlexLogic Entry 12	Protection Element	NEUTRAL IOC1 OP
FlexLogic Entry 13	OR	4 Input
FlexLogic Entry 14	AND	2 Input
FlexLogic Entry 15	Assign Virtual Output	= Trip 52-1 (V02)
FlexLogic Entry 16	Protection Element	ANY MAJOR ERROR
FlexLogic Entry 17	POSITIVE ONE SHOT	1 Input
FlexLogic Entry 18	Protection Element	ANY MAJOR ERROR

- Click the **Save** button to save and apply changes to the settings template.
- Select the **Template Mode > View In Template Mode** option to view the template.
- Optionally apply a password to the template by right-clicking the device and selecting the **Template Mode > Password Protect Template** option.

Once the template has been applied, users are limited to view and edit the FlexLogic entries not locked by the template. The effect of applying the template to the FlexLogic entries is shown here.

Figure 4-9: Locking FlexLogic entries through settings templates

FlexLogic Equation Editor // F60 Feeder.urs : C:\Documents and Settings\All Users\Documents...		
Save	Restore	VIEW ALL
Default	Reset	mode
FLEXLOGIC ENTRY	TYPE	SYNTAX
View Graphic	View	View
FlexLogic Entry 1	Virtual Inputs On	Close HMI On (V11)
FlexLogic Entry 2	Virtual Inputs On	Close SCADA On (V12)
FlexLogic Entry 3	Contact Inputs On	Manual Close On(H5A)
FlexLogic Entry 4	OR	3 Input
FlexLogic Entry 5	Assign Virtual Output	= Close 52-1 (VO1)
FlexLogic Entry 6	Contact Inputs On	52-1 Closed On(H5C)
FlexLogic Entry 7	Contact Inputs On	52-1 Rack In On(H5A)
FlexLogic Entry 8	AND	2 Input
FlexLogic Entry 9	Protection Element	PHASE IOC1 OP
FlexLogic Entry 10	Protection Element	PHASE TOC1 OP
FlexLogic Entry 11	Protection Element	GROUND IOC1 OP
FlexLogic Entry 12	Protection Element	NEUTRAL IOC1 OP
FlexLogic Entry 13	OR	4 Input
FlexLogic Entry 14	AND	2 Input
FlexLogic Entry 15	Assign Virtual Output	= Trip 52-1 (VO2)
FlexLogic Entry 16	Protection Element	ANY MAJOR ERROR
FlexLogic Entry 17	POSITIVE ONE SHOT	1 Input

F60 Feeder.urs | FlexLogicScreen ID: 171

FlexLogic Equation Editor // F60 Feeder.urs : C:\Documents and Settings\All Users\Documents...		
Save	Restore	VIEW
Default	Reset	mode
FLEXLOGIC ENTRY	TYPE	SYNTAX
View Graphic	View	View
FlexLogic Entry 1	Virtual Inputs On	Close HMI On (V11)
FlexLogic Entry 2	Virtual Inputs On	Close SCADA On (V12)
FlexLogic Entry 3	Contact Inputs On	Manual Close On(H5a)
FlexLogic Entry 4	OR	3 Input
FlexLogic Entry 5	Assign Virtual Output	= Close 52-1 (VO1)
FlexLogic Entry 6	Locked	Locked
FlexLogic Entry 7	Locked	Locked
FlexLogic Entry 8	Locked	Locked
FlexLogic Entry 9	Locked	Locked
FlexLogic Entry 10	Locked	Locked
FlexLogic Entry 11	Locked	Locked
FlexLogic Entry 12	Locked	Locked
FlexLogic Entry 13	Locked	Locked
FlexLogic Entry 14	Locked	Locked
FlexLogic Entry 15	Locked	Locked
FlexLogic Entry 16	Protection Element	ANY MAJOR ERROR
FlexLogic Entry 17	POSITIVE ONE SHOT	1 Input
FlexLogic Entry 18	Protection Element	ANY MAJOR ERROR

F60 Feeder.urs | FlexLogicScreen ID: 171

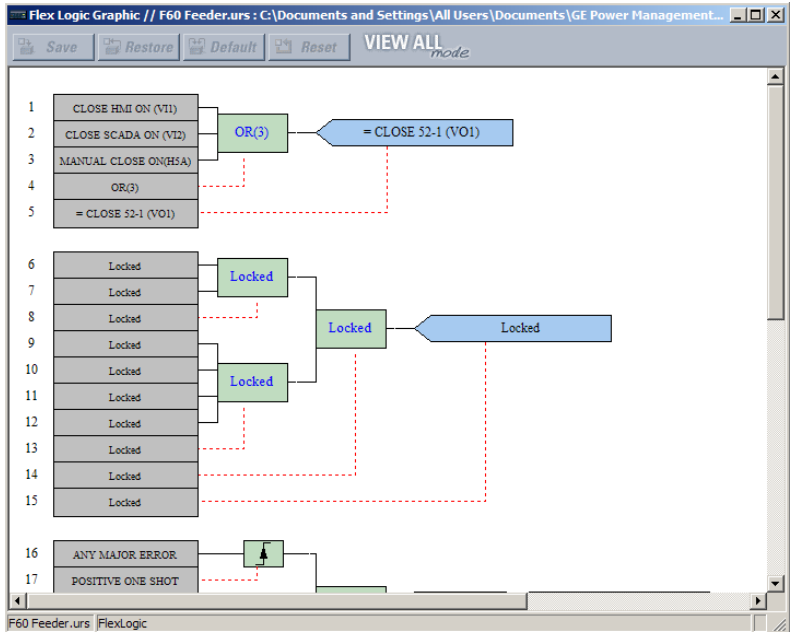
Typical FlexLogic™ entries without template applied.

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

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The FlexLogic entries are also shown as locked in the graphical view and on the front panel display.

Figure 4-10: Secured FlexLogic in graphical view

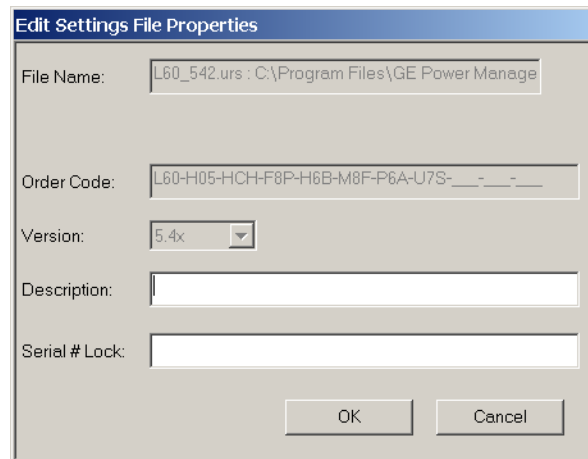


4.1.7.2 Lock FlexLogic equations to the serial number

A settings file and associated FlexLogic equations also can be locked to a UR serial number. Once FlexLogic entries in a settings file have been secured, use the following procedure to lock the settings file to a serial number. A serial number is viewable under **Actual Values > Product Info > Model Information**, the inside front panel, and the rear of the device.

1. Right-click the setting file in the Offline Window area and select the **Edit Settings File Properties** item. The window opens.

Figure 4-11: Settings file properties window



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

- File Name:** A text field containing "L60_542.urs : C:\Program Files\GE Power Manage".
- Order Code:** A text field containing "L60-H05-HCH-F8P-H6B-M8F-P6A-U7S-__-__-__".
- Version:** A dropdown menu currently showing "5.4x".
- Description:** An empty text field.
- Serial # Lock:** An empty text field.
- Buttons:** "OK" and "Cancel" buttons at the bottom right.

2. Enter the serial number of the B90 device to lock to the settings file in the **Serial # Lock** field.
3. Click the **OK** button to apply the change. The serial number is not validated.

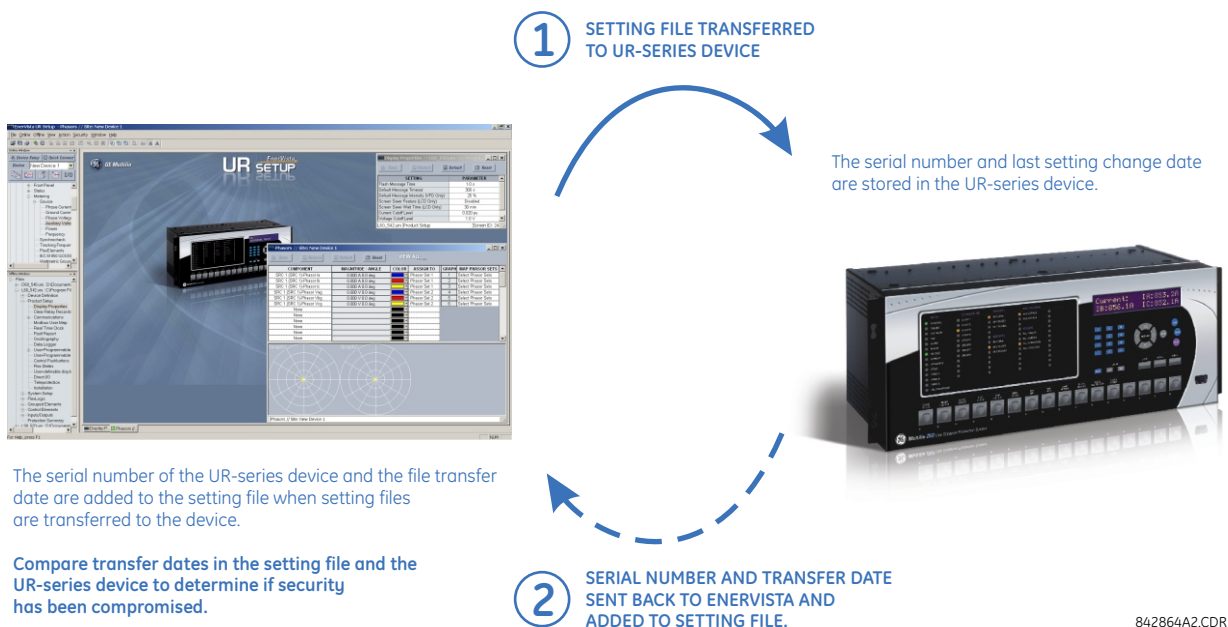
The settings file and corresponding secure FlexLogic equations are now locked to the B90 device specified by the serial number.

4.1.8 Settings file traceability

A traceability feature for settings files allows the user to quickly determine if the settings in a B90 device have been changed since the time of installation from a settings file. When a settings file is transferred to a B90 device, the date, time, and serial number of the B90 are sent back to EnerVista UR Setup and added to the settings file on the local computer. This information can be compared with the B90 actual values at any later date to determine if security has been compromised.

The traceability information is only included in the settings file if a complete settings file is either transferred to the B90 device or obtained from the B90 device. Any partial settings transfers by way of drag and drop do not add the traceability information to the settings file.

Figure 4-12: Settings file traceability



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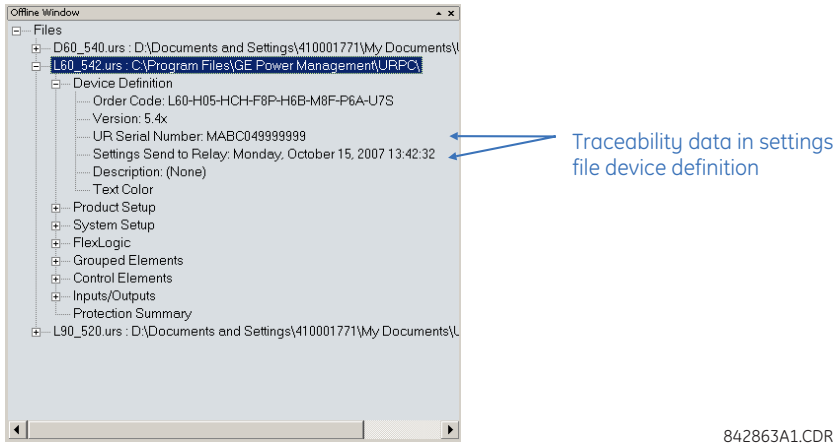
With respect to the figure, the traceability feature is used as follows.

- 1. The transfer date of a settings file written to a B90 is logged in the relay and can be viewed in the EnerVista software or the front panel display. Likewise, the transfer date of a settings file saved to a local computer is logged in the EnerVista software.
- 2. Comparing the dates stored in the relay and on the settings file at any time in the future indicates if any changes have been made to the relay configuration since the settings file was saved.

4.1.8.1 Settings file traceability information

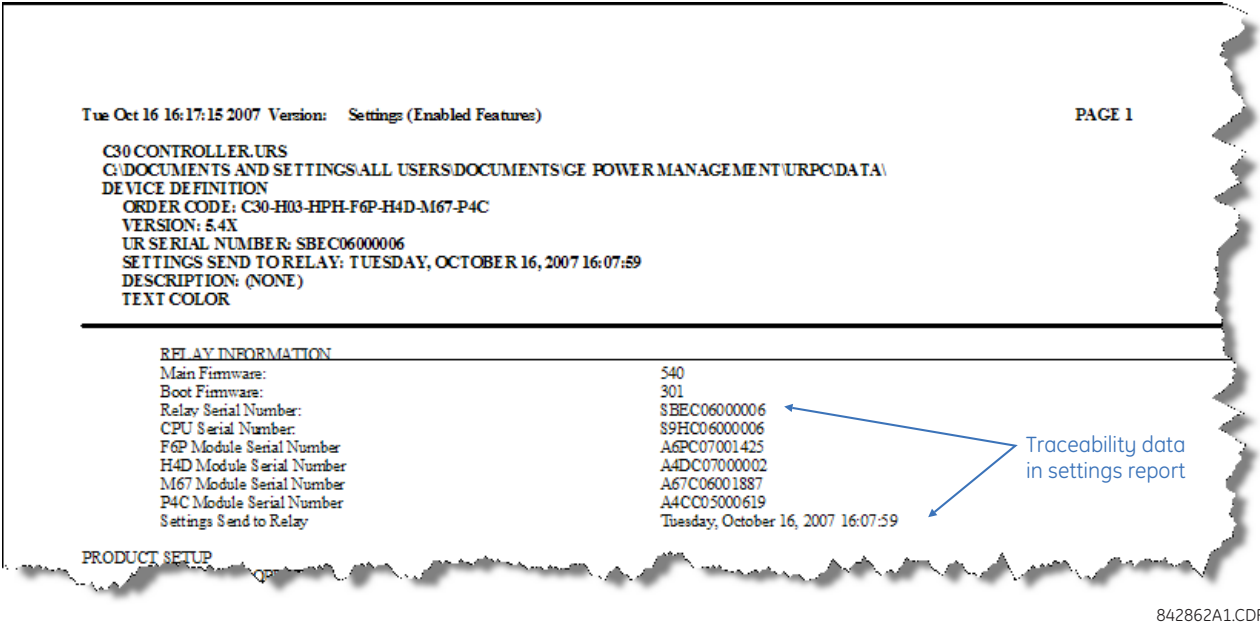
The serial number and file transfer date are saved in the settings files when they are sent to a B90 device. The B90 serial number and file transfer date are included in the settings file device definition within the EnerVista UR Setup offline window as shown in the example.

Figure 4-13: Device definition showing traceability data



This information is also available in printed settings file reports as shown in the example. A report is generated by right-clicking and selecting the **Print Settings** option.

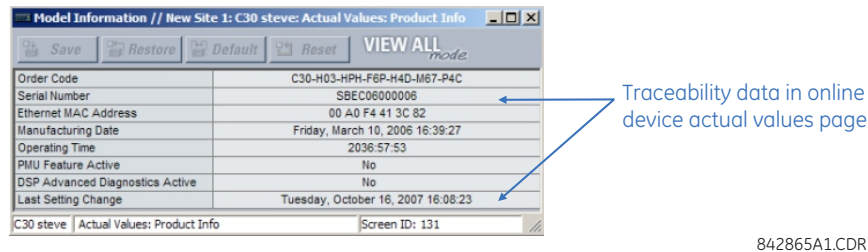
Figure 4-14: Settings file report showing traceability data



4.1.8.2 Online device traceability information

The B90 serial number and file transfer date are available for an online device through the actual values. Select the **Actual Values > Product Info > Model Information** menu item within the EnerVista online window as shown in the example.

Figure 4-15: Traceability data in Actual Values window



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

ACTUAL VALUES ⇒ PRODUCT INFO ⇒ MODEL INFORMATION ⇒ SERIAL NUMBER

ACTUAL VALUES ⇒ PRODUCT INFO ⇒ MODEL INFORMATION ⇒ LAST SETTING CHANGE

4.1.8.3 Additional traceability rules

The following additional rules apply for the traceability feature:

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

4.2 Front panel interface

This section explains use of the front panel.

4.2.1 Front panel display

Messages display on a backlit liquid crystal display (LCD) to make them visible under poor lighting conditions. When the keypad and display are not actively being used, the display defaults to user-defined messages. Any high-priority event-driven message overrides the default messages and displays.

Settings files conversion from previous firmware versions is supported.

4.2.2 Front panel 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 divided further into further submenus.

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

The decimal key initiates and advances to the next character in text edit mode or enters a decimal point.

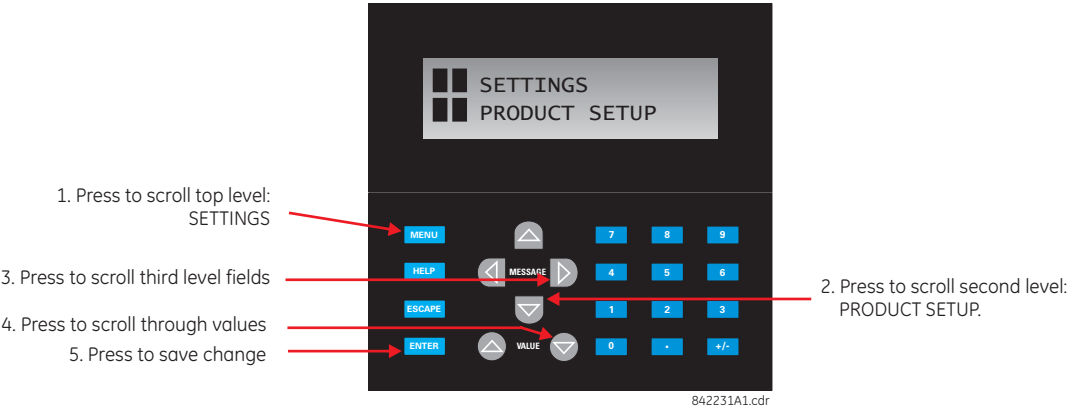
The **HELP** key can be pressed at any time for context-sensitive help messages.

The **ENTER** key stores setting values.

When entering an IP address on the front panel, key in the first sequence of the number, then press the **•** key for the decimal place. For example, for 127.0.0.1, press 127, then **•**, then 0, then **•**, then 0, then **•**, then 1. To save the address, press the **ENTER** key.

The figure shows the sequence to use to enter a setting. Subsequent sections provide more detail.

Figure 4-16: Front panel keypad use



4.2.3 Menu navigation

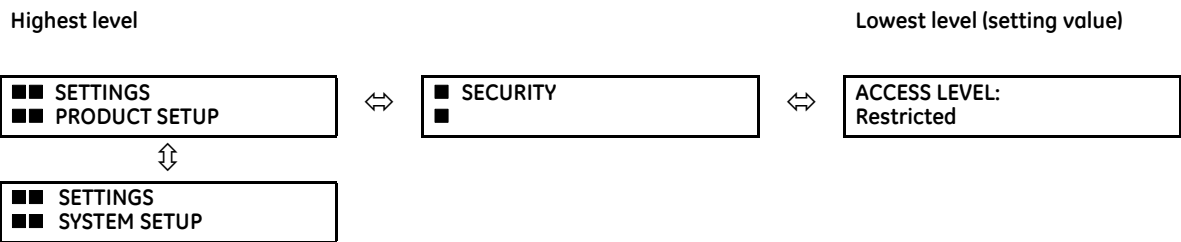
Press the **MENU** key to select a header display page (top-level menu). The header title appears momentarily followed by a header display page menu item. Each press of the **MENU** key advances through the following main headings:

- Actual Values
- Settings
- Commands
- Targets
- Factory Service
- User displays (when enabled)

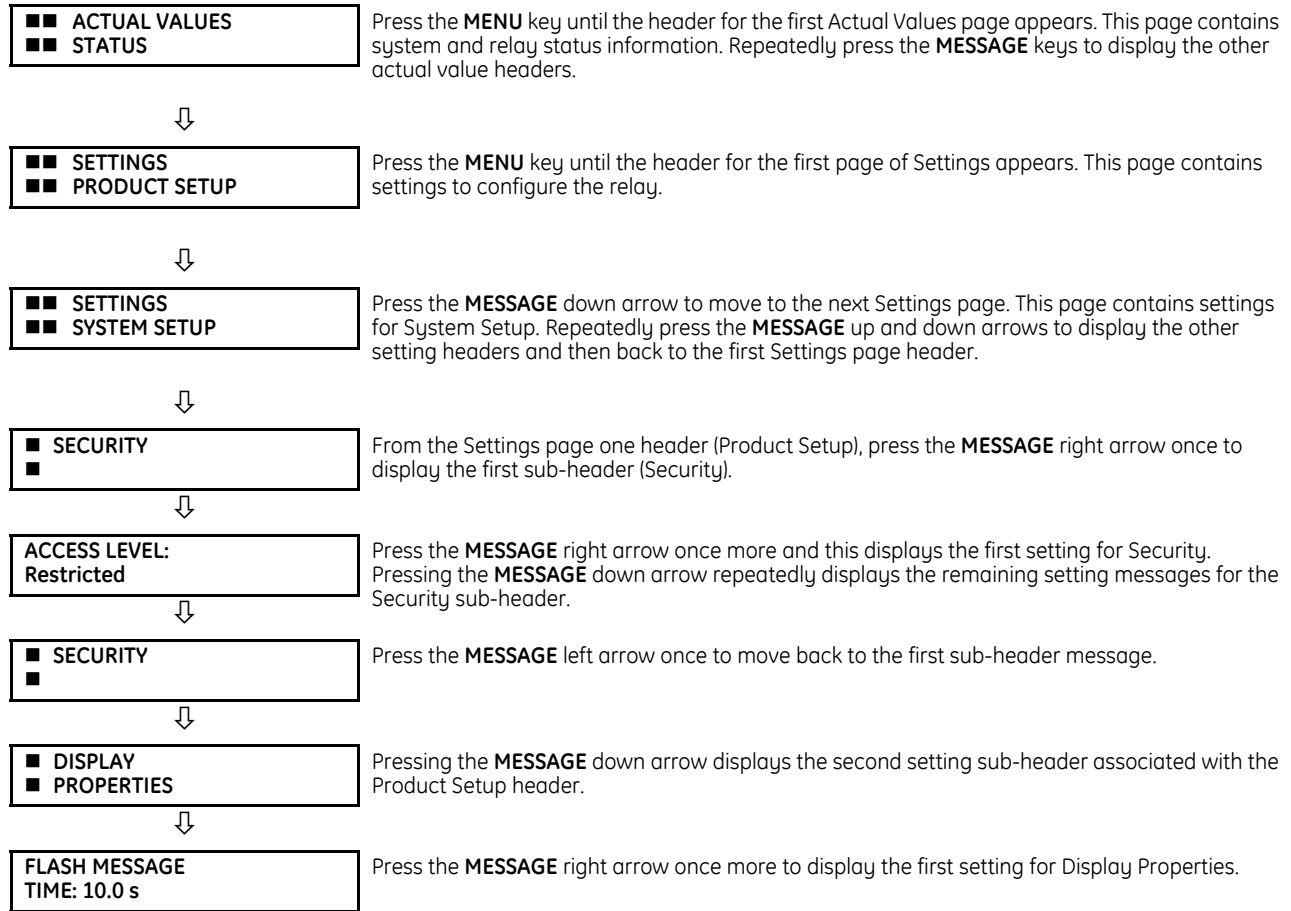
4.2.4 Menu hierarchy

The setting and actual value messages are arranged hierarchically. The header display pages are indicated by double scroll bars (■■), while sub-header pages are indicated by single scroll bar (■). The header display pages represent the highest level of the hierarchy and the sub-header display pages fall below this level. The **MESSAGE** up and down arrow keys move within a group of headers, sub-headers, setting values, or actual values. Continually pressing the **MESSAGE** right arrow from a header display displays specific information for the category. Conversely, continually pressing the **MESSAGE** left arrow from a setting value or actual value display returns to the header display.

Default values are indicated in this instruction manual in mixed case. In the example shown here, the default access level is Restricted.



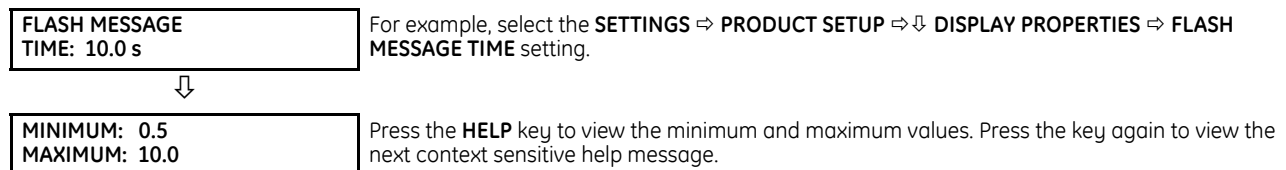
4.2.4.1 Example



4.2.5 Changing settings

4.2.5.1 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.



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 a calculator. A number is entered one digit at a time. The leftmost digit is entered first and the rightmost digit is entered last. Pressing the **MESSAGE** left arrow or pressing the **ESCAPE** key, returns the original value to the display.
- **VALUE keys** — The **VALUE** up arrow increments the displayed value by the step value, up to the maximum value allowed. While at the maximum value, pressing the **VALUE** up arrow again allows the setting selection to continue upward from the minimum value. The **VALUE** down arrow decrements the displayed value by the step value, down to

the minimum value. While at the minimum value, pressing the **VALUE** down arrow again allows 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 changes as the digits are being entered.
↓	
NEW SETTING HAS BEEN STORED	Until ENTER is pressed, editing changes are not registered by the relay. Press ENTER to store the new value in memory. This flash message momentarily appears as confirmation of the storing process. Numerical values that contain decimal places are rounded-off if more decimal place digits are entered than specified by the step value.

4.2.5.2 Entering enumeration data

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

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

Enumeration type values are changed using the **VALUE** keys. The **VALUE** up arrow displays the next selection while the **VALUE** down arrow displays the previous selection.

ACCESS LEVEL: Setting	If the ACCESS LEVEL needs to be "Setting," press the VALUE keys until the proper selection displays. 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.

4.2.5.3 Entering alphanumeric text

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

There are several places where text messages can 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, enter the text "Breaker #1".

1. Press the decimal point to enter text edit mode.
2. Press the **VALUE** keys until the character 'B' appears; press the decimal key to advance the cursor to the next position.
3. Repeat step 2 for the remaining characters: r,e,a,k,e,r, ,#,1.
4. Press **ENTER** to store the text.
5. If you have any problem, press **HELP** to view context sensitive help. Flash messages appear sequentially for several seconds each. For the case of a text setting message, pressing **HELP** displays how to edit and store new values.

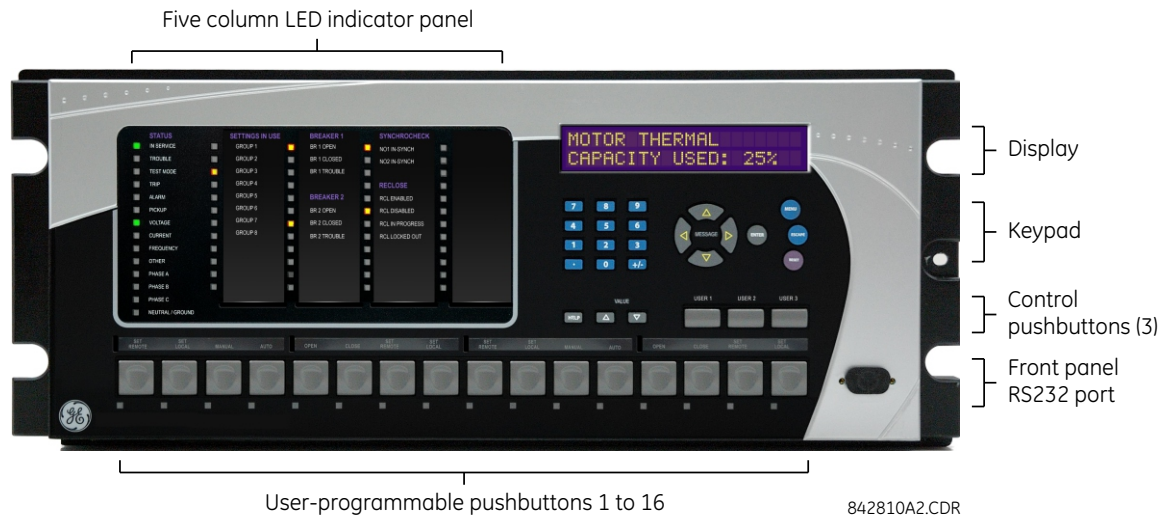
4.2.6 Faceplate

4.2.6.1 Enhanced faceplate

The front panel consists of LED panels, an RS232 port, keypad, LCD display, control pushbuttons, and optional user-programmable pushbuttons.

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

Figure 4-17: Enhanced faceplate

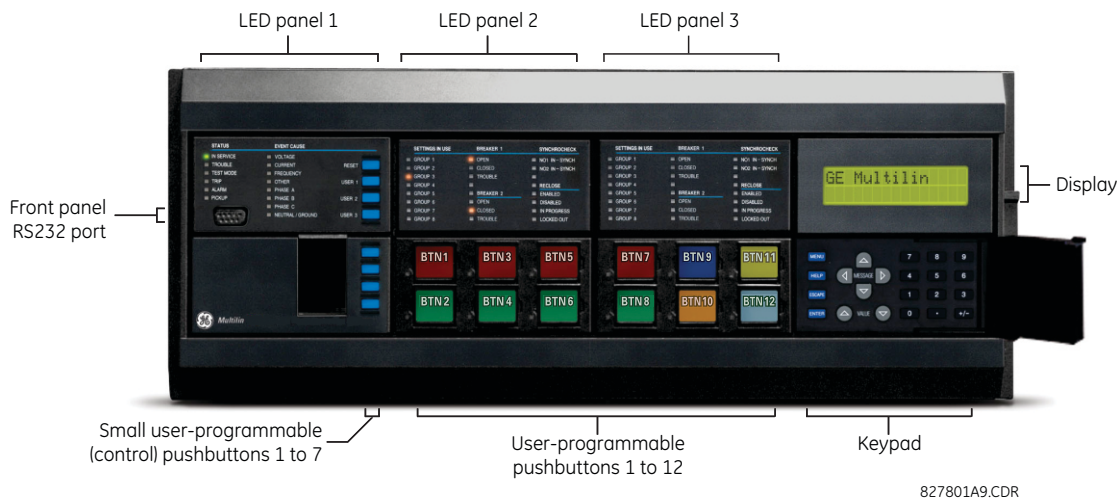


4.2.6.2 Basic faceplate

The front panel consists of LED panels, an RS232 port, keypad, LCD display, control pushbuttons, and optional user-programmable pushbuttons.

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

Figure 4-18: Standard horizontal faceplate



4.2.7 LED indicators

4.2.7.1 Enhanced faceplate

The enhanced front panel display provides five columns of LED indicators. The first column contains 14 status and event-cause LEDs. The next four columns contain the 48 user-programmable LEDs.

The **RESET** key is used to reset any latched LED indicator or target message, once the condition has been cleared (these latched conditions can also be reset via the **SETTINGS** ⇒ **INPUT/OUTPUTS** ⇒ **RESETTING** menu).

The **USER** keys are not used in this unit.

Figure 4-19: B90 LED panel for enhanced faceplate



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The status indicators in the first column are as follows:

- **IN SERVICE** — This LED indicates that control power is applied, all monitored inputs, outputs, and internal systems are OK, and that the device has been programmed
- **TROUBLE** — This LED indicates that the relay has detected an internal problem
- **TEST MODE** — This LED indicates that the relay is in test mode. For more information, see the Test Mode section in the Settings chapter.
- **TRIP** — This LED indicates that the FlexLogic operand serving as a trip switch has operated. This indicator always latches; as such, a reset command must be initiated to allow the latch to reset.
- **ALARM** — This LED indicates that the FlexLogic operand serving as an alarm switch has operated. This indicator is never latched.
- **PICKUP** — This LED indicates that an element is picked up. This indicator is never latched.

The event-cause indicators in the first column are as follows.

Event-cause LEDs are turned on or off by protection elements that have their respective target setting selected as either “Enabled” or “Latched.” If a protection element target setting is “Enabled,” then the corresponding event-cause LEDs remain on as long as the operate operand associated with the element remains asserted. If a protection element target setting is “Latched,” then the corresponding event-cause LEDs turn on when the operate operand associated with the element is asserted and remain on until the **RESET** button on the front panel is pressed after the operand is reset.

All elements that are able to discriminate faulted phases can independently turn off or on the phase A, B, or C LEDs. This includes phase instantaneous overcurrent, phase undervoltage, and so on. This means that the phase A, B, and C operate operands for individual protection elements are ORed to turn on or off the phase A, B, or C LEDs.

- **VOLTAGE** — This LED indicates voltage was involved
- **CURRENT** — This LED indicates current was involved
- **FREQUENCY** — Not used
- **OTHER** — This LED indicates a composite function was involved, BUS 5 OP was asserted, or BUS 6 OP was asserted. In the B90, composite function means either any Digital Element OP or any TRIP BUS op.
- **ZONE 1** — Driven by Zone 1 OP
- **ZONE 2** — Driven by Zone 2 OP
- **ZONE 3** — Driven by Zone 3 OP
- **ZONE 4** — Driven by Zone 4 OP

The user-programmable LEDs consist of 48 amber LED indicators in four columns. The operation of these LEDs is user-defined. Support for applying a customized label beside every LED is provided. Default labels are shipped in the label package of every B90, together with custom templates. The default labels can be replaced by user-printed labels.

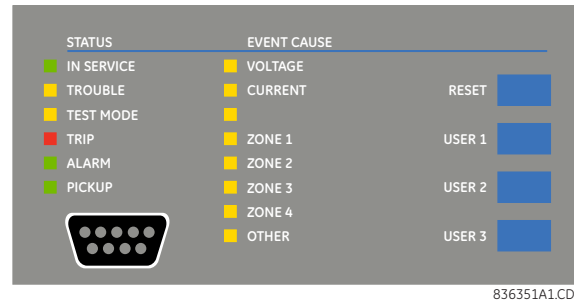
User customization of LED operation is of maximum benefit in installations where languages other than English are used to communicate with operators. See the User-Programmable LEDs section in chapter 5 for the settings used to program the operation of the LEDs on these panels.

4.2.7.2 Basic faceplate

The basic faceplate consists of three panels with LED indicators, keys, and a communications port. The **RESET** key is used to reset any latched LED indicator or target message, once the condition has been cleared (these latched conditions can also be reset via the **SETTINGS** ⇒ **INPUT/OUTPUTS** ⇒ **RESETTING** menu). The RS232 port is for connection to a computer.

The **USER** keys are not used in this unit.

Figure 4-20: LED panel 1



Status indicators

- **IN SERVICE** — Indicates that control power is applied, all monitored inputs/outputs and internal systems are fine, 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. For more information, see the Test Mode section in the Settings chapter.
- **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

Event-cause LEDs are turned on or off by protection elements that have their respective target setting selected as either "Enabled" or "Latched." If a protection element target setting is "Enabled," then the corresponding event cause LEDs remain on as long as operate the operand associated with the element remains asserted. If a protection element target setting is "Latched," then the corresponding event cause LEDs turn on when the operate operand associated with the element is asserted and remain on until the **RESET** button on the front panel is pressed after the operand is reset.

All elements that are able to discriminate faulted phases can independently turn off or on the phase A, B, or C LEDs. This includes phase instantaneous overcurrent, phase undervoltage, and so on. This means that the phase A, B, and C operate operands for individual protection elements are ORed to turn on or off the phase A, B, or C LEDs.

- **VOLTAGE** — Indicates voltage was involved
- **CURRENT** — Indicates current was involved
- **FREQUENCY** — Not used
- **OTHER** — Indicates a composite function was involved, BUS 5 OP was asserted, or BUS 6 OP was asserted. For the B90, a composite function means either any Digital Element OP or any TRIP BUS OP.
- **PHASE A** — Not used
- **PHASE B** — Not used

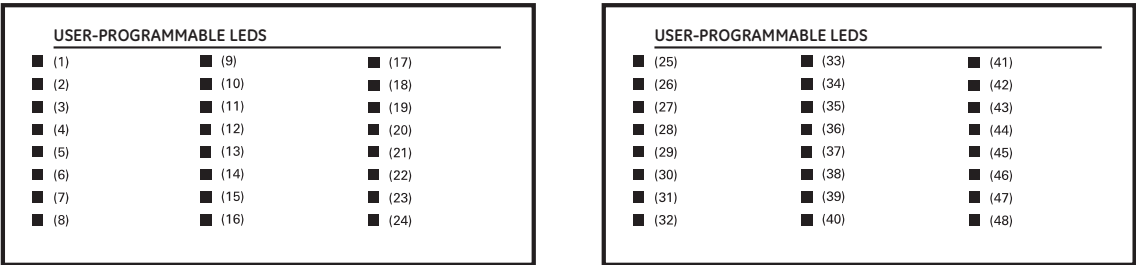
- **PHASE C** — Not used
- **NEUTRAL/GROUND** — Not used
- **ZONE 1** — BUS 1 OP asserted (or active)
- **ZONE 2** — BUS 2 OP asserted (or active)
- **ZONE 3** — BUS 3 OP asserted (or active)
- **ZONE 4** — BUS 4 OP asserted (or active)

User-programmable indicators

The second and third 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. See the User-programmable LEDs section in chapter 5 for the settings used to program the operation of the LEDs on these panels.

Figure 4-21: LED panels 2 and 3 (index template)



Default labels for LED panel 2

The default labels are intended to represent the following:

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

The relay is shipped with the default label for the LED panel 2. The LEDs, however, are not pre-programmed. To match the pre-printed label, the LED settings must be entered as shown in the User-programmable LEDs section of chapter 5. The LEDs are fully user-programmable. The default labels can be replaced by user-printed labels for both panels as explained in the next section.

Figure 4-22: LED panel 2 (default labels)



4.2.8 Custom LED labeling

4.2.8.1 Enhanced faceplate

The following procedure requires these pre-requisites:

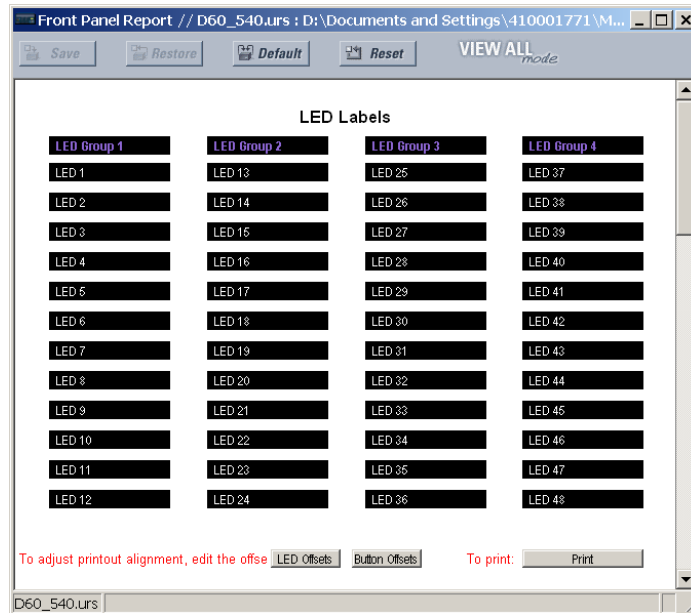
- EnerVista UR Setup software is installed and operational

- The B90 settings have been saved to a settings file
- The UR front panel label cutout sheet (GE part number 1006-0047) has been downloaded from <http://www.gegridsolutions.com/products/support/ur/URLEDenhanced.doc> and printed
- Small-bladed knife

To create custom LED labels for the enhanced front panel display:

1. Start the EnerVista UR Setup software.
2. Select the **Front Panel Report** item at the bottom of the navigation menu for the settings file. The front panel report window displays.

Figure 4-23: Front panel report window



3. Enter the text to appear next to each LED and above each user-programmable pushbutton in the fields provided.
4. Feed the UR front panel label cutout sheet into a printer and press the **Print** button in the front panel report window.
5. When printing is complete, fold the sheet along the perforated lines and punch out the labels.
6. Remove the UR label insert tool from the package and bend the tabs as described in the following procedures. These tabs are used for removal of the default and custom LED labels.



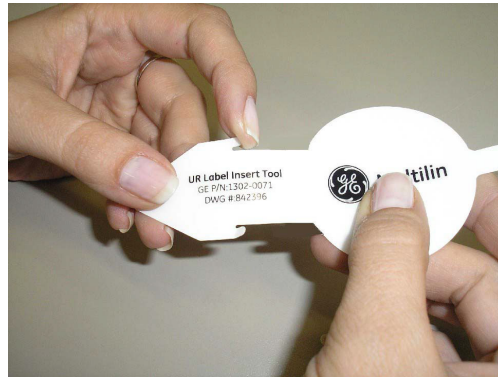
Use the tool EXACTLY as outlined as follows, with the printed side containing the GE part number facing the user.

The label package shipped with every B90 contains the three default labels, the custom label template sheet, and the label removal tool.

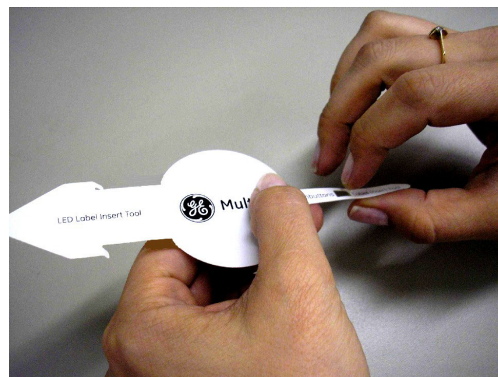
If the default labels are suitable for your application, insert them in the appropriate slots and program the LEDs to match them. If you require custom labels, use the following procedures to remove the original labels and insert the new ones.

To set up and use the label removal tool:

1. Bend the tabs at the left end of the tool upwards as shown.



Bend the tab at the center of the tool tail as shown.

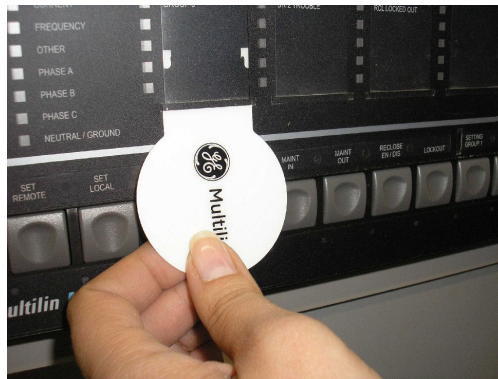


To remove the LED labels from the B90 enhanced front panel and insert the custom labels:

1. Use the knife to lift the LED label and slide the label tool underneath. Ensure that the bent tabs are pointing away from the relay.



- Slide the label tool under the LED label until the tabs snap out as shown. This attaches the label tool to the LED label.



- Remove the tool and attached LED label as shown.



- Slide the new LED label inside the pocket until the text is properly aligned with the LEDs, as shown.



To remove the user-programmable pushbutton labels from the B90 enhanced front panel and insert the custom labels:

- Use the knife to lift the pushbutton label and slide the tail of the label tool underneath, as shown. Ensure that the bent

tab points away from the relay.



2. Slide the label tool under the user-programmable pushbutton label until the tabs snap out as shown. This attaches the label tool to the user-programmable pushbutton label.



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



4. Slide the new user-programmable pushbutton label inside the pocket until the text is properly aligned with the

buttons.



4.2.9 Change passwords

The information in this section refers to password security. For information on how to set the password for the first time or change CyberSentry passwords, see the previous chapter or the Settings > Product Setup > Security > CyberSentry section in the next chapter.

The B90 supports password entry from a local or remote connection.

Local access is defined as access to settings or commands via the faceplate. This includes both keypad entry and the RS232 port. Remote access is defined as access to settings or commands via any rear communications port. This includes both Ethernet and RS485 connections. Any change to the local or remote password enables this functionality.

When entering a settings or command password via EnerVista or any serial interface, the user must enter the corresponding connection password. If the connection is to the back of the B90, the remote password must be used. If the connection is to the RS232 port of the faceplate, the local password must be used.

There are two user security access levels, setting and command, for which you can set a password for each. Use of a password for each level controls whether users can enter commands or change settings. Another option is to specify setting and/or command access for individual user accounts.

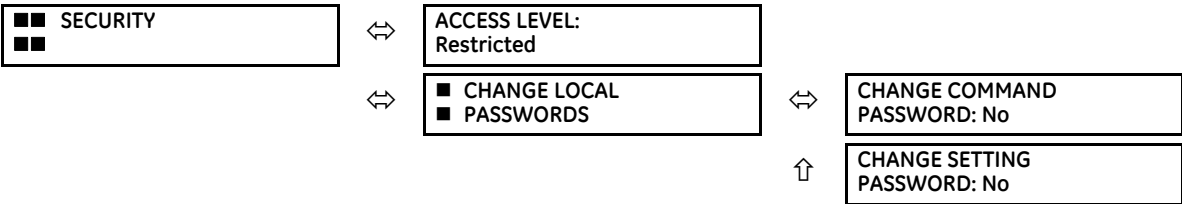
- **Setting** — Allows the user to make any changes to any of the setting values:
 - Changing any setting
 - Test mode operation
- **Command** — Restricts the user from making any settings changes, but allows the user to perform the following operations:
 - Changing the state of virtual inputs
 - Clearing the event records
 - Clearing the oscillography records
 - Changing the date and time
 - Clearing the data logger
 - Clearing the user-programmable pushbutton states

To enter the initial setting or command password:

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

display.

- 2. Press the **MESSAGE** right arrow until the **ACCESS LEVEL** message appears on the display.
- 3. Press the **MESSAGE** down arrow until the **CHANGE LOCAL PASSWORDS** message appears on the display.
- 4. Press the **MESSAGE** right arrow until the **CHANGE SETTING PASSWORD** or **CHANGE COMMAND PASSWORD** message appears on the display.



- 5. After the **CHANGE...PASSWORD** message appears on the display, press the **VALUE** up or down arrow to change the selection to "Yes."
- 6. Press the **ENTER** key and the display prompts you to **ENTER NEW PASSWORD**.
- 7. Type in a password and press the **ENTER** key.
- 8. When **VERIFY NEW PASSWORD** displays, re-type the password and press **ENTER**.



- 9. When the **NEW PASSWORD HAS BEEN STORED** message appears, your new Setting (or Command) password is active.

4.2.10 Invalid password entry

By default, when an incorrect Command or Setting password has been entered via the faceplate interface three times within five minutes, the **LOCAL ACCESS DENIED** FlexLogic operand is set to "On" and the B90 does not allow settings or command level access via the faceplate interface for five minutes.

By default, when an incorrect Command or Setting password has been entered via any external communications interface three times within five minutes, the **REMOTE ACCESS DENIED** FlexLogic operand is set to "On" and the B90 does not allow settings or command access via the any external communications interface for five minutes. The **REMOTE ACCESS DENIED** FlexLogic operand is set to "Off" after five minutes for a Command password or 30 minutes for a Settings password.

These default settings can be changed in EnerVista under **Settings > Product Setup > Security**.

4.3 Logic diagrams

Logic diagrams in this instruction manual provide an overview of function and settings. A logic diagram is based on

- Inputs-on the left side, which are setting and operands
- Logical gates, which is Boolean algebra to combine logical lines using AND, OR, NOT, and other gates to get a new logical state
- Logical operators, which are timers, one-shot operations, latches, and so on
- Outputs-on the right side, which are products of the manipulations with inputs, logical gates, and logical operators to produce new operands and define the output state of the element

True and false values are denoted by 1 and 0 respectively. A function usually is high/on/enabled when 1.

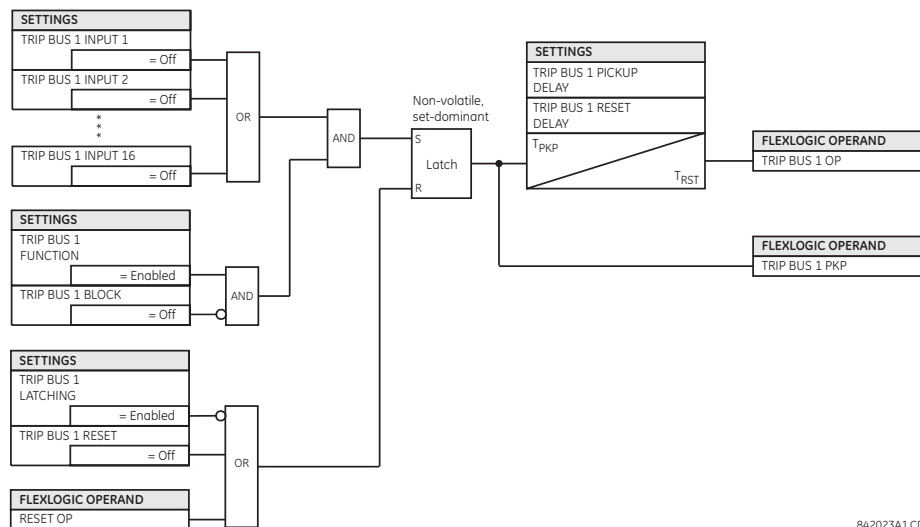
Reading from right to left in the following diagram, the **TRIP BUS 1 OP** and **TRIP BUS 1 PKP** FlexLogic operands on the right side are triggered when either the settings or reset latch in the middle of the diagram is triggered. When this applies, the **TRIP BUS 1 OP** operand is triggered after the delay set by the **TRIP BUS 1 PICKUP DELAY** or **TRIP BUS 1 RESET DELAY** setting, while the **TRIP BUS 1 PKP** operand initiates immediately. The settings or reset latch in the middle of the diagram is triggered as follows.

- For the reset, one of three conditions are required to meet the OR requirement shown at the bottom left. That is, the **TRIP BUS 1 LATCHING** setting must be 0=Disabled (which is negated by the NOT function to become 1=Enabled), output from the **TRIP BUS 1 RESET** FlexLogic operand must be 1, or output from the **RESET OP** FlexLogic operand must be 1.
- For the settings, one of 16 input conditions at the top left must be met for the OR, the **TRIP BUS 1 FUNCTION** must be Enabled, and the **TRIP BUS 1 BLOCK** output must output as 0, which is then negated/reversed by NOT to become 1.

Table 4-2: Logic diagram symbols

Symbol	Description
= Off	Output from FlexLogic operand, so user-defined
= Enabled	1 = Enabled and 0 = Disabled
OR	Any function input on the left side satisfies the condition
AND	All functions input on the left side are required to satisfy the condition
○	Not. Negates/reverses the output, for example 0 becomes 1.
●	Connection
S, R	Set, Reset
T _{PKP}	Timer pickup. Triggered by the settings latch in the diagram.
T _{RST}	Timer reset. Triggered by the reset latch in the diagram.

Figure 4-24: Logic diagram



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B90 Low Impedance Bus Differential System

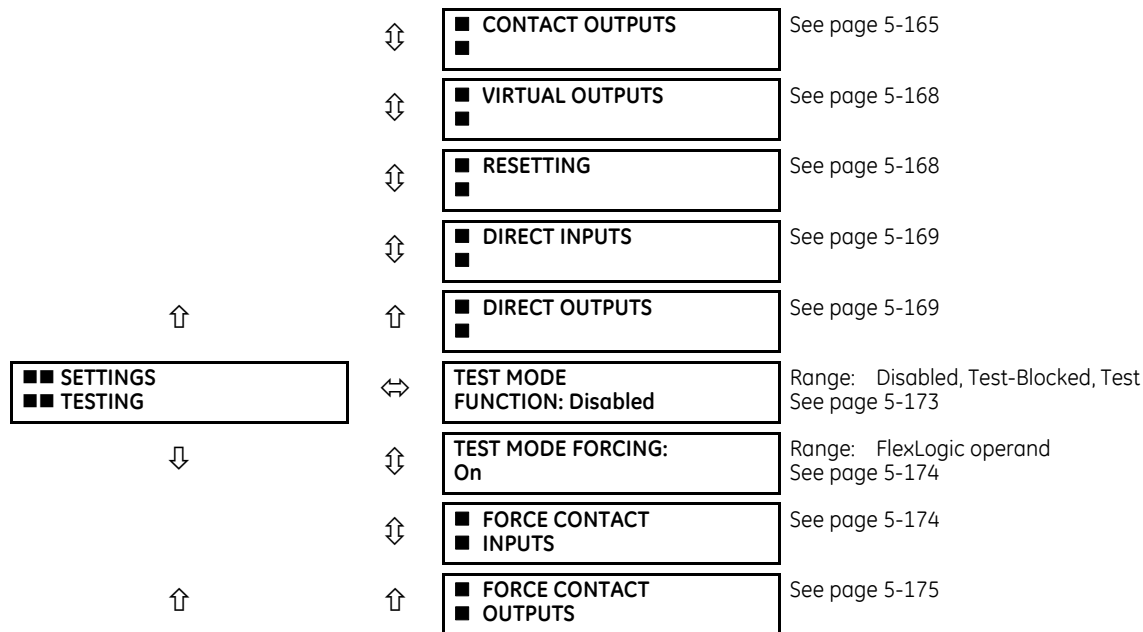
Chapter 5: Settings

This chapter outlines front panel and/or software settings. The relay is not taken out of service when saving settings; the relay is taken out of service when a settings file is written to it.

5.1 Settings menu

■ ■ SETTINGS ■ ■ PRODUCT SETUP	↔	■ B90 FUNCTION ■	See page 5-4
↓	↕	■ SECURITY ■	See page 5-5
	↕	■ DISPLAY ■ PROPERTIES	See page 5-22
	↕	■ CLEAR RELAY ■ RECORDS	See page 5-24
	↕	■ COMMUNICATIONS ■	See page 5-24
	↕	■ MODBUS USER MAP ■	See page 5-75
	↕	■ REAL TIME ■ CLOCK	See page 5-75
	↕	■ USER-PROGRAMMABLE ■ FAULT REPORT	See page 5-80
	↕	■ OSCILLOGRAPHY ■	See page 5-81
	↕	■ USER-PROGRAMMABLE ■ LEDS	See page 5-82
	↕	■ USER-PROGRAMMABLE ■ SELF TESTS	See page 5-86
	↕	■ CONTROL ■ PUSHBUTTONS	See page 5-86

	⇅	■ USER-PROGRAMMABLE ■ PUSHBUTTONS	See page 5-88
	⇅	■ FLEX STATE ■ PARAMETERS	See page 5-93
	⇅	■ USER-DEFINABLE ■ DISPLAYS	See page 5-94
	⇅	■ DIRECT I/O ■	See page 5-96
↑	↑	■ INSTALLATION ■	See page 5-103
■ ■ SETTINGS ■ ■ SYSTEM SETUP	↔	■ AC INPUTS ■	See page 5-103
↓	⇅	■ POWER SYSTEM ■	See page 5-104
	⇅	■ FLEXCURVES ■	See page 5-104
↑	↑	■ BUS ■	See page 5-111
■ ■ SETTINGS ■ ■ FLEXLOGIC	↔	■ FLEXLOGIC ■ EQUATION EDITOR	See page 5-126
↓	⇅	■ FLEXLOGIC ■ TIMERS	See page 5-126
↑	↑	■ NON-VOLATILE ■ LATCHES	See page 5-126
■ ■ SETTINGS ■ ■ GROUPED ELEMENTS	↔	■ SETTING GROUP 1 ■	See page 5-127
↓	⇅	■ SETTING GROUP 2 ■	
	⇅	■ SETTING GROUP 3 ■	
	⇅	■ SETTING GROUP 4 ■	
	⇅	■ SETTING GROUP 5 ■	
↑	↑	■ SETTING GROUP 6 ■	
■ ■ SETTINGS ■ ■ CONTROL ELEMENTS	↔	■ TRIP BUS ■	See page 5-151
↓	⇅	■ SETTING GROUPS ■	See page 5-153
	⇅	■ DIGITAL ELEMENTS ■	See page 5-154
↑	↑	■ MONITORING ■ ELEMENTS	See page 5-157
■ ■ SETTINGS ■ ■ INPUTS / OUTPUTS	↔	■ CONTACT INPUTS ■	See page 5-162
↓	⇅	■ VIRTUAL INPUTS ■	See page 5-164



5.2 Overview

5.2.1 Introduction to elements

For URs, 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 sets the output to logic 1, also referred to as *setting the flag*. A single comparator can make multiple tests and provide multiple outputs. For example, the time overcurrent comparator sets a pickup flag when the current input is above the setting and sets an operate flag when the input current has been at a level above the pickup setting for the time specified by the time-current curve settings. All comparators use analog actual values as the input.



An exception to this rule is digital elements, which use logic states as inputs.

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

The main characteristics of an element are shown on a logic diagram. This includes the inputs, settings, fixed logic, and the output operands generated. The previous chapter explains how to read a logic diagram, and the abbreviations used in a diagram are defined in the Abbreviations chapter.

Some settings are specified in per-unit (pu) calculated quantities:

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

Where the current source is from a single current transformer (CT), the *base quantity* is the nominal secondary or primary current of the CT. Use the secondary current base to convert per-unit settings to/from a secondary current value, and use the primary current base to convert to/from a primary current value.

For voltage elements, the primary base quantity is the nominal phase-to-phase primary voltage of the protected system provided that the VT ratio setting is set to the nominal ratio of the VTs and the secondary voltage setting is set to the phase-to-phase voltage seen by the relay when the voltage of the protected system is nominal. The UR uses the convention that nominal voltages in a three-phase system are phase-to-phase voltages.

For example, on a system with a 13.8 kV nominal primary voltage, the base quantity is 13800 V. With 14400:120 V delta-connected VTs, the secondary base quantity and secondary voltage setting is:

$$\frac{13800}{14400} \times 120 = 115 \text{ V}$$

Eq. 5-1

For wye-connected VTs, the primary and secondary base quantities are as before, but the secondary voltage setting (here a phase-to-ground value) is:

$$\frac{13800}{14400} \times \frac{120}{\sqrt{3}} = 66.4 \text{ V}$$

Eq. 5-2

Many settings are common to most elements, outlined as follows:

- **FUNCTION setting** — This setting programs the element to operate when selected as “Enabled.” The factory default is “Disabled.” Once “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.
- **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 can be provided to define the range of the measured parameters that cause the element to pick up.
- **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 remains 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 can happen when the element is in the operate state if the reset delay time is not zero.

Not every operand of a given element in a UR relay generates events, only the major output operands. Elements, asserting output per phase, log operating phase output only, without asserting the common three-phase operand event.

5.3 Product setup

5.3.1 B90 function

SETTINGS ⇄ PRODUCT SETUP ⇄ B90 FUNCTION

■ B90 FUNCTION

■

⇄

B90 FUNCTION:

Logic

Range: Protection, Logic

The setting acts as a B90 master switch enabling certain relay elements. All features dependent on AC inputs (such as system setup, bus differential, instantaneous overcurrent, time overcurrent, end fault protection, CT Trouble, AC metering, and undervoltage) become available if the **B90 FUNCTION** is set to "Protection." Features that are not dependent on AC signals (such as logic part of the Breaker Failure protection or Isolator Monitoring) become available if the **B90 FUNCTION** is set to "Logic."

Typically, three IEDs in the B90 system have hardware configured to support AC inputs (set **B90 FUNCTION** to "Protection"), while the fourth IED is configured to support all required input contacts and is intended for isolator monitoring and other logic functions (set **B90 FUNCTION** to "Logic").

The **B90 FUNCTION** setting allows the user to work with a single setting file, program all required functions (both protection and logic), download the same file to all the B90 IEDs, and modify the settings accordingly to finalize the application. This means that some modules, for example CT/VT module when set to "Logic," can become unusable. Communications and **B90 FUNCTION** settings are typically modified when downloading the common B90 setting file.

If hardware modules do not match the B90 order code, the minor self-test error "Discrepancy between order code and h/w" displays. The B90 remains in service, and features are available as per detected hardware. If, for example, the B90 order code assumes 24 feeder configuration, but there are two DSP modules with 16 CT inputs, the B90 configuration allows 16 current terminals in the **SETTINGS** ⇒ **SYSTEM SETUP** ⇒ **AC INPUTS** ⇒ **CURRENT TERMINAL F1(S8)** menu.

5.3.2 Security

5.3.2.1 Security overview

The following security features are available:

- Password security — Basic security present by default
- EnerVista security — Role-based access to various EnerVista software screens and configuration elements. The feature is present by default in the EnerVista software.
- CyberSentry security — Advanced security available as a software option. When purchased, the options are automatically enabled, and the default Password security and EnerVista security are disabled.

Lost password

If all passwords are lost, recovery is possible by resetting the unit to default values. Note that the relay is reset to default values, not just the passwords.

To reset the unit after a lost password:

1. Email GE customer service at multilin.tech@ge.com with the serial number and using a recognizable corporate email account. Customer service provides a code to reset the relay to the factory defaults.
2. Enter the reset code on the front panel, under **COMMANDS** ⇒ **RELAY MAINTENANCE** ⇒ **SERVICE COMMAND**.
3. Change the default password of ChangeMe1# as outlined in the Set Up CyberSentry and Change Default Password section at the end of the Installation chapter.

Password requirements

A user account requires an alpha-numeric password that meets the following requirements:

- Password is case-sensitive
- Password cannot contain the user account name or parts of the user account that exceed two consecutive characters
- Password must be 6 to 20 characters in length
- Password must contain characters from three of the following four categories:
 - English uppercase characters (A through Z)
 - English lowercase characters (a through z)
 - Base 10 digits (0 through 9)
 - Non-alphabetic characters (for example, ~, !, @, #, \$, %, &)

5.3.2.2 Password security

SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY

■ SECURITY	↔	ACCESS LEVEL: Restricted	Range: Restricted, Command, Setting, Factory Service (for factory use only)
	↕	■ CHANGE LOCAL ■ PASSWORDS	See page 5-7
	↕	■ CHANGE REMOTE ■ PASSWORDS	See page 5-7
	↕	■ AC CESS ■ SUPERVISION	See page 5-8
	↕	■ DUAL PERMISSION ■ SECURITY ACCESS	See page 5-9
	↑	PASSWORD ACCESS: EVENTS: Disabled	Range: Disabled, Enabled

The B90 supports password entry from a local or remote connection.

Local access is defined as access to settings or commands via the faceplate. This includes both keypad entry and the RS232 port. Remote access is defined as access to settings or commands via any rear communications port. This includes both Ethernet and RS485 connections. Any change to the local or remote password enables this functionality.

5



For a relay without a CyberSentry software option, any user can activate the **RESET** button without password entry.

ACCESS LEVEL — The "Restricted" option means that settings and commands can be accessed, but there is no access to factory configuration. Access automatically reverts to the Restricted level according to the access level timeout setting values. The access level is set to Restricted when control power is cycled.

The "Factory Service" level is not available and intended for factory use only.

There are two user security access levels, setting and command, for which you can set a password for each. Use of a password for each level controls whether users can enter commands or change settings. Another option is to specify setting and/or command access for individual user accounts.

- **Setting** — Allows the user to make any changes to any of the setting values:
 - Changing any setting
 - Test mode operation
- **Command** — Restricts the user from making any settings changes, but allows the user to perform the following operations:
 - Changing the state of virtual inputs
 - Clearing the event records
 - Clearing the oscillography records
 - Changing the date and time
 - Clearing the data logger
 - Clearing the user-programmable pushbutton states

When entering a settings or command password via EnerVista or any serial interface, the user must enter the corresponding connection password. If the connection is to the back of the B90, the remote password must be used. If the connection is to the RS232 port of the faceplate, the local password must be used.

The local setting and command sessions are initiated by the user through the front panel display and are disabled either by the user or by timeout (via the setting and command level access timeout settings). The remote setting and command sessions are initiated by the user through the EnerVista software and are disabled either by the user or by timeout.

The state of the session (local or remote, setting or command) determines the state of the following FlexLogic operands:

- **ACCESS LOC SETG OFF** — Asserted when local setting access is disabled
- **ACCESS LOC SETG ON** — Asserted when local setting access is enabled
- **ACCESS LOC CMND OFF** — Asserted when local command access is disabled
- **ACCESS LOC CMND ON** — Asserted when local command access is enabled
- **ACCESS REM SETG OFF** — Asserted when remote setting access is disabled
- **ACCESS REM SETG ON** — Asserted when remote setting access is enabled
- **ACCESS REM CMND OFF** — Asserted when remote command access is disabled
- **ACCESS REM CMND ON** — Asserted when remote command access is enabled

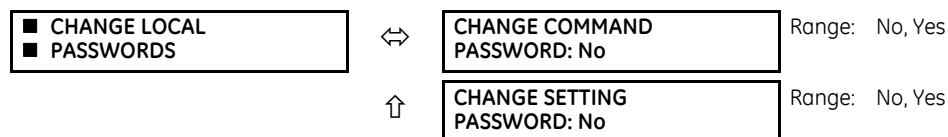


A command or setting write operation is required to update the state of the remote and local security operands listed.

PASSWORD ACCESS EVENTS — This setting allows recording of password access events in the event recorder.

Change local passwords

SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY ⇒ CHANGE LOCAL PASSWORDS



As outlined in the previous section, there are two user security access levels, setting and command. Use of a password for each level controls whether users can enter commands or change settings.

Proper password codes are required to enable each access level. When a **CHANGE COMMAND PASSWORD** or **CHANGE SETTING PASSWORD** setting is programmed to “Yes” via the front panel interface, the following message sequence is invoked:

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

To gain write access to a “Restricted” setting, program the **ACCESS LEVEL** setting in the main security menu to “Setting” and then change the setting, or attempt to change the setting and follow the prompt to enter the programmed password. If the password is correctly entered, access is allowed. Access automatically reverts to the “Restricted” level according to the access level timeout setting values and when power is cycled.



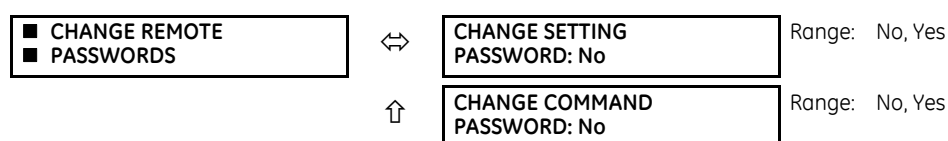
If the setting and command passwords are identical, then this one password allows access to both commands and settings.

If a remote connection is established, local passcodes are not visible.

Change remote passwords

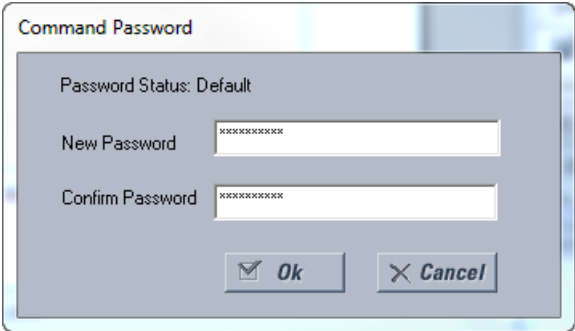
Proper passwords are required to enable each command or setting level access, which are explained in the previous section.

SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY ⇒ CHANGE REMOTE PASSWORDS



To set the command or setting password:

1. In the EnerVista software or from the front panel, navigate to **Settings > Product Setup > Security** menu item to open the remote password settings window.
2. Click the command or setting password **Change** button.
3. Enter the new password in the **New Password** field. Requirements are outlined in the Password Requirements section earlier in this chapter. When an original password has already been used, enter it in the **Enter Password** field and click the **Send Password to Device** button.
4. Re-enter the password in the **Confirm Password** field.
5. Click the **OK** button. The password is checked to ensure that it meets requirements.



If you establish a local (serial) connection to the relay, you cannot view remote passcodes.

Access supervision

SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY ⇒ ACCESS SUPERVISION

■ ACCESS ■ SUPERVISION	↔	■ ACCESS LEVEL ■ TIMEOUTS	See below
	⇅	INVALID ATTEMPTS BEFORE LOCKOUT: 3	Range: 2 to 5 in steps of 1
	↑	PASSWORD LOCKOUT DURATION: 5 min	Range: 5 to 60 minutes in steps of 1

This menu displays when the **ACCESS LEVEL** setting is other than Restricted or Command.

The following access supervision settings are available.

INVALID ATTEMPTS BEFORE LOCKOUT — This setting specifies the number of times that an incorrect password can be entered within a three-minute time span before lockout occurs. When lockout occurs, the [LOCAL ACCESS DENIED](#) or [REMOTE ACCESS DENIED](#) FlexLogic operands are set to “On.” These operands are returned to the “Off” state upon expiration of the lockout.

PASSWORD LOCKOUT DURATION — This setting specifies the time that the B90 locks out password access after the number of invalid password entries specified by the **INVALID ATTEMPTS BEFORE LOCKOUT** setting has occurred.

The B90 provides a means to raise an alarm upon failed password entry. If password verification fails while accessing a password-protected level of the relay (either settings or commands), the [UNAUTHORIZED ACCESS](#) FlexLogic operand is asserted. The operand can be programmed to raise an alarm via contact outputs or communications. This feature can be used to protect against both unauthorized and accidental access attempts.

The [UNAUTHORIZED ACCESS](#) operand is reset with the **COMMANDS ⇒ CLEAR RECORDS ⇒ RESET UNAUTHORIZED ALARMS** command. Therefore, to apply this feature with security, password-protect the Command level. The operand does not generate events or targets.

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

The following table outlines access level timeout settings.

SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY ⇒ ACCESS SUPERVISION ⇒ ACCESS LEVEL TIMEOUTS

■ ACCESS LEVEL ■ TIMEOUTS	↔	COMMAND LEVEL ACCESS TIMEOUT: 5 min	Range: 5 to 480 minutes in steps of 1
	↑	SETTING LEVEL ACCESS TIMEOUT: 30 min	Range: 5 to 480 minutes in steps of 1

These settings allow the user to specify the length of inactivity required before returning to the Restricted access level. Note that the access level is set to Restricted when control power is cycled.

COMMAND LEVEL ACCESS TIMEOUT — This setting specifies the length of inactivity (no local or remote access) required to return to Restricted access from the Command password level.

SETTING LEVEL ACCESS TIMEOUT — This setting specifies the length of inactivity (no local or remote access) required to return to Restricted access from the Settings password level.

Dual-permission security access

SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY ⇒ DUAL PERMISSION SECURITY ACCESS

■ DUAL PERMISSION ■ SECURITY ACCESS	↔	LOCAL SETTING AUTH: On	Range: selected FlexLogic operands (see below)
	↕	REMOTE SETTING AUTH: On	Range: FlexLogic operand
	↑	ACCESS AUTH TIMEOUT: 30 min	Range: 5 to 480 minutes in steps of 1

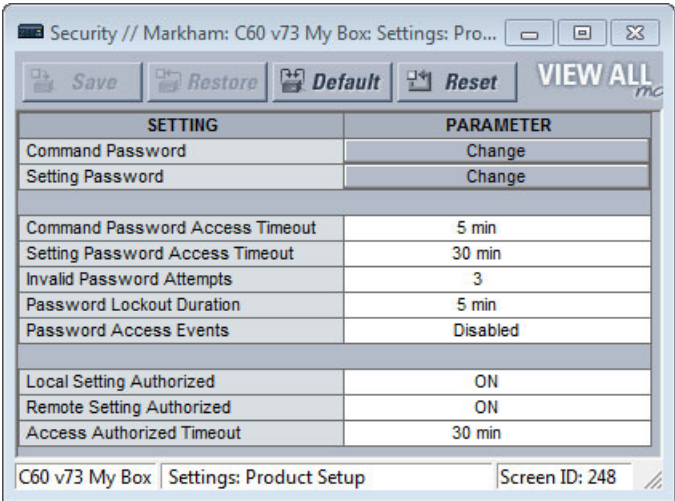
This menu displays when the **ACCESS LEVEL** setting is other than Restricted or Command.

This feature provides a mechanism to prevent unauthorized or unintended upload of settings to a relay through the local or remote interface.

The following settings are available through the local (front panel) interface only.

- LOCAL SETTING AUTH** — This setting is used for local (front panel or RS232 interface) setting access supervision. Valid values for the FlexLogic operands are either "On" (default) or any physical "Contact Input ~~ On" value.
 If this setting is "On," then local setting access functions as normal; that is, a local setting password is required. If this setting is any contact input on FlexLogic operand, then the operand must be asserted (on) prior to providing the local setting password to gain setting access.
 If setting access is *not* authorized for local operation (front panel or RS232 interface) and the user attempts to obtain setting access, then the UNAUTHORIZED ACCESS message displays on the front panel.
 If this setting is "Off," firmware upgrades are blocked. If this setting is "On," firmware upgrades are allowed.
- REMOTE SETTING AUTH** — This setting is used for remote (Ethernet or RS485 interface) setting access supervision.
 If this setting is "On" (the default setting), then remote setting access functions as normal; that is, a remote password is required. If this setting is "Off," then remote setting access is blocked even if the correct remote setting password is provided. If this setting is any other FlexLogic operand, then the operand must be asserted (set as on) prior to providing the remote setting password to gain setting access.
 If this setting is "Off," firmware upgrades are blocked. If this setting is "On," firmware upgrades are allowed.
- ACCESS AUTH TIMEOUT** — This setting represents the timeout delay for local setting access. This setting is applicable when the **LOCAL SETTING AUTH** setting is programmed to any operand except "On." The state of the FlexLogic operand is monitored continuously for an off-to-on transition. When this occurs, local access is permitted and the timer programmed with the **ACCESS AUTH TIMEOUT** setting value is started. When this timer expires, local setting access is immediately denied. If access is permitted and an off-to-on transition of the FlexLogic operand is detected, the timeout is restarted. The status of this timer updates every five seconds.

The following settings are available through the remote (EnerVista UR Setup) interface only. Select the **Settings > Product Setup > Security** menu item to display the security settings window.



The **Remote Settings Authorized** setting is used for remote (Ethernet or RS485 interface) setting access supervision. If this setting is “On” (the default setting), then remote setting access functions as normal; that is, a remote password is required. If this setting is “Off,” then remote setting access is blocked even if the correct remote setting password is provided. If this setting is any other FlexLogic operand, then the operand must be asserted (on) prior to providing the remote setting password to gain setting access.

The **Access Authorized Timeout** setting represents the timeout delay remote setting access. It applies when the **Remote Settings Authorized** setting is programmed to any operand except “On” or “Off.” The state of the FlexLogic operand is continuously monitored for an off-to-on transition. When this occurs, remote setting access is permitted, and the timer programmed with the **Access Authorized Timeout** setting value is started. When this timer expires, remote setting access is denied immediately. If access is permitted and an off-to-on transition of the FlexLogic operand is detected, the timeout is restarted. The status of this timer updates every five seconds.

5.3.2.3 EnerVista security

Enable the security management system

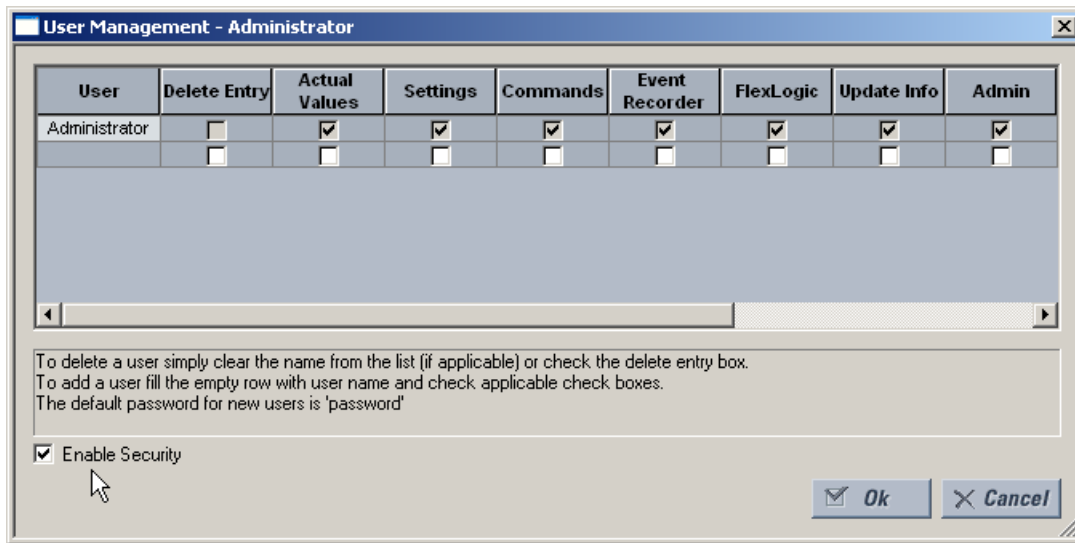
Access to files is controlled by the operating system and EnerVista software as follows:

- Access privileges to files are defined by the Windows operating system. A standard user does not have access to a file created by an administrator or another user.
- When the EnerVista UR Setup software security system is disabled (passwords are not required), all users have administrator access

The EnerVista security system allows an administrator to manage access privileges of multiple users of EnerVista. It is disabled by default to allow access to the device immediately after installation. When security is disabled, all users have administrator access. GE recommends enabling the EnerVista security before placing the device in service.

To enable the security system and require password use:

1. Select the **Security > User Management** menu to open the user management window.



2. Enable the **Enable Security** check box in the lower-left corner to enable the security management system.
3. Click the **Ok** button.



If you force password entry by using this feature, ensure that you know the Administrator password. If you do not know the password and are locked out of the software, contact GE Grid Solutions for the default password of a UR device. When using CyberSentry, the default password is "ChangeMe1#".

Security is now enabled for the EnerVista UR Setup software. Upon starting the software, users are now required to enter a username and password.

Add a new user

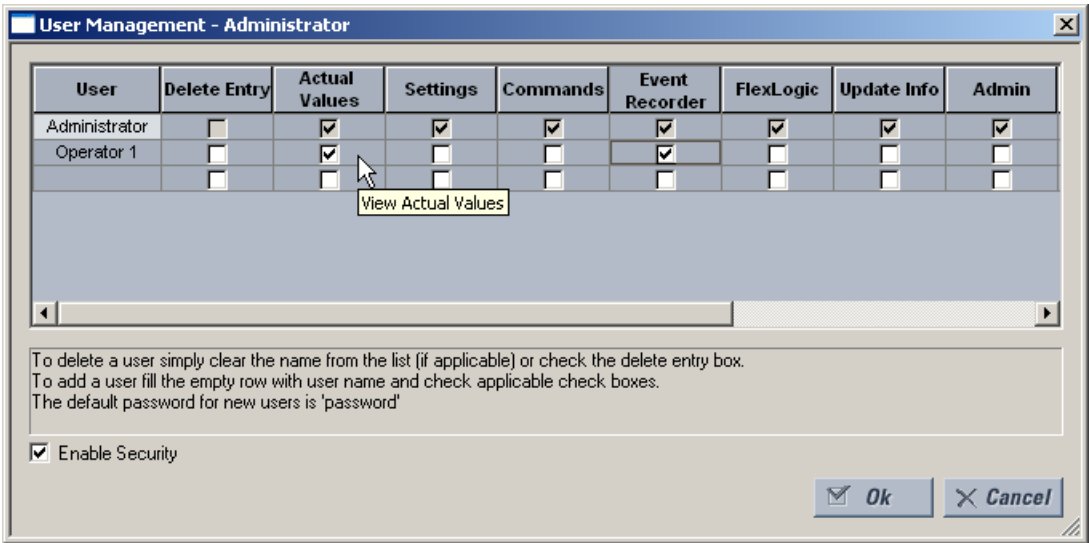
The following pre-requisites are required to add user accounts to the EnerVista security management system:

- The user adding the account must have administrator rights
- The EnerVista security management system must be enabled (previous section)

To add a user account:

1. Select the **Security > User Management** item from the top menu to open the user management window.
2. Enter a username in the **User** field. The username must be four to 20 characters in length.

3. Select the user access rights by enabling the check box of one or more fields.



The table outlines access rights.

Table 5-1: Access rights summary

Field	Description
Delete Entry	Deletes the user account when exiting the user management window
Actual Values	Allows the user to read Actual Values
Settings	Allows the user to read Settings values
Commands	Allows the user to execute Commands
Event Recorder	Allows the user to use the Event Recorder
FlexLogic	Allows the user to read FlexLogic values
Update Info	Allows the user to write to any function to which they have read privileges. When any of the Settings , Event Recorder , and FlexLogic check boxes are enabled by themselves, the user is granted read access. When any of them are enabled in conjunction with the Update Info box, they are granted read and write access. The user is not granted write access to functions that are not enabled, even if the Update Info field is enabled.
Admin	When the check box is enabled, the user becomes an EnerVista UR Setup administrator and has all administrative rights. Exercise caution when granting administrator rights.

4. Click **OK** to add the user account to the system.

Modify user privileges

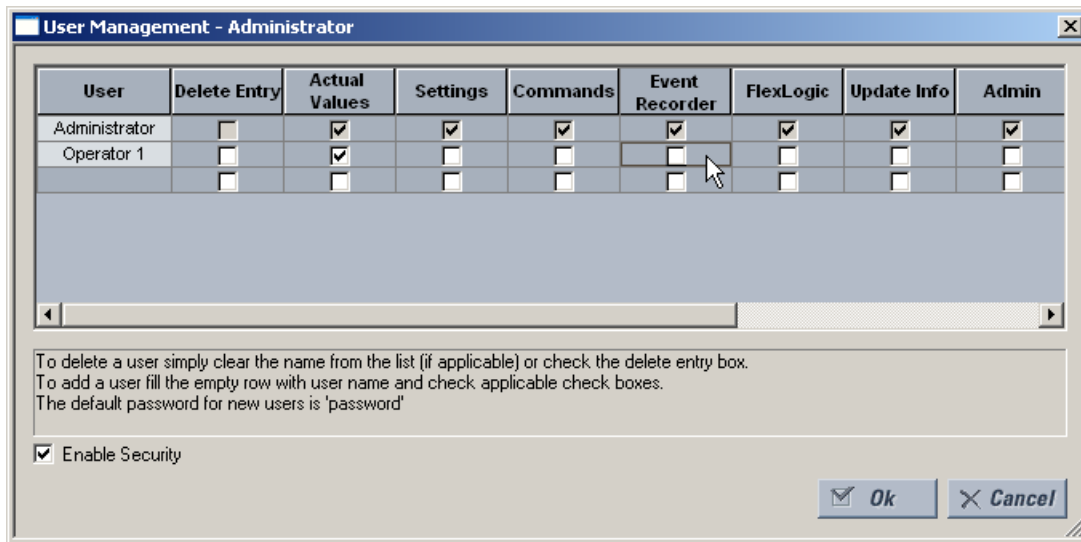
The following pre-requisites are required to modify user privileges in the EnerVista security management system:

- The user modifying the privileges must have administrator rights
- The EnerVista security management system must be enabled (the **Enable Security** check box enabled)

To modify user privileges:

1. Select the **Security > User Management** item from the top menu to open the user management window.
2. Locate the username in the **User** field.

3. Modify the user access rights by enabling or disabling one or more of the check boxes.



The table outlines access rights.

Table 5-2: Access rights summary

Field	Description
Delete Entry	Deletes the user account when exiting the user management window
Actual Values	Allows the user to read actual values
Settings	Allows the user to read setting values
Commands	Allows the user to execute commands
Event Recorder	Allows the user to use the digital fault recorder
FlexLogic	Allows the user to read FlexLogic values
Update Info	Allows the user to write to any function to which they have read privileges. When any of the Settings , Event Recorder , and FlexLogic check boxes are enabled by themselves, the user is granted read access. When any of them are enabled in conjunction with the Update Info box, they are granted read and write access. The user is not granted write access to functions that are not enabled, even if the Update Info field is enabled.
Admin	When this check box is enabled, the user becomes an EnerVista UR Setup administrator and has all administrative rights. Exercise caution when granting administrator rights.

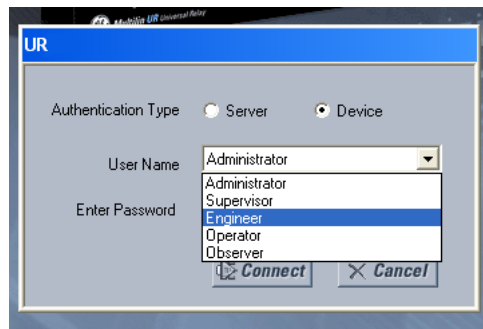
4. Click **OK** to save the changes.

5.3.2.4 CyberSentry security

The EnerVista software provides the means to configure and authenticate the B90 access using either a server or the device. Access to functions depends on user role.

The login screen of EnerVista has two options for access to the B90, these being Server and Device authentication.

Figure 5-1: Login screen for CyberSentry



When the "Server" **Authentication Type** is selected, the B90 uses the RADIUS server and not its local authentication database to authenticate the user.

When the "Device" button is selected, the B90 uses its local authentication database and not the RADIUS server to authenticate the user. In this case, it uses built-in roles (Administrator, Engineer, Supervisor, Operator, Observer, or Administrator and Supervisor when Device Authentication is disabled), as login accounts and the associated passwords are stored on the B90 device. In this case, access is not user-attributable. In cases where user-attributable access is required, especially for auditable processes for compliance reasons, use server authentication (RADIUS) only.

No password or security information is displayed in plain text by the EnerVista software or the UR device, nor are they ever transmitted without cryptographic protection.

5



Only (TCP/UDP) ports and services that are needed for device configuration and for customer enabled features are open. All the other ports are closed. For example, Modbus is on by default, so its TCP port 502, is open. But if Modbus is disabled, port 502 is closed. This function has been tested and no unused ports have been found open.

When CyberSentry is enabled, Modbus communications over Ethernet is encrypted, which is not always tolerated by SCADA systems. The UR has a bypass access feature for such situations, which allows unencrypted Modbus over Ethernet. The **Bypass Access** setting is available on the **SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY ⇒ SUPERVISORY** screen. Note that other protocols (DNP, 101, 103, 104, EGD) are not encrypted, and they are good communications options for SCADA systems when CyberSentry is enabled.

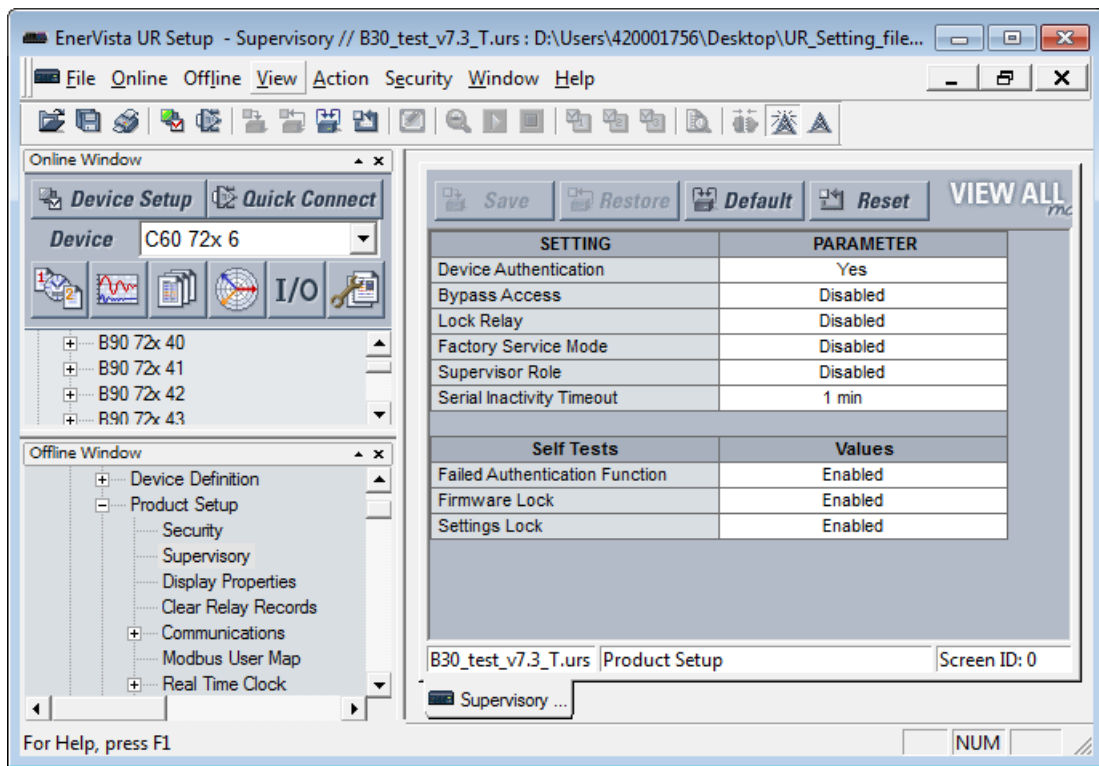
When using the rear RS485 port and CyberSentry, registers can be read with a maximum buffer of 64 bytes. Settings may or may not be written, so use another port or configure the **SERIAL INACTIVITY TIMEOUT** setting to a high value, such as eight minutes, to give the relay enough time to finish the task.

CyberSentry settings through EnerVista

CyberSentry security settings are configured under **Device > Settings > Product Setup > Security**.

For the **Device > Settings > Product Setup > Supervisory** option, the panel looks like the following.

Figure 5-2: Supervisory panel



For the Security panel, the following settings are available.

Table 5-3: RADIUS server settings

Setting name	Description	Minimum	Maximum	Default	Units	Minimum permission
Primary RADIUS IP Address	IP address of the main RADIUS server. Default value indicates no Primary RADIUS server is configured, and hence RADIUS is disabled. Restart the relay for any change to take effect.	0.0.0.0	223.255.255.254	0.0.0.0	-	Administrator
Primary Authentication Port	RADIUS authentication port	1	65535	1812	-	Administrator
Primary Accounting Port	RADIUS accounting port	1	65535	1813	-	Administrator
Vendor ID	An identifier that specifies RADIUS vendor-specific attributes used with the protocol			Value that represents General Electric		Administrator
RADIUS Authentication (Shared) Secret	Shared secret used in authentication. It displays as asterisks. This setting must meet the CyberSentry password requirements.	See the Password Requirements section earlier in this chapter	See the following password section for requirements	N/A	-	Administrator
RADIUS Authentication Method	Authentication method used by RADIUS server. Currently fixed to EAP-TTLS.	EAP-TTLS	EAP-TTLS	EAP-TTLS	-	Administrator
Confirm RADIUS Authentication (Shared) Secret	Confirmation of the shared secret. The entry displays as asterisks.	See the Password Requirements section	245 characters	N/A	-	Administrator

Table 5-4: General security settings

Setting name	Description	Minimum	Maximum	Default	Units	Minimum permission
Session Lockout	Number of failed authentications before the device blocks subsequent authentication attempts for the lockout period	0 (lockout disabled)	99	3	-	Administrator
Session Lockout Period	The period in minutes that a user is prevented from logging in after being locked out	0 (no period)	9999	3	min	Administrator
Syslog Server IP Address	The IP address of the target Syslog server to which all security events are transmitted	0.0.0.0	223.255.255.254	0.0.0.0	-	Administrator
Syslog Server Port Number	The UDP port number of the target syslog server to which all security events are transmitted	1	65535	514	-	Administrator
Device Authentication	When enabled, local Device authentication with roles is allowed. When disabled, the UR only authenticates to the AAA server (RADIUS). NOTE: Administrator and Supervisor (if still enabled) remain active even after Device authentication is disabled. The only permission for local Administrator is to re-enable Device authentication when Device authentication is disabled. To re-enable Device authentication, the Supervisor unlocks the device for setting changes, and then the Administrator can re-enable Device authentication.	Disabled	Enabled	Enabled	-	Administrator
Firmware Lock (via Lock Relay)	Indicates if the device receives firmware upgrades. If Enabled and the firmware upgrade attempt is made, the device denies the upgrade and displays an error message that the lock is set. On each firmware upgrade, this setting goes back to the default. The Lock Relay setting blocks settings and firmware updates.	Disabled	Enabled	Enabled	-	Administrator
Factory Service Mode	When enabled, the device can go into factory service mode. To enable, Supervisor authentication is necessary.	Disabled	Enabled	Disabled	-	Supervisor (Administrator when Supervisor is disabled)
Restore to Defaults	Sets the device to factory defaults	No	Yes	No	-	Administrator
Supervisor Role	When enabled, the Supervisor role is active. To enable, Administrator authentication is necessary. When disabled, the Supervisor role is inactive. To disable, Supervisor authentication is necessary.	Disabled	Enabled	Enabled	-	Administrator to enable and Supervisor to disable
RADIUS user names	Ensures that RADIUS user names are not the same as local/device role names	See RADIUS server documents	See RADIUS server documents		-	Administrator
Password	Local/device roles except for Observer are password-protected. All RADIUS users are password-protected.	See the Password Requirements section earlier in this chapter	See the following password section for requirements	Change Me1#	Text	The specified role and Administrator, except for Supervisor, where it is only itself

Table 5-5: Security alarm settings

Setting name	Description / Details	Min	Max	Default	Units	Minimum permissions
Failed Authentications	A threshold number indicating when an alarm is set off to indicate too many failed authentication attempts	Disabled	Enabled	Enabled	-	Administrator

Setting name	Description / Details	Min	Max	Default	Units	Minimum permissions
Firmware Lock	A value indicating if the device can receive a firmware upgrade. If Enabled and a firmware upgrade attempt is made, the device alarm activates. If Disabled, the device alarm does not activate. On each firmware upgrade this setting goes back to the default.	Disabled	Enabled	Enabled	-	Administrator
Settings Lock	A value indicating if the device can accept any settings changes. If Enabled and a settings change attempt is made, the device alarm activates. If Disabled, the device alarm does not activate.	Disabled	Enabled	Enabled	-	Supervisor (Administrator if Supervisor has been disabled)

CyberSentry settings through the front panel

SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY

■ SECURITY	↔	LOGIN: None	Range: Administrator, Engineer, Supervisor, Operator, Factory (for factory use only), None
	↕	■ CHANGE DEVICE ■ PASSWORD	See page 5-18
	↕	■ SESSION ■ SETTINGS	See page 5-18
	↕	■ RESTORE DEFAULTS ■	See page 5-18
	↕	■ SUPERVISORY ■	See page 5-19
	↕	SYSLOG IP ADDRESS: 0.0.0.0	Range: 0.0.0.0, 255.255.255.255
	↑	SYSLOG PORT NUMBER: 514	Range: 1 to 65535

LOGIN — This setting is applicable for Device authentication only. This setting allows a user to log in with a specific role, as outlined here. For the Supervisor role, enable the “Supervisor Role” setting.

Whenever a new role is logged in, the user is prompted to enter a password. Passwords must obey the requirements specified earlier in the chapter in the Password Requirements section. The UR device supports five roles. Roles have their corresponding passwords, except the Observer role, which does not require a password. There are no time-outs for the Administrator, Engineer, Operator, and Supervisor when logged in using the front panel; log out manually or use the **Command > Security** commands in the software.

The roles are defined as follows:

- **Administrator** — Complete read/write access to all settings and commands. This role does not allow concurrent access. This role has an operand to indicate when it is logged on.
- **Engineer** — Complete read/write access to all settings and commands except configuring Security settings and firmware upgrades. This role does not allow concurrent access.
- **Operator** — The Operator has read/write access to all settings under the Commands menu/section. This role does not exist offline.
- **Supervisor** — This is only an approving role. This role’s authentication commits setting changes submitted by Administrator or Engineer. The Supervisor role authenticates to unlock the UR relay for setting changes and not approve changes after the fact. Only a Supervisor can set the Settings Lock and Firmware Lock in the Security settings. This role also has the ability to forcefully log off any other role and clear the security event log. This role can also be disabled, but only through a Supervisor authentication. When this role is disabled its permissions are assigned to the Administrator role.
- **Observer** — This role has read-only access to all B90 settings. This role allows concurrent access but it has no download access to any files on the device. Observer is the default role if no authentication has been done to the

device. This role displays as "None" on the front panel. When local authentication is used, no password is required for this role. When RADIUS server authentication is used, a password is required.



The Factory service role is not available. It is for factory use only.

Change device password

SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY ⇒ CHANGE DEVICE PASSWORD

CHANGE DEVICE
PASSWORD

↔

NEW PASSWORD:

Range: 20 alphanumeric characters

↑

CONFIRM PASSWORD:

Range: 20 alphanumeric characters

The menu displays on the front panel and in EnerVista upon successful login of the Administrator role.
Passwords are stored in text format. No encryption is applied.



In Device authentication mode, the Observer role does not have a password associated with it. In Server authentication mode the Observer role requires a password.
If you are locked out of the software, contact GE Grid Solutions for the default password. When using CyberSentry, the default password is "ChangeMe1#".
Once the passwords are set, the Administrator with Supervisor approval can change the role-associated password.
In CyberSentry, password encryption is not supported.

Session settings

SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY ⇒ SESSION SETTINGS

SESSION
SETTINGS

↔

SESSION LOCKOUT:
3

Range: 0 to 99

↑

SESSION LOCKOUT
PERIOD: 3 min

Range: 0 to 9999 minutes

SESSION LOCKOUT — This setting specifies the number of failed authentications before the device blocks subsequent authentication attempts for the lockout period. A value of zero means lockout is disabled.
SESSION LOCKOUT PERIOD — This setting specifies the period of time in minutes of a lockout period. A value of 0 means that there is no lockout period.

Restore defaults

SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY ⇒ RESTORE DEFAULTS

RESTORE DEFAULTS

↔

LOAD FACTORY
DEFAULTS: No

Range: Yes, No

LOAD FACTORY DEFAULTS — This setting is used to reset all the settings, communication, and security passwords. An Administrator role is used to change this setting and a Supervisor role (if not disabled) approves it.

Supervisory

SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY ⇒ ↓ SUPERVISORY

■ SUPERVISORY ■	⇔	DEVICE AUTHENTICATION: Yes	Range: Yes, No
	⇕	BYPASS ACCESS: Disabled	Range: Local, Remote, Local and Remote, Disabled
	⇕	LOCK RELAY: Disabled	Range: Enabled, Disabled
	⇕	FACTORY SERVICE MODE: Disabled	Range: Enabled, Disabled
	⇕	■ SELF TESTS	See below
	⇕	SUPERVISOR ROLE: Disabled	Range: Enabled, Disabled
	↑	SERIAL INACTIVITY TIMEOUT: 1 min	Range: 1 to 9999 minutes

The Supervisory menu settings are available for Supervisor role only, or if the Supervisor role is disabled then for the Administrator role only.

DEVICE AUTHENTICATION — This setting is enabled by default, meaning "Yes" is selected. When enabled, Device authentication with roles is enabled. When this setting is disabled, the UR only authenticates to the AAA server (RADIUS). However, the Administrator and Supervisor (when enabled) remain active even after device authentication is disabled and their only permission is to re-enable Device authentication. To re-enable Device authentication, the Supervisor unlocks the device for settings changes, then the Administrator re-enables device authentication.

BYPASS ACCESS — The bypass security feature provides an easier access, with no authentication and encryption for those special situations when this is considered safe. Only the Supervisor, or the Administrator when the Supervisor role is disabled, can enable this feature.

Mode	Front panel or serial (RS232, RS485)	Ethernet
Normal mode	Authentication — Role Based Access Control (RBAC) and passwords in clear	Authentication — RBAC and passwords encrypted SSH tunneling
Bypass access mode	No passwords for allowed RBAC levels	No passwords for allowed RBAC levels No SSH tunneling

The bypass options are as follows:

- Local — Bypasses authentication for push buttons, keypad, and RS232
- Remote — Bypasses authentication for RS485 and Ethernet
- Local and Remote — Bypasses authentication for push buttons, keypad, RS232, RS485, and Ethernet

LOCK RELAY — This setting uses a Boolean value (Enabled/Disabled) to indicate if the device accepts settings changes and whether the device can receive a firmware upgrade. This setting can be changed by the Supervisor role, if it is enabled, or by the Administrator if the Supervisor role is disabled. The Supervisor role disables this setting for the relay to start accepting settings changes, command changes, or firmware upgrade. After all the setting changes are applied or commands executed, the Supervisor enables to lock settings changes.

Example: If this setting is enabled and an attempt is made to change settings or upgrade the firmware, the UR device denies the settings changes or denies upgrading the firmware. If this setting is disabled, the UR device accepts settings changes and firmware upgrade.

This role is disabled by default.

FACTORY SERVICE MODE — When Enabled, the device can go into factory service mode. For this setting to become enabled a Supervisor authentication is necessary. The default value is Disabled.

SUPERVISOR ROLE — When Enabled, the Supervisor role is active. To Disable this setting a Supervisor authentication is necessary. If disabled, the Supervisor role is not allowed to log in. In this case, the Administrator can change the settings under the Supervisory menu.

If enabled, Supervisor authentication is required to change the settings in the Supervisory menu. If the Supervisor disables their role after authentication, the Supervisor session remains valid until they switch to another role using MMI or until they end the current Supervisor session if using communications.

This role is disabled by default.

SERIAL INACTIVITY TIMEOUT — The role logged via a serial port is auto logged off after the Serial Inactivity timer times out. A separate timer is maintained for RS232 and RS485 connections. Set this value to a high number, such as eight minutes, when using the rear RS485 terminals for settings write.

Self-tests

SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY ⇒ ⬇ SUPERVISORY ⇒ SELF TESTS

■ SELF TESTS

⇔

■ FAILED
■ AUTHENTICATE

See below

⇕

FIRMWARE LOCK:
Enabled

Range: Enabled, Disabled

⬆

SETTINGS LOCK:
Enabled

Range: Enabled, Disabled

FAILED AUTHENTICATE — When Enabled, the number of failed authentications is compared with the Session Lockout threshold. When the Session Lockout threshold is exceeded, a minor alarm indication comes up. Operand is [AUTHENTICATION FAIL](#).

FIRMWARE LOCK — When Enabled, any firmware upgrade attempt brings up a minor self-test alarm. Operand is [UNAUTH FW ATTEMPT](#).

SETTINGS LOCK — When Enabled, an unauthorized write attempt to a setting for a given role activates a minor self test alarm. Operand is [UNAUTH SETTING WRITE](#).

SETTINGS ⇒ PRODUCT SETUP ⇒ SECURITY ⇒ ⬇ SUPERVISORY ⇒ SELF TESTS ⇒ FAILED AUTHENTICATE

■ FAILED
■ AUTHENTICATE

⇔

FAILED AUTHENTICATE:
Enabled

Range: Enabled, Disabled

CyberSentry setup

When first using CyberSentry security, use the following procedure for setup.

1. Log in to the relay as Administrator by using the **VALUE** keys on the front panel to enter the default password "ChangeMe1#". Note that the Lock Relay setting needs to be disabled in the **Security > Supervisory** menu. When this setting is disabled, configuration and firmware upgrade are possible. By default, this setting is disabled.
2. Enable the Supervisor role if you have a need for it.
3. Make any required changes in configuration, such as setting a valid IP address for communication over Ethernet.
4. Log out of the Administrator account by choosing None.
5. Next, Device or Server authentication can be chosen on the login screen, but the choice is available only in EnerVista. Use Device authentication to log in using the five pre-configured roles (Administrator, Supervisor, Engineer, Operator, Observer). When using a serial connection, only Device authentication is supported. When Server authentication is required, characteristics for communication with a RADIUS server must be configured. This is possible only in the EnerVista software. The RADIUS server itself also must be configured. The appendix called RADIUS Server at the end of this instruction manual gives an example of how to set up a simple RADIUS server. Once both the RADIUS server and the parameters for connecting the UR to the server have been configured, you can choose Server authentication on the login screen of EnerVista.

NOTICE

The use of CyberSentry for devices communicating through an Ethernet-to-RS485 gateway is not supported. Because these gateways do not support the secure protocols necessary to communicate with such devices, the connection cannot be established. Use the device as a non-CyberSentry device.

Users logged in through the front panel are not timed out and cannot be forcefully logged out by a supervisor. Roles logged in through the front panel that do not allow multiple instances (Administrator, Supervisor, Engineer, Operator) must switch to None (equivalent to a logout) when they are done in order to log out.

For all user roles except Observer, only one instance can be logged in at a time, for both login by front panel and software.

To configure Server authentication:

1. In the EnerVista software, choose Device authentication and log in as Administrator.
2. Configure the following RADIUS server parameters: IP address, authentication port, shared secret, and vendor ID.
3. On the RADIUS server, configure the user accounts. Do not use the five pre-defined roles as user names (Administrator, Supervisor, Engineer, Operator, Observer) in the RADIUS server. If you do, the UR relay automatically provides the authentication from the device.
4. In the EnerVista software, choose Server authentication and log in using the user name and password configured on the RADIUS server for Server authentication login.
5. After making any required changes, log out.

NOTICE

When changing settings offline, ensure that only settings permitted by the role that performs the settings download are changed because only those changes are applied.

Pushbuttons (both user-control buttons and user-programmable buttons) located on the front panel can be pressed by an Administrator or Engineer role. This also applies to the **RESET** button, which resets targets, where targets are errors displayed on the front panel or the Targets panel of the EnerVista software. The **RESET** button has special behavior in that it allows these two roles to press it even when they are logged in through the RS232 port and not through the front panel.

To reset the security event log and self-test operands:

1. Log in as Supervisor (if the role is enabled) or Administrator (if the Supervisor role is disabled) and execute a clear security command under **Commands > Security > Clear Security**.

Syslog format

System logs are produced with the CyberSentry option. The format is as follows.

	Security log	Event Number	Date & Timestamp	Username	IP address	Role	Activity Value
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Event Number — Event identification number (index)

Date & Timestamp — UTC date and time

Username — 255 chars maximum, but in the security log it is truncated to 20 characters

IP address — Device IP address

Role — 16 bit unsigned, of type format F617

Enumeration	Role
0	None
1	Administrator
2	Supervisor
3	Engineer
4	Operator
5	Factory

Activity Value — 16 bit unsigned

Enumeration	Description
1	Authentication Failed
2	User Lockout
3	FW Upgrade
4	FW Lock
5	Settings Lock
6	Settings Change. Because this can fill the entire event log, it is supported by the already existing Settings_Change.log file. This event is not required.
7	Clear Oscillography command
8	Clear Data Logger command (not applicable to all UR products)
9	Clear Demand Records command (not applicable to all UR products)
10	Clear Energy command (not applicable to all UR products)
11	Clear Unauthorized Access command
12	Clear Teleprotection Counters command (not applicable to all UR products)
13	Clear All Relay Records command
14	Role Log in
15	Role Log off

The following events are recorded in the syslog.

Table 5-6: System events recorded

Event	Severity	Description
FAILED_AUTH, ORIGIN, TIMESTAMP	Warning (4)	A failed authentication with origin information (username and IP:MAC address), a time stamp in UTC time when it occurred
AUTH_LOCKOUT, ORIGIN, TIMESTAMP	Error (3)	An authentication lockout has occurred because of too many failed authentication attempts
FIRMWARE_UPGD, ORIGIN, TIMESTAMP	Warning (4)	Indicates that a change of firmware has occurred
FIRMWARE_LOCK, ORIGIN, TIMESTAMP	Critical (1)	An attempt was made to change firmware while the firmware lock was enabled
SETTING_CHG, ORIGIN, TIMESTAMP	Notice (5)	Indicates setting change(s)
SETTING_LOCK, ORIGIN, TIMESTAMP	Critical (1)	An attempt was made to change settings while the settings lock was enabled
LOGIN, ORIGIN, TIMESTAMP	Warning (4)	Indicates when a certain role logged in
LOGOUT, ORIGIN, TIMESTAMP	Notice (5)	Indicates when a certain role logged out or timed out
CLEAR_OSCILLOGRAPHY	Notice (5)	Clear oscillography command was issued
CLEAR_DATA_LOGGER	Notice (5)	Clear data logger command was issued
CLEAR_DEMAND_RECS	Notice (5)	Clear demand records command was issued
CLEAR_ENERGY	Notice (5)	Clear energy command was issued
RESET_UNAUTH_ACCESS	Warning (4)	Reset Unauthorized access command was issued
CLEAR_TELEPROTECTION_CNT	Notice (5)	Clear teleprotection counters command was issued
CLEAR_ALL_RECS	Warning (4)	Clear all records command was issued

5.3.3 Display properties

SETTINGS ⇒ PRODUCT SETUP ⇒ ⇅ DISPLAY PROPERTIES

☒ DISPLAY ☒ PROPERTIES	⇅	LANGUAGE: English	Range: English; English, French; English, Russian; English, Chinese; English, German (examples; depends on order code) Visible when language other than English purchased
---	---	------------------------------------	--

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

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

LANGUAGE — This setting selects the language used to display settings, actual values, and targets. This setting displays when a language other than English was purchased, and the range depends on the order code of the relay. Restart the relay after changing this setting.

FLASH MESSAGE TIME — Flash messages are status, warning, error, and information messages displayed in response to certain key presses during settings programming. These messages override any normal messages. Use this setting to change the duration of flash messages on the display.

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 using this setting to ensure that 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 B90 has a liquid crystal display (LCD) and control its backlighting. When the **SCREEN SAVER FEATURE** is “Enabled,” the LCD backlighting turns off after the **DEFAULT MESSAGE TIMEOUT** followed by the **SCREEN SAVER WAIT TIME**, provided that no keys have been pressed and no target messages are active. When a keypress occurs or a target becomes active, the LCD backlighting turns 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 to display even when the value reflects noise rather than the actual signal. The B90 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 B90 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 to cut-off.



NOTE

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

5.3.4 Clear relay records

SETTINGS ⇒ PRODUCT SETUP ⇒ CLEAR RELAY RECORDS

CLEAR RELAY RECORDS	↔	CLEAR USER REPORTS: Off	Range: FlexLogic operand
	↕	CLEAR EVENT RECORDS: Off	Range: FlexLogic operand
	↕	CLEAR OSCILLOGRAPHY: Off	Range: FlexLogic operand
	↕	RESET UNAUTH ACCESS: Off	Range: FlexLogic operand
	↑	CLEAR DIR I/O STATS: Off	Range: FlexLogic operand Visible only for units with Direct I/O module

RESET UNAUTH ACCESS — Resets the access restriction counter.

Selected records can be cleared from user-programmable conditions with FlexLogic operands. Assigning user-programmable pushbuttons to clear specific records is a typical application for these commands. Since the B90 responds to rising edges of the configured FlexLogic operands, they must be asserted for at least 50 ms to take effect.

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

For example, to assign user-programmable pushbutton 1 to clear demand records, apply the following settings.

- 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"

5.3.5 Communications

5.3.5.1 Menu

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS

COMMUNICATIONS	↔	SERIAL PORTS	See page 5-25
	↕	NETWORK	See page 5-28
	↕	ROUTING	See page 5-30
	↕	MODBUS PROTOCOL	See page 5-33
	↕	PROTOCOL: DNP 3.0	Range: DNP 3.0, IEC 60870-5-104, IEC 60870-5-103 See page 5-34
	↕	DNP PROTOCOL	See page 5-34
	↕	DNP / IEC104 POINT LISTS	See page 5-38

↕	■ IEC 61850 PROTOCOL ■	Access in EnerVista See page 5-39
↕	■ WEB SERVER ■ HTTP PROTOCOL	See page 5-67
↕	■ TFTP PROTOCOL ■	See page 5-68
↕	■ IEC 60870-5-104 ■ PROTOCOL	See page 5-68
↑	■ IEC103 ■ PROTOCOL	See page 5-70

5.3.5.2 Serial ports

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ SERIAL PORTS

■ SERIAL PORTS ■	↔	RS232 BAUD RATE: 115200	Range: 19200, 115200
	↕	RS485 COM2 BAUD RATE: 19200	Range: 300, 1200, 2400, 4800, 9600, 14400, 19200, 28800, 33600, 38400, 57600, 115200 bit/s
	↕	RS485 COM2 PARITY: Even	Range: None, Odd, Even
	↑	RS485 COM2 RESPONSE MIN TIME: 0 ms	Range: 0 to 1000 ms in steps of 10

RS232 BAUD RATE, RS485 COM2 BAUD RATE, and PARITY — The B90 is equipped with two independent serial communication ports. The faceplate RS232 port is intended for local use and has two options for baud rate. The rear COM2 port is RS485 and has 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 can be connected to a computer running the EnerVista software. This software can download and upload setting files, view measured parameters, and upgrade the relay firmware. A maximum of 32 relays can be daisy-chained and connected to a DCS, PLC, or computer using the RS485 ports. If IEC 60870-103 is chosen as the protocol, valid baud rates are 9600 and 19200 bit/s, and valid parity is Even.

RS485 COM2 RESPONSE MIN TIME — This setting specifies the minimum time before the rear RS485 port transmits after receiving data from a host. This feature allows operation with hosts that hold the RS485 transmitter active for some time after each transmission.

5.3.5.3 Ethernet network topology

The B90 has three Ethernet ports. Each Ethernet port must belong to a different network or subnetwork. Configure the IP address and subnet to ensure that each port meets this requirement. Two subnets are different when the bitwise AND operation performed between their respective IP address and mask produces a different result. Communication becomes unpredictable when more than one port is configured to the same subnet.

Example 1

IP1/Mask1: 10.1.1.2/255.255.255.0 (where LAN 1 is 10.1.1.x/255.255.255.0)

IP2/Mask2: 10.2.1.2/255.255.255.0 (where LAN2 is 10.2.1.x/255.255.255.0)

IP3/Mask3: 10.3.1.2/255.255.255.0 (where LAN3 is 10.3.1.x/255.255.255.0)

Example 2

IP1/Mask1: 10.1.1.2/255.0.0.0 (where LAN1 is 10.x.x.x/255.0.0.0)

IP2/Mask2: 11.1.1.2/255.0.0.0 (where LAN2 is 11.x.x.x/255.0.0.0)

IP3/Mask3: 12.1.1.2/255.0.0.0 (where LAN3 is 12.x.x.x/255.0.0.0)

Example 3 — Incorrect

IP1/Mask1: 10.1.1.2/255.0.0.0

IP2/Mask2: 10.2.1.2/255.0.0.0

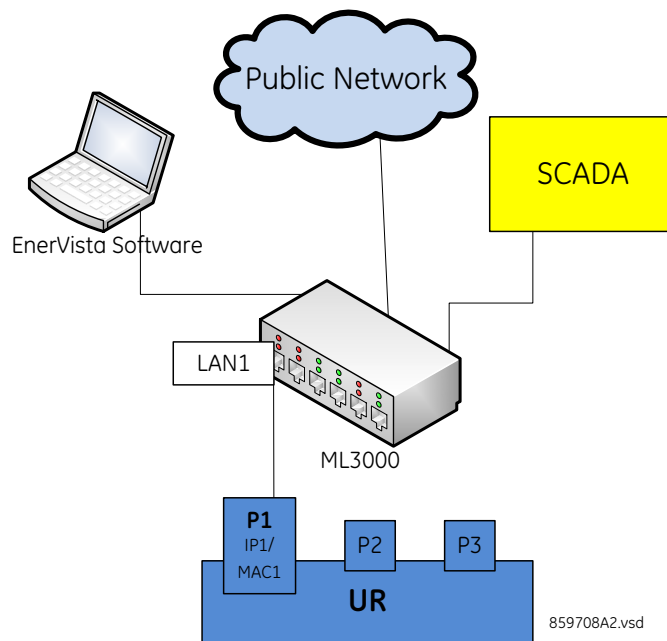
IP3/Mask3: 10.3.1.2/255.0.0.0

This example is incorrect because the mask of 255.0.0.0 used for the three IP addresses makes them belong to the same network of 10.x.x.x.

Single LAN, no redundancy

The topology shown in the following figure allows communications to SCADA, local configuration/monitoring through EnerVista, and access to the public network shared on the same LAN. No redundancy is provided.

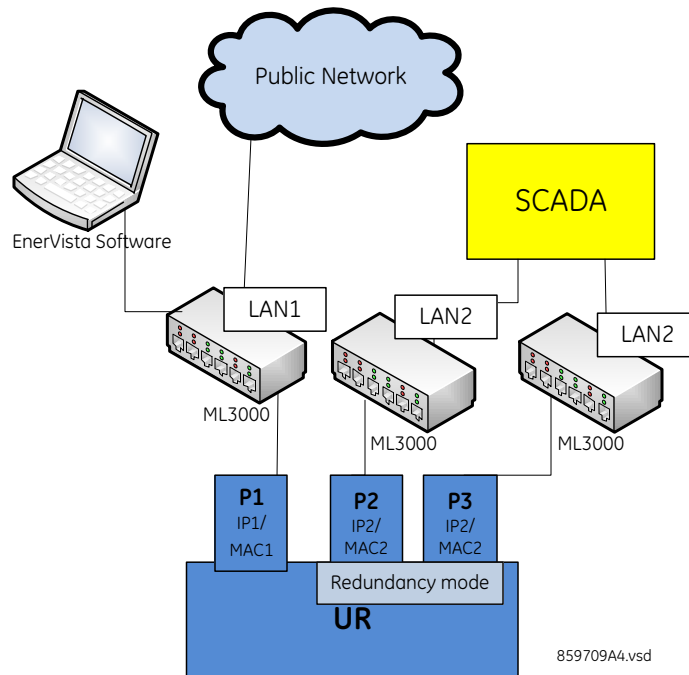
Figure 5-3: Network configuration for single LAN



Multiple LANS, with redundancy

The following topology provides local configuration/monitoring through EnerVista software and access to the public network shared on LAN1, to which port 1 (P1) is connected. There is no redundancy provided on LAN1. Communications to SCADA is provided through LAN2. P2 and P3 are connected to LAN2, where P2 is the primary channel and P3 is the redundant channel. In this configuration, P3 uses the IP and MAC addresses of P2.

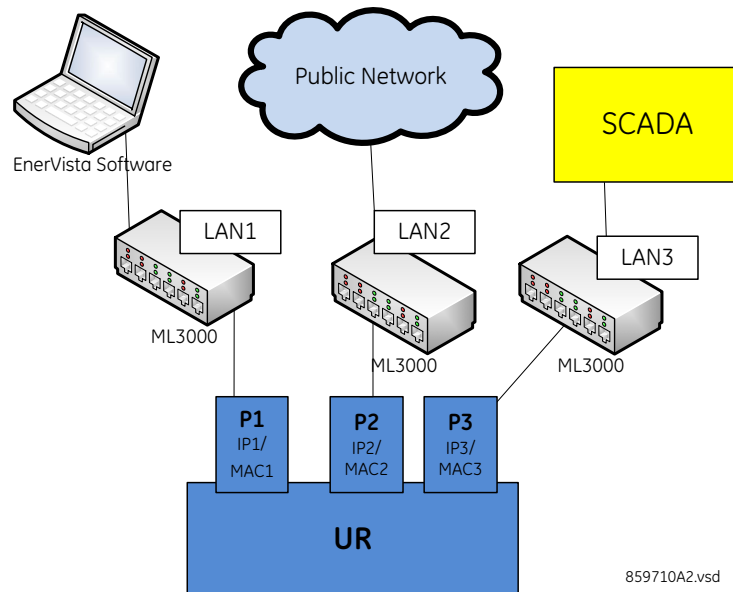
Figure 5-4: Multiple LANs, with redundancy



Multiple LANS, no redundancy

The following topology provides local configuration/monitoring through EnerVista software on LAN1, to which port 1 (P1) is connected, access to the public network on LAN2, to which port 2 (P2) is connected, and communications with SCADA on LAN3, to which port 3 (P3) is connected. There is no redundancy.

Figure 5-5: Multiple LANS, no redundancy



5.3.5.4 Network

As outlined in the previous section, when using more than one Ethernet port, configure each to belong to a different network or subnet using the IP addresses and mask. Configure the network IP and subnet settings before configuring the routing settings.

Follow the IP and subnet mask rules outlined in the Configuring the UR for Software Access section of the Installation chapter.

To obtain a list of all port numbers used, for example for audit purposes, contact GE technical support with substantiating information, such as the serial number and order code of your device.

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ NETWORK 1(3)

■ NETWORK PORT 1

■

↔

PRT1 IP ADDRESS:

127.0.0.1

Range: standard IPV4 address format

↑

PRT1 SUBNET IP MASK:

255.0.0.0

Range: standard IPV4 address format

■ NETWORK PORT 2

■

↔

PRT2 IP ADDRESS:

127.0.0.1

Range: standard IPV4 address format

↕

PRT2 SUBNET IP MASK:

255.0.0.0

Range: standard IPV4 address format

↕

PRT2 REDUNDANCY:

None

Range: None, Failover, PRP
Range if no PRP license: None, Failover

↑

PRP MCST ADDR:

01-15-4E-00-01-00

Range: 01-15-4E-00-01-00 to 01-15-4E-00-01-FF

■ NETWORK PORT 3

■

↔

PRT3 IP ADDRESS:

127.0.0.1

Range: standard IPV4 address format

↑

PRT3 SUBNET IP MASK:

255.0.0.0

Range: standard IPV4 address format

The IP addresses are used with the DNP, Modbus/TCP, IEC 61580, IEC 60870-5-104, TFTP, HTTP, and PRP protocols. PRP is explained in its own section later.

Use the front panel to change these settings. When online, the EnerVista software can be used to enable/disable each port only. In the Offline Window area, all settings can be changed except port 2 redundancy.

PRT1 (2 or 3) IP ADDRESS — This setting sets the port's IPv4 address in standard IPV4 format. This setting is valid on port 3 if port 2 **REDUNDANCY** is set to None.

PRT1 (2 or 3) SUBNET MASK — This setting sets the port's IPv4 subnet mask in standard IPV4 format. This setting is valid on port 3 if port 2 **REDUNDANCY** is set to None.

PRT2 REDUNDANCY — Determines if ports 2 and 3 operate in redundant or independent mode. If the software options in the order code include PRP, the available options are None, Failover, and PRP. If the software options in the order code do not include PRP, the available options are None and Failover. In non-redundant mode (**REDUNDANCY** set to None), ports 2 and 3 operate independently with their own MAC, IP, and mask addresses. If **REDUNDANCY** is set to Failover, the operation of ports 2 and 3 is as follows:

- Ports 2 and 3 use the port 2 MAC address, IP address, and mask
- The configuration fields for IP address and mask on port 3 are hidden
- Port 3 is in standby mode and does not actively communicate on the Ethernet network but monitors its link to the Multilink switch. If port 2 detects a problem with the link, communications is switched to Port 3. Port 3 is, in effect, acting as a redundant or backup link to the network for port 2. Once port 2 detects that the link between itself and the switch is good and that communication is healthy for five minutes, then switching back to port 2 is performed. The delay in switching back ensures that rebooted switching devices connected to the B90, which signal their ports as

active prior to being completely functional, have time to completely initialize themselves and become active. Once port 2 is active again, port 3 returns to standby mode.

If **REDUNDANCY** is set to PRP, the operation of ports 2 and 3 is as follows:

- Ports 2 and 3 use the port 2 MAC address, IP address, and mask
- The configuration fields for IP address and mask on port 3 are overwritten with those from port 2. This is visible on the front panel but not displayed in the EnerVista software.
- Port 2 **MCST ADDRESS** field is visible
- The port 2 PTP function still uses only port 2 and the port 3 PTP function still uses only port 3. The relay still synchronizes to whichever port has the best master. When ports 2 and 3 see the same master, as is typically the case for PRP networks, the port with the better connectivity is used.



The two ports must be connected to completely independent LANs with no single point of failure, such as common power supplies that feed switches on both LANs.

When **REDUNDANCY** is set to PRP or failover and the network path with resolved default gateway is broken, then the ARP table needs approximately five seconds to rebuild. The layer 2 protocols (GOOSE and PTP) are not affected. However, the TCP/IP or UDP protocols (MMS connections, DNP3.0, and so on) can require reconnection if their active connection does not ride through re-transmission frames.

For any changes to this setting to take effect, restart the unit.

PRP MCST ADDR — This setting allows the user to change the multicast address used by the PRP supervision frames. This setting is available if **REDUNDANCY** is set to PRP. All devices in the same PRP network need to have the same multicast address. Choose an address that does not conflict with another multicast protocol.

5.3.5.5 Far-End Fault Indication (FEFI)

Since 100BASE-FX does not support Auto-Negotiation, a Far-End Fault Indication (FEFI) feature is included since UR 7 that allows for detection of link failures.

The purpose of the Far-End Fault feature is to allow the stations on both ends of a pair of fibers to be informed when there is a problem with one of the fibers. Without the Far-End Fault feature, it is impossible for a fiber interface to detect a problem that affects only its transmit fiber.

When the Far-End Fault feature is supported, a loss of receive signal (link) causes the transmitter to generate a Far-End Fault pattern in order to inform the device at the far end of the fiber pair that a fault has occurred.

When the local receiver again detects a signal, the local transmitter automatically returns to normal operation.

If a Far-End Fault pattern is received by a fiber interface that supports the Far-End Fault feature and it is enabled, it reacts by dropping the link as if there were no signal at all.

If the receiving interface does not support the Far-End Fault feature or has it disabled, an incoming Far-End Fault pattern is ignored.

It is strongly recommended to have switches used for substation automation that support the Far-End Fault feature, especially when UR 7 redundancy Failover is selected for redundancy.

5.3.5.6 Parallel Redundancy Protocol (PRP)

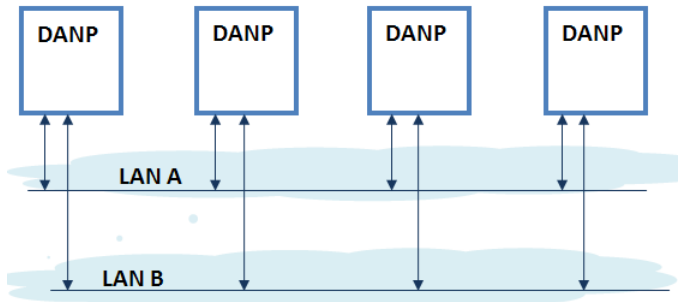


The B90 is provided with optional PRP capability. This feature is specified as a software option at the time of ordering. See the Order Codes section in chapter 2 for details.

The Parallel Redundancy Protocol (PRP) defines a redundancy protocol for high availability in substation automation networks. It applies to networks based on Ethernet technology (ISO/IEC 8802-3) and is based on the second edition (July 2012) of IEC 62439-3, clause 4.

PRP is designed to provide seamless recovery in case of a single failure in the network, by using a combination of LAN duplication and frame duplication. Identical frames are sent on two completely independent networks that connect source and destination. Under normal circumstances both frames reach the destination and one of them is sent up the OSI stack to the destination application, while the second one is discarded. If an error occurs in one of the networks and traffic is prevented from flowing on that path, connectivity is provided through the other network to ensure continuous communication. Take care when designing the two LANs, so that no single point of failure (such as a common power supply) is encountered, as such scenarios can bring down both LANs simultaneously.

Figure 5-6: Example of parallel redundant network



PRP uses specialized nodes called doubly attached nodes (DANPs) for handling the duplicated frames. DANP devices have an additional module, called a Link Redundancy Entity (LRE). LRE is responsible for duplicating frames and adding the specific PRP trailer when sending the frames out on the LAN, as well as making decisions on received frames as to which one is sent up the OSI stack to the application layer and which one is discarded. LRE is responsible for making PRP transparent to the higher layers of the stack.

In addition, there is a second type of specialized device used in PRP networks, called RedBox, with the role of connecting Single Attached Nodes (SANs) to a redundant network.

UR relays implement the DANP functionality. The RedBox functionality is not implemented.

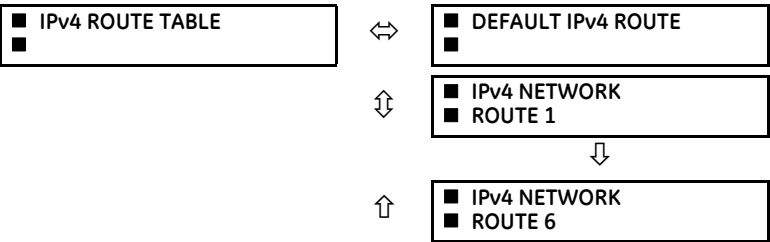
The original standard IEC 62439-3 (2010) was amended to align PRP with the High-availability Seamless Redundancy (HSR) protocol. To achieve this, the original PRP was modified at the cost of losing compatibility with the PRP 2010 version. The revised standard IEC 62439-3 (2012) is commonly referred to as PRP-1, while the original standard is PRP-0. The UR relays support PRP-1.

The relay implements PRP on two of its Ethernet ports, specifically Ports 2 and 3 of the CPU module. Use the previous section (network port configuration) to configure PRP.

PRP is purchased as a separate option. If purchased (valid order code), PRP can be enabled in configuration through a setting available on the network configuration menu, REDUNDANCY, which already has the capability of enabling failover redundancy. The options on this setting must be changed to accommodate two types of redundancy: failover and PRP. When REDUNDANCY is set to either failover or PRP, the ports dedicated for PRP (Ports 2 and 3) operate in redundant mode. In this mode, Port 3 uses the MAC, IP address, and mask of Port 2.

5.3.5.7 Routing

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ IPv4 ROUTE TABLE 1(6)



A default route and up to six static routes can be configured.

The default route is used as the last choice when no other route towards a given destination is found.

■ DEFAULT IPv4 ROUTE ■	↔	GATEWAY ADDRESS: 127.0.0.1	Range: standard IPV4 unicast address format
■ IPv4 NETWORK ■ ROUTE 1	↔	RT1 DESTINATION: 127.0.0.1	Range: standard IPV4 address format
	↕	RT1 NET MASK: 255.0.0.0	Range: standard IPV4 subnet mask format
	↑	RT1 GATEWAY: 127.0.0.1	Range: standard IPV4 unicast address format

Configure the network IP and subnet settings before configuring the routing settings.

Add and delete static routes

Host routes are not supported at present.

The routing table configuration is available on the serial port and front panel. This is a deliberate decision, to avoid loss of connectivity when remotely configuring the B90.

By default, the value of the destination field is 127.0.0.1 for all static routes (1 to 6). This is equivalent to saying that the static routes are not configured. When the destination address is 127.0.0.1, the mask and gateway also must be kept on default values.

By default, the value of the route gateway address is 127.0.0.1. This means that the default route is not configured.

To add a route:

1. Use any of the static network route entries numbered 1 to 6 to configure a static network route. Once a route destination is configured for any of the entries 1 to 6, that entry becomes a static route and it must meet all the rules listed in the next section, General Conditions to be Satisfied by Static Routes.
2. To configure the default route, enter a default gateway address. Once a default gateway address is configured, it must be validated against condition 2 of the General Conditions to be Satisfied by Static Routes, where the route gateway must be on a connected network.

To delete a route:

1. Replace the route destination with the default loopback address of 127.0.0.1. When deleting a route, the mask and gateway also must be brought back to default values.
2. Delete the default route by replacing the default gateway with the default value of 127.0.0.1.

General conditions to be satisfied by static routes

The following rules are validated internally:

- The route mask has IP mask format. In binary this needs to be a set of contiguous bits of 1 from left to right, followed by one or more contiguous bits of 0.
- The route destination and mask must match. This can be verified by checking that $RtDestination \text{ and } RtMask = RtDestination$
Example of good configuration: $RtDestination = 10.1.1.0$; $RtMask = 255.255.255.0$
Example of bad configuration: $RtDestination = 10.1.1.1$; $RtMask = 255.255.255.0$

The following rules must be observed when you configure static routes:

- The route destination must not be a connected network
- The route gateway must be on a connected network. This rule applies to the gateway address of the default route as well. This can be verified by checking that:
 $(RtGwy \ \& \ Prt1Mask) == (Prt1IP \ \& \ Prt1Mask) \ || \ (RtGwy \ \& \ Prt2Mask) == (Prt2IP \ \& \ Prt2Mask) \ || \ (RtGwy \ \& \ Prt3Mask) == (Prt3IP \ \& \ Prt3Mask)$
 where

& is the bitwise-AND operator

== is the equality operator

|| is the logical OR operator

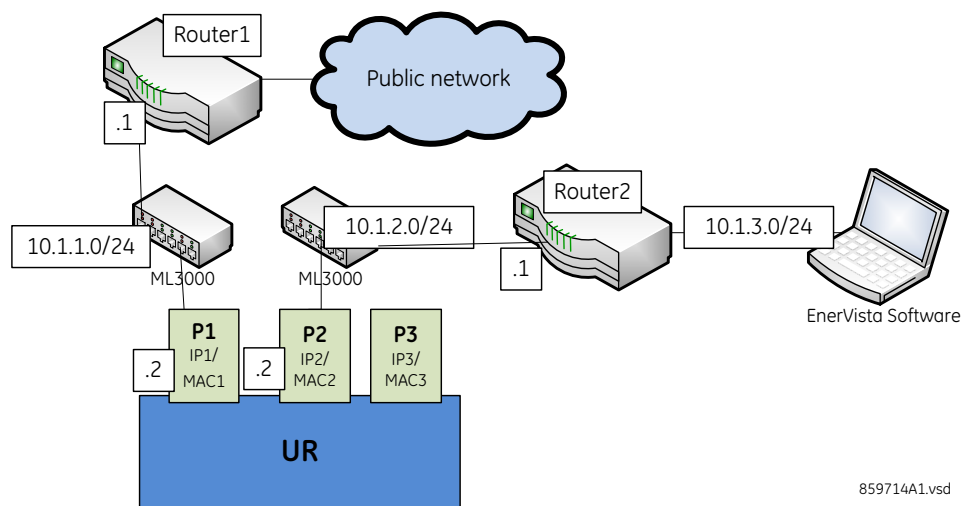
Routing behavior compared to previous releases

Prior to release 7.10, UR devices did not have an explicit manner of configuring routes. The only available route was the default route configured as part of the network settings (port gateway IP address). This limited the ability to route to specific destinations, particularly if these destinations were reachable through a different interface than the one on which the default gateway was.

Starting with UR 7.10, up to six static network routes can be configured in addition to a default route. The default route configuration was also moved from the network settings into the routing section.

The figure shows an example of topology that benefits from the addition of static routes.

Figure 5-7: Using static routes



In the figure, the UR connects through the following two Ethernet ports:

- Port 1 (IP address 10.1.1.2) connects the UR to LAN 10.1.1.0/24 and to the Internet through Router1. Router1 has an interface on 10.1.1.0/24 and the IP address of this interface is 10.1.1.1.
- Port 2 (IP address 10.1.2.2) connects the UR to LAN 10.1.2.0/24 and to the EnerVista software through Router2. Router2 has an interface on 10.1.2.0/24 and the IP address of this interface is 10.1.2.1.

The configuration before release 7.10 was as follows:

- PRT1 IP ADDRESS = 10.1.1.2
PRT1 SUBNET IP MASK = 255.255.255.0
PRT1 GWY IP ADDRESS = 10.1.1.1
- PRT2 IP ADDRESS = 10.1.2.2
PRT2 SUBNET IP MASK = 255.255.255.0

The behavior before release 7.10 was as follows. When sending packets to EnerVista, the UR noticed that the destination was not on a connected network and it tried to find a route to destination. Since the default route was the only route it knew, it used it. Yet EnerVista was on a private network, which was not reachable through Router1. Hence a destination unreachable message was received from the router.

The configuration starting with release 7.10 is as follows:

- PRT1 IP ADDRESS = 10.1.1.2
PRT1 SUBNET IP MASK = 255.255.255.0
- PRT2 IP ADDRESS = 10.1.2.2
PRT2 SUBNET IP MASK = 255.255.255.0

IPV4 DEFAULT ROUTE: GATEWAY ADDRESS = 10.1.1.1

STATIC NETWORK ROUTE 1: RT1 DESTINATION = 10.1.3.0/24; RT1 NET MASK = 255.255.255.0; and RT1 GATEWAY = 10.1.2.1

The behavior since release 7.10 is as follows. There is one added static network route to the destination 10.1.3.0/24, where a computer running EnerVista is located. This static route uses a different gateway (10.1.2.1) than the default route. This gateway is the address of Router2, which has knowledge about 10.1.3.0 and is able to route packets coming from the UR and destined to EnerVista.

Show routes and ARP tables

This feature is available on the Web interface, where the main menu contains an additional Communications menu and two submenus:

- Routing Table
- ARP Table

The tables outline the information displayed when the two submenus are selected.

Table 5-7: Routing table information

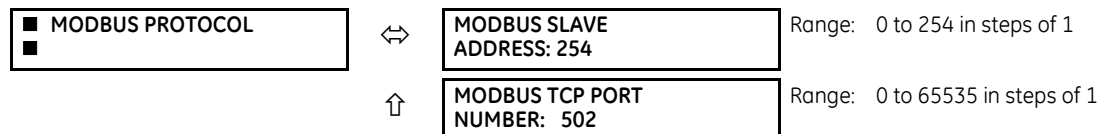
Field	Description
Destination	The IP address of the remote network to which this route points
Mask	The network mask for the destination
Gateway	The IP address of the next router to the remote network
Interface	Interface through which the specified network can be reached

Table 5-8: IP ARP information

Field	Description
IP Address	The network address that corresponds to Hardware Address
Age (min)	Age, in minutes, of the cache entry. A hyphen (-) means the address is local.
Hardware Address	LAN hardware address, a MAC address that corresponds to network address
Type	Dynamic or Static
Interface	Interface to which this address mapping has been assigned

5.3.5.8 Modbus protocol

SETTINGS ⇒ PRODUCT SETUP ⇒ ⚙ COMMUNICATIONS ⇒ ⚙ MODBUS PROTOCOL



The serial communication ports utilize the Modbus protocol, unless the port is configured for DNP or IEC 60870-5-103 operation. This allows the EnerVista UR Setup software to be used on the port. UR devices operate as Modbus slave devices only.

For more information on the protocol, including the memory map table, see the UR Series Communications Guide.

MODBUS SLAVE ADDRESS — When using the Modbus protocol on the RS232 port, the B90 responds regardless of the **MODBUS SLAVE ADDRESS** programmed. For the RS485 port, each device on the serial bus must have a unique slave address from 1 to 254. Address 0 and addresses from 248 and up are reserved by the Modbus protocol specification, and so their use here is not recommended. Address 0 is the broadcast address to which all Modbus slave devices listen. When **MODBUS SLAVE ADDRESS** is set to 0, the B90 accepts broadcast messages, but in compliance with protocol specifications for broadcast messages, never replies. Addresses do not have to be sequential, but no two devices can have the same address or conflicts resulting in errors occur. Generally, starting at 1, set each device added to the link to use the next higher address. When using Modbus TCP/IP, the client must use the programmed **MODBUS SLAVE ADDRESS** value in the Unit Identifier field.

MODBUS TCP PORT NUMBER — Modbus over TCP/IP can also be used on any of the Ethernet ports. The listening TCP port 502 is reserved for Modbus communications, and only in exceptional cases when **MODBUS TCP PORT NUMBER** is set to any other port. The **MODBUS TCP PORT NUMBER** setting sets the TCP port used by Modbus on Ethernet. A **MODBUS TCP PORT NUMBER** of 0 disables Modbus over TCP/IP, meaning closes the Modbus TCP port. When the port number is changed to 0, the change takes effect when the B90 is restarted. When it is set to 0, use the front panel or serial port to communicate with the relay.



Do not set more than one protocol to the same TCP/UDP port number, as this results in unreliable operation of those protocols.

5.3.5.9 Protocol selection

The **PROTOCOL** menu setting allows selection of one of the following protocols: DNP 3.0, IEC60870-104, or IEC60870-103. For any change to take effect, restart the unit.

The table shows which of DNP 3.0, IEC 60870-5-104, IEC 60870-5-103, and IEC 61850 protocols are operational on the RS232, RS485, and Ethernet ports. It shows all possible combinations of the **PROTOCOL** and **DNP CHANNEL 1(2) PORT** settings.

Table 5-9: Port and protocol combinations

PROTOCOL setting	DNP CHANNEL 1(2) PORT settings	RS232	RS485	Ethernet
DNP	Channel 1: Eth TCP Channel 2: Eth TCP	Modbus	Modbus	DNP, Modbus, IEC 61850
	Channel 1: Eth TCP Channel 2: none	Modbus	Modbus	DNP, Modbus, IEC 61850
	Channel 1: none Channel 2: Eth TCP	Modbus	Modbus	DNP, Modbus, IEC 61850
	Channel 1: Eth UDP Channel 2: none	Modbus	Modbus	DNP, Modbus, IEC 61850
	Channel 1: Eth TCP Channel 2: RS485	Modbus	DNP	DNP, Modbus, IEC 61850
	Channel 1: Eth TCP Channel 2: RS232	DNP	Modbus	DNP, Modbus, IEC 61850
	Channel 1: Eth UDP Channel 2: RS485	Modbus	DNP	DNP, Modbus, IEC 61850
	Channel 1: Eth UDP Channel 2: RS232	DNP	Modbus	DNP, Modbus, IEC 61850
	Channel 1: RS485 Channel 2: Eth TCP	Modbus	DNP	DNP, Modbus, IEC 61850
	Channel 1: RS232 Channel 2: Eth TCP	DNP	Modbus	DNP, Modbus, IEC 61850
	Channel 1: RS485 Channel 2: RS232	DNP	DNP	Modbus, IEC 61850
	Channel 1: RS232 Channel 2: RS485	DNP	DNP	Modbus, IEC 61850
	Channel 1: RS485 Channel 2: none	Modbus	DNP	Modbus, IEC 61850
IEC 104		Modbus	Modbus	IEC 104, Modbus, IEC 61850
IEC 103		Modbus	IEC 103	Modbus, IEC 61850

5.3.5.10 DNP protocol

SETTINGS ⇒ PRODUCT SETUP ⇒ ⚡ COMMUNICATIONS ⇒ ⚡ DNP PROTOCOL



↕	DNP ADDRESS: 1	Range: 0 to 65535 in steps of 1
↕	■ DNP NETWORK ■ CLIENT ADDRESSES	See below
↕	DNP TCP/UDP PORT NUMBER: 20000	Range: 0 to 65535 in steps of 1
↕	DNP UNSOL RESPONSE FUNCTION: Disabled	Range: Enabled, Disabled
↕	DNP UNSOL RESPONSE TIMEOUT: 5 s	Range: 0 to 60 s in steps of 1
↕	DNP UNSOL RESPONSE MAX RETRIES: 10	Range: 1 to 255 in steps of 1
↕	DNP UNSOL RESPONSE DEST ADDRESS: 1	Range: 0 to 65519 in steps of 1
↕	DNP CURRENT SCALE FACTOR: 1	Range: 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000, 100000
↕	DNP VOLTAGE SCALE FACTOR: 1	Range: 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000, 100000
↕	DNP POWER SCALE FACTOR: 1	Range: 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000, 100000
↕	DNP ENERGY SCALE FACTOR: 1	Range: 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000, 100000
↕	DNP PF SCALE FACTOR: 1	Range: 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000, 100000
↕	DNP OTHER SCALE FACTOR: 1	Range: 0 to 100000000 in steps of 1
↕	DNP CURRENT DEFAULT DEADBAND: 30000	Range: 0 to 100000000 in steps of 1
↕	DNP VOLTAGE DEFAULT DEADBAND: 30000	Range: 0 to 100000000 in steps of 1
↕	DNP POWER DEFAULT DEADBAND: 30000	Range: 0 to 100000000 in steps of 1
↕	DNP ENERGY DEFAULT DEADBAND: 30000	Range: 0 to 100000000 in steps of 1
↕	DNP PF DEFAULT DEADBAND: 30000	Range: 0 to 100000000 in steps of 1
↕	DNP OTHER DEFAULT DEADBAND: 30000	Range: 0 to 100000000 in steps of 1
↕	DNP TIME SYNC IIN PERIOD: 1440 min	Range: 1 to 10080 min. in steps of 1
↕	DNP MESSAGE FRAGMENT SIZE: 240	Range: 30 to 2048 in steps of 1
↕	DNP OBJECT 1 DEFAULT VARIATION: 2	Range: 1, 2
↕	DNP OBJECT 2 DEFAULT VARIATION: 2	Range: 1, 2, 3
↕	DNP OBJECT 20 DEFAULT VARIATION: 1	Range: 1, 2, 5, 6

↕	DNP OBJECT 21 DEFAULT VARIATION: 1	Range: 1, 2, 9, 10
↕	DNP OBJECT 22 DEFAULT VARIATION: 1	Range: 1, 2, 5, 6
↕	DNP OBJECT 23 DEFAULT VARIATION: 1	Range: 1, 2, 5, 6
↕	DNP OBJECT 30 DEFAULT VARIATION: 1	Range: 1, 2, 3, 4, 5
↕	DNP OBJECT 32 DEFAULT VARIATION: 1	Range: 1, 2, 3, 4, 5, 7
↕	DNP NUMBER OF PAIRED CONTROL POINTS: 0	Range: 0 to 32 in steps of 1
↑	DNP TCP CONNECTION TIMEOUT: 120 s	Range: 10 to 7200 s in steps of 1

The Distributed Network Protocol (DNP) allows for the optimization of control and data acquisition between the equipment in the substation and the central control center. The protocol is scalable; that is, it is designed to be compatible with the latest high speed LAN technology yet still be implemented over slower speed serial links.

The DNP improves upon many master-slave protocols by improving overall communication performance requirements and provides time-stamping with millisecond accuracy.

The B90 supports the Distributed Network Protocol (DNP) version 3.0. DNP is enabled when the **SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ PROTOCOL** setting is set to DNP 3.0. The B90 can be used as a DNP slave device connected to multiple DNP masters (usually an RTU or a SCADA master station). Since the B90 maintains two sets of DNP data change buffers and connection information, two DNP masters can actively communicate with the B90 at one time.

See the UR Series Communications Guide for more information on DNP.



For any change to DNP settings, restart the relay.

NOTE

The DNP Channels sub-menu is shown.

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ DNP PROTOCOL ⇒ DNP CHANNELS

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

The **DNP CHANNEL 1 PORT** and **DNP CHANNEL 2 PORT** settings select the communications port assigned to the DNP protocol for each channel. Once DNP is assigned to a serial port, DNP is the only protocol running on that port; Modbus or IEC 60870-5-103 are disabled. If DNP is assigned to RS485, the protocol must be set to DNP on the serial port configuration as well, for the change to take effect. When the **DNP CHANNEL 1(2) PORT** setting is set to “Network - TCP,” the channel 1(2) DNP protocol can be used over TCP/IP on the Ethernet ports. When this value is set to “Network - UDP,” the DNP protocol can be used over UDP/IP on channel 1 only.



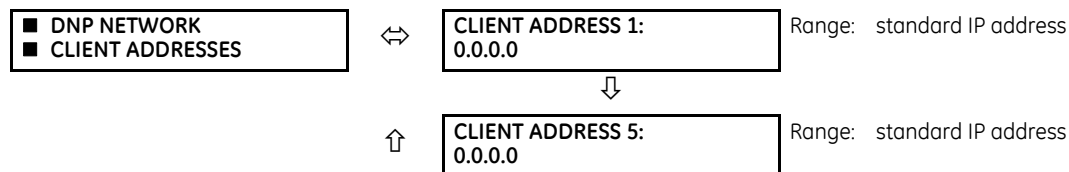
Do not set more than one protocol to the same TCP/UDP port number, as this results in unreliable operation of those protocols.

NOTE

The **DNP ADDRESS** setting is the DNP slave address. This number identifies the B90 on a DNP communications link. Assign a unique address to each DNP slave.

The B90 can specify a maximum of five clients for its DNP connections. These are IP addresses for the controllers to which the B90 can connect. The settings follow.

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ DNP PROTOCOL ⇒ DNP NETWORK CLIENT ADDRESSES



The **DNP TCP/UDP PORT NUMBER** setting is for normal DNP operation. To close the port, set the port number to 0.

The **DNP UNSOL RESPONSE FUNCTION** is set to “Disabled” for RS485 applications since there is no collision avoidance mechanism. The **DNP UNSOL RESPONSE TIMEOUT** sets the time the B90 waits for a DNP master to confirm an unsolicited response. The **DNP UNSOL RESPONSE MAX RETRIES** setting determines the number of times the B90 retransmits an unsolicited response without receiving confirmation from the master; a value of “255” allows infinite re-tries. The **DNP UNSOL RESPONSE DEST ADDRESS** is the DNP address to which all unsolicited responses are sent. The IP address to which solicited responses are sent is determined by the B90 from the current TCP connection or the most recent UDP message.

The DNP scale factor settings are numbers used to scale analog input point values. These settings group the B90 analog input data into the following types: current, voltage, power, energy, power factor, and other. Each setting represents the scale factor for all analog input points of that type. For example, if the **DNP VOLTAGE SCALE FACTOR** setting is set to “1000,” all DNP analog input points that are voltages are returned with values 1000 times smaller (for example, a value of 72000 V on the B90 is returned as 72). These settings are useful when analog input values must be adjusted to fit within certain ranges in DNP masters. Note that a scale factor of 0.1 is equivalent to a multiplier of 10 (that is, the value is 10 times larger).

The **DNP DEFAULT DEADBAND** settings determine when to trigger unsolicited responses containing analog input data. These settings group the B90 analog input data into the following types: current, voltage, power, energy, power factor, and other. Each setting represents the default deadband value for all analog input points of that type. For example, to trigger unsolicited responses from the B90 when any current values change by 15 A, the **DNP CURRENT DEFAULT DEADBAND** setting is 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.



The B90 relay does not support power metering. As such, the **DNP POWER SCALE FACTOR** and **DNP POWER DEFAULT DEADBAND** settings are not applicable.



The B90 relay does not support energy metering. As such, the **DNP ENERGY SCALE FACTOR** and **DNP ENERGY DEFAULT DEADBAND** settings are not applicable.

The **DNP TIME SYNC IIN PERIOD** setting determines how often the Need Time Internal Indication (IIN) bit is set by the B90. 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 provides more robust data transfer over noisy communication channels.



Check the “DNP Points Lists” B90 web page to view the analog inputs and/or binary inputs points lists. This page can be viewed with a web browser by entering the IP address of the B90 Ethernet port employed to access the B90 Main Menu, then by clicking the **Device Information Menu** item, then the **DNP Points Lists** item.

The **DNP OBJECT 1 DEFAULT VARIATION** to **DNP OBJECT 32 DEFAULT VARIATION** settings select the DNP default variation number for object types 1, 2, 20, 21, 22, 23, 30, and 32. The default variation refers to the variation response when variation 0 is requested and/or in class 0, 1, 2, or 3 scans. See the DNP Implementation section in the UR Series Communications Guide.

The DNP binary outputs typically map one-to-one to IED data points. That is, each DNP binary output controls a single physical or virtual control point in an IED. In the B90 relay, DNP binary outputs are mapped to virtual inputs. However, some legacy DNP implementations use a mapping of one DNP binary output to two physical or virtual control points to support the concept of trip/close (for circuit breakers) or raise/lower (for tap changers) using a single control point. That is, the DNP master can operate a single point for both trip and close, or raise and lower, operations. The B90 can be configured to support paired control points, with each paired control point operating two virtual inputs. The **DNP NUMBER OF PAIRED CONTROL POINTS** setting allows configuration of 0 to 32 binary output paired controls. Points not configured as paired operate on a one-to-one basis.

The **DNP TCP CONNECTION TIMEOUT** setting specifies a time delay for the detection of dead network TCP connections. If there is no data traffic on a DNP TCP connection for greater than the time specified by this setting, the connection is aborted by the B90. This frees up the connection to be re-used by a client.



For any change to DNP settings, restart the relay.

NOTE

5.3.5.11 DNP / IEC 60870-5-104 point lists

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ DNP / IEC104 POINT LISTS

■ DNP / IEC104
■ POINT LISTS

↔

■ BINARY INPUT / MSP
■ POINTS

See below

↑

■ ANALOG INPUT / MME
■ POINTS

See below

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

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

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

■ BINARY INPUT / MSP
■ POINTS

↔

Point: 0
Off

Range: FlexLogic operand

↕

Point: 1
Off

Range: FlexLogic operand

↓

Point: 255
Off

Range: FlexLogic operand

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

Changes to the DNP / IEC 60870-5-104 point lists take effect when the B90 is restarted.

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

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

■ ANALOG INPUT / MME
■ POINTS

↔

Point: 0
Off

Range: any FlexAnalog parameter

↕

Point: 1
Off

Range: any FlexAnalog parameter

↓

Point: 255
Off

Range: any FlexAnalog parameter

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

Changes to the DNP / IEC 60870-5-104 point lists take effect when the B90 is restarted.



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

5.3.5.12 IEC 61850 protocol



The B90 is provided with optional IEC 61850 communications capability. This feature is specified as a software option at the time of ordering. See the Order Codes section in chapter 2 for details.

The IEC 61850 settings are accessible in EnerVista software or a substation configuration language (SCL) generating tool. The path is **Settings > Product Setup > Communications > IEC 61850**. The settings are not accessible from the front panel of the device.



IEC 61850 messaging can form part of protection schemes. Consider IEC 61850 settings with the same criticality as protection element settings. To ensure reliable performance of protection schemes utilizing IEC 61850 messaging, route IEC 61850 traffic on a separate port from SCADA communications, or use redundant, independent ports, and a high speed network recovery method, such as PRP.

Overview

IEC 61850 is a series of international standards and technical reports applicable to power utility automation systems. It includes semantics, abstract communication services, specific communication services, performance specifications, network engineering guidelines, configuration description methodologies, and engineering processes. The standard enables interoperability among intelligent electronic devices (IEDs) from different suppliers and interoperability among software configuration tools from different suppliers. Interoperability in this case is the ability for IEDs to operate on the same network or communication path sharing information and commands, and for configuration tools to understand each other's configuration files.

The UR series supports a large subset of IEC 61850 features. These are detailed in the UR Series Communications Guide and include the information model, GOOSE publish, GOOSE subscribe, buffered report server, unbuffered report server, and Manufacturing Message Specification (MMS) query, read, write, and control services. In addition, the UR and EnerVista UR Setup software support IEC 61850 Substation Configuration Language (SCL) file import/export.

Whereas prior UR releases used edition 1.0 of IEC 61850, this release uses edition 2.0, with certain modifications according to IEC/TR 61850-90-5. Only edition 2.0 61850 configuration tools can interoperate with edition 2.0 devices such as the UR 7.3x release. The UR release uses edition 2.0 SCL, which differs from edition 1.0 SCL. GSSE, fixed GOOSE, and fixed report services of previous releases are no longer supported, and thus UR devices of previous releases using these features have to be converted to configurable GOOSE to communicate with a 7.3x device.

Many settings of UR protection, control, and monitoring elements, that is to say elements that are not concerned with the IEC 61850 protocol, can nevertheless be accessed via IEC 61850. These settings are documented elsewhere in this Settings chapter. This section of the Settings chapter deals solely with the settings that configure the IEC 61850 protocol itself.

The maximum number of simultaneous clients supported by the UR series is five.

EnerVista setup for IEC 61850

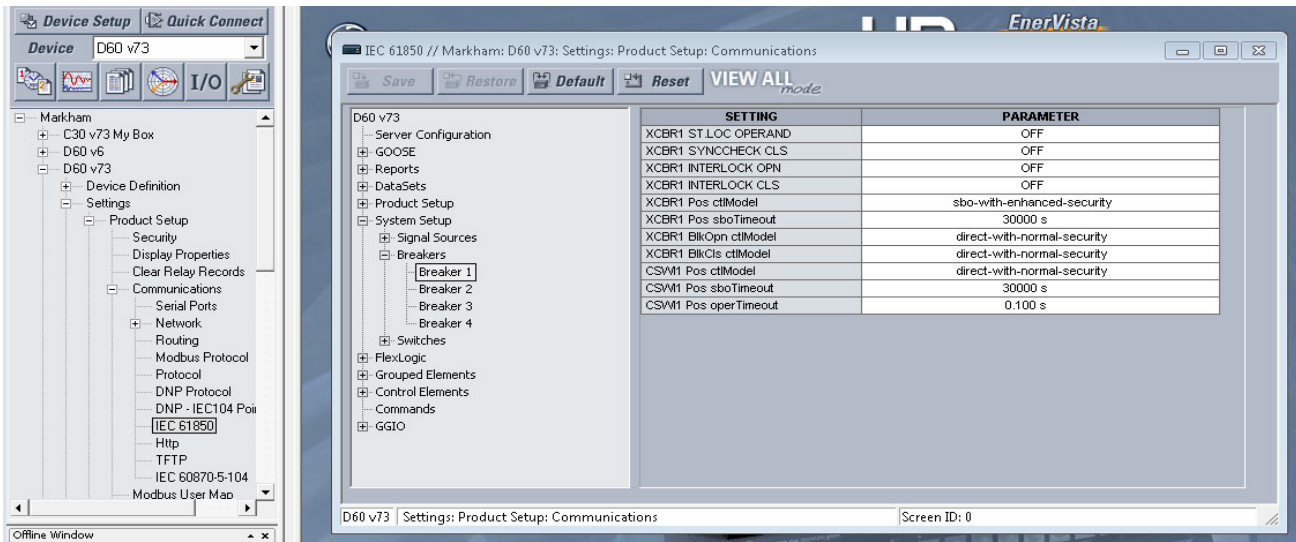
The EnerVista UR Setup software provides the interface to configure B90 settings for the IEC 61850 protocol. This section describes this interface. The software also supports import and export of IEC 61850 Substation Configuration Language (SCL) files as documented in the UR Series Communications Guide.

Unlike other UR settings, IEC 61850 protocol configuration settings cannot be accessed through the UR front panel. These settings are accessible with the EnerVista software, via MMS query, read, and write services, or via 61850 Substation Configuration Language (SCL) file transfer. Accordingly, whereas other settings are presented in this manual as they appear on the front panel, IEC 61850 settings are presented as they appear in the software. See the UR Series Communications Guide for MMS and SCL access. Note that if you update the IEC 61850 settings in the EnerVista software by writing to them by MMS while the corresponding IEC 61850 panel is open in EnerVista, you need to close then open the panel in EnerVista for the correct readings to display.

All IEC 61850 protocol configuration settings are accessed through software panels that are selected either in the **Online Window** area (see figure) or the **Offline Window** area in the EnerVista software.

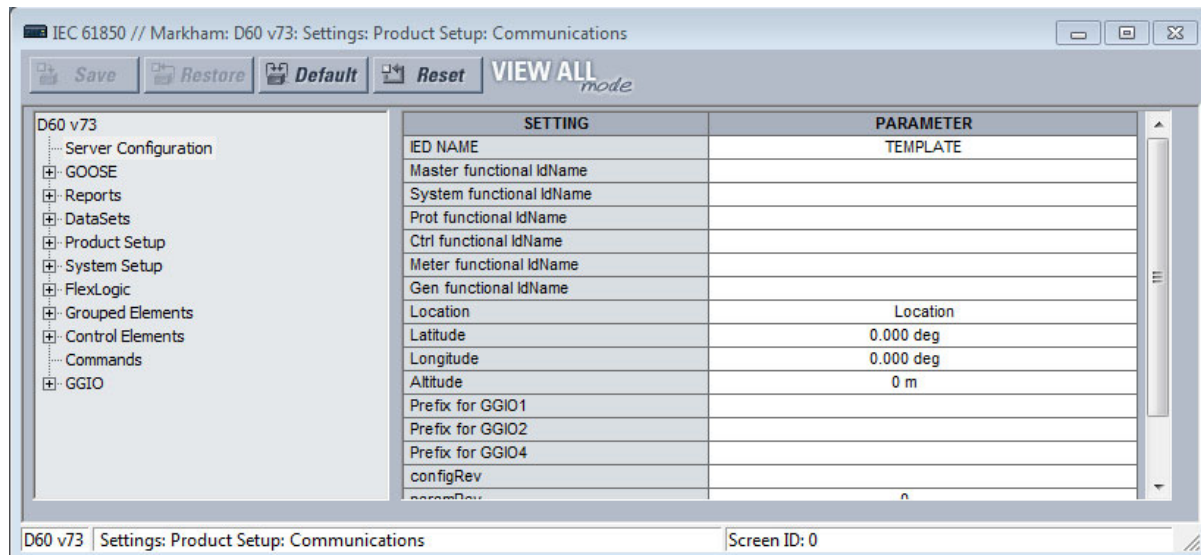
The EnerVista software also includes an interface that is compatible with firmware versions 5.0 to 7.2 to configure subscribers. Use the Simplified GOOSE Configurator in the Offline Window area.

Figure 5-8: IEC 61850 protocol panel in EnerVista software



The IEC 61850 window is divided into a navigation pane on the left and a settings panel on the right. You expand and click an option on the left to display its panel on the right. The following figure shows an example for Server Configuration. The setting entry panel contains in the **SETTING** column the names of the settings, and the settings entry boxes are in the **PARAMETER** column. Hovering the mouse over a setting name displays a tool-tip showing the 61850 information model name of the setting or its location in SCL files.

Figure 5-9: Main IEC 61850 panel



Opening the IEC 61850 window while online causes the UR Setup software to retrieve and import an SCL file from the connected B90. This SCD file contains all the settings in the UR at the time of the file request, both those that are mapped into the IEC 61850 information model (that is, the "public" sections) and those that are not in the model (that is, the "private" section). The UR Setup software imports all of these settings into the current session, not just those in the IEC 61850 window. To avoid loss of any unsaved setting changes made in other panels during the current session, all other panels for the B90 must be closed before the IEC 61850 panel can be opened; the software prompts for this when applicable. Panels for other devices can be open concurrently to facilitate parameter coordination.

When CyberSentry is enabled, editable settings depend on role logged in. For example, an Administrator and Engineer can change settings. If prompted for a "Settings password," it means Administrator or Engineer password.

The **Restore** button restores settings in the window to their last saved values. The **Default** button reverts settings in the window to factory default values or Oscillography, Data Logger, or FlexLogic Equation Editor pre-configured values. The **Reset** button reverts all IEC 61850 settings to the factory default values, not just the current window. (In other settings windows, the button reverts settings in the window to factory default values.)

Create CID and settings files

When the **Save** button in the online IEC 61850 window is clicked, UR Setup software prepares a configured IED description (CID) file containing all the device's settings and sends the CID file to the connected B90. On receipt of a CID file, the B90 checks it for correctness, and if no error is found, reboots using the settings in the CID file. UR Setup displays a message when the B90 is running the new settings, confirming successful transfer. This process can take a minute or so due to the extensive amount of processing required by the software and the B90.

Certain settings not related to IEC 61850 are indicated in this manual as taking effect only when the device is restarted. The reboot following CID file transfer described in the previous paragraph does not make these setting changes take effect, as the B90 does not accept the setting change until after the CID file transfer reboot. For any change in the indicated settings to take effect, after the automatic restart due to CID file transfer, you must perform a manual restart, for example by executing the **Maintenance > Reboot Relay Command** in the software.

When the **Save** button in the offline IEC 61850 window is clicked, UR Setup software saves to local storage, for example the hard drive, a .urs file containing all of the device's settings.

Server configuration

The Server Configuration panel contains IEC 61850 settings relevant to the server functions of the IED implementation.

The path is **Settings > Product Setup > Communications > IEC 61850 > Server Configuration**.

The following settings are available, where <iedName> is a syntactic variable representing the present value of the IED NAME setting.

IED NAME

Range: 1 to 58 VisibleString characters

Default: TEMPLATE

The value entered sets the IED name used by IEC 61850 for the B90. An IED name unique within the network must be entered for proper operation. Valid characters are upper and lowercase letters, digits, and the underscore (_) character. The first character must be a letter.

The **IED NAME** and the **Product LD inst name** comprise the <LDName> for a product. LD inst are fixed, with the longest being "Master" and "System" at six characters. So the IED NAME needs to be restricted to 58 characters to meet a 64 character limit.

Master functional IdName

Range: 0 to 64 VisibleString characters

Default:

The Master logical device contains the UR logical nodes modelling communications and setting group control. Valid characters are upper and lowercase letters, digits, and the underscore (_) character. If the number of characters entered is greater than zero, this setting sets the name used in communications for the Master logical device. If an IdName is entered, a name unique within the network must be entered for proper operation. The standard recommends choosing this name according to IEC 81346-1. If the number of characters entered is zero, the name used in communications for the Master logical device is "<iedName>Master", where <iedName> is the value of setting **IED NAME** described earlier.

5



NOTE

Throughout the remainder of this section, <LDName> is a syntactic variable representing the present name of the master logical device. Depending on its context, <LDName> can be a product-related name or a function-related name. In SCL files, <LDName> is always the product-related name. In IEC 61850 messages, <LDName> is the function-related name if one is set by the Master functional IdName setting, otherwise <LDName> is again the product-related name. The product-related name of the Master logical device is "<iedName>Master". The function related name of the Master logical device is the value of the Master functional IdName setting.

System functional IdName

Range: 0 to 64 VisibleString characters

Default:

This setting is similar to setting **Master functional IdName**, but is for the System logical device, which contains the UR logical nodes modelling power system devices: breakers, switches, CTs, VTs, and so on, including interface to these such as AC inputs, contact I/O, transducer I/O, and HardFiber I/O.

Prot functional IdName

Range: 0 to 64 VisibleString characters

Default:

This setting is similar to setting **Master functional IdName**, but is for the Prot logical device instance, which contains the UR logical nodes modelling protection and protection related functions.

Ctrl functional IdName

Range: 0 to 64 VisibleString characters

Default:

This setting is similar to setting **Master functional IdName**, but is for the Ctrl logical device instance, which contains the UR logical nodes modelling control and monitoring functions.

Meter functional IdName

Range: 0 to 64 VisibleString characters

Default:

This setting is similar to setting **Master functional IdName**, but is for Meter the logical device instance, which contains the UR logical nodes modelling metering and measurement, including Signal Sources.

Gen functional ldName*Range: 0 to 64 VisibleString characters**Default:*

This setting is similar to setting **Master functional ldName**, but is for the Gen logical device instance, which contains the UR logical nodes modelling FlexLogic, Virtual Outputs, non-volatile latches, FlexElements, recording (for example oscillography), security, front panel, and clock.

Location*Range: 0 to 255 ASCII characters**Default: Location*

The value entered sets the value of the data attribute <LDName>/LPHD1.PhyNam.location. This data attribute is provided by the protocol to allow the user to declare where the equipment is installed.

Latitude*Range: -90.000 to 90.000 degrees in steps of 0.001 degree**Default: 0.000 deg*

The value entered sets the value of the data attribute <LDName>/LPHD1.PhyNam.latitude. This data attribute is provided by the protocol to allow the user to declare the geographical position of the device in WGS84 coordinates -latitude. Negative values indicate a southern latitude. WGS refers to the world geodetic system, which is used in global positioning systems (GPS), and 84 is the current version of the standard.

Longitude*Range: -180.000 to 180.000 degrees in steps of 0.001 degree**Default: 0.000 deg*

The value entered sets the value of the data attribute <LDName>/LPHD1.PhyNam.longitude. This data attribute is provided by the protocol to allow the user to declare the geographical position of the device in WGS84 coordinates - longitude. Negative values indicate a western longitude.

Altitude*Range: 0 to 10,0000 m in steps of 1 m**Default: 0 m*

The value entered sets the value of the data attribute <LDName>/LPHD1.PhyNam.altitude. This data attribute is provided by the protocol to allow the user to declare the geographical position of the device in WGS84 coordinates - altitude.

Prefix for GGIO1*Range for Edition 2: 0 to 11 VisibleString characters**Range for Edition 1: 0 to 6 VisibleString characters**Default:*

This setting sets the LN Prefix of the logical node GGIO1 that is described in the GGIO1 section later. Valid characters are upper and lowercase letters, digits, and the underscore (_) character. The first character must be a letter.

Prefix for GGIO2*Range for Edition 2: 0 to 11 VisibleString characters**Range for Edition 1: 0 to 6 VisibleString characters**Default:*

This setting sets the LN Prefix of logical node GGIO2 that is described in the GGIO2 section later. Valid characters are upper and lowercase letters, digits, and the underscore (_) character. The first character must be a letter.

Prefix for GGIO4*Range for Edition 2: 0 to 11 VisibleString characters**Range for Edition 1: 0 to 6 VisibleString characters**Default:*

This setting sets the LN Prefix of logical node GGIO4 that is described in the GGIO4 section later. Valid characters are upper and lowercase letters, digits, and the underscore (_) character. The first character must be a letter.

Master configRev*Range: 0 to 255 ASCII characters**Default:*

This data attribute is provided by the protocol to allow the user to declare changes to the semantic of the data model of the UR. The intent is that the user changes Master configRev each time that the semantic or data model changes, so that clients can readily detect the change. A semantic change is a logical node getting a new semantic use; for example, an instance of logical node CSWI is now serving a different physical switch, or an instance of a logical node PDIS is now used for another zone. A data model change is a change in the presence of logical nodes, data objects, data attributes, or instance names.

The scope of Maser configRev is the entire relay configuration as the Master logical device is the root logical device. Similar settings are provided for the other logical nodes; the scope of these other configRev settings is limited to the corresponding logical device configuration.

paramRev*Range: -2,147,483,648 to 2,147,483,647 in steps of 1**Default: 0*

This data attribute is provided by the protocol to make changes to the settings of the B90 apparent to clients. The Substation Configuration Tool and UR Setup software advance the value of paramRev each time any setting changes. The B90 increments the value of parmRev when a setting change is made other than through CID file download.

LLN0.Mod.ctlModel*Range: status-only, direct-with-normal-security, sbo-with-normal-security**Default: sbo-with-normal-security*

This setting specifies the control service that clients must use to control the TEST MODE FUNCTION of the B90. An "on" control to <LDName>/LLN0.Mod changes TEST MODE FUNCTION to Disabled, an "on-blocked" control changes it to Forcible, and a "test/blocked" changes it to Isolated.

IEC/MMS TCP PORT NUMBER*Range: 0 to 65535 in steps of 1**Default: 102*

This setting allows the user to change the TCP port number for Manufacturing Message Specification (MMS) connections. It is recommended that this setting be left at the default value.



NOTE

Do not set more than one protocol to the same TCP/UDP port number, as this results in unreliable operation of those protocols.

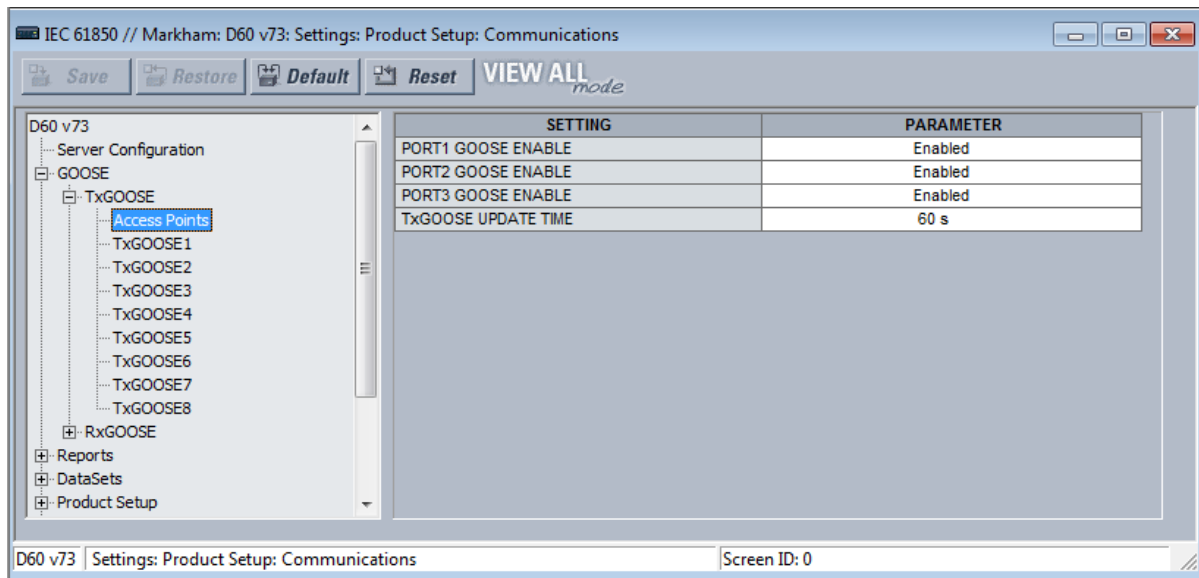
Configuration Type*Range: G2, E3-2.0**Default: G2*

This setting specifies the method used to describe GOOSE subscription configuration in SCL. See the UR Series Communications Guide for details. Basically, in the G2 mode, the CID file contains IED elements for IEDs subscribed to by this IED containing GOOSE subscription information. In the E3 2.0 mode, the CID file has only one IED element and GOOSE subscription information is coded in data objects in the standard LGOS logical node used to monitor reception of the subscribed GOOSE. UR 7.30 or later accepts either mode.

GOOSE

The path is **Settings > Product Setup > Communications > IEC 61850 > GOOSE**.

Figure 5-10: IEC 61850 TxGOOSE Access Points panel



Support for Routable GOOSE

Routable GOOSE (R-GOOSE) is supported in firmware releases 7.4 and later. Routable GOOSE allows UR and other devices to be located in separate networks. Encryption/decryption of messages is performed by a separate gateway device. Messages are routed using a separate router, using IP addresses.

Conversion can be required for R-GOOSE and GOOSE message exchange. Examples include the following:

- A v7.4 device can send an R-GOOSE message to another v7.4 device when both have R-GOOSE active as the protocol. No conversion is required.
- A v7.4 device can send a GOOSE message to another v7.4 device when both have GOOSE active as the protocol. No conversion is required.
- For a v7.4 device to send an R-GOOSE message to a v7.3 or v5.9 device, for example, a C30 Controller System with the GOOSE Protocol Converter (software option 99) is required to transform the R-GOOSE to GOOSE for the other devices
- Similarly, a device that sends GOOSE messages to a v7.4 device that is expecting R-GOOSE requires the C30 with the converter

See the GOOSE Protocol Converter section in firmware version 7.4 or later C30 instruction manual for more information.

TxGOOSE

IEC 61850 GOOSE is an efficient method for simultaneous high-speed delivery of a set of generic substation event information in a publishing physical device to more than one subscribing physical device. A TxGOOSE is a UR element implementing a single IEC 61850 GOOSE message publishing service. The subscribing function in URs is performed by RxGOOSE elements, as described in the next section. Each UR with IEC 61850 order code options has eight TxGOOSE elements. Each TxGOOSE element can publish the values of up to 64 attributes of the IEC 61850 nodes in the UR.

Published TxGOOSE messages configured in the EnerVista UR Setup software can be subscribed by and the published operand values understood by other UR devices. In fact, they can be subscribed to and understood by any device of any manufacturer that implements the IEC 61850 edition 1.0 or 2.0 GOOSE subscription mechanism. The messages are published with a multicast address so that the network sends the messages to all devices; any number of devices that want to subscribe can.

The entities whose values are published in GOOSE messages are known as members. The members are itemized in an ordered list known as a data set. Each TxGOOSE can use any one of the data sets provided. See the DataSets section later for details.

Each enabled TxGOOSE transmits its message whenever a value change is detected in one or more of its members. To guard against the possibility that such a message is lost in the network before it reaches all subscribers, the message is quickly retransmitted several times. To allow subscribers to verify that their link to the publisher and the publisher itself are healthy, each message is also periodically retransmitted even while the values are unchanging. These latter messages are known as heartbeat messages, while the former are known as event messages. Heartbeat messages also provide means for a subscriber newly online to receive the published values in the absence of an event.

TxGOOSE1 and TxGOOSE2 scan for value changes in its FlexLogic operand members as frequently as such a change can occur. TxGOOSE1 and TxGOOSE2 are therefore suitable for highly time critical signals, such as tripping and dynamic blocking. FlexAnalog members are scanned for value changes only every 250 ms. See the Deadband Settings section later for a description of what is considered a value change in an analog member.

The remaining TxGOOSE, meaning TxGOOSE3 and up, scan both their FlexLogic and FlexAnalog members for value changes every 250 ms. They are suited for control applications, such as voltage control or power factor regulation.

The details of TxGOOSE message construction are contained in the UR Series Communications Guide. Knowledge of these details is not required to configure GOOSE.

The UR does not implement the Fixed-Length encoded GOOSE messages option specified in IEC 61850-8-1:2011 clause A.3; the UR always uses the ASN.1 Basic encoding rules (as specified in ISO/IEC 8825-1) as specified in IEC 61850-8-1:2004 and as optional in IEC 61850-8-1:2011 clause A.3. So do not try to configure the UR for fixed-offset TxGOOSE.

TxGOOSE

Navigate to **Settings > Product Setup > Communications > IEC 61850 > GOOSE > TxGOOSE > Access Points** to access the settings that are common to all GOOSE messages published.

The following settings are available.

PORT1 GOOSE ENABLE

Range: Enabled, Disabled

Default: Enabled

When set to Disabled, no GOOSE messages are published on B90 Ethernet port 1, and any GOOSE messages received on port 1 are ignored. When set to Enabled, all enabled GOOSE messages are published on B90 Ethernet port 1, and any GOOSE messages received on port 1 are listened to.

B90 Ethernet ports 2 and 3 each have a similar setting.

TxGOOSE UPDATE TIME

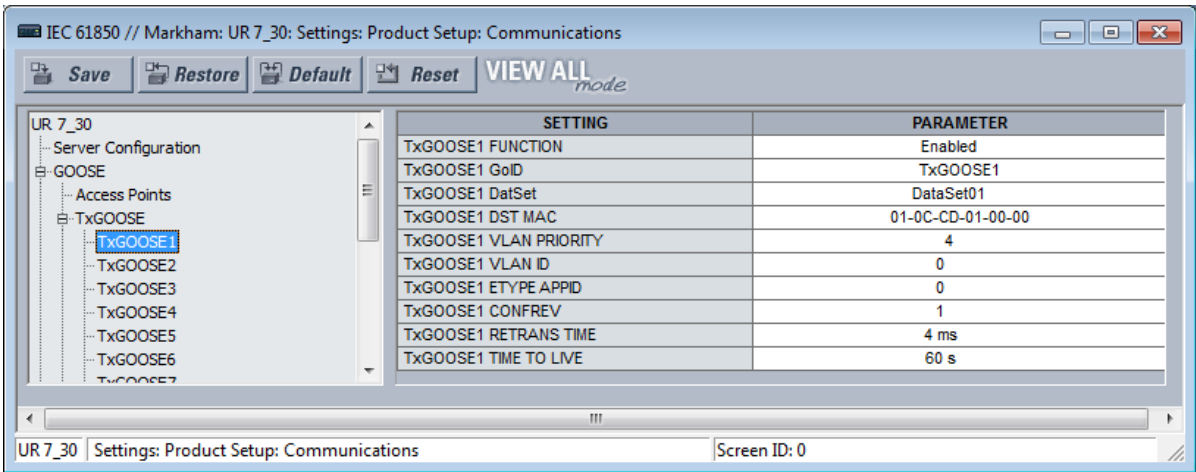
Range: 1 to 60 s in steps of 1 s

Default: 60 s

This setting specifies the time interval between heartbeat messages, which are messages that are sent periodically while no events are detected. The standard suggests that the heartbeat time be less than (actually half) of the timeAllowedtoLive parameter, which is set by the **TxGOOSE TIME TO LIVE** settings described later.

Navigate to **Settings > Product Setup > Communications > IEC 61850 > GOOSE > TxGOOSE > TxGOOSE1** to access the settings for the first TxGOOSE. The settings and functionality for the others are similar.

Figure 5-11: IEC 61850 TxGOOSE panel



TxGOOSE1 FUNCTION

Range: Enabled, Disabled
Default: Enabled

When set to Disabled, TxGOOSE1 messages are not published. When set to Enabled, TxGOOSE1 messages are published. When TxGOOSE1 to 8 are set to Disabled in EnerVista and subsequently Enabled by writing via MMS, the panel continues to read Disabled until relaunched. There is no polling capability to update automatically the IEC 61860 readings, so the panel needs to be closed then opened for the correct status to display.

TxGOOSE1 GoID

Range for Edition 2: 0 to 129 VisibleString characters
Range for Edition 1: 0 to 65 VisibleString characters
Default: TxGOOSE1

The entered value sets the goID value published in TxGOOSE1 messages, and can be used by subscribers to discriminate the TxGOOSE1 messages from other GOOSE messages.

TxGOOSE1 DataSet

Range: None, DataSet01, DataSet02,...
Default: None

This setting selects the published data set using the UR Setup software designator for the data set. The IEC 61850 name of the data sets are configured in the Datasets panel, as described later.

An ObjectReference to the data set, which consists of the concatenation of the string "<LDName>/LLN0." and the data set name, is published in the dataSet field of TxGOOSE1 messages and can be used by subscribers to discriminate TxGOOSE1 messages from other GOOSE messages.

TxGOOSE1 DST MAC

Range: any 12 digit hexadecimal number
Default: 01-0C-CD-01-00-00

The value entered sets the Ethernet destination Media Access Control (MAC) address in published TxGOOSE1 messages. As the standard requires that the address have the multicast bit set TRUE, that is to say the second digit is set to an odd number, messages transmitted have the multicast bit set TRUE no matter its value in this setting.

The destination MAC address can be used by the network to restrict message delivery to selected devices that need to receive them, reducing network loading. This address also can be used by hardware in receiving devices to filter out messages that are of no interest to them, reducing processor burden. Different filtering algorithms are implemented by different devices. The standard recommends that the algorithm used by hardware of the receiving device be considered when assigning destination multicast addresses.

Subscribers can use this address to discriminate TxGOOSE1 messages from other GOOSE messages.

TxGOOSE1 VLAN PRIORITY

Range: 0, 1, 2, 3, 4, 5, 6, 7, 5-4, 6-4, 6-5, 7-4, 7-5, 7-6

Default: 4

When the value entered is 0, 1, 2, 3, 4, 5, 6, or 7, the User Priority value in the IEEE 802.1Q VLAN tag included in published TxGOOSE1 messages is set to that value. When one of the two-digit values is entered, the dynamic priority feature is selected: the first event message has the User Priority value of the first digit, and User Priority is decremented in each following message until reaching the value of the second digit. For instance, if the selected value is 7-5, then the User Priority values in successive messages beginning with the message triggered by an event is 7, 6, 5, 5, 5, 5, 5, and so on. Do not make a dynamic priority selection when standard behavior is required.

Network devices can forward a message with a higher priority value before a message with a lower priority value, which speeds delivery of high priority messages in heavily loaded networks. The standard recommends that higher priority messages, such as GOOSE, have priority values in the range of 4 to 7.

TxGOOSE1 VLAN ID

Range: 0 to 4095 in steps of 1

Default: 0

The value entered sets the VID value in the IEEE 802.1Q VLAN tag included in published TxGOOSE1 messages. VID can be used by network devices to direct messages to only selected devices, reducing network burden. VID values of 0 and 1 are assigned by IEEE 802.1Q to other functions and are not to be used for GOOSE.

TxGOOSE1 ETYPE APPID

Range: 0 to 65535 in steps of 1

Default: 0

The value entered sets the APPID value in published GOOSE messages and can be used by subscribers to discriminate TxGOOSE1 messages from other GOOSE messages.

The standard reserves the value range 0 to 16383 for GOOSE Type 1 (Fast messages), and reserves the value range 32768 to 41151 for GOOSE Type 1A (Trip messages). Some subscribers can process messages in the Type 1A range faster than messages in the Type 1 range. The standard reserves the default value (0) to indicate lack of configuration. The standard strongly recommends unique, source-orientated APPIDs within a given system.

TxGOOSE1 ConfRev

Range: 0 to 4294967295 in steps of 1

Default: 1

The value entered sets the confRev value in published GOOSE messages, and can be used by subscribers to discriminate TxGOOSE messages of the expected configuration revision from messages of a different revision. The standard requires that confRev be incremented each time the members or the order of the members published is changed, and each time the data set name is changed. The standard states that the value of 0 is reserved.

TxGOOSE1 RETRANS TIME

Range: 0 to 100 ms in steps of 1 ms

Default: 4 ms

If the entered time is non-zero, when a member value change is detected, four event transmissions are sent, then heartbeat transmissions resume. The interval between the first and second event transmissions, and between the second and third, is the time set here. The interval between the third and the fourth event transmission is double the set time. If the entered time is zero, only a single event transmission occurs, then heartbeat transmissions resume.

TxGOOSE1 TIME TO LIVE

Range: 1 to 300 s in steps of 1 s

Default: 300 s

The value entered sets the timeAllowedtoLive value in published TxGOOSE1 messages. The standard requires subscribers to assume a failure has occurred when another TxGOOSE1 message is not received within the published timeAllowedtoLive time.

Base this setting on the **TxGOOSE UPDATE TIME** and the tolerable number of contiguous message delivery misses. For example, if the heartbeat time is 10 s, and missing up to three successive messages is tolerable, make the setting $10 \times 3 + 1 = 31$ s. The extra second is to ensure that arrival of the third heartbeat transmission beats the timeAllowedtoLive timer. The standard suggests that the heartbeat time be less than (actually half) of the timeAllowedtoLive parameter.

RxGOOSE

Navigate to **Settings > Product Setup > Communications > IEC 61850 > GOOSE > RxGOOSE > RxGOOSE Messages**.

IEC 61850, GOOSE is an efficient method for simultaneous high-speed delivery of the same generic substation event information in a publishing physical device to more than one subscribing physical device. An RxGOOSE is a UR element implementing a single IEC 61850 GOOSE message subscribing service. The publishing function in URs is performed by TxGOOSE elements, as described in the previous section. Each B90 has 16 RxGOOSE elements. Each RxGOOSE element can subscribe to GOOSE messages from a specified publisher. Subscribed messages can contain up to 64 of any set of data attributes with basic types BOOLEAN, FLOAT32, INT32, Dbpos, TimeStamp, or Quality. Messages containing data objects, that is to say structured data, are not accepted.

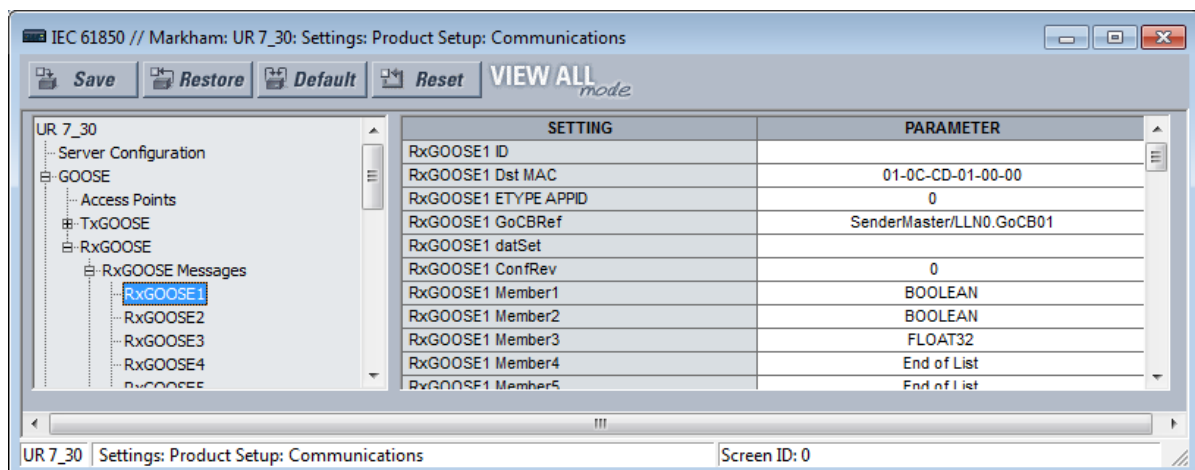
With these conditions, GOOSE messages from any device of any manufacturer that implements the IEC 61850 edition 1.0 or 2.0 GOOSE publish service can be subscribed to. The UR accepts both the variable-length encoded GOOSE messages specified in IEC 61850-8-1:2004 and the Fixed-Length encoded GOOSE messages as specified in IEC 61850-8-1:2011 clause A.3.

Each enabled RxGOOSE monitors for interruption of the GOOSE messages that it subscribes to based on the value in the timeAllowedtoLive field of the last message received. If a new message is not received within that time interval, the RxGOOSE assumes that connectivity is lost. FlexLogic operands (for example, RxGOOSE1 On, RxGOOSE1 Off) reflect the status of each RxGOOSE connectivity. RxGOOSE connectivity of an RxGOOSE with non-zero MAC address is also considered lost after the B90 finishes restart until a message is received. When RxGOOSE connectivity is lost, a common RxGOOSE Fail self-test activates.

Navigate to **Settings > Product Setup > Communications > IEC 61850 > GOOSE > RxGOOSE > RxGOOSE Messages > RxGOOSE1** to access the settings that specify the messages to be accepted by the first RxGOOSE element. Messages that contain the value true in the ndsCom field are never accepted. Messages that contain the value true in the simulation field (test field in edition 1.0 messages) are accepted only when the UR test mode is Forcible or Isolated; see the Testing section at the end of this chapter for details. The settings and functionality for the other RxGOOSE are similar.

Navigate to **Settings > Product Setup > Communications > IEC 61850 > GOOSE > RxGOOSE > RxGOOSE Messages > RxGOOSE1**. The following settings are available.

Figure 5-12: IEC 61850 RxGOOSE Messages panel



RxGOOSE1 ID

Range: 0 to 129 VisibleString characters

Default:

If the value entered has one or more characters, the gold field of incoming GOOSE messages must exactly match this value for the message to be accepted as a valid RxGOOSE1 message. If the entered value is the empty string, RxGOOSE1 does not check the value received in the gold field.

RxGOOSE1 Dst MAC

Range: any 12 digit hexadecimal number

Default: 00-00-00-00-00-00

Set this setting to the MAC address of the publisher. Only received GOOSE messages having a Media Access Control (MAC) address equal to this value are accepted as valid RxGOOSE1 messages. An entered address of zero disables RxGOOSE1.

If the publisher is a UR Series 7.3x device, the setting needs to match the value of the publisher's **TxGOOSE Dst MAC** setting.

RxGOOSE1 ETYPE APPID

Range: 0 to 65535 in steps of 1

Default: 0

If the value entered is non-zero, the APPID field of incoming GOOSE messages must exactly match this value for the message to be accepted as a valid RxGOOSE1 message. If the value entered is zero, RxGOOSE1 does not check the value received in the APPID field.

If the publisher is a UR Series 7.3x device, the setting needs to match the value of the publisher's **TxGOOSE ETYPE APPID** setting.

RxGOOSE1 GoCRef

Range for Edition 2: 0 to 129 alphanumeric, underscore, slash and period characters, beginning with an alpha character

Range for Edition 1: 0 up to 65 alphanumeric, underscore, slash and period characters, beginning with an alpha character

Default:

The gocbRef field of incoming GOOSE messages must match this value for the message to be accepted as a valid RxGOOSE1 message. If the entered value is the empty string, RxGOOSE1 is disabled. If not the empty string, the entry needs to be an ACSI ObjectReference to the publishing control block in the format:

<LDName>/LLN0.<GoCBName>

where <LDName> is the function-related name if the logical device containing the publishing control block has "ldName" configured, otherwise the product-related name of that logical device, and <GoCBName> is the name of the publishing control block.

The B90 translates the ACSI format required for this setting to the MMS format used in GOOSE messages:

<LDName>/LLN0\$GO\$<GoCBName>

If the publisher is a UR 7.3x series device, <LDName> is the value of the publisher's Master functional ldName setting if that setting is not empty, otherwise it is the value of the publisher's IED NAME suffixed with "Master". If the publisher is a UR 7.3x series device, <GoCBName> is "GoCB" suffixed with the two digit TxGOOSE instance number, for example "GoCB01".

RxGOOSE1 datSet

Range for Edition 2: 0 to 32 alphanumeric and underscore characters, beginning with an alpha character

Range for Edition 1: 0 to 32 alphanumeric and underscore characters, beginning with an alpha character

Default:

If the entered value has one or more characters, the datSet field of incoming GOOSE messages must exactly match this value prefixed by <LDName>/LLN0\$ for the message to be accepted as a valid RxGOOSE1 message. <LDName> is as specified in the RxGOOSE GoCRef setting above. If the entered value is the empty string, RxGOOSE1 does not check the value received in the datSet field.

If the publisher is a UR 7.3x series device, set this setting to the value of the publisher's DataSetxx name setting, where xx is the instance number of the data set selected by the publisher's **TxGOOSE datSet** setting.

RxGOOSE1 ConfRev

Range: 0 to 4294967295 in steps of 1

Default: 1

If the value entered is non-zero, the confRev field of incoming GOOSE messages must exactly match this value for the message to be accepted as a valid RxGOOSE1 message. If the entered value is zero, RxGOOSE1 does not check the value received in the confRev field.

If the publisher is a UR 7.3x series device, set this setting to match the value of the publisher's **TxGOOSE ConfRev** setting.

RxGOOSE1 Member 1

Range: End of List, BOOLEAN, Dbpos (DPS), FLOAT32, INT32, Quality, TimeStamp

Default: End of List

This setting specifies the type that the first member of incoming GOOSE messages must be for the message to be accepted as a valid RxGOOSE1 message. There are similar settings for each of the members that the UR is able to subscribe to in a given GOOSE message. The member before the first member setting set to "End of List" must be the last member of the message for the message to be accepted as a valid RxGOOSE1 message.

If the publisher is a UR 7.3x series device, set these settings to match the basic type of the members of the publisher's data set selected by the publisher's **TxGOOSE dataSet** setting.

RxGOOSE inputs

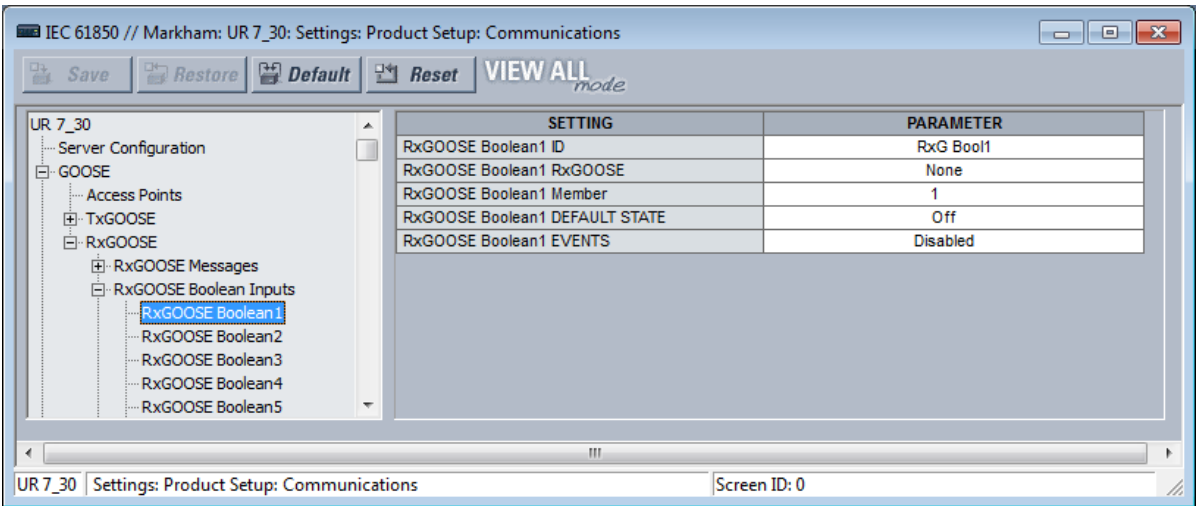
The values received by RxGOOSE elements need to be converted to FlexLogic or FlexAnalog operands so that they can be used by other UR elements. This conversion is done by RxGOOSE Boolean, RxGOOSE DPS, and RxGOOSE Analog elements. Each RxGOOSE Boolean can convert the value of a specified Boolean member received by a specified RxGOOSE to a FlexLogic operand. Each RxGOOSE DPS can convert the value of a specified Dbpos (Double bit position) member to four FlexLogic operands, one for each of the four possible Dbpos states. Each RxGOOSE Analog can convert the value of a specified FLOAT32 member to a FlexAnalog operand. Each of these operands reverts to its default state when the RxGOOSE connectivity is lost. INT32, Quality, and TimeStamp members cannot be converted to operands, and thus although they can be accepted in GOOSE messages, they have no effect on the UR.

RxGOOSE Boolean, RxGOOSE DPS, and RxGOOSE Analog elements are mapped to various data objects in <iedName>Master/GGIO3. This is to allow reading of their values via MMS and to allow references to them in SCL files. GGIO3 has no settings, nor is it visible via UR Setup software. See the UR Communications Guide for more information on GGIO3.

RxGOOSE Boolean inputs

Navigate to **Settings > Product Setup > Communications > IEC 61850 > GOOSE > RxGOOSE > RxGOOSE Boolean Inputs > RxGOOSE Boolean1** to access the settings for the first RxGOOSE Boolean. The settings and functionality for the others are similar.

Figure 5-13: RxGOOSE Boolean panel



RxGOOSE Boolean1 ID

Range: 0 to 12 characters
Default: RxG Bool1

This setting allows the user to assign descriptive text to the name of the RxGOOSE Boolean1 FlexLogic operand. The full operand name is the value of this setting appended with " On". This descriptive text also appears in the SCL files associated with the UR.

RxGOOSE Boolean1 RxGOOSE

Range: None, RxGOOSE1, RxGOOSE2, and so on
Default: None

This setting selects the RxGOOSE containing the value that drives the RxGOOSE Boolean1 FlexLogic operand. If set to None, the RxGOOSE Boolean1 FlexLogic operand assumes its default state.

RxGOOSE Boolean1 Member

Range: 1 to 64 in steps of 1
Default: 1

This setting selects the GOOSE message member that drives the RxGOOSE Boolean1 FlexLogic operand. A setting of 1 selects the first member, 2 selects the second member, and so on. Entering a number greater than the number of members in the message and entering the number of a member that is not a BOOLEAN results in the RxGOOSE Boolean1 FlexLogic operand assuming its default state.

RxGOOSE Boolean1 DEFAULT STATE

Range: On, Off, Latest/On, Latest/Off
Default: On

This setting selects the logic state for the RxGOOSE Boolean1 FlexLogic operand if the UR has just completed startup and the selected RxGOOSE has not yet received a message, or the selected RxGOOSE has lost its connectivity with the publisher. The following choices are available:

- "On" value defaults the input to logic 1
- "Off" value defaults the input to logic 0
- "Latest/On" freezes the input in case of lost connectivity. If the latest state is unknown, such as after UR power-up but before the first communication, the input defaults to logic 1. When communication resumes, the input becomes fully operational.
- "Latest/Off" freezes the input in case of lost connectivity. If the latest state is unknown, such as after UR power-up but before the first communication, the input defaults to logic 0. When communication resumes, the input becomes fully operational.

RxGOOSE Boolean1 EVENTS

Range: Disabled, Enabled

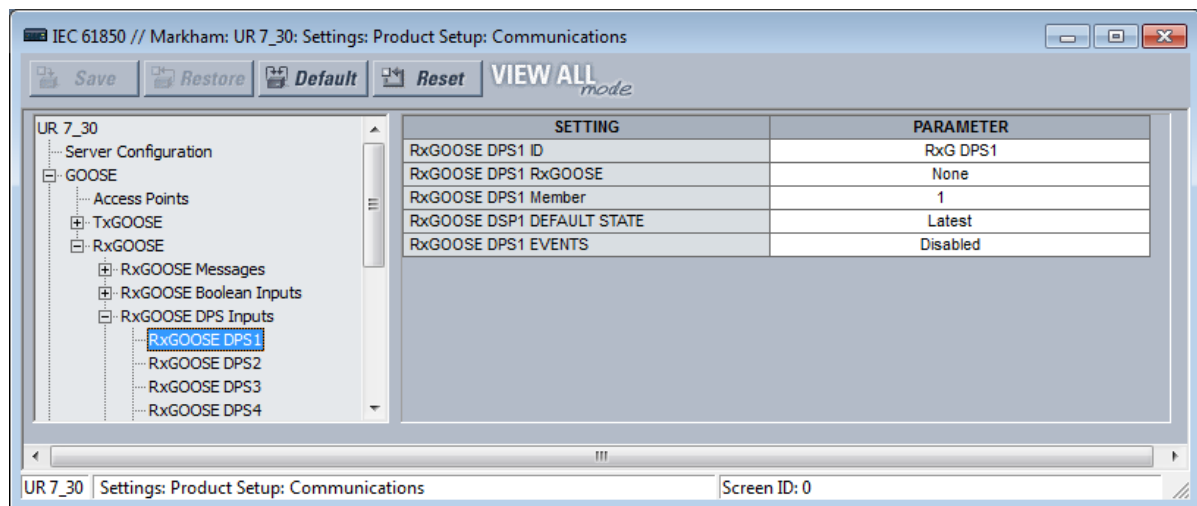
Default: Disabled

This setting selects whether Off to On transitions of the RxGOOSE Boolean1 FlexLogic operand are recorded by the event recorder. If set to Enabled, Off to On transitions are recorded. On to Off transitions are not recorded, even if events are enabled.

RxGOOSE DPS inputs

Navigate to **Settings > Product Setup > Communications > IEC 618560 > GOOSE > RxGOOSE > RxGOOSE DPS Inputs > RxGOOSE DPS1** to access the settings for the first RxGOOSE Boolean. The settings and functionality for the others are similar.

Figure 5-14: RxGOOSE DPS Inputs panel

**RxGOOSE DPS1 ID**

Range: 0 to 12 characters

Default: RxG DPS1

This setting allows the user to assign descriptive text to the names of the four RxGOOSE DPS1 FlexLogic operands. The full operand name is the value of this setting appended with "Intermediate," "On," "Off," or "Bad." This descriptive text also appears in the SCL files associated with the B90.

RxGOOSE DPS1 RxGOOSE

Range: None, RxGOOSE1, RxGOOSE2, and so on

Default: None

This setting selects the RxGOOSE containing the value that drives the RxGOOSE DPS1 FlexLogic operand. If set to None, the RxGOOSE DPS1 FlexLogic operand assumes its default state.

RxGOOSE DPS1 Member

Range: 1 to 64 in steps of 1

Default: 1

This setting selects the GOOSE message member that drives the RxGOOSE DPS1 FlexLogic operand. A setting of 1 selects the first member, 2 selects the second member, and so on. Entering a number greater than the number of members in the message and entering the number of a member that is not a Dbpos results in the RxGOOSE DPS1 FlexLogic operand assuming its default state.

RxGOOSE DPS1 DEFAULT STATE

Range: intermediate-state, off, on, bad-state, Latest
Default: Latest

This setting selects the logic state for the data attribute @Master/GGIO3.IndPos01.stVal when the UR has just completed start-up and the selected RxGOOSE has not yet received a message, and when the RxGOOSE has lost its connectivity with the publisher. When this setting is selected to Latest, the value of @Master/GGIO3.IndPosψ.stVal is intermediate-state when the UR has just completed start-up and the selected RxGOOSE has not yet received a message, and the latest received value when the RxGOOSE loses its connectivity with the publisher.

RxGOOSE DPS1 EVENTS

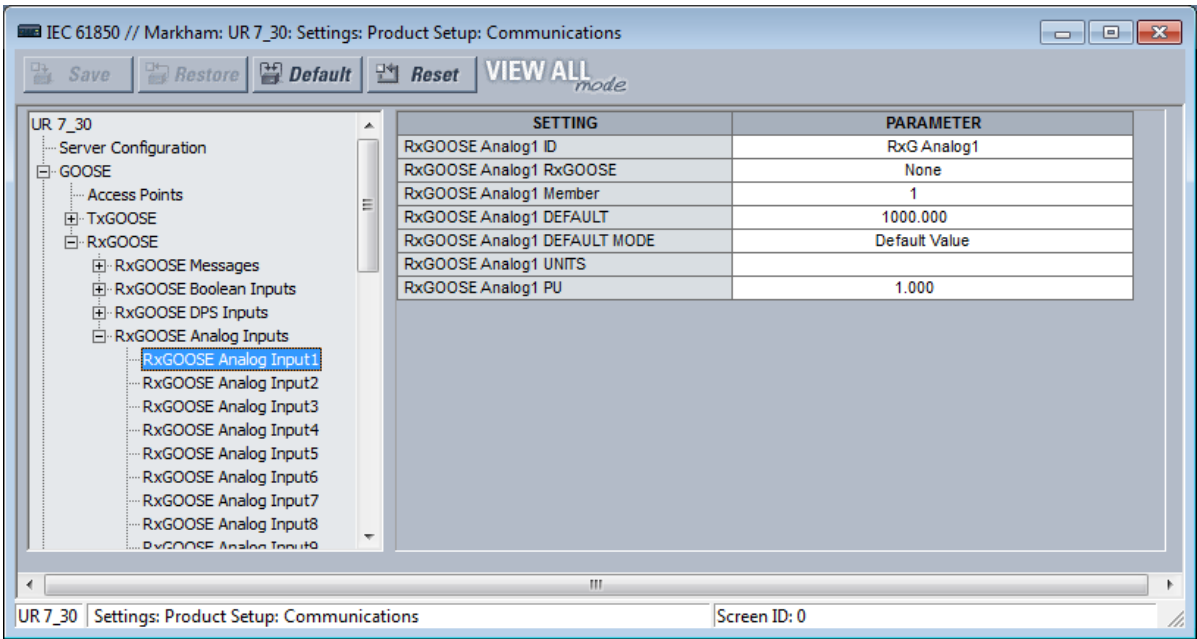
Range: Disabled, Enabled
Default: Disabled

This setting selects whether Off to On transitions of the RxGOOSE DPS1 FlexLogic operands are recorded by the event recorder. If set to Enabled, Off to On transitions are recorded. On to Off transitions are not recorded, even if events are enabled.

RxGOOSE analog inputs

Navigate to **Settings > Product Setup > Communications > IEC 61850 > GOOSE > RxGOOSE > RxGOOSE Analog Inputs > RxGOOSE Analog Input1** to access the settings for the first RxGOOSE Boolean. The settings and functionality for the others are similar.

Figure 5-15: RxGOOSE Analog Inputs panel



RxGOOSE Analog1 ID

Range: 0 to 12 characters
Default: RxG Analog1

This setting allows the user to assign descriptive text to RxGOOSE Analog1. This descriptive text also appears in the SCL files associated with the B90. Unlike RxGOOSE Booleans and RxGOOSE DPS, the RxGOOSE Analog operands have fixed names, for example RxGOOSE Analog1.

RxGOOSE Analog1 RxGOOSE

Range: None, RxGOOSE1, RxGOOSE2, and so on

Default: None

This setting selects the RxGOOSE containing the value that drives the RxGOOSE Analog1 FlexAnalog operand. If set to None, the RxGOOSE Analog1 FlexAnalog operand assumes its default state.

RxGOOSE Analog1 Member

Range: 1 to 64 in steps of 1

Default: 1

This setting selects the GOOSE message member that drives the RxGOOSE Analog1 FlexAnalog operand. A setting of 1 selects the first member, 2 selects the second member, and so on. Entering a number greater than the number of members in the message and entering the number of a member that is not a FLOAT32 results in the RxGOOSE Analog1 FlexAnalog operand assuming its default state.

RxGOOSE Analog1 DEFAULT

Range: -1000000.000 to 1000000.000 in steps of 0.001

Default: 1000.000

This setting specifies the value of the GOOSE analog input when the selected RxGOOSE has lost its connectivity with the publisher and the RxGOOSE Analog1 DEFAULT MODE is set to "Default Value." Otherwise this setting has no effect. This setting is stored as an IEEE 754 / IEC 60559 floating point number. Because of the large range of this setting, not all possible values can be stored. Some values can be rounded to the closest possible floating point number.

RxGOOSE Analog1 DEFAULT MODE

Range: Default Value, Last Known

Default: Default Value

When the selected RxGOOSE has lost its connectivity with the publisher and this setting is "Last Known," the value of the RxGOOSE Analog1 FlexLogic operand remains at the last received value. When the selected RxGOOSE has lost its connectivity with the publisher and this setting value is "Default Value," then the RxGOOSE Analog1 FlexLogic operand is defined by the RxGOOSE Analog1 DEFAULT setting. After restart, until a message is received, the operand value is the default value.

RxGOOSE Analog1 UNITS

Range: up to 4 characters

Default:

This setting specifies a four-character string that can be used in the actual values display of RxGOOSE Analog1.

RxGOOSE Analogs are floating-point values, with no units. The RxGOOSE UNIT and PU base settings allow the user to configure RxGOOSE Analog, so that it can be used in a FlexElement.

RxGOOSE Analogs that represent current, voltage, power, frequency, angles, or power factor can be used in a FlexElement. The following text must be used in the UNITS setting, to represent these types of analogs: A, V, W, var, VA, Hz, deg, and no text (blank setting) for power factor.

RxGOOSE Analogs can be compared to other RxGOOSE Analogs with any character string or no string.

RxGOOSE Analog1 PU

Range: 0.000 to 1000000000.000 in steps of 0.001

Default: 1.000

This setting specifies the per-unit base value for other B90 features to use with the RxGOOSE Analog1 operand. A FlexElement for instance subtracts two quantities after converting their values to integers rescaled to a common base, the common base being the largest of the base values of the two quantities. If one of quantities is RxGOOSE Analog1 and its per-unit base value is not appropriate, the rescaling operation can result in unnecessary loss of precision or overflow in the integer result. The FlexElement Base Units table in the Settings > FlexLogic > FlexElements section later, which tabulates the per-unit base value used by its pickup setting and implies the per-unit base used by other FlexAnalog, can be of use in selecting a value for the **RxGOOSE Analog1 PU** setting.

Some UR elements have requirements for the type of input operands, for instance current type or voltage type. These elements assume that RxGOOSE Analog operands are of whatever type is necessary to meet these requirements.

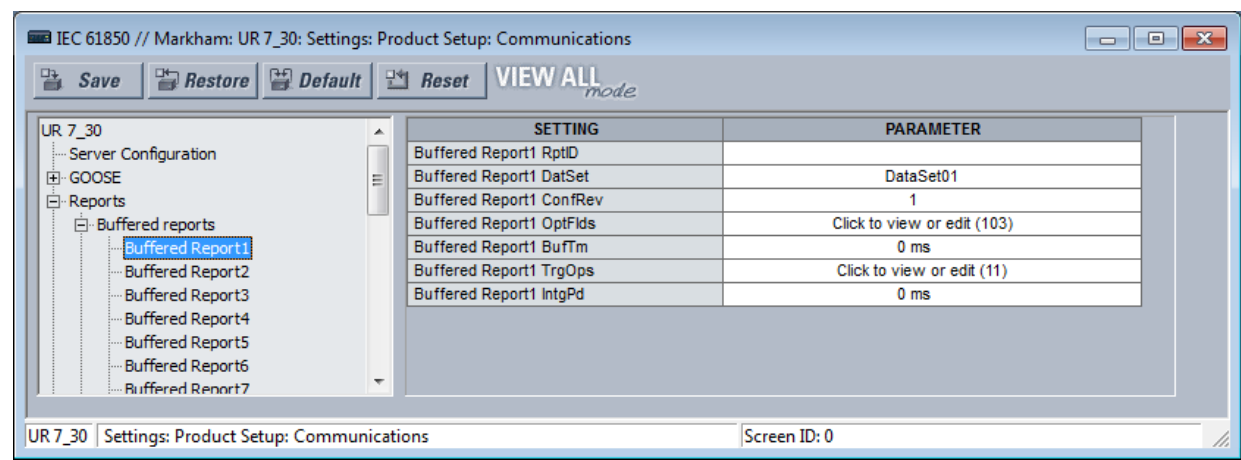
The per-unit base setting represents thousands, not single units. For example, a PU base of 1.000 is actually 1000 and a PU base of 0.001 is 1.

When using RxGOOSE Analogs and PU base in FlexElements, the largest value that can be displayed in the FlexElement actual values is 2,140,000.000.

Reports

Navigate to **Settings > Product Setup > Communications > IEC 61850 > Reports**.

Figure 5-16: IEC 61850 buffered report panel



5

An IEC 61850 Report server is an efficient method for delivery of generic substation event information in a single server to a single client, such as a supervisory control IED. A Configurable Report is a UR element implementing an IEC 61850 Report server, either of the buffered or unbuffered kind. The following table lists the number of Configurable Report elements. Each Configurable Report element can report the values of up to 64 FlexLogic or FlexAnalog operands. Buffered report elements queue value changes that occur while the client is offline and delivered when the client re-connects. Up to 512 events can be queued. Unbuffered control blocks purge all value change events when the connection to the client is lost; any events that occur while the client is not connected are lost.

Table 5-10: Number of report elements

	Number
Buffered reports	20
Unbuffered reports	14

Configurable Reports interoperate with any client device of any manufacturer that conforms to the IEC 61850 edition 1.0 or 2.0 report client requirements.

The entities whose values are reported by a Configurable Report are known as members. The members are itemized in an ordered list known as a data set. Each Configurable Report can use any one of the data sets provided.

Each enabled Configurable Report transmits an update to its client whenever a value change is detected in one or more of its members. Also, the control block can be configured to send integrity reports containing the present value of all members either on demand from the client or periodically. A TCP handshaking mechanism causes messages that are not read and acknowledged by the client to be retransmitted.

For a Configurable Report to operate, its members must be selected (that is, its data set configured) and a client must open a connection to, configure, and enable its report control block. Control blocks and data sets can be pre-configured by sending the B90 a CID file. See the UR Series Communications Guide for details. EnerVista UR Setup also can be used to select the data set members and to pre-configure the control blocks.

Each buffered report has the following settings.

Buffered Report1 RptID

Range: 0 to 129 VisibleString characters
Default: empty string

The name of the report. The entered value sets the RptID value in Buffered Report1 messages, and it can be used by the client to discriminate Buffered Report1 messages from other messages. If the number of characters entered is zero, the value used for RptID in messages is an ObjectReference to the report's control block, that is, "<LDName>/LLN0\$BR\$BRCB01".

Buffered Report1 DataSet

Range: None, DataSet01, DataSet02, ...
Default: None

This setting selects the data set whose members' status is reported in Buffered Report1 messages using the UR Setup software designator for the data set. The IEC 61850 name of the data sets are configured in the Datasets panel, as described later.

An ObjectReference to the data set, which consists of the concatenation of the string "<LDName>/LLN0\$" and the data set name, is used in the datSet field of report messages, and it can be used by the client to discriminate Buffered Report1 messages from other messages.

Buffered Report1 ConfRev

Range: 0 to 4294967295 in steps of 1
Default: 1

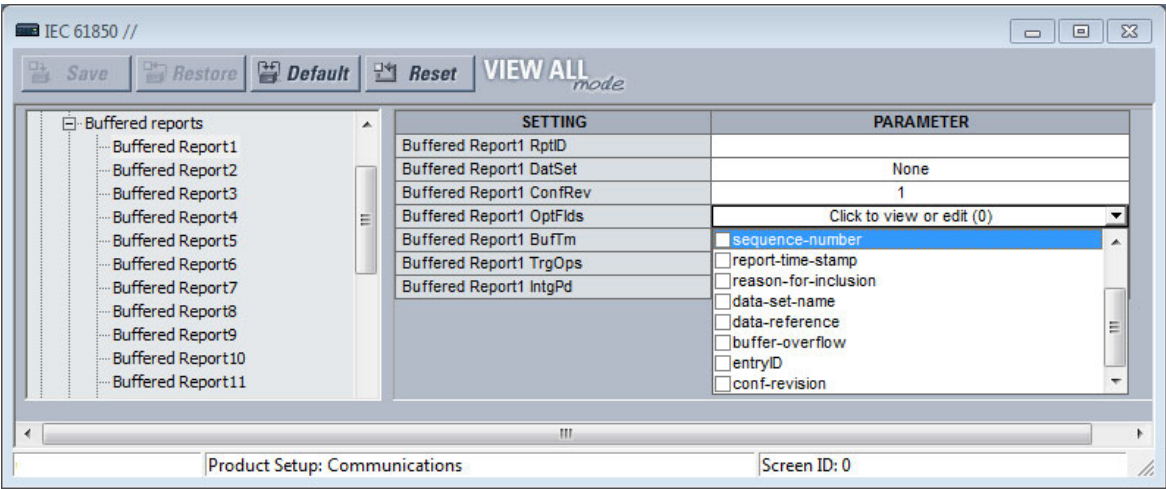
The entered value sets the confRev value in Buffered Report1 messages, and it can be used by clients to discriminate report messages of the expected configuration revision from messages of a different revision. The standard requires that confRef be incremented each time the members or the order of the members is changed, and each time the data set name is changed. The standard states that the value of 0 is reserved.

Buffered Report1 OptFlds

Range: The check box for each individual bit can be enabled or not (see figure)
Default: All bits true

The OptFlds setting is bitstring that controls which of the optional fields are included in report messages. The figure shows the available option bits.

Figure 5-17: Options for buffered report messages



Buffered Report1 BufTm

Range: 0 to 4294967295 in steps of 1
Default: 0

The entered value sets the time interval in milliseconds for the buffering of events for inclusion in a single report.

Buffered Report1 TrgOps

Range: The check box for an individual bit can be enabled or not

Default: All bits true

The TrgOps setting is bitstring that controls which trigger conditions are monitored in this report. The options are as follows:

- data-change
- quality-change
- integrity
- general interrogation

Buffered Report1 IntgPd

Range: 0 to 4294967295 in steps of 1

Default: 0

The entered value sets the period in milliseconds for generating Buffered Report1 integrity reports. An integrity report includes the values of all members of the referenced data set, whether a change has occurred or not.

Each unbuffered report has the following settings.

Unbuffered Report1 RptID

Range: 0 to 129 VisibleString characters

Default:

The name of the report. The entered value sets the RptID value in Unbuffered Report1 messages, and it can be used by the client to discriminate Unbuffered Report1 messages from other messages. If the number of characters entered is zero, the value used for RptID in messages is an ObjectReference to the report's control block, that is, "<LDName>/LLN0\$RP\$\"URCB01\"".

Unbuffered Report1 DatSet

Range: None, DataSet01, DataSet02, ...

Default: None

This setting selects the data set whose members' status is reported in Unbuffered Report1 messages using the UR Setup software designator for the data set. The IEC 61850 name of the data sets are configured in the Datasets panel, as described later.

An ObjectReference to the data set, which consists of the concatenation of the string "<LDName>/LLN0\$" and the data set name, is used in the datSet field of report messages, and it can be used by the client to discriminate Unbuffered Report1 messages from other messages.

Unbuffered Report1 ConfRev

Range: 0 to 4294967295 in steps of 1

Default: 0

The entered value sets the confRev value in Unbuffered Report1 messages, and it can be used by clients to discriminate report messages of the expected configuration revision from messages of a different revision. The standard requires that confRef be incremented each time the members or the order of the members is changed, and each time the data set name is changed.

Unbuffered Report1 OptFlds

Range: The check box for an individual bit can be enabled or not

Default: All bits true

The OptFlds setting is bitstring that controls which of the optional fields are included in report messages. The options are as follows:

- sequence-number
- report-time-stamp
- reason-for-inclusion
- data-set-name

- data-reference
- conf-revision

Notice that OptFlds bits buffer-overflow and entryID are not applicable to unbuffered reports even though the bits exist in the protocol. They are therefore labelled N/A (not applicable) on the display.

Unbuffered Report1 BufTm

Range: 0 to 4294967295 in steps of 1

Default: 0

The entered value sets the time interval in milliseconds for the buffering of events for inclusion into a single report.

Unbuffered Report1 TrgOps

Range: The check box for an individual bit can be enabled or not

Default: All bits true

The TrgOps setting is bitstring that controls which trigger conditions are monitored in this report. The options are as follows:

- data-change
- quality-change
- integrity
- general interrogation

Unbuffered Report1 IntgPd

Range: 0 to 4294967295 in steps of 1.

Default: 0

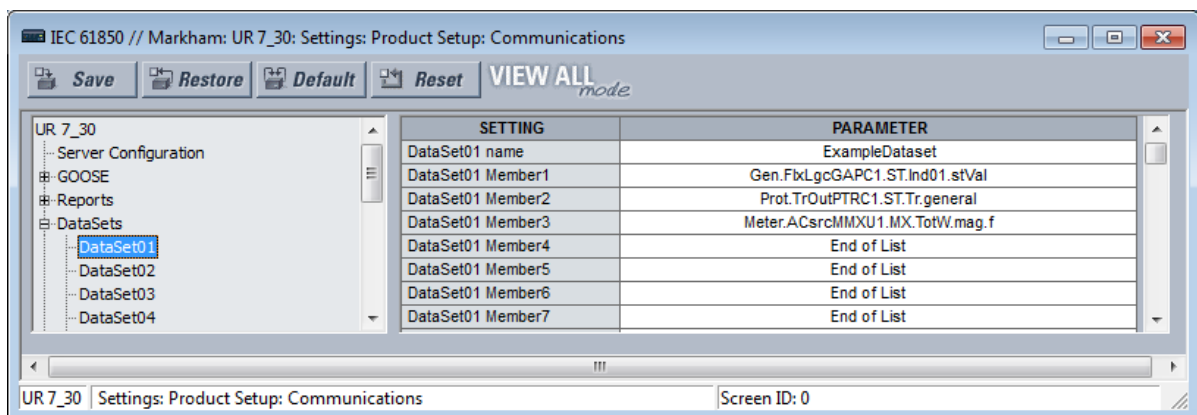
The entered value sets the period in milliseconds for generating Unbuffered Report1 integrity reports. An integrity report includes the values of all members of the referenced data set, whether a change has occurred or not.

DataSets

Navigate to **Settings > Product Setup > Communications > IEC 61850 > DataSets**.

As mentioned in the preceding GOOSE and Reports sections, the members whose values are communicated by these services are itemized in an ordered list known as a data set. Each UR with the IEC 61850 option has 12 data sets. Each data set can contain as many as 64 members. Any data set can be used simultaneously by any number of TxGOOSE elements and/or by any number of Configurable Report elements. UR Setup software can configure any FlexLogic operands and any FlexAnalog operands as members.

Figure 5-18: IEC 61850 DataSets



UR Setup requires data set members to be IEC 61850 data objects or data attributes with Functional Constraint ST or MX. Certain FlexLogic and FlexAnalog operands have factory assigned data attributes as tabulated in the UR Series Communications Guide. All FlexLogic and FlexAnalog operands can be user-assigned to GGIO1 or GGIO4 data attributes, so that operands without factory assigned data attributes can still have their values published. See the GGIO1 and GGIO4 sections later for details.

Datasets used by TxGOOSE1, TxGOOSE2, and/or by reports also provide a chatter suppression service for their Boolean members. Oscillation in a value, also known as chatter, can be caused by errors in logic programming, inadequate hysteresis (deadband) on a threshold, or a failed station component. Chatter can flood a communications network with GOOSE messages, degrading response time for all users. If chatter is detected in a Boolean member, TxGOOSE suspends GOOSE event message triggering and report message triggering from that member for as long as the condition exists, and for a minimum period of one second. While sending is suspended, a self-test message identifying the specific data item detected as oscillating is activated.

Navigate to **Settings > Product Setup > Communications > IEC 61850 > DataSets > DataSet01** to access the settings for the first data set. The settings and functionality for the others are similar.

DataSet01 name

Range: 0 to 32 VisibleString characters
Default: DataSet01

The value entered sets the name of the data set, which is required to be unique within the UR for proper operation. An ObjectReference to the data set consists of a string that is the concatenation of "<LDName>/LLN0\$" and the DataSet01 name setting value. An ObjectReference to the data set is published in the datSet field of TxGOOSE messages, and it can be used by subscribers to discriminate the messages of that TxGOOSE from other GOOSE messages. An ObjectReference to the data set is optionally published in the DatSet field of Report messages. Valid characters are upper and lowercase letters, digits, and the underscore (_) character. The first character must be a letter.

DataSet01 Member1

Range: End of List or any instantiated 61850 data object or data attribute with Functional Constraint ST or MX
Default: End of List

This setting specifies the first member in TxGOOSE1 messages. There is a similar setting for each of the up to 64 members that the UR allows in a Dataset. Only values of members before the first set to End of List are published.

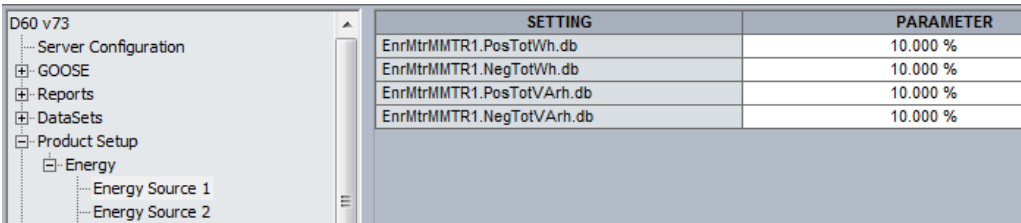
Deadband settings

A deadband is a range in which no action occurs, expressed as a percentage.

The IEC 61850 panels contain hundreds of deadband settings, such as in the following panels: System Setup > Signal Sources, FlexLogic, Grouped Elements, Control Elements, and GGIO4. Each panel is not outlined here.

Deadband setting names all end either with "DEADBAND" or .db. As they all work the same way, but each on a different analog value, a single description applicable to all deadband settings is given here. The analog value that each deadband setting applies to is usually obvious from the name of the setting. However, a tabulation of the analog values and their associated deadband setting can be found in the UR Series Communications Guide.

Figure 5-19: Deadband settings with .db suffix

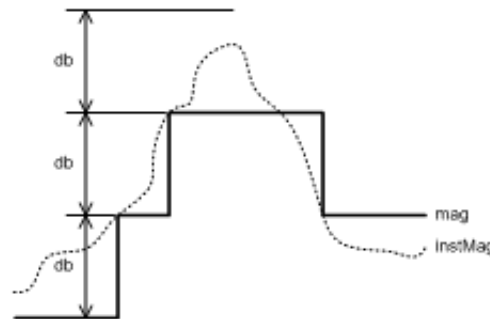


SETTING	PARAMETER
EnrMtrMMTR1.PosTotWh.db	10.000 %
EnrMtrMMTR1.NegTotWh.db	10.000 %
EnrMtrMMTR1.PosTotVArh.db	10.000 %
EnrMtrMMTR1.NegTotVArh.db	10.000 %

GOOSE, buffered report, and unbuffered report messages are for the most part transmitted only when there is a value change in one or more of their members. Most analog values continuously dither by an amount that is not significant. Were a report to be sent each time an insignificant analog value change occurred, then the communications network floods with GOOSE and report messages, degrading response time for all users.

To control this, a deadband setting is provided for each analog value. Also, in addition to the present actual value of each analog ("instMag" in the following figure), there is a deadbanded value ("mag" in the figure), which is updated with the present value only when the difference between the two exceeds the deadband setting (db in the figure). Changes to this deadbanded value trigger transmissions when included in GOOSE and report data sets.

Figure 5-20: Deadband settings



Deadband settings are entered in UR Setup in units of percent of the difference between the "max." and "min." of the associated analog value. A zero deadband setting suppresses transmission triggering. The range of deadband settings is 0.000 to 100.000% in steps of 0.001. The default value is 10.000%.

GGIO4 elements have individual settings for "min." and "max." The min. and max. for FlxEIGAPC#.OpSig.db (FLEXELEMENT # OpSig) are -50 pu and +50 pu respectively. The min. value for all other quantities is 0. The max. values are as follows:

- Phase current — 46 x phase CT primary setting
- Neutral current — 46 x ground CT primary setting
- Phase and phase-to-phase voltage — 275 x VT ratio setting
- Power (real, reactive, apparent, 3-phase, and 1-phase) — 46 x phase CT primary setting x 275 x VT ratio setting
- Energy (real or imaginary) — 46 x phase CT primary setting x 275 x VT ratio setting x 1 hour
- Frequency — 90 Hz
- Frequency rate of change — 90 Hz/s
- Power factor — 2
- Angle — 360 degrees

Select the deadband settings from knowledge of the characteristics of the power system quantity measured and knowledge of the demands of the applications receiving the measurement via GOOSE or report such that changes of significance to the application are promptly reported, yet the network is not overly burdened with event messages.



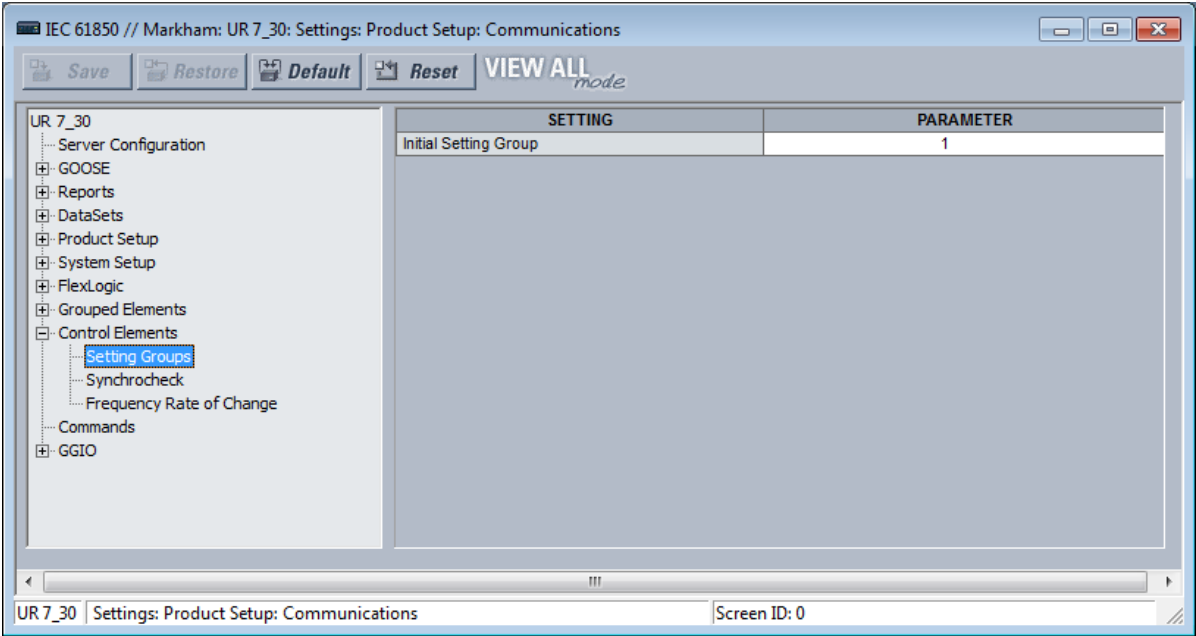
After making changes to settings that affect the per unit bases, such as CT PRIMARY, CT SECONDARY, VT SECONDARY, VT RATIO, and VT CONNECTION settings, cycle power to the relay to force recalculation of the IEC 61850 deadband interval in primary units. Until the relay restarts, for some quantities, the deadband interval in primary units calculated for the previous settings remains in effect.

Setting Groups

The UR implements a setting groups element as detailed in the Control Elements > Setting Groups section of this chapter. The active setting group and the setting group open for edits can be selected via MMS commands SelectActiveSG and SelectEditSG. The setting related to these IEC 61850 commands are described here.

Navigate to **Settings > Product Setup > Communications > IEC 61850 > Control Elements > Setting Groups** to access the setting that configures the IEC 61850 setting group commands.

Figure 5-21: Setting Groups panel



5

Initial Setting Group

Range: 1 to 6 in steps of 1
Default: 1

The entered value sets the initial value of the non-volatile register normally controlled by the service SelectActiveSG. This initialization occurs only on the UR reboot immediately following the receipt of a valid CID file.

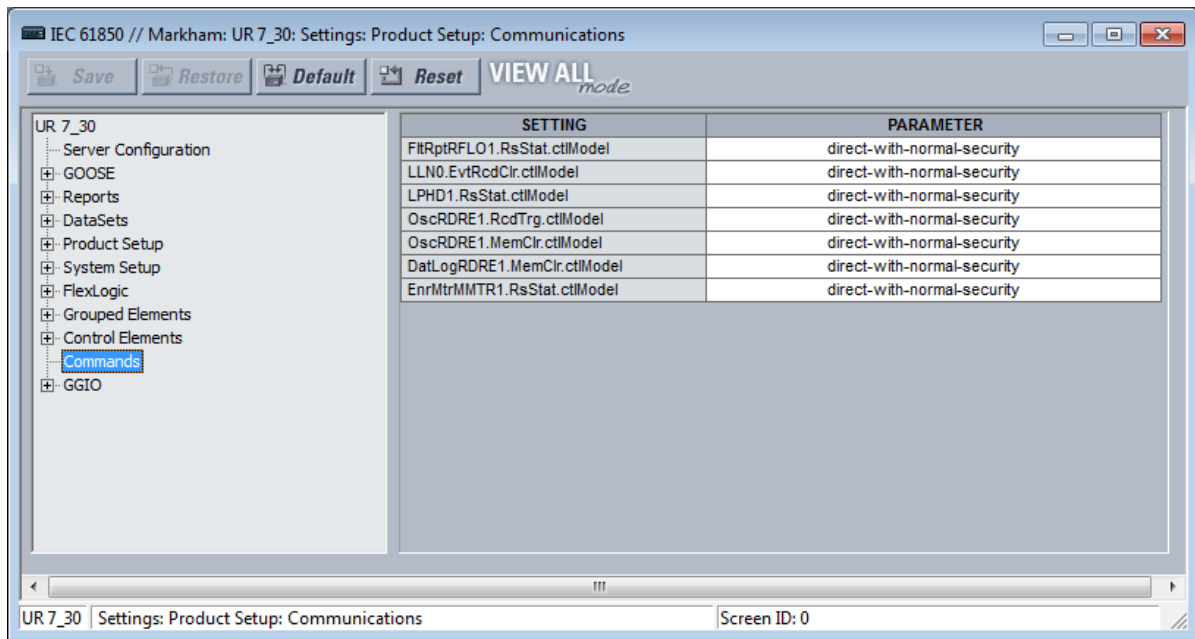
This setting is not mapped into the IEC 61850 information model, but sets the value of SettingControl element attribute actSG in SCL files.

Commands

The UR implements a number of clear records commands as detailed in the Commands and Targets chapter of this manual. Several of these commands also can be issued via IEC 61850. The settings related to these IEC 61850 commands are described here.

Navigate to **Settings > Product Setup > Communications > IEC 61850 > Commands** to access the settings that configure the IEC 61850 protocol interface for record clear commands.

Figure 5-22: Commands panel

**FltRptRFLO1.RsStat.ctlModel**

Range: direct-with-normal-security, sbo-with-normal-security

Default: direct-with-normal-security

This setting selects the control model clients must use to successfully control the command CLEAR FAULT REPORTS. "sbo" here is select-before-operate. Enhanced security means that the B90 reports to the client the breaker 1 position at the end of the command sequence.

LLN0.EvtRcdClr.ctlModel

Range: direct-with-normal-security, sbo-with-normal-security

Default: direct-with-normal-security

This setting selects the control model clients must use to successfully control the command CLEAR EVENT RECORDS.

LPHD1.RsStat.ctlModel

Range: direct-with-normal-security, sbo-with-normal-security

Default: direct-with-normal-security

This setting selects the control model clients must use to successfully control the command CLEAR ALL RELAY RECORDS.

OscRDRE1.RcdTrg.ctlModel

Range: direct-with-normal-security, sbo-with-normal-security

Default: direct-with-normal-security

This setting selects the control model clients must use to successfully control the command FORCE TRIGGER.

OscRDRE1.MemClr.ctlModel

Range: direct-with-normal-security, sbo-with-normal-security

Default: direct-with-normal-security

This setting selects the control model clients must use to successfully control the command CLEAR OSCILLOGRAPHY.

DatLogRDRE1.MemClr.ctlModel

Range: direct-with-normal-security, sbo-with-normal-security

Default: direct-with-normal-security

This setting selects the control model clients must use to successfully control the command CLEAR DATA LOGGER.

EnrMtrMMTR.RsStat.ctlModel

Range: direct-with-normal-security, sbo-with-normal-security
Default: direct-with-normal-security

This setting selects the control model clients must use to successfully control the command CLEAR ENERGY.

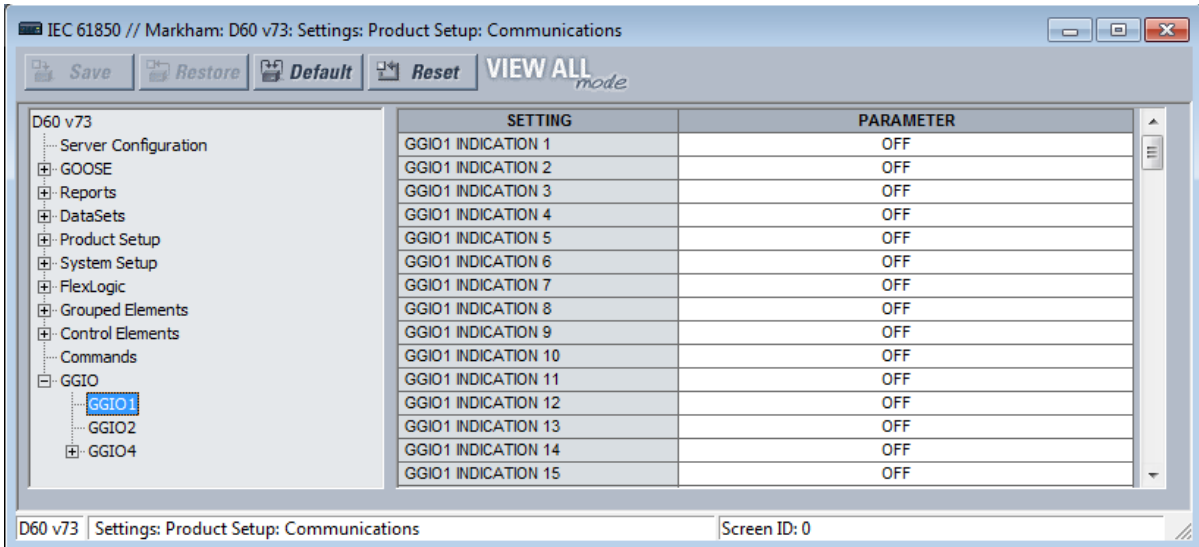
GGIO1

GGIO1 is a UR feature that allows up to 128 UR FlexLogic operands to be user-mapped to IEC 61850 information model data attributes.

For the value of a FlexLogic operand to be read via MMS, included in TxGOOSE messages, or included in buffered/unbuffered reports, the value must be assigned to a data attribute. GGIO1 allows those FlexLogic operands that have not yet been factory-assigned to a data attribute to be user-assigned to a generic data attribute, and thus have their values included in IEC 61850 communications.

Navigate to **Settings > Product Setup > Communications > IEC 61850 > GGIO > GGIO1** to access the settings for GGIO1.

Figure 5-23: IEC 61850 GGIO1 panel



GGIO1 INDICATION 1

Range: any FlexLogic operand
Default: OFF

This setting selects the FlexLogic operand whose value is mapped into the IEC 61850 data attribute <LDName>/GGIO1.Ind001.stVal. See the FlexLogic section in this chapter for a list of FlexLogic operands.

GGIO1 INDICATION 2

Range: any FlexLogic operand
Default: OFF

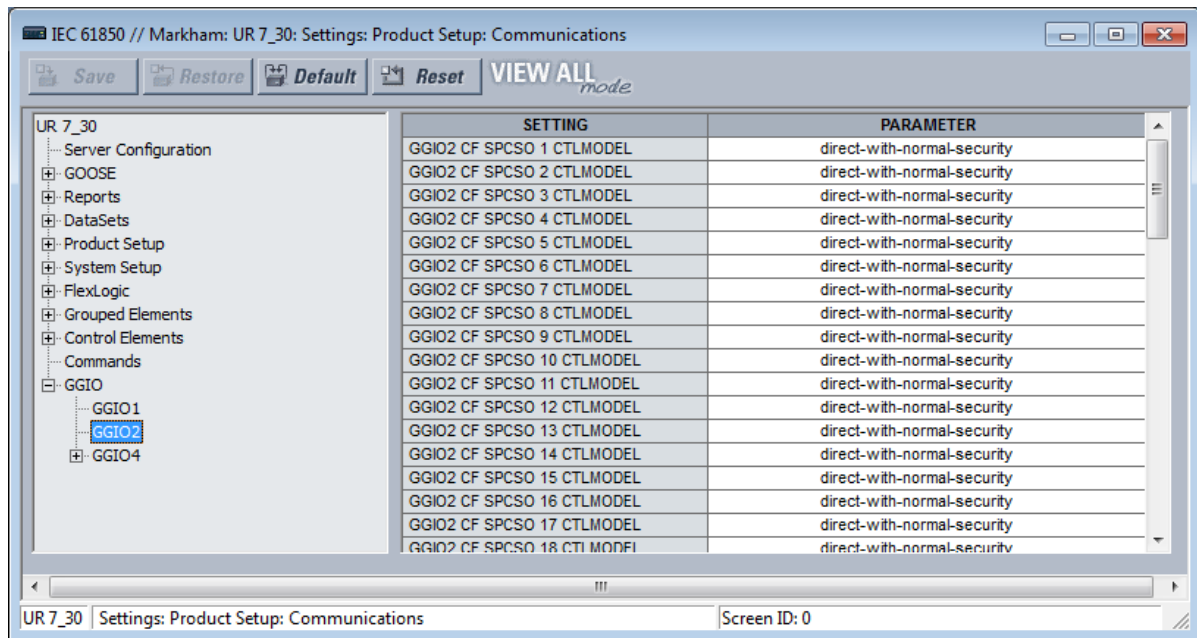
Selects the FlexLogic operand mapped to <LDName>/GGIO1.Ind002.stVal, and so on.

GGIO2

Virtual Inputs are controllable FlexLogic operands that can be controlled via IEC 61850 commands to GGIO2, by DNP, by Modbus, and by the UR front panel. The settings related to these IEC 61850 commands are described here.

Navigate to **Settings > Product Setup > Communications > IEC 61850 > GGIO > GGIO2** to access the settings that configure the IEC 61850 protocol interface for Virtual Input commands.

Figure 5-24: GGIO2 panel

**GGIO2 CF SPCSO 1 ctlModel**

Range: status-only, direct-with-normal-security, sbo-with-normal-security

Default: direct-with-normal-security

This setting selects the control model clients must use to successfully control Virtual Input 1. "sbo" here is select-before-operate.

GGIO2 CF SPCSO 2 ctlModel

Range: status-only, direct-with-normal-security, sbo-with-normal-security

Default: direct-with-normal-security

Selects the control model for Virtual Input 2, and so on.

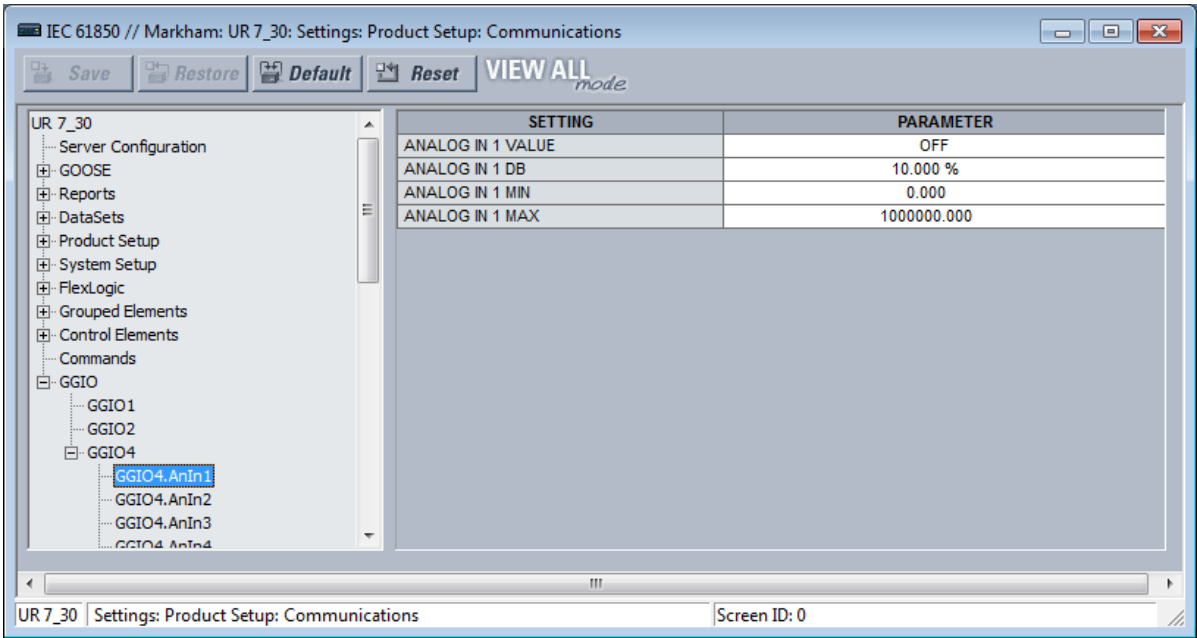
GGIO4

GGIO4 is a UR feature that allows any of up to 32 UR FlexAnalog operands to be user-mapped to an IEC 61850 information model data attribute.

For the value of a FlexAnalog operand to be read via MMS, included in TxGOOSE messages, or included in buffered/unbuffered reports, the value must be assigned to a data attribute. GGIO4 allows those FlexAnalog operands that have not yet been factory assigned to a data attribute to be user-assigned to a generic data attribute, and thus have their values included in IEC 61850 communications.

Navigate to **Settings > Product Setup > Communications > IEC 61850 > GGIO > GGIO4 > GGIO4.AnIn1** to access the settings for the first GGIO4 value. The settings and functionality for the others are similar.

Figure 5-25: GGIO4 panel



5

ANALOG IN 1 VALUE

Range: any FlexAnalog operand
Default: OFF

This setting selects the FlexAnalog operand whose value is mapped into the IEC 61850 data attribute <LDName>/GGIO4.AnIn01.instMag.f. The value of the FlexAnalog operand is converted automatically to the format and scaling required by the standard, that is to say primary amperes, primary volts, and so on. See Appendix A for a list of FlexAnalog operands.

ANALOG IN 1 DB

Range: 0.000 to 100.000% in steps of 0.001
Default: 10.000%

This setting specifies the deadband for the **ANALOG IN 1 VALUE**. The deadband is used to determine when to update the deadbanded magnitude from the instantaneous magnitude. The deadband is a percentage of the difference between the "max." and "min." values. Here, the "max." and "min." are as specified by the settings **ANALOG IN 1 MAX** and **ANALOG IN 1 MIN**.

See the Deadband Settings section earlier for a description of deadbanded values.

ANALOG IN 1 MIN

Range: -1000000000.000 to 1000000000.000 in steps of 0.001
Default: 1000.000

This setting specifies the "min." value used in deadband calculations. The scaling of this setting is the same as used by <LDName>/GGIO4.AnIn01.instMag.f. This setting is stored as an IEEE 754 / IEC 60559 floating point number. Because of the large range of this setting, not all possible values can be stored. Some values are rounded to the closest possible floating point number.

ANALOG IN 1 MAX

Range: -1000000000.000 to 1000000000.000 in steps of 0.001
Default: 0.000

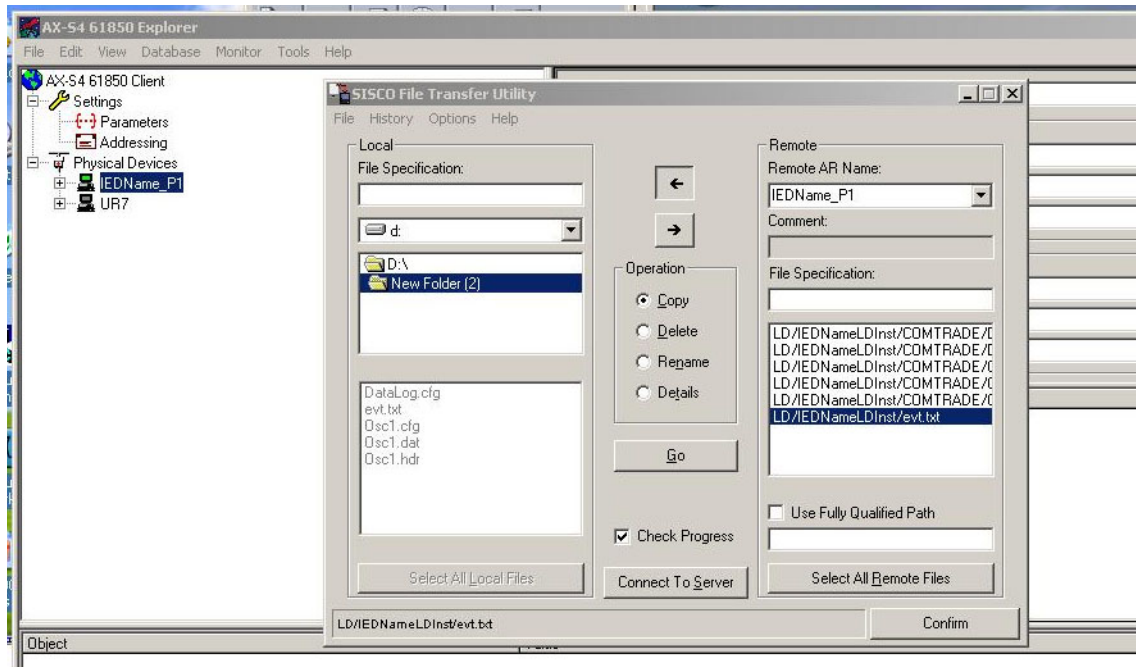
This setting specifies the "max." value used in deadband calculations. The scaling of this setting is the same as used by <LDName>/GGIO4.AnIn01.instMag.f. This setting is stored as an IEEE 754 / IEC 60559 floating point number. Because of the large range of this setting, not all possible values can be stored. Some values are rounded to the closest possible floating point number.

File transfer by IEC 61850

The B90 supports file transfer by IEC 61850. The approach is as follows, using the SISCO AX-S4 61850 client software as an example.

1. In the AX-S4 61850 Explorer window, click the **Tools** menu and access the SISCO File Transfer Utility.
2. Select the **Remote AR Name** from the drop-down list. Available files appear in the **File Specification** area on the right side of the window.
3. With the **Copy** option active, select a file to transfer and click the **Go** button. The file is copied and displays in the **Local** list on the left side of the window.
4. Repeat the process to transfer any other files.

Figure 5-26: File transfer by IEC 61850



5.3.5.13 Web server HTTP protocol

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ WEB SERVER HTTP PROTOCOL

WEB SERVER HTTP PROTOCOL	⇔	HTTP TCP PORT NUMBER: 80	Range: 0 to 65535 in steps of 1
---	---	---	---------------------------------

The B90 contains an embedded web server and can display pages in a web browser. The web pages are organized as a series of menus that can be accessed starting at the B90 "Main Menu." Web pages are read-only and are available showing DNP and IEC 60870-5-104 points lists, Modbus registers, event records, fault reports, and so on. First connect the B90 and a computer to an Ethernet network, then enter the IP address of the B90 Ethernet port in a web browser.

To close the port, set the port number to 0.

Any change takes effect when the B90 is restarted.

Figure 5-27: Example of UR web page showing event records



GE Multilin

C60 Breaker Relay
Revision 7.31

Relay Name: Relay-1
IP Address: 10.14.22.72

Event Recorder: Last 10 Events

[Click Here For The Main Menu](#)

UR

Event Number	Time and Date	Event Cause
214	Nov 04 2014 14:02:56.062087	PROTOTYPE FIRMWARE
213	Nov 04 2014 14:02:56.062087	POWER ON
212	Nov 03 2014 14:00:20.364906	POWER OFF
211	Nov 03 2014 13:55:15.061866	PROTOTYPE FIRMWARE
210	Nov 03 2014 13:55:15.061866	POWER ON
209	Nov 03 2014 13:10:59.733179	POWER OFF
208	Nov 03 2014 13:06:11.062104	PROTOTYPE FIRMWARE
207	Nov 03 2014 13:06:11.062104	POWER ON
206	Oct 31 2014 10:07:25.078203	POWER OFF
205	Oct 31 2014 10:00:44.062027	PROTOTYPE FIRMWARE

5



NOTE

Do not set more than one protocol to the same TCP/UDP port number, as this results in unreliable operation of those protocols.

5.3.5.14 TFTP protocol

SETTINGS ⇒ PRODUCT SETUP ⇒ ⬇ COMMUNICATIONS ⇒ ⬇ TFTP PROTOCOL

TFTP PROTOCOL

⇔

TFTP MAIN UDP PORT
NUMBER: 69

Range: 0 to 65535 in steps of 1

⇕

TFTP DATA UDP PORT 1
NUMBER: 0

Range: 0 to 65535 in steps of 1

⇕

TFTP DATA UDP PORT 2
NUMBER: 0

Range: 0 to 65535 in steps of 1

The Trivial File Transfer Protocol (TFTP) can be used to transfer files from the B90 over a network. The B90 operates as a TFTP server. TFTP client software is available from various sources, including Microsoft Windows NT. The dir.txt file obtained from the B90 contains a list and description of all available files, for example event records and oscillography.

While TFTP is supported, the put function is not for security reasons. For example, you can enter a "get" command but not a "put" command.

TFTP MAIN UDP PORT NUMBER — To close the port, set the port number to 0. Any change takes effect when the B90 is restarted.



NOTE

Do not set more than one protocol to the same TCP/UDP port number, as this results in unreliable operation of those protocols.

5.3.5.15 IEC 60870-5-104 protocol

SETTINGS ⇒ PRODUCT SETUP ⇒ ⬇ COMMUNICATIONS ⇒ ⬇ IEC 60870-5-104 PROTOCOL

IEC 60870-5-104
PROTOCOL

⇔

IEC TCP PORT
NUMBER: 2404

Range: 0 to 65535 in steps of 1

↕	■ IEC NETWORK ■ CLIENT ADDRESSES	See below
↕	IEC COMMON ADDRESS OF ASDU: 0	Range: 0 to 65535 in steps of 1
↕	IEC CYCLIC DATA PERIOD: 60 s	Range: 1 to 65535 s in steps of 1
↕	IEC CURRENT DEFAULT THRESHOLD: 30000	Range: 0 to 65535 in steps of 1
↕	IEC VOLTAGE DEFAULT THRESHOLD: 30000	Range: 0 to 65535 in steps of 1
↕	IEC POWER DEFAULT THRESHOLD: 30000	Range: 0 to 65535 in steps of 1
↕	IEC ENERGY DEFAULT THRESHOLD: 30000	Range: 0 to 65535 in steps of 1
↕	IEC PF DEFAULT THRESHOLD: 1.00	Range: 0.00 to 1.00
↕	IEC OTHER DEFAULT THRESHOLD: 30000	Range: 0 to 65535 in steps of 1
↑	IEC REDUNDANCY ENABLED: No	Range: No, Yes

IEC 60870-5-104 is a transmission protocol for network access, specifically for communication between a control station and substation over a TCP/IP network.

The B90 supports the IEC 60870-5-104 protocol. This protocol is enabled when the **SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ PROTOCOL** setting is set to IEC 60870-5-104. The B90 can be used as an IEC 60870-5-104 slave device connected to a maximum of two masters (usually either an RTU or a SCADA master station). Since the B90 maintains two sets of IEC 60870-5-104 data change buffers, ideally no more than two masters actively communicate with the B90 at one time.

The **IEC ----- DEFAULT THRESHOLD** settings are used to determine when to trigger spontaneous responses containing M_ME_NC_1 analog data. These settings group the B90 analog data into types: current, voltage, power, energy, and other. Each setting represents the default threshold value for all M_ME_NC_1 analog points of that type. For example, to trigger spontaneous responses from the B90 when any current values change by 15 A, the **IEC CURRENT DEFAULT THRESHOLD** setting is set to 15. Note that these settings are the default values of the deadbands. P_ME_NC_1 (parameter of measured value, short floating point value) points can be used to change threshold values, from the default, for each individual M_ME_NC_1 analog point. Whenever power is removed and re-applied to the B90, the default thresholds are in effect.

The **IEC REDUNDANCY** setting decides whether multiple client connections are accepted or not. If redundancy is set to Yes, two simultaneous connections can be active at any given time.

IEC TCP PORT NUMBER — To close the port, set the port number to 0. Any change takes effect when the B90 is restarted.

IEC COMMON ADDRESS OF ASDU — The change takes effect when the B90 is restarted.

IEC CYCLIC DATA PERIOD — The change takes effect when the B90 is restarted.



The B90 relay does not support power metering. As such, the **IEC POWER DEFAULT THRESHOLD** setting is not applicable.



The B90 relay does not support energy metering. As such, the **IEC ENERGY DEFAULT THRESHOLD** setting is not applicable.



Do not set more than one protocol to the same TCP/UDP port number, as this results in unreliable operation of those protocols.

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ IEC 60870-5-104 PROTOCOL ⇒ IEC NETWORK CLIENT ADDRESSES

■ IEC NETWORK ■ CLIENT ADDRESSES	↔	CLIENT ADDRESS 1: 0.0.0.0	Range: standard IPV4 address format
	⇕	CLIENT ADDRESS 5: 0.0.0.0	Range: standard IPV4 address format

The B90 can specify a maximum of five clients for its IEC 104 connections. These are IP addresses for the controllers to which the B90 can connect. A maximum of two simultaneous connections are supported at any given time.

5.3.5.16 IEC 60870-5-103 protocol

SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ IEC 60870-5-103

■ IEC103 ■ PROTOCOL	↔	IEC103 COMMON ADDRESS OF ASDU: 0	Range: 0 to 254 in steps of 1
	⇕	IEC103 SYNC TIMEOUT: 1	Range: 1 to 1440 min in steps of 1
	⇕	■ IEC103 INPUTS ■ BINARY	See below
	⇕	■ IEC103 INPUTS ■ MEASURANDS	See below
	⇕	■ IEC103 COMMANDS ■	See below



The B90 is provided with optional IEC 60870-5-103 communications capability. This feature is specified as a software option at the time of ordering. See the Order Codes section in chapter 2 for details.

IEC 60870-5-103 is a companion standard to the IEC 60870-5 suite of standards for transmission protocols. It defines messages and procedures for interoperability between protection equipment and devices of a control system in a substation for communicating on a serial line.

The IEC 60870-5-103 protocol is enabled when the **SETTINGS ⇒ PRODUCT SETUP ⇒ COMMUNICATIONS ⇒ PROTOCOL** setting is set to IEC 60870-5-103.

The IEC 60870-5-103 is an unbalanced (master-slave) protocol for coded-bit serial communication, exchanging information with a control system. In the context of this protocol, the protection equipment is the slave and the control system is the master. The communication is based on a point-to-point principle. The master must be able to interpret the IEC 60870-5-103 communication messages.

The UR implementation of IEC 60870-5-103 consists of the following functions:

- Report binary inputs
- Report analog values (measurands)
- Commands
- Time synchronization

The RS485 port supports IEC 60870-5-103.

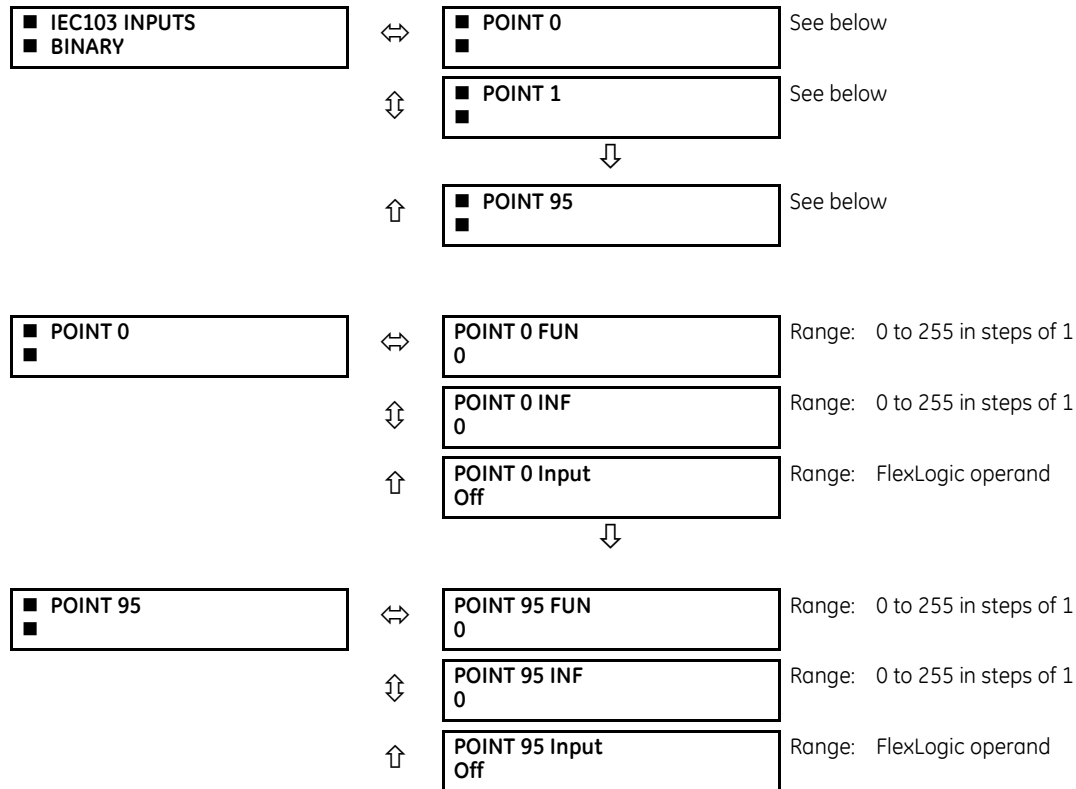
The UR Series Communications Guide contains more information on the protocol.

IEC103 COMMON ADDRESS OF ASDU — This setting uniquely defines this B90 on the serial line. Select an ID between 0 and 254. This ID does not need to be in sequential order for all stations that communicate with a controller, but it is recommended. Note that RS485 only allows a maximum of 32 slave stations on a communication line, so the entire range of 254 addresses is never exhausted.

IEC103 SYNC TIMEOUT — This setting defines the time that the B90 waits for a synchronization message. The B90 synchronizes its clock using all available sources, with the source synchronizing more frequently overwriting the time of the other sources. Since the synchronization message received from the IEC 60870-5-103 master is less frequent than IRIG-B, PTP, or SNTP, its time is overwritten by these three sources, if any of them is active. If the synchronization timeout occurs and none of IRIG-B, PTP, or SNTP is active, the B90 sets the invalid bit in the time stamp of a time-tagged message.

The settings for the remaining menus are outlined as follows.

SETTINGS ⇒ PRODUCT SETUP ⇒ ↓ COMMUNICATIONS ⇒ ↓ IEC 60870-5-103 ⇒ ↓ IEC103 INPUTS BINARY



The binary input points are mapped using elements from a list of possible FlexLogic operands. A maximum of 96 binary inputs (points) can be mapped this way.

The IEC 60870-5-103 point list always starts with point 0 and ends at the first "Off" value. Since the IEC 60870-5-103 point list must be in a continuous block, any points assigned after the first "Off" point are ignored.

For each defined point, set appropriate values for the Function Type (FUN) and Information Number (INF), which form the Information Object Identifier field of the ASDU, as defined in IEC 60870-5-103.

The binary input points are sent as Class 1 data. They are sent either as a response to a general interrogation received from the controller or reported spontaneously. Spontaneous transmission occurs as a response to cyclic Class 2 requests. If the B90 wants to transmit Class 1 data at that time, it demands access for Class 1 data transmission (ACD=1 in the control field of the response).

For any change to take effect, restart the relay.

SETTINGS ⇒ PRODUCT SETUP ⇒ ⚡ COMMUNICATIONS ⇒ ⚡ IEC 60870-5-103 ⇒ ⚡ IEC103 INPUTS MEASURANDS

☐ IEC103 INPUTS ☐ MEASURANDS	↔	☐ ASDU 1 ☐	See below
		↓	
	↑	☐ ASDU 4 ☐	
☐ ASDU 1 ☐	↔	ASDU 1 TYP: 9	Range: 3 or 9
	↕	ASDU 1 FUN: 0	Range: 0 to 255 in steps of 1
	↕	ASDU 1 INF: 0	Range: 0 to 255 in steps of 1
	↕	ASDU 1 SCAN TOUT: 0	Range: 0 to 1000 s in steps of 1
	↕	ASDU 1 ANALOG 1 Off	Range: FlexAnalog parameter
	↕	ASDU 1 ANALOG 1 FACTOR: 1.000	Range: 0.000 to 65.535 in steps of 0.001
	↕	ASDU 1 ANALOG 1 OFFSET: 0	Range: -32768 to 32767 in steps of 1
		↓	
	↕	ASDU 1 ANALOG 9 Off	Range: FlexAnalog parameter
	↕	ASDU 1 ANALOG 9 FACTOR: 1.000	Range: 0.000 to 65.535 in steps of 0.001
	↕	ASDU 1 ANALOG 9 OFFSET: 0	Range: -32768 to 32767 in steps of 1
		↓	
☐ ASDU 4 ☐	↕	ASDU 4 TYP: 9	Range: 3 or 9
	↕	ASDU 4 FUN: 0	Range: 0 to 255 in steps of 1
	↕	ASDU 4 INF: 0	Range: 0 to 255 in steps of 1
	↕	ASDU 4 SCAN TOUT: 0	Range: 0 to 1000 s in steps of 1
	↕	ASDU 4 ANALOG 1 Off	Range: FlexAnalog parameter
	↕	ASDU 4 ANALOG 1 FACTOR: 1.000	Range: 0.000 to 65.535 in steps of 0.001
	↕	ASDU 4 ANALOG 1 OFFSET: 0	Range: -32768 to 32767 in steps of 1
		↓	
	↕	ASDU 4 ANALOG 9 Off	Range: FlexAnalog parameter

↕	ASDU 4 ANALOG 9 FACTOR: 1.000	Range: 0.000 to 65.535 in steps of 0.001
↑	ASDU 4 ANALOG 9 OFFSET: 0	Range: -32768 to 32767 in steps of 1

The configuration menu allows a maximum of four ASDUs containing measurands.

Measurands are sent as a response to Class 2 requests, which are cyclic requests coming from the master.

TYPE IDENTIFICATION (TYP) — The configuration field TYP indicates how many measurands are present in the corresponding ASDU. Each ASDU can take either 4 or 9 measurands maximum, depending on the type identification (3 respectively 9).

FUNCTION TYPE (FUN) and **INFORMATION NUMBER (INF)** — These two fields form the Information Object Identifier of the ASDU as defined in IEC 60870-103.

SCAN TIMEOUT (SCAN TOUT) — This is the cyclic period used by the B90 to decide when a measurand ASDU is included in a response. The measurand is sent as response to a Class 2 request when the corresponding timeout expires. The default value 0 means 500 ms.

ANALOG # — This field contains the actual measurand to be sent in the response to the master. The measurands can be mapped using elements from a list of FlexAnalog operands. The measurands sent are voltage, current, power, power factor, and frequency. If any other FlexAnalog is chosen, the B90 sends 0 instead of its value. Note that the power is transmitted in KW, not W. Measurands are transmitted as ASDU 3 or ASDU 9 (type identification value set to measurands I, respectively measurands II).

Each IEC 60870-5-103 measurands list ends at the first unconfigured ("Off") value. Any measurand assigned after the first "Off" value is ignored.

At least one measurand per ASDU must be configured in order to configure the following ASDU. For example, the user can configure only one measurand for each ASDU, but the user is not allowed to skip ASDU 2 and configure measurands in ASDU 3.

For any change to take effect, restart the relay.

ANALOG # FACTOR and **OFFSET** — For each measurand included in the ASDU, a factor and offset also can be configured. The factor and offset allow for scaling to be performed on measurands. The final measurement sent to the IEC 60870-103 master is then " $a \cdot x + b$," where x is the measurand, a is the multiplying factor and b is the offset. The master has to perform the reversed operation in order to retrieve the actual value if such scaling is done. By default $a = 1$ and $b = 0$, so no scaling is done if these values are left at their defaults. Examples of when scaling is appropriate are as follows:

- If the measured value contains decimals and it is important to preserve the resolution. Since the format for transmitting the measurand does not permit decimals, a factor $a > 1$ can be applied before transmission. For example, a frequency $F = 59.9\text{Hz}$ can be transmitted as $F_t = 10 \cdot F = 10 \cdot 59.9 = 599$. In this case $a = 10$, $b = 0$. The master receives 599 and has to divide by 10 to retrieve the real value 59.9.
- If the measured value is larger than what fits in the format defined in IEC 103. The format defined in the standard allows for signed integers up to 4095. By offsetting, unsigned integers up to $4096 + 4095 = 8191$ are supported. Scaling using factors < 1 can be required in such cases. The calculation is outlined in the IEC 60870-5-103 chapter of the UR Series Communications Guide. Two examples follow, where you decide factors a and b .

Example 1: Nominal power $P_n = 100\text{ MW} = 100000\text{ KW}$ (power is transmitted in KW)

Since P can be both positive and negative:

$$\begin{aligned} \text{Transmitted power } P_t &= (4095 / (P_n \cdot 2.4)) \cdot P = (4095 / (100000 \cdot 2.4)) \cdot P \\ &= 0.017 \cdot P \end{aligned}$$

$$a = 0.017$$

$$b = 0$$

$$P_t = 0.017 \cdot P$$

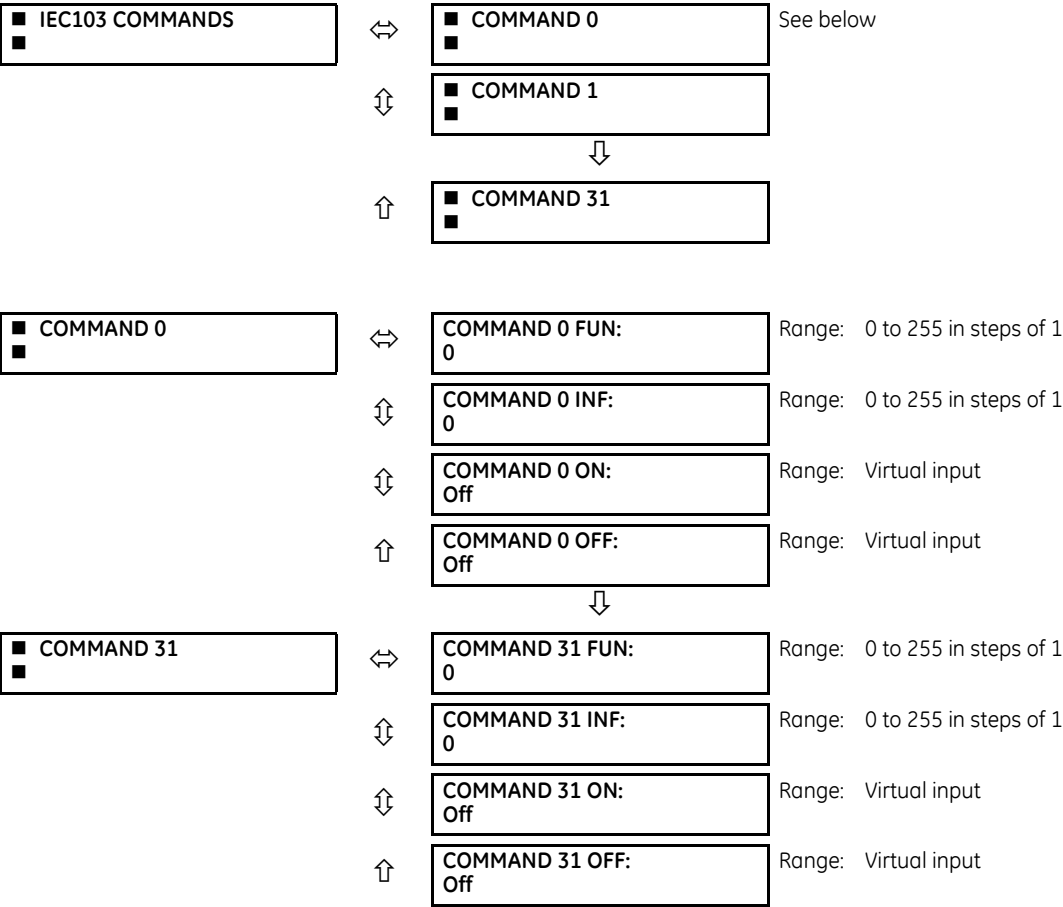
For a max power $100000\text{ KW} \cdot 2.4 = 240000\text{ KW}$, we transmit

$$P_t = 0.017 \cdot 240000 = 4080$$

A value above 240 MW is indicated by overflow.

Example 2: Nominal voltage $V_n = 500000\text{ V}$
Since RMS voltage V can be only positive:
Transmitted voltage $V_t = (8191/(V_n \cdot 2.4)) \cdot V - 4096 =$
 $= (8191/(500000 \cdot 2.4)) \cdot V - 4096 = 0.0068 \cdot V - 4096$
 $a = 0.0068$
Since the step is in increments of 0.001, we round it at:
 $a = 0.006$
 $b = -4096$
 $V_t = 0.006 \cdot V - 4096$
For max voltage $500000\text{ V} \cdot 2.4 = 1200000\text{ V}$, we transmit
 $V_t = 0.006 \cdot 1200000 - 4096 = 7200 - 4096 = 3104$

SETTINGS ⇒ PRODUCT SETUP ⇒ ⚡ COMMUNICATIONS ⇒ ⚡ IEC 60870-5-103 ⇒ ⚡ IEC103 COMMANDS



Commands are received as General Command (Type Identification 20). The user can configure the action to perform when an ASDU command comes.

A list of available mappings is provided on the B90. This includes 64 virtual inputs (see the following table). The ON and OFF for the same ASDU command can be mapped to different virtual inputs.

Each command is identified by the unique combination made by the function type (FUN) and information number (INF). If the master sends an ASDU command that does not have the FUN and INF of any configured command, the relay rejects it.

Table 5-11: Commands mapping table

Description	Value
Off	0
Virtual Input 1	1
Virtual Input 2	2
...	...
Virtual Input 64	64

For any change to take effect, restart the relay.

5.3.6 Modbus user map

SETTINGS ⇒ PRODUCT SETUP ⇒ MODBUS USER MAP

☒ MODBUS USER MAP

↔

↓

↑

ADDRESS 1: 0
 VALUE: 0

Range: 0 to 65535 in steps of 1

☒ MODBUS USER MAP

↔

↓

↑

ADDRESS 256: 0
 VALUE: 0

Range: 0 to 65535 in steps of 1

The Modbus user map provides read-only access for up to 256 registers. To obtain a memory map value, enter the address in the **ADDRESS** line (converted from hex to decimal format). The corresponding value (if programmed) displays 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" display for all registers. Different **ADDRESS** values can be entered as required in any of the register positions.

The UR Series Communications Guide outlines the Modbus memory map. The map is also viewable in a web browser; enter the IP address of the B90 in a web browser and click the option.

5.3.7 Real-time clock

5.3.7.1 Menu

SETTINGS ⇒ PRODUCT SETUP ⇒ REAL TIME CLOCK

☒ REAL TIME
☒ CLOCK

↔

⇅

⇅

⇅

⇅

↑

SYNCHRONIZING SOURCE:
 None

Range: None, PP/IRIG-B/PTP/SNTP, IRIG-B/PP/PTP/SNTP, PP/PTP/IRIG-B/SNTP

☒ REAL TIME
☒ CLOCK

↔

⇅

⇅

⇅

⇅

↑

REAL TIME CLOCK
 EVENTS: Disabled

Range: Enabled, Disabled

☒ REAL TIME
☒ CLOCK

↔

⇅

⇅

⇅

⇅

↑

IRIG-B SIGNAL TYPE:
 None

Range: None, DC Shift, Amplitude Modulated

☒ REAL TIME
☒ CLOCK

↔

⇅

⇅

⇅

⇅

↑

☒ PRECISION TIME
☒ PROTOCOL (1588)

See below

☒ REAL TIME
☒ CLOCK

↔

⇅

⇅

⇅

⇅

↑

☒ SNTP PROTOCOL

See below

☒ REAL TIME
☒ CLOCK

↔

⇅

⇅

⇅

⇅

↑

☒ LOCAL TIME

See below

The relay contains a real time clock (RTC) to create timestamps for communications protocols as well as for historical data, such as event records and oscillography. When the relay restarts, the RTC initializes from an onboard battery-backed clock, which has the same accuracy as an electronic watch, approximately ± 1 minute per month (~ 23 ppm). Once the RTC is synchronized with the Precision Time Protocol (PTP), IRIG-B, or SNTP, its accuracy approaches that of the synchronizing

time delivered to the relay. While the RTC is not synchronized via PTP or IRIG-B, or the relay determines that it has an offset possibly greater than 10 μ s from the international time standard, the **CLOCK UNSYNCHRONIZED** FlexLogic operand is activated.

The **SYNCHRONIZING SOURCE** setting displays when the relay includes the IEEE 1588 software option. The setting configures the priority sequence of the time synchronization source, to determine which of the available external time sources to use for time synchronization. A setting of None causes the RTC and the synchrophasor clock to free-run, and the clock can be changed from the front panel or from communications protocols. A setting of PP/IRIG-B/PTP/SNTP, IRIG-B/PP/PTP/SNTP, or PP/PTP/IRIG-B/SNTP causes the relay to track the first source named that is enabled and operational, or free-run if none of these are available. Here, PP means a time source that is strictly compliant with PP, and PTP means a time source that is not strictly compliant with PP. When a time source fails or recovers, the relay automatically transfers synchronization as required by this setting.

When the relay does not have the IEEE 1588 software option and this setting does not display, it uses IRIG-B when enabled and operational, then failing that SNTP when configured and operational, and otherwise it free-runs unless the clock is changed from the front panel or from communications protocols.

Setup for IRIG-B is illustrated in the Installation chapter.

Whenever a time synchronization message is received through any of the active protocols, the B90 clock updates. However, given that IEC 60870-5-103, IEC 60870-5-104, Modbus, and DNP are low-accuracy time synchronization methods, avoid their use for synchronization when better accuracy time protocols, such as IRIG-B and PTP are active in the system. If IRIG-B or PTP is used to update the relay clock, the other protocols (such as SNTP) are not allowed to update, even if active.

For version 7.32 and later in 7.3x, the SNTP priority includes other protocols, such as IEC 60870-5-103, IEC 60870-5-104, and DNP.

See the **COMMANDS ⇒ SET DATE AND TIME** menu section of this manual to manually set the RTC.

The **REAL TIME CLOCK EVENTS** setting allows changes to the date and/or time to be captured in the event record. The event records the RTC time before the adjustment. A Date/Time Changed event is generated when:

- The real time clock changed from SNTP/PTP/IRIG-B and the time difference is more than one second
- The real time clock changed from the front panel or via Modbus register. The relay always generates this event regardless of the time difference.
- The Daylight Saving Time (DST) setting gets enabled and the current relay time is already in the DST zone
- The real time clock enters or leaves DST

To enable IRIG-B synchronization, the input **IRIG-B SIGNAL TYPE** must be set to DC Shift or Amplitude Modulated. IRIG-B synchronization can be disabled by making this setting None.

To configure and enable PTP and/or SNTP, or to set local time parameters (for example time zone, daylight savings), use the following sections.

5.3.7.2 Precision time protocol (1588)

SETTINGS ⇒ PRODUCT SETUP ⇒ ⚙ REAL TIME CLOCK ⇒ ⚙ PRECISION TIME PROTOCOL (1588)

■ PRECISION TIME

■ PROTOCOL (1588)

⇔

STRICT POWER PROFILE: Disabled

Range: Enabled, Disabled

↕

PTP DOMAIN NUMBER:
0

Range: 0 to 255

↕

PTP VLAN PRIORITY:
4

Range: 0 to 7

↕

PTP VLAN ID:
0

Range: 0 to 4095

↑

■ PTP PORT 1
■

See below

SETTINGS ⇒ PRODUCT SETUP ⇒ ⚡ REAL TIME CLOCK ⇒ ⚡ PRECISION TIME PROTOCOL (1588) ⇒ ⚡ PTP PORT 1(3)

■ PTP PORT 1 ■	↕	PORT 1 PTP FUNCTION: Disabled	Range: Enabled, Disabled
	↕	PORT 1 PATH DELAY ADDER: 0 ns	Range: 0 to 60 000 ns in steps of 1
	↑	PORT 1 PATH DELAY ASYMMETRY: 0 ns	Range: -1 000 to +1 000 ns in steps of 1



The B90 is provided with optional Precision Time Protocol capability. This feature is specified as the IEEE 1588 software option at the time of ordering. See the Order Codes section in chapter 2 for details.

The B90 supports the Precision Time Protocol (PTP) specified in IEEE Std 1588 2008 using the Power Profile (PP) specified in IEEE Std C37.238 2011. This enables the relay to synchronize to the international time standard over an Ethernet network that implements PP.

The relay can be configured to operate on some PTP networks that are not strictly PP. Time accuracy can be less than specified for a PP network. Tolerated deviations from strict PP include 1) missing declaration of PP compliance in the messages, 2) connection to a network device that does not support the PTP peer delay mechanism, 3) jitter substantially greater than 1 μ s in received event messages, and 4) certain non-compliant announce and sync message update rates.

The relay implements PTP according to IEEE Std 1588 2008 and the equivalent IEC 61588:2009(E), sometimes referred to as version 2 PTP. It does not support the previous version of the standard (version 1).

PTP is a protocol that allows multiple clocks in a network to synchronize with one another. It permits synchronization accuracies better than 1 ns, but this requires that each and every component in the network achieve very high levels of accuracy and a very high baud rate, faster than normally used for relay communications. When operating over a generic Ethernet network, time error can amount to 1 ms or more. PP is a profile of PTP which specifies a limited subset of PTP suitable for use in power system protection, control, automation, and data communication applications, and thereby facilitates interoperability between different vendor's clocks and switches. PP specifies a worst-case delivered time error of less than 1 μ s over a 16-hop network.

In a PTP system and in a PP system, the clocks automatically organize themselves into a master-slave synchronization hierarchy with the "best" clock available making itself the "grandmaster" at the top of the hierarchy; all others make themselves "slaves" and track the grandmaster. Typically the grandmaster clock receives its time from GPS satellites or some other link to the international time standard. If the grandmaster fails, the next "best" clock available in the domain assumes the grandmaster role. When a clock on start-up discovers that it is "better" than the present grandmaster, it assumes the grandmaster role and the previous grandmaster reverts to slave. The B90 qualification mechanism accepts a potential master clock as a new grandmaster, when in a four-second interval it has received three announce messages from it, all better than the present grandmaster clock and better than any other announce in this interval.

Time messages issued by the grandmaster are delayed as they pass through the network both due to the finite speed of the signal in the interconnecting fiber or wire, and due to processing delays in the Ethernet switches. Each clock and switch implementing PP measures the propagation delay to each of its PP neighbors, and compensates for these delays in the time received. Each network device implementing PP measures the processing delay it introduces in each time message and compensates for this delay in the time it transmits. As a result, the time delivered to end-devices such as the UR are virtually identical to the grandmaster time. If one of the network devices in the hierarchy does not fully implement PP, the associated propagation delay and/or latency may not be compensated for, and the time received at the end-device can be in error by more than 100 μ s.

See the preceding Real Time Clock section for a description of when time values received via PTP are used to update the relay's real time clock.

The following settings are available for configuring the relay for PTP. The PTP menu displays only when the option was purchased.

STRICT POWER PROFILE — Power profile (IEEE Std C37.238 2011) requires that the relay only select a power profile compliant clock as a grandmaster, that the delivered time have worst-case error of $\pm 1 \mu$ s, and that the peer delay mechanism be implemented. With the strict power profile setting enabled, the relay only selects as master the clocks displaying the

IEEE_C37_238 identification codes. It uses a port only when the peer delay mechanism is operational. With the strict power profile setting disabled, the relay uses clocks without the power profile identification when no power profile clocks are present, and uses ports even if the peer delay mechanism is non-operational. This setting applies to all of the relay's PTP capable ports.

PTP DOMAIN NUMBER — Set this setting to the domain number of the grandmaster-capable clock(s) to be synchronized to. A network can support multiple time distribution domains, each distinguished with a unique domain number. More commonly, there is a single domain using the default domain number zero.

This setting applies to all of the relay's PTP capable ports.

PTP VLAN PRIORITY — This setting selects the value of the priority field in the 802.1Q VLAN tag in request messages issued by the relay's peer delay mechanism. In compliance with PP the default VLAN priority is 4, but it is recommended that it be set to 7 in accordance with PTP. Depending on the characteristics of the device to which the relay is linked directly, VLAN Priority can have no effect.

This setting applies to all of the relay's PTP capable ports.

PTP VLAN ID — This setting selects the value of the ID field in the 802.1Q VLAN tag in request messages issued by the relay's peer delay mechanism. It is provided in compliance with PP. As these messages have a destination address that indicates they are not to be bridged, their VLAN ID serves no function, and so can be left at its default value. Depending on the characteristics of the device to which the relay is linked directly, VLAN ID can have no effect. This setting applies to all of the relay's PTP capable ports.

PORT 1 ... 3 FUNCTION — While this port setting is selected to disabled, PTP is disabled on this port. The relay does not generate or listen to PTP messages on this port.

PORT 1 ... 3 PATH DELAY ADDER — The time delivered by PTP is advanced by the time value in this setting prior to the time being used to synchronize the relay's real time clock. This is to compensate to the extent practical for time delivery delays not compensated for in the network. In a fully compliant PP network, the peer delay and the processing delay mechanisms compensate for all the delays between the grandmaster and the relay. In such networks, make this setting zero.

In networks containing one or more switches and/or clocks that do not implement both of these mechanisms, not all delays are compensated, so the time of message arrival at the relay is later than the time indicated in the message. This setting can be used to approximately compensate for this delay. However, as the relay is not aware of network switching that dynamically changes the amount of uncompensated delay, there is no setting that always and completely corrects for uncompensated delay. A setting can be chosen that reduces the worst-case error to half of the range between minimum and maximum uncompensated delay, if these values are known.

PORT 1 ... 3 PATH DELAY ASSYMMETRY — This setting corresponds to "delayAsymmetry" in PTP, which is used by the peer delay mechanism to compensate for any difference in the propagation delay between the two directions of a link. Except in unusual cases, the two fibers are of essentially identical length and composition, so make this setting zero.

In unusual cases where the length of the link is different in different directions, set this setting to the number of nanoseconds the Ethernet propagation delay to the relay is longer than the mean of path propagation delays to and from the relay. For instance, if it is known say from the physical length of the fibers and the propagation speed in the fibers that the delay from the relay to the Ethernet switch it is connected to is 9000 ns and that the delay from the switch to the relay is 11000 ns, then the mean delay is 10000 ns, and the path delay asymmetry is 11000 - 10000 = +1000 ns.

5.3.7.3 SNTP protocol

SETTINGS ⇒ PRODUCT SETUP ⇒ REAL TIME CLOCK ⇒ SNTP PROTOCOL

■ SNTP PROTOCOL

⇔

SNTP FUNCTION:
Disabled

Range: Enabled, Disabled

⇕

SNTP SERVER IP ADDR:
0.0.0.0

Range: standard IP address format

↑

SNTP UDP PORT
NUMBER: 123

Range: 0 to 65535 in steps of 1

The B90 supports the Simple Network Time Protocol specified in RFC-2030. With SNTP, the B90 can obtain clock time over an Ethernet network. The B90 acts as an SNTP client to receive time values from an SNTP/NTP server, usually a dedicated product using a GPS receiver. UR series relays support unicast, broadcast, multicast, and anycast SNTP functionality.

The **SNTP FUNCTION** setting enables or disables the SNTP feature on the B90.

To use SNTP in unicast mode, set **SNTP SERVER IP ADDR** to the SNTP/NTP server IP address. Once this address is set and **SNTP FUNCTION** is “Enabled,” the B90 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 B90 clock is closely synchronized with the SNTP/NTP server. It takes up to two minutes for the B90 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 B90 then listens to SNTP messages sent to the “all ones” broadcast address for the subnet. The B90 waits up to 18 minutes (>1024 seconds) without receiving an SNTP broadcast message before signaling an SNTP self-test error.

The **SNTP UDP PORT NUMBER** is 123 for normal SNTP operation. If SNTP is not required, close the port by setting the port number to 0, after which the change takes effect when the B90 is restarted.



Do not set more than one protocol to the same TCP/UDP port number, as this results in unreliable operation of those protocols.

5.3.7.4 Local time

SETTINGS ⇒ PRODUCT SETUP ⇒ ⬅ REAL TIME CLOCK ⇒ ⬅ LOCAL TIME

LOCAL TIME	↔	LOCAL TIME OFFSET FROM UTC: 0.0 hr	Range: -24.0 to 24.0 hr in steps of 0.5
	↕	DAYLIGHT SAVINGS TIME: Disabled	Range: Disabled, Enabled
	↕	DST START MONTH: January	Range: January to December (all months)
	↕	DST START DAY: Sunday	Range: Sunday to Saturday (all days of the week)
	↕	DST START DAY INSTANCE: First	Range: First, Second, Third, Fourth, Last
	↕	DST START HOUR: 2:00	Range: 0:00 to 23:00
	↕	DST STOP MONTH: January	Range: January to December (all months)
	↕	DST STOP DAY: Sunday	Range: Sunday to Saturday (all days of the week)
	↕	DST STOP DAY INSTANCE: First	Range: First, Second, Third, Fourth, Last
	⬆	DST STOP HOUR: 2:00	Range: 0:00 to 23:00

The B90 maintains two times: local time and Universal Coordinated Time (UTC). Local time can be provided by IRIG-B signals. UTC time is provided by SNTP servers.

The real-time clock (RTC) and timestamps reported in historical records and communication protocols can be incorrect if the Local Time settings are not configured properly.

See the IRIG-B section in the Installation chapter for guidance on these settings when using an IRIG-B source that sets the IRIG-B control bits according to IEEE Std 1344-1995.

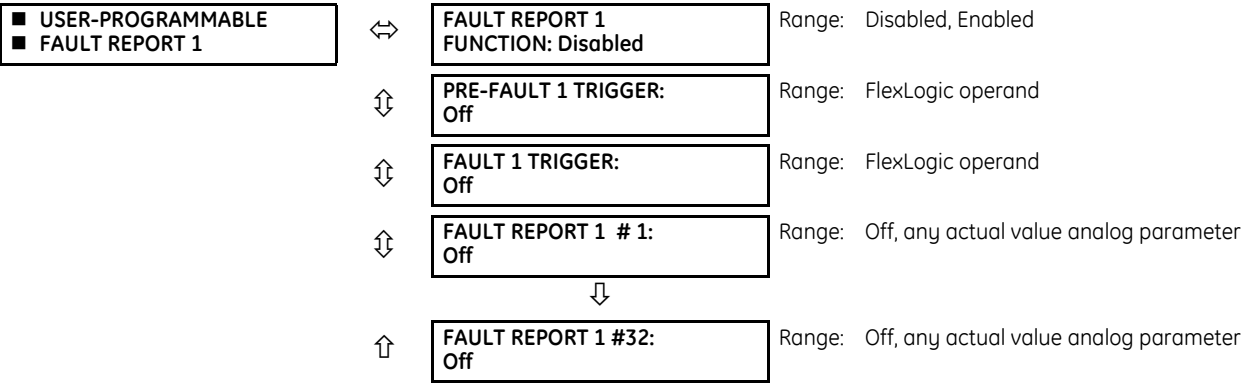
LOCAL TIME OFFSET FROM UTC — Used to specify the local time zone offset from UTC (Greenwich Mean Time) in hours. Time zones in the eastern hemisphere have positive values; time zones in the western hemisphere have negative values. A value of zero causes the relay to use UTC for local time. This setting has two uses. When the system RTC is synchronized with a communications protocol providing only local time or it is free-running, the offset setting is used to calculate UTC from the

local time these provide. When the RTC is synchronized with a communications protocol providing only UTC (such as PTP or SNTP), the time offset setting is used to determine local time from the UTC provided. PTP
ALTERNATE_TIME_OFFSET_INDICATOR TLVs are not used to calculate local time.

DAYLIGHT SAVINGS TIME and **DST** — Can be used to allow the relay to follow the DST rules of the local time zone. Note that when IRIG-B time synchronization is active, the local time in the IRIG-B signal contains any daylight savings time offset and so the DST settings are ignored. Note that the following items do not include the DST: Time of Day Timer Start Time; Time of Day Timer Stop Time; Event Recorder Last Cleared Date; Source x Demand VAR Maximum Date; Source x Demand WATT Maximum Date; Source x Demand VA Maximum Date; Source x Demand Ia Maximum Date; Source x Demand Ib Maximum Date; Source x Demand Ic Maximum Date; PMU x Last Cleared Date; PMU One-Shot Time; Data Logger Newest Time; Data Logger Oldest Time; Oscillography Last Cleared Date; Last Settings Change Date; User Programmable Fault Report Cleared Date; Digital Counter x Frozen Time Stamp; HIZ RMS Capture x Time; and HIZ Capture x Time.

5.3.8 User-programmable fault report

SETTINGS ⇒ PRODUCT SETUP ⇒ ⇅ USER-PROGRAMMABLE FAULT REPORTS ⇅⇅ USER-PROGRAMMABLE FAULT REPORT 1(2)



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

The user programmable record contains the following information: the user-programmed relay name, detailed firmware revision (x.xx, for example) and relay model (B90), the date and time of trigger, the name of pre-fault trigger (a specific FlexLogic operand), the name of fault trigger (a specific FlexLogic operand), the active setting group at pre-fault trigger, the active setting group at fault trigger, pre-fault values of all programmed analog channels (one cycle before pre-fault trigger), and fault values of all programmed analog channels (at the fault trigger).

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

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

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

PRE-FAULT 1 TRIGGER — Specifies the FlexLogic operand to capture the pre-fault data. The rising edge of this operand stores one cycle-old data for subsequent reporting. The element waits for the fault trigger to actually create a record as long as the operand selected as **PRE-FAULT 1 TRIGGER** is “On.” If the operand remains “Off” for 1 second, the element resets and no record is created.

FAULT 1 TRIGGER — Specifies the FlexLogic operand to capture the fault data. The rising edge of this operand stores the data as fault data and results in a new report. The trigger (not the pre-fault trigger) controls the date and time of the report.

FAULT REPORT 1 # 1 to FAULT REPORT 1 #32 — These settings specify an actual value such as voltage or current magnitude, true RMS, phase angle, frequency, temperature, and so on, to be stored when the report is created. Up to 32 channels can be configured. Two reports are configurable to cope with variety of trip conditions and items of interest.

5.3.9 Oscillography

5.3.9.1 Menu

SETTINGS ⇒ PRODUCT SETUP ⇒ ⬇ OSCILLOGRAPHY

■ OSCILLOGRAPHY	↔	NUMBER OF RECORDS: 15	Range: 3 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	See below
	↑	■ ANALOG CHANNELS	See below

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 can be captured simultaneously.

The **NUMBER OF RECORDS** is selectable, but the number of cycles captured in a single record varies considerably based on other factors, such as sample rate and the number of operational modules. There is a fixed amount of data storage for oscillography; the more data captured, the less the number of cycles captured per record. See the **ACTUAL VALUES** ⇒ ⬇ **RECORDS** ⇒ ⬇ **OSCILLOGRAPHY** menu to view the number of cycles captured per record. The following table provides sample configurations with corresponding cycles/record. The minimum number of oscillographic records is three.

Table 5-12: Oscillography cycles/record example

Records	CT/VTs	Sample rate	Digital channels	Analog channels	Cycles per record
3	1	32	32	16	2399
3	1	64	32	16	1450
16	1	32	32	16	666
16	1	64	32	16	402
32	1	32	32	16	352
32	1	64	32	16	213
3	2	32	32	16	1516
3	2	64	32	16	851
16	2	32	32	16	421

TRIGGER MODE — A new record automatically overwrites an older record when **TRIGGER MODE** is set to “Automatic Overwrite.”

TRIGGER POSITION — Set this to a percentage of the total buffer size (for example, 10%, 50%, 75%, and so on). A trigger position of 25% consists of 25% pre- and 75% post-trigger data.

TRIGGER SOURCE — Always captured in oscillography and can be any FlexLogic parameter (element state, contact input, virtual output, and so on). The relay sampling rate is 64 samples per cycle.

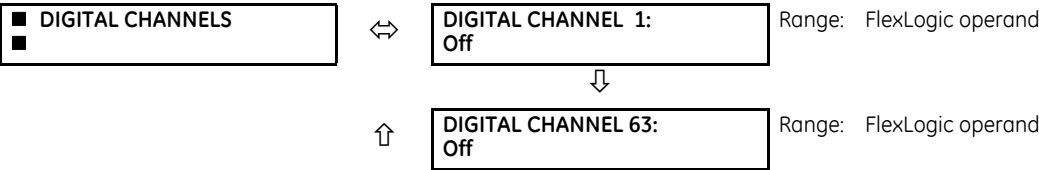
AC INPUT WAVEFORMS — Determines the sampling rate at which AC input signals (that is, current and voltage) are stored. Reducing the sampling rate allows longer records to be stored. This setting has no effect on the internal sampling rate of the relay, which is always 64 samples per cycle. That is, it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

NOTE

When changes are made to the oscillography settings, all existing oscillography records are cleared.

5.3.9.2 Digital channels

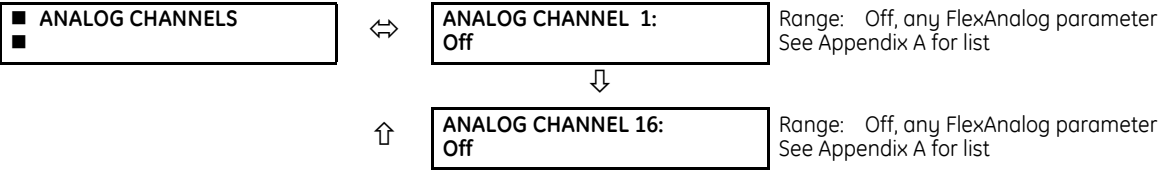
SETTINGS ⇒ PRODUCT SETUP ⇒ ⬇ OSCILLOGRAPHY ⇒ ⬇ DIGITAL CHANNELS



DIGITAL 1(63) CHANNEL — This setting selects the FlexLogic operand state recorded in an oscillography trace. The length of each oscillography trace depends in part on the number of parameters selected here. Parameters set to “Off” are ignored.

5.3.9.3 Analog channels

SETTINGS ⇒ PRODUCT SETUP ⇒ ⬇ OSCILLOGRAPHY ⇒ ⬇ ANALOG CHANNELS



These settings select the metering actual value recorded in an oscillography trace. The length of each oscillography trace depends in part on the number of parameters selected here. Parameters set to “Off” are ignored. The parameters available in a given relay depend 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

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 time-consuming to scan through the list of parameters via the relay keypad and display — entering this number via the relay keypad causes the corresponding parameter to display.

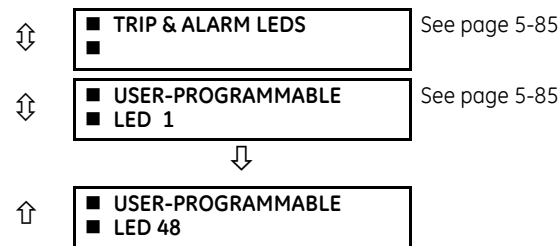
If there are no CT/VT modules and analog input modules, no analog traces appear in the file; only the digital traces appear.

5.3.10 User-programmable LEDs

5.3.10.1 Menu

SETTINGS ⇒ PRODUCT SETUP ⇒ ⬇ USER-PROGRAMMABLE LEDs

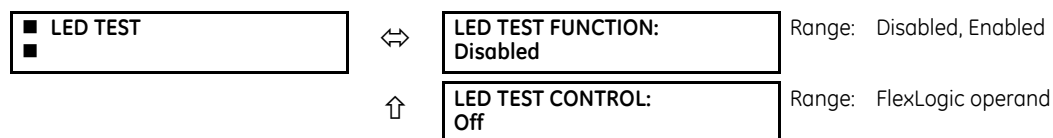




The 48 amber LEDs on relay panels 2 and 3 can be customized to illuminate when a selected FlexLogic operand is in the logic 1 state. The trip and alarm LEDs on panel 1 can also be customized in a similar manner. To ensure correct functionality of all LEDs, an LED test feature is also provided.

5.3.10.2 LED test

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 a 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 the following three stages:

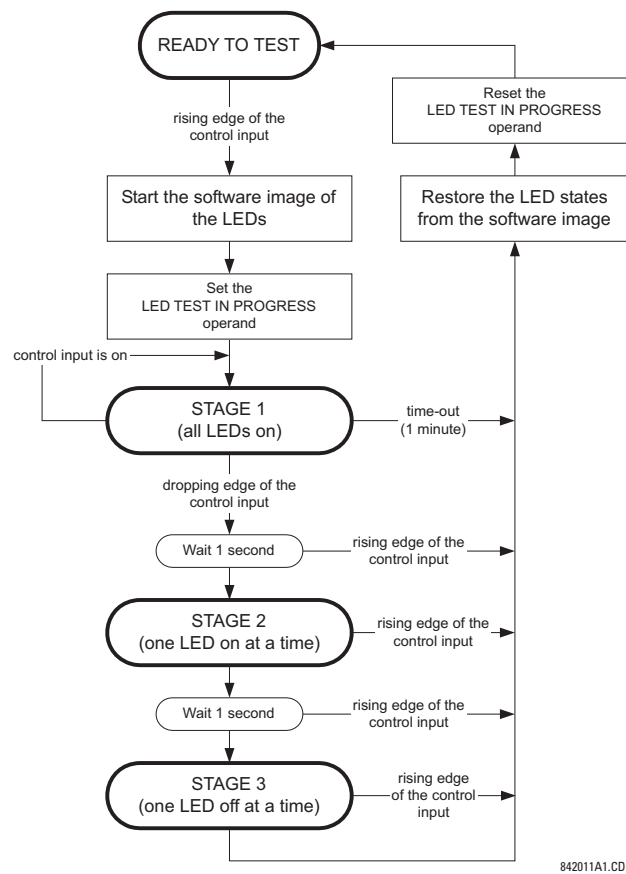
1. All 62 LEDs on the relay are illuminated. This is a quick test to verify if any of the LEDs is “burned.” This stage lasts as long as the control input is on, up to a maximum of 1 minute. After 1 minute, the test ends.
2. All the LEDs are turned off, and then one LED at a time turns on for 1 second, then back off. The test routine starts at the top left panel, moving from the top to bottom of each LED column. This test checks for hardware failures that lead to more than one LED being turned on from a single logic point. This stage can be interrupted at any time.
3. All the LEDs are turned on. One LED at a time turns off for 1 second, then back on. The test routine starts at the top left panel moving from top to bottom of each column of the LEDs. This test checks for hardware failures that lead to more than one LED being turned off from a single logic point. This stage can be interrupted at any time.

When testing is in progress, the LEDs are controlled by the test sequence, rather than the protection, control, and monitoring features. However, the LED control mechanism accepts all the changes to LED states generated by the relay and stores the actual LED states (on or off) in memory. When the test completes, the LEDs reflect the actual state resulting from relay response during testing. The reset pushbutton does 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 5-28: LED test sequence



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Application example 1

Assume one needs to check if any of the LEDs is “burned” through user-programmable pushbutton 1. Apply the following settings.

Configure user-programmable pushbutton 1 by making the following entries in the **SETTINGS ⇒ PRODUCT SETUP ⇒ USER-PROGRAMMABLE PUSHBUTTONS ⇒ USER PUSHBUTTON 1** menu. (The option does not display when not purchased.)

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 is initiated when the user-programmable pushbutton 1 is pressed. Keep the pushbutton pressed for as long as the LEDs are being visually inspected. When finished, release the pushbutton. The relay then automatically starts stage 2. At this point, test can be cancelled by pressing the pushbutton.

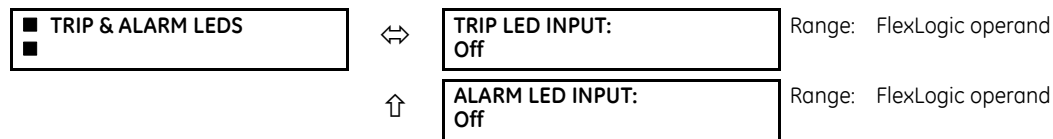
Application example 2

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. When finished, release the pushbutton so that the relay then automatically starts stage 2. When stage 2 is completed, stage 3 starts automatically. The test can be cancelled at any time by pressing the pushbutton.

5.3.10.3 Trip and alarm LEDs

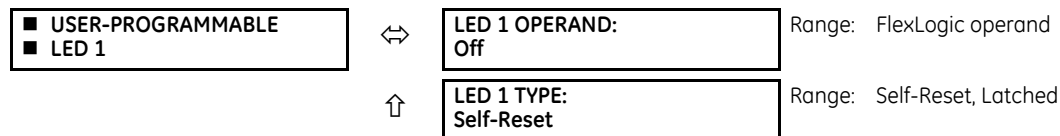
SETTINGS ⇒ PRODUCT SETUP ⇒ ⇅ USER-PROGRAMMABLE LEDs ⇅ ⇅ TRIP & ALARMS LEDs



The trip and alarm LEDs are in the first LED column (enhanced faceplate) and on LED panel 1 (basic faceplate). Each indicator can be programmed to become illuminated when the selected FlexLogic operand is in the logic 1 state.

5.3.10.4 User-programmable LED 1(48)

SETTINGS ⇒ PRODUCT SETUP ⇒ ⇅ USER-PROGRAMMABLE LEDs ⇅ ⇅ USER-PROGRAMMABLE LED 1(48)



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

For the basic faceplate, the LEDs are located as follows:

- LED Panel 2 — User-programmable LEDs 1 through 24
- LED Panel 3 — User programmable LEDs 25 through 48

For the enhanced faceplate, the LEDs are located as follows:

- LED column 2 — User-programmable LEDs 1 through 12
- LED column 3 — User-programmable LEDs 13 through 24
- LED column 4 — User-programmable LEDs 25 through 36
- LED column 5 — User-programmable LEDs 37 through 48

See the LED Indicators section in chapter 4 for information on the location of these indexed LEDs.

The user-programmable LED settings select the FlexLogic operands that control the LEDs. If the **LED 1 TYPE** setting is “Self-Reset” (the default setting), the LED illumination tracks the state of the selected LED operand. If the **LED 1 TYPE** setting is “Latched,” the LED, once lit, remains so until reset by the faceplate **RESET** button, from a remote device via a communications channel, or from any programmed operand, even if the LED operand state de-asserts.

Table 5-13: Recommended settings for user-programmable LEDs

Setting	Parameter	Setting	Parameter
LED 1 operand	SETTING GROUP ACT 1	LED 13 operand	Off
LED 2 operand	SETTING GROUP ACT 2	LED 14 operand	Off
LED 3 operand	SETTING GROUP ACT 3	LED 15 operand	Off
LED 4 operand	SETTING GROUP ACT 4	LED 16 operand	Off
LED 5 operand	SETTING GROUP ACT 5	LED 17 operand	Off
LED 6 operand	SETTING GROUP ACT 6	LED 18 operand	Off
LED 7 operand	Off	LED 19 operand	Off
LED 8 operand	Off	LED 20 operand	Off
LED 9 operand	Off	LED 21 operand	Off
LED 10 operand	Off	LED 22 operand	Off
LED 11 operand	Off	LED 23 operand	Off
LED 12 operand	Off	LED 24 operand	Off

5.3.11 User-programmable self-tests

SETTINGS ⇒ PRODUCT SETUP ⇒ USER-PROGRAMMABLE SELF TESTS

■ USER-PROGRAMMABLE ■ SELF TESTS	↔	DIRECT RING BREAK FUNCTION: Enabled	Range: Disabled, Enabled. Valid for units equipped with Direct Input/Output module.
	↕	DIRECT DEVICE OFF FUNCTION: Enabled	Range: Disabled, Enabled. Valid for units equipped with Direct Input/Output module.
	↕	REMOTE DEVICE OFF FUNCTION: Enabled	Range: Disabled, Enabled
	↕	FIRST ETHERNET FAIL FUNCTION: Disabled	Range: Disabled, Enabled
	↕	SEC. ETHERNET FAIL FUNCTION: Disabled	Range: Disabled, Enabled
	↕	THIRD ETHERNET FAIL FUNCTION: Disabled	Range: Disabled, Enabled
	↕	BATTERY FAIL FUNCTION: Enabled	Range: Disabled, Enabled
	↕	SNTP FAIL FUNCTION: Enabled	Range: Disabled, Enabled
	↕	IRIG-B FAIL FUNCTION: Enabled	Range: Disabled, Enabled
	↕	PTP FAIL FUNCTION: Enabled	Range: Disabled, Enabled
	↑	SFP MODULE FAIL FUNCTION: Disabled	Range: Disabled, Enabled

All major self-test alarms are reported automatically with their corresponding FlexLogic operands, events, and targets. Most of the minor alarms can be disabled if so wanted.

When in the Disabled mode, minor alarms do not assert a FlexLogic operand, write to the event recorder, or display target messages. Moreover, they do not trigger the ANY MINOR ALARM or ANY SELF-TEST messages. When in Enabled mode, minor alarms continue to function along with other major and minor alarms. See the Relay Self-tests section in chapter 7 for information on major and minor self-test alarms.

5.3.12 Control pushbuttons

SETTINGS ⇒ PRODUCT SETUP ⇒ CONTROL PUSHBUTTONS ⇒ CONTROL PUSHBUTTON 1(7)

■ CONTROL ■ PUSHBUTTON 1	↔	CONTROL PUSHBUTTON 1 FUNCTION: Disabled	Range: Disabled, Enabled
	↑	CONTROL PUSHBUTTON 1 EVENTS: Disabled	Range: Disabled, Enabled

There are three standard control pushbuttons, labeled USER 1, USER 2, and USER 3, on the basic and enhanced front panels. These are user-programmable and can be used for various applications such as performing an LED test, switching setting groups, and invoking and scrolling through user-programmable displays.

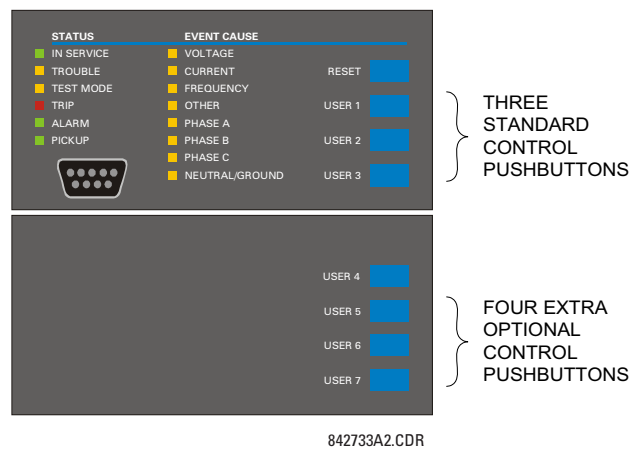
The locations of the control pushbuttons are shown in the following figures.

Figure 5-29: Control pushbuttons (enhanced faceplate)



An additional four control pushbuttons are included on the basic faceplate when the B90 is ordered with the 12 user-programmable pushbutton option.

Figure 5-30: Control pushbuttons (basic faceplate)

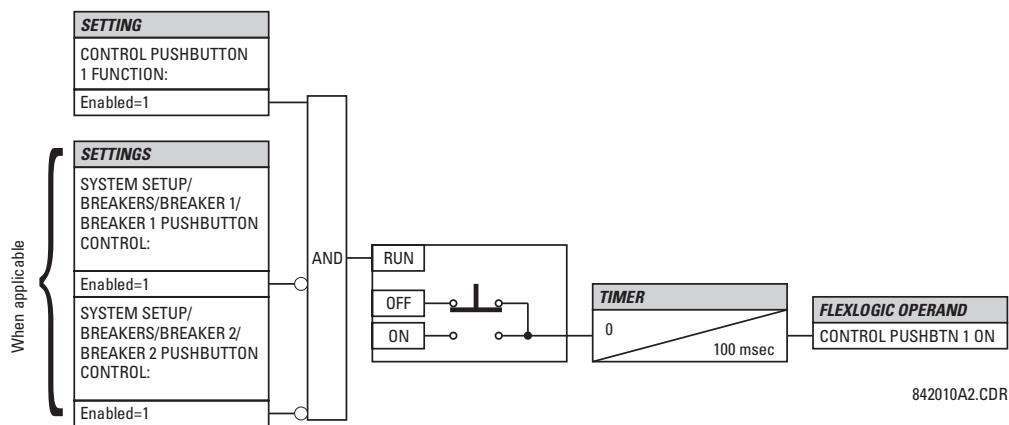


Control pushbuttons are not typically used for critical operations and are not protected by the control password. However, by supervising their output operands, the user can dynamically enable or disable control pushbuttons for security reasons.

Each control pushbutton asserts its own FlexLogic operand. Each operand need to be configured appropriately to perform the required function. Each 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 is recognized by various features that can use control pushbuttons as inputs.

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

Figure 5-31: Control pushbutton logic



5.3.13 User-programmable pushbuttons

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

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



This option is available when an Inter-Relay Communications card is specified at the time of ordering (see the Order Code tables). With the option, direct inputs/outputs display by default. When you enable the teleprotection feature, direct I/O is not visible.

User-programmable pushbuttons provide an easy and error-free method of entering digital state (on, off) information. The number depends on the front panel ordered.

- Enhanced horizontal front panel — 16 user-programmable pushbuttons
- Enhanced vertical front panel — 6 user-programmable pushbuttons
- Basic horizontal front panel — 12 user-programmable pushbuttons

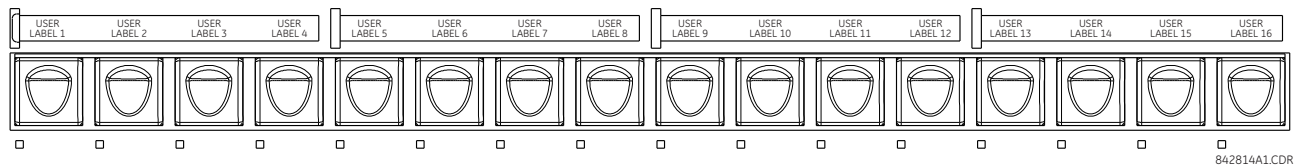


User-programmable pushbuttons require a front panel with that option. If the front panel was ordered separately, update the EnerVista software under **Maintenance > Change Front Panel**.

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

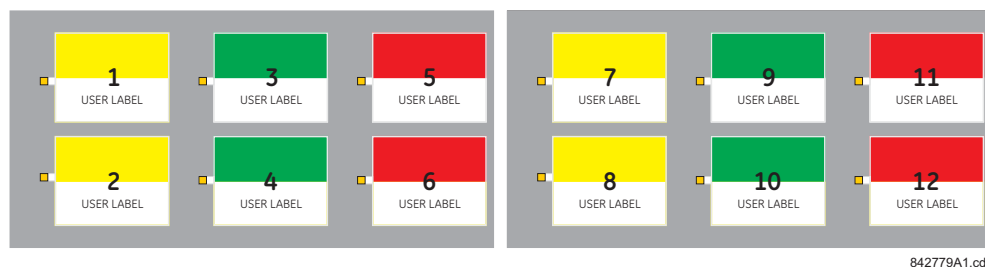
The figure shows user-configurable pushbuttons for the enhanced front panel.

Figure 5-32: User-programmable pushbuttons (enhanced front panel)



The following figure shows user-configurable pushbuttons for the basic front panel.

Figure 5-33: User-programmable pushbuttons (basic front panel)



Both the basic and enhanced front panel pushbuttons can be custom labeled with a factory-provided template, available online at <http://www.gegridsolutions.com/multilin>. The EnerVista software can also be used to create labels for the enhanced front panel.

Each pushbutton asserts its own “On” and “Off” FlexLogic operands (for example, **PUSHBUTTON 1 ON** and **PUSHBUTTON 1 OFF**). These operands are available for each pushbutton and are used to program specific actions. If any pushbutton is active, the **ANY PB ON** operand is asserted.

Each pushbutton has an associated LED indicator. By default, this indicator displays the present status of the corresponding pushbutton (on or off). However, each LED indicator can be assigned to any FlexLogic operand through the **PUSHBTN 1 LED CTL** setting.

The activation and deactivation of user-programmable pushbuttons depends on whether latched or self-reset mode is programmed.

- Latched mode** — In latched mode, a pushbutton can be set (activated) by asserting the operand assigned to the **PUSHBTN 1 SET** setting or by directly pressing the associated front panel pushbutton. The state of each pushbutton is stored in non-volatile memory and maintained through a loss of control power.
 The pushbutton is reset (deactivated) in latched mode by asserting the operand assigned to the **PUSHBTN 1 RESET** setting or by directly pressing the active front panel pushbutton.
 It can also be programmed to reset automatically through the **PUSHBTN 1 AUTORST** and **PUSHBTN 1 AUTORST DELAY** settings. These settings enable the autoreset timer and specify the associated time delay. The autoreset timer can be used in select-before-operate (SBO) breaker control applications, where the command type (close/open) or breaker location (feeder number) must be selected prior to command execution. The selection must reset automatically if control is not executed within a specified time period.
- Self-reset mode** — In self-reset mode, a user-programmable pushbutton can be set (activated) by asserting the operand assigned to the **PUSHBTN 1 SET** setting or by pressing the front panel pushbutton. A pushbutton remains active for the time it is pressed plus the dropout time specified in the **PUSHBTN 1 DROP-OUT TIME** setting. If the pushbutton is activated via FlexLogic, the pulse duration is specified by the **PUSHBTN 1 DROP-OUT TIME** only. The time the operand assigned to the **PUSHBTN 1 SET** setting remains On has no effect on the pulse duration.



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

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

The inhibit functions are not applied to the autoreset feature. The inhibit function can be used in SBO control operations to prevent user-programmable pushbutton activation and ensuring “one-at-a-time” select operation.

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

Pushbutton states can be logged by the event recorder. User-defined messages can also be associated with each pushbutton and displayed when the pushbutton is activated and when in latched mode when the pushbutton deactivated.

PUSHBUTTON 1 FUNCTION — This setting selects the mode of the pushbutton (Self-Reset, Latched, Disabled). If set to “Disabled,” the pushbutton is not active and the corresponding FlexLogic operands (both “On” and “Off”) are de-asserted.

PUSHBTN 1 ID TEXT — This setting specifies the top 20-character line of the user-programmable pushbutton message and is intended to provide ID information of the pushbutton. See the User-definable Displays section in this chapter 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 pushbutton message and is displayed when the pushbutton is in the “on” position. See 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 pushbutton message and displays when the pushbutton is deactivated and the **PUSHBUTTON 1 FUNCTION** is “Latched.” A message does not display when the **PUSHBUTTON 1 FUNCTION** is “Self-reset” as the pushbutton operand status is implied to be “Off” upon its release. The length of the “Off” message is configured with the **PRODUCT SETUP** ⇒ **DISPLAY PROPERTIES** ⇒ **FLASH MESSAGE TIME** setting.

PUSHBTN 1 HOLD — This setting specifies the time required for a front panel pushbutton to be pressed before it is deemed active. This timer is reset upon release of the pushbutton. Note that user-programmable pushbutton operation requires the front panel pushbutton to be pressed a minimum of 50 ms. This minimum time is required prior to activating the user-programmable pushbutton hold timer.

PUSHBTN 1 SET — This setting assigns the FlexLogic operand serving to activate the user-programmable pushbutton element. The duration of the incoming set signal must be at least 50 ms.

PUSHBTN 1 RESET — This setting assigns the FlexLogic operand serving to deactivate the user-programmable pushbutton element. This setting is applicable only if the user-programmable pushbutton is in "Latched" mode.

PUSHBTN 1 AUTORST — This setting enables the user-programmable pushbutton autoreset feature. This setting is applicable only if the pushbutton is in "Latched" mode.

PUSHBTN 1 AUTORST DELAY — This setting specifies the time delay for automatic reset of the pushbutton when in "Latched" mode.

PUSHBTN 1 REMOTE — This setting assigns the FlexLogic operand serving to inhibit user-programmable pushbutton operation from the operand assigned to the **PUSHBTN 1 SET** or **PUSHBTN 1 RESET** settings.

PUSHBTN 1 LOCAL — This setting assigns the FlexLogic operand serving to inhibit user-programmable pushbutton operation from the front panel pushbuttons. This inhibit functionality is not applicable to pushbutton autoreset.

PUSHBTN 1 DROP-OUT TIME — This setting applies only to "Self-Reset" mode and specifies the duration of the user-programmable pushbutton active status after the front panel pushbutton has been released. When activated remotely, this setting specifies the entire activation time of the pushbutton; the length of time the operand selected by **PUSHBTN 1 SET** remains on has no effect on the pulse duration.

PUSHBTN 1 LED CTL — This setting assigns the FlexLogic operand serving to drive the front panel pushbutton LED. If this setting is "Off," then LED operation is directly linked to the **PUSHBUTTON 1 ON** operand.

PUSHBTN 1 MESSAGE — This setting controls the behavior of the user-programmable pushbutton on message that is programmed in the **PUSHBTN 1 ID** and **PUSHBTN 1 ON TEXT** settings, and the behavior of the user-programmable pushbutton off message that is programmed in the **PUSHBTN 1 ID** and **PUSHBTN 1 OFF TEXT** settings.

When set to "Disabled", user-programmable pushbutton messages do not display. Otherwise the on message displays when the user-programmable pushbutton becomes activated, and if in the "Latched" mode the off message displays when the user-programmable pushbutton becomes deactivated.

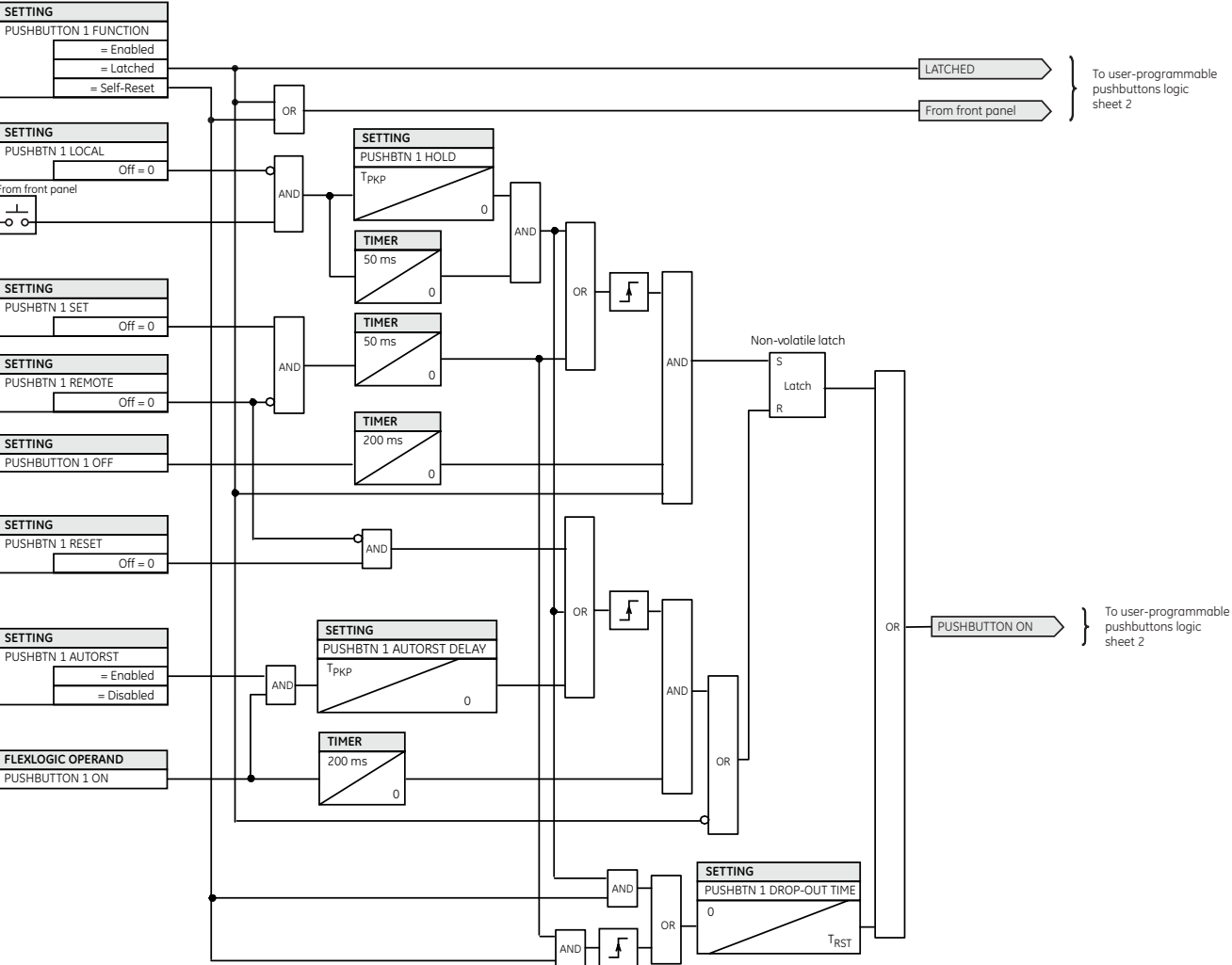
When set to "Normal", the duration the message displays is as specified by the **FLASH MESSAGE TIME** setting.

When set to "High Priority", the duration of the off message is as specified by the **FLASH MESSAGE TIME** setting, but the on message is displayed as long as the user-programmable pushbutton is activated. While activated, target and other messages are suppressed. To allow front panel keypad operation, when a keypad button is pressed the message is suppressed for 10 seconds.

PUSHBUTTON 1 EVENTS — If this setting is enabled, each user-programmable pushbutton state change is logged as an event into the event recorder.

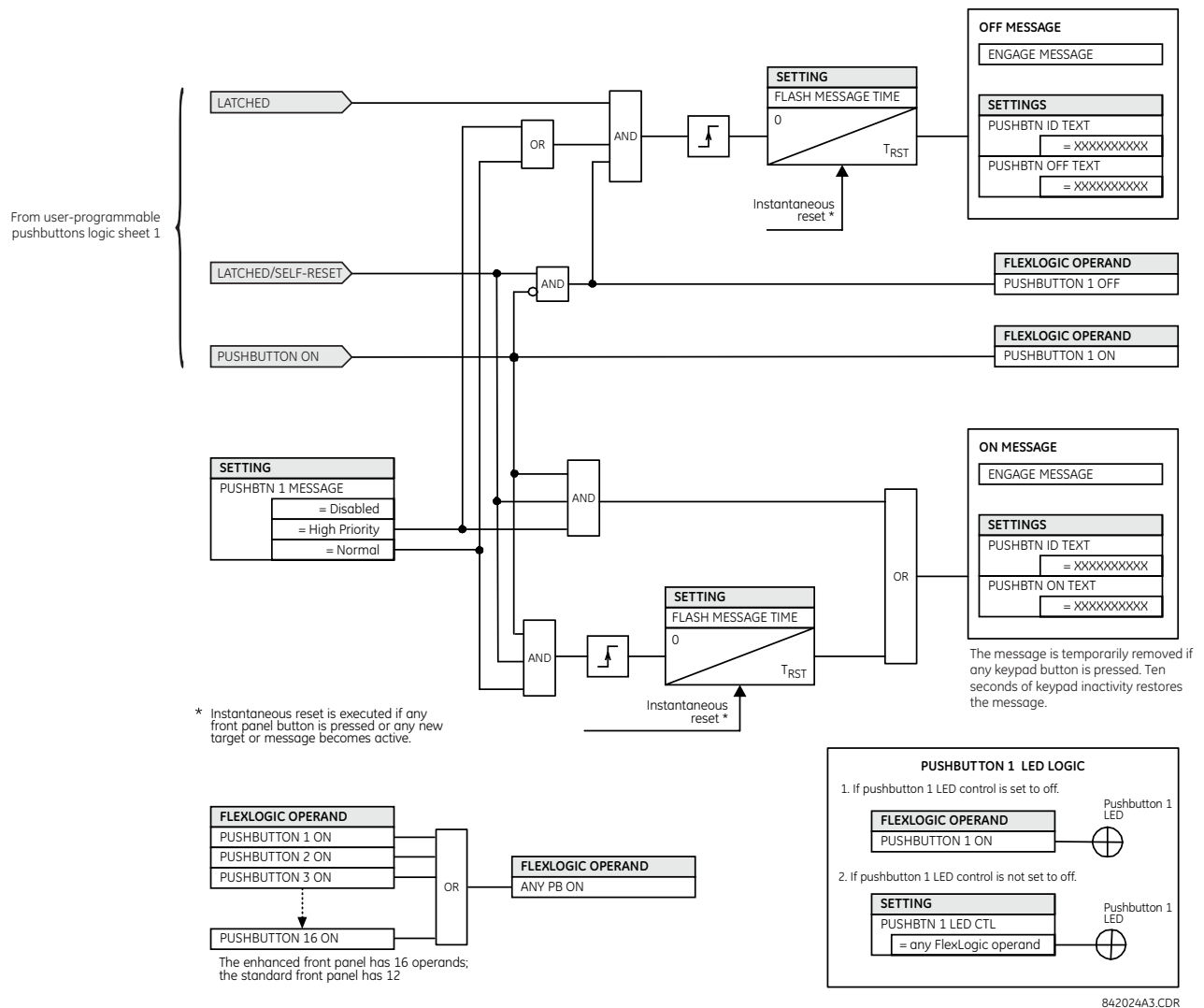
The figures show the user-programmable pushbutton logic.

Figure 5-34: User-programmable pushbutton logic (Sheet 1 of 2)



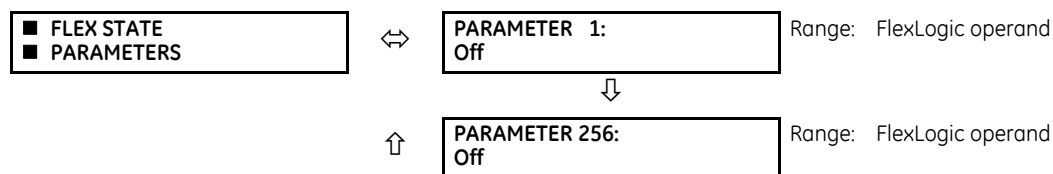
842021A4.CDR

Figure 5-35: User-programmable pushbutton logic (Sheet 2 of 2)



5.3.14 Flex state parameters

SETTINGS ⇒ PRODUCT SETUP ⇒ FLEX STATE PARAMETERS



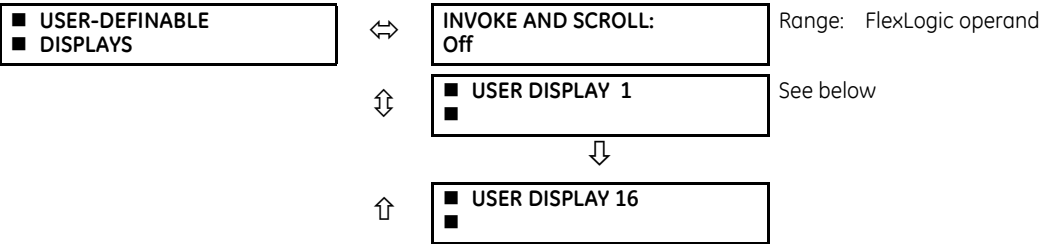
This feature provides a mechanism where any of 256 selected FlexLogic operand states can be used for efficient monitoring. The feature allows user-customized access to the FlexLogic operand states in the relay. The state bits are packed so that 16 states are readable in a single Modbus register. The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

The state bits can be read out in the "Flex States" register array beginning at Modbus address 0900h. Sixteen states are packed into each register, with the lowest-numbered state in the lowest-order bit. Sixteen registers accommodate the 256 state bits.

5.3.15 User-definable displays

5.3.15.1 Menu

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 DISPLAY** 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.

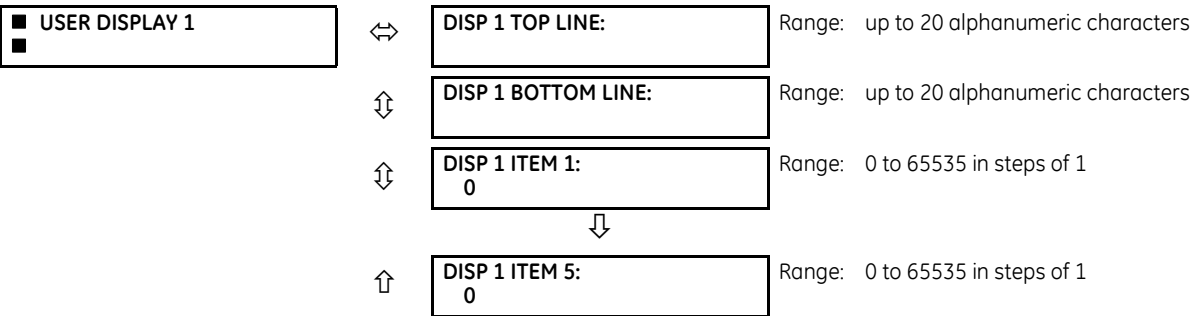
- **Keypad** — Use the **MENU** key to select the **USER DISPLAY** menu item to access the first user-definable display (note that only the programmed screens are displayed). The screens can be scrolled using the up and down arrow keys. The display disappears after the default message time-out period 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 arrow key operate concurrently.

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

5.3.15.2 User display 1(16)

SETTINGS ⇒ PRODUCT SETUP ⇒ ⇅ USER-DEFINABLE DISPLAYS ⇒ ⇅ USER DISPLAY 1(16)



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 then prompts with **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 can be edited subsequently.

This menu is used to enter user-defined text and user-selected Modbus-registered data fields into the particular user display. Each user display consists of two 20-character lines (top and bottom). The tilde (~) character is used to mark the start of a data field – the length of the data field needs to be accounted for. Up to five separate data fields can be entered in a user display – the *n*th tilde (~) refers to the *n*th item.

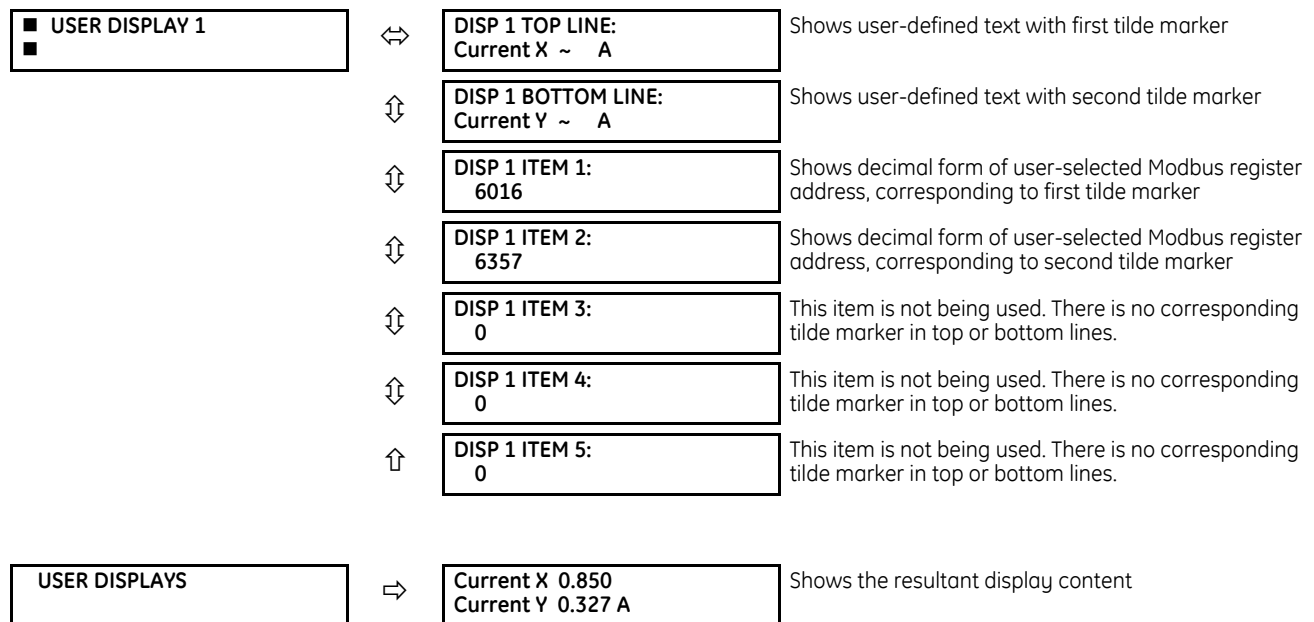
A user display can be entered from the faceplate keypad or the EnerVista interface (preferred for convenience). The following procedure shows how to enter text characters in the top and bottom lines from the faceplate keypad:

1. Select the line to be edited.
2. Press the decimal key to enter text edit mode.
3. Use either **VALUE** key to scroll through the characters. A space is selected like a character.
4. Press the decimal key to advance the cursor to the next position.
5. Repeat step 3 and continue entering characters until the desired text is displayed.
6. The **HELP** key can be pressed at any time for context sensitive help information.
7. Press the **ENTER** key to store the new settings.

To enter a numerical value for any of the five items (the *decimal form* of the selected Modbus address) from the faceplate keypad, use the number keypad. Use the value of "0" for any items not being used. Use the **HELP** key at any selected system display (setting, actual value, or command) which has a Modbus address, to view the *hexadecimal form* of the Modbus address, then manually convert it to decimal form before entering it (EnerVista 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 show in sequence, changing every four seconds. While viewing a user display, press the **ENTER** key and then select the 'Yes' option to remove the display from the user display list. Use the **MENU** key again to exit the user displays menu.

An example of user display setup and result is shown as follows.



If the parameters for the top line and the bottom line items have the same units, then the unit is displayed on the bottom line only. The units are only displayed on both lines if the units specified both the top and bottom line items are different.

5.3.16 Direct inputs and outputs

5.3.16.1 Menu

SETTINGS ⇒ PRODUCT SETUP ⇒ DIRECT I/O

■ DIRECT I/O ■	↔	DIRECT OUTPUT DEVICE ID: 1	Range: 1 to 16 in steps of 1
	↕	DIRECT I/O CH1 RING CONFIGURATION: Yes	Range: Yes, No
	↕	DIRECT I/O CH2 RING CONFIGURATION: Yes	Range: Yes, No
	↕	DIRECT I/O DATA RATE: 64 kbps	Range: 64 kbps, 128 kbps
	↕	DIRECT I/O CHANNEL CROSSOVER: Disabled	Range: Disabled, Enabled
	↕	■ CRC ALARM CH1 ■	See page 5-102
	↕	■ CRC ALARM CH2 ■	
	↕	■ UNRETURNED ■ MESSAGES ALARM CH1	See page 5-102
	↕	■ UNRETURNED ■ MESSAGES ALARM CH2	



This option is available when an Inter-Relay Communications card is specified at the time of ordering (see the Order Code tables). With the option, direct inputs/outputs display by default. When you enable the teleprotection feature, direct I/O is not visible.

Direct inputs and outputs exchange status information (inputs and outputs) between UR-series relays connected directly via type 7 digital communications cards. The mechanism is very similar to IEC 61850 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 are resent (forwarded) when it is determined that the message did not originate at the receiver.

For the direct I/Os to function properly, all UR devices sending I/Os using an Inter-Relay Communications card must have identical firmware revisions.



Teleprotection inputs/outputs and direct inputs/outputs are mutually exclusive. As such, they cannot be used simultaneously. Once teleprotection inputs and outputs are enabled, direct inputs and outputs are blocked, and vice versa.

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

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

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

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

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

For B90 applications, the **DIRECT I/O DATA RATE** should be set to 128 kbps.

Table 5-14: Direct input and output data rates

Module	Channel	Supported data rates
74	Channel 1	64 kbps
	Channel 2	64 kbps
7L	Channel 1	64 kbps, 128 kbps
	Channel 2	64 kbps, 128 kbps
7M	Channel 1	64 kbps, 128 kbps
	Channel 2	64 kbps, 128 kbps
7P	Channel 1	64 kbps, 128 kbps
	Channel 2	64 kbps, 128 kbps
7T	Channel 1	64 kbps, 128 kbps
7W	Channel 1	64 kbps, 128 kbps
	Channel 2	64 kbps, 128 kbps
7V	Channel 1	64 kbps, 128 kbps
	Channel 2	64 kbps, 128 kbps
2A	Channel 1	64 kbps
2B	Channel 1	64 kbps
	Channel 2	64 kbps
2G	Channel 1	128 kbps
2H	Channel 1	128 kbps
2I	Channel 1	64 kbps, 128 kbps
	Channel 2	64 kbps, 128 kbps
2J	Channel 1	64 kbps, 128 kbps
	Channel 2	64 kbps, 128 kbps

Module	Channel	Supported data rates
76	Channel 1	64 kbps
77	Channel 1	64 kbps
	Channel 2	64 kbps
75	Channel 1	64 kbps
	Channel 2	64 kbps
7E	Channel 1	64 kbps
	Channel 2	64 kbps
7F	Channel 1	64 kbps
	Channel 2	64 kbps
7G	Channel 1	64 kbps
	Channel 2	64 kbps
7Q	Channel 1	64 kbps
	Channel 2	64 kbps
7R	Channel 1	64 kbps
7S	Channel 1	64 kbps
	Channel 2	64 kbps



NOTE

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

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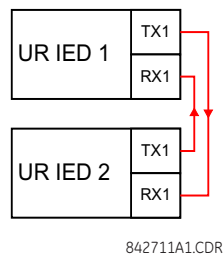
The **DIRECT I/O CHANNEL CROSSOVER** setting applies to B90s with dual-channel communication cards and allows crossing over messages from channel 1 to channel 2. This places all UR-series IEDs into one direct input and output network regardless of the physical media of the two communication channels.

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

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

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

Figure 5-36: Input and output extension via direct inputs and outputs



In this application, apply the following settings. For UR-series IED 1:

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

For UR-series IED 2:

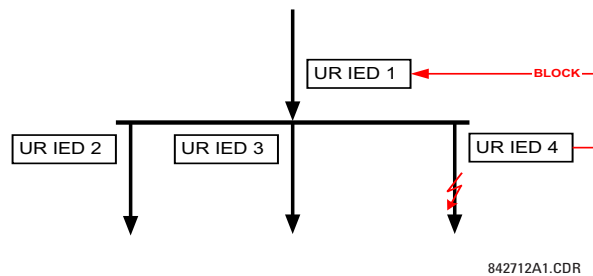
DIRECT OUTPUT DEVICE ID: "2"
 DIRECT I/O CH1 RING CONFIGURATION: "Yes"
 DIRECT I/O DATA RATE: "128 kbps"

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

Example 2: Interlocking busbar protection

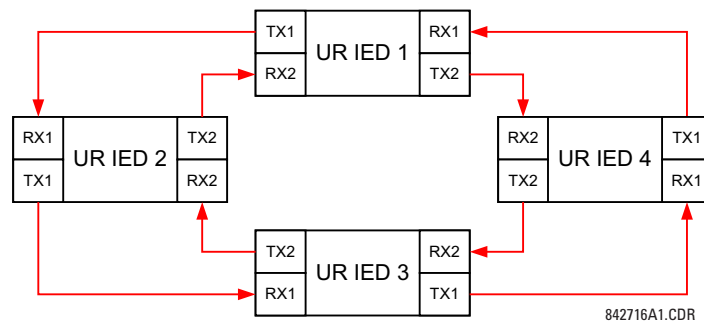
A simple interlocking busbar protection scheme could be accomplished by sending a blocking signal from downstream devices, say 2, 3, and 4, to the upstream device that monitors a single incomer of the busbar, as shown.

Figure 5-37: Sample interlocking busbar protection scheme



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

Figure 5-38: Interlocking bus protection scheme via direct inputs/outputs



In this application, apply the following settings. For UR-series IED 1:

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

For UR-series IED 2:

DIRECT OUTPUT DEVICE ID: "2"
 DIRECT I/O CH1 RING CONFIGURATION: "Yes"
 DIRECT I/O CH2 RING CONFIGURATION: "Yes"

For UR-series IED 3:

DIRECT OUTPUT DEVICE ID: "3"
 DIRECT I/O CH1 RING CONFIGURATION: "Yes"
 DIRECT I/O CH2 RING CONFIGURATION: "Yes"

For UR-series IED 4:

DIRECT OUTPUT DEVICE ID: "4"
 DIRECT I/O CH1 RING CONFIGURATION: "Yes"
 DIRECT I/O CH2 RING CONFIGURATION: "Yes"

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

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

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

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

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

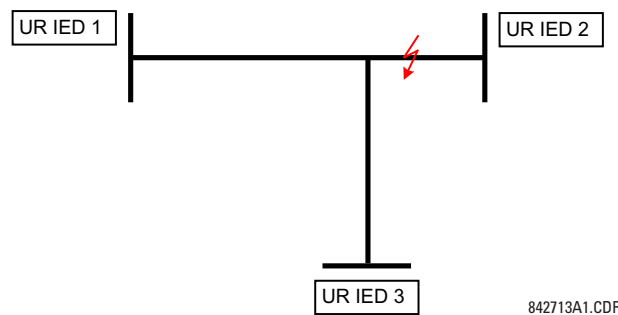
A coordinating timer for this bus protection scheme could be selected to cover the worst case scenario (0.4 of a power system cycle). Upon detecting a broken ring, the coordination time is adaptively increased to 0.6 of a power system cycle. The complete application requires addressing a number of issues,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

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Example 3: Pilot-aided schemes

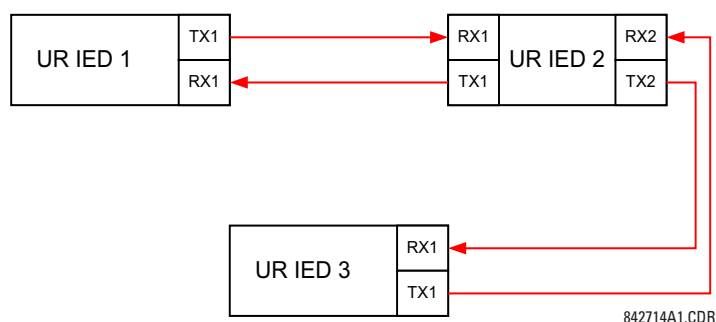
Consider the three-terminal line protection application shown.

Figure 5-39: Three-terminal line application



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

Figure 5-40: Single-channel open loop configuration



In this application, apply the following settings. For UR-series IED 1:

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

For UR-series IED 2:

DIRECT OUTPUT DEVICE ID: "2"
 DIRECT I/O CH1 RING CONFIGURATION: "Yes"
 DIRECT I/O CH2 RING CONFIGURATION: "Yes"

For UR-series IED 3:

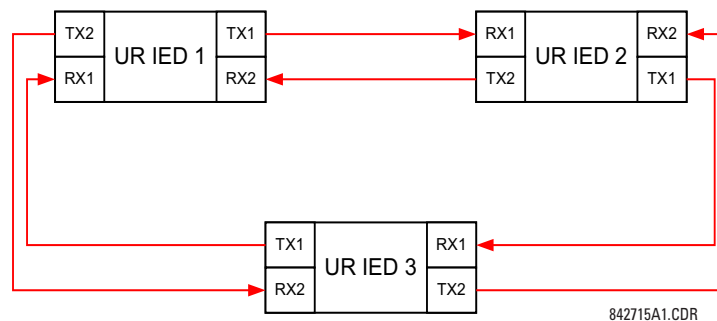
DIRECT OUTPUT DEVICE ID: "3"
 DIRECT I/O CH1 RING CONFIGURATION: "Yes"
 DIRECT I/O CH2 RING CONFIGURATION: "Yes"

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

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

In this scheme, IEDs 1 and 3 do not communicate directly. IED 2 must be configured to forward the messages as explained in the Inputs and Outputs section. Implement a blocking pilot-aided scheme with more security and, ideally, faster message delivery time. This is accomplished using a dual-ring configuration as shown here.

Figure 5-41: Dual-channel closed loop (dual-ring) configuration



In this application, apply the following settings. For UR-series IED 1:

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

For UR-series IED 2:

DIRECT OUTPUT DEVICE ID: "2"
 DIRECT I/O CH1 RING CONFIGURATION: "Yes"
 DIRECT I/O CH2 RING CONFIGURATION: "Yes"

For UR-series IED 3:

DIRECT OUTPUT DEVICE ID: "3"
 DIRECT I/O CH1 RING CONFIGURATION: "Yes"
 DIRECT I/O CH2 RING CONFIGURATION: "Yes"

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

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

The two communications configurations can be applied to both permissive and blocking schemes. Take speed, reliability, and cost into account when selecting the required architecture.

5.3.16.2 CRC alarm CH1(2)

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

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

The B90 checks integrity of the incoming direct input and output messages using a 32-bit CRC. The CRC alarm function is available for monitoring the communication medium noise by tracking the rate of messages failing the CRC check. The monitoring function counts all incoming messages, including messages that failed the CRC check. A separate counter adds up messages that failed the CRC check. When the failed CRC counter reaches the user-defined level specified by the **CRC ALARM CH1 THRESHOLD** setting within the user-defined message count **CRC ALARM CH1 MESSAGE COUNT**, the **DIR IO CH1 CRC ALARM** FlexLogic operand is set.

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

Configure the operand to drive an output contact, user-programmable LED, or selected communication-based output. Latching and acknowledging conditions—if required—are programmed accordingly.

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

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

5.3.16.3 Unreturned messages alarm CH1(2)

SETTINGS ⇒ PRODUCT SETUP ⇒ DIRECT I/O ⇒ UNRETURNED MESSAGES ALARM CH1(2)

UNRETURNED MESSAGES ALARM CH1	↔	UNRET MSGS ALARM CH1 FUNCTION: Disabled	Range: Enabled, Disabled
	↕	UNRET MSGS ALARM CH1 MESSAGE COUNT: 600	Range: 100 to 10000 in steps of 1
	↕	UNRET MSGS ALARM CH1 THRESHOLD: 10	Range: 1 to 1000 in steps of 1
	↑	UNRET MSGS ALARM CH1 EVENTS: Disabled	Range: Enabled, Disabled

The B90 checks integrity of the direct input and output communication ring by counting unreturned messages. In the ring configuration, all messages originating at a given device should return within a pre-defined period of time. The unreturned messages alarm function is available for monitoring the integrity of the communication ring by tracking the rate of

unreturned messages. This function counts all the outgoing messages and a separate counter adds the messages have failed to return. When the unreturned messages counter reaches the user-definable level specified by the **UNRET MSGS ALARM CH1 THRESHOLD** setting and within the user-defined message count **UNRET MSGS ALARM CH1 COUNT**, the **DIR IO CH1 UNRET ALM** FlexLogic operand is set.

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

Configure the operand to drive an output contact, user-programmable LED, or selected communication-based output. Latching and acknowledging conditions, if required, are programmed accordingly.

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

5.3.17 Installation

SETTINGS ⇒ PRODUCT SETUP ⇒ INSTALLATION

☒ INSTALLATION ☐	↔	RELAY SETTINGS: Not Programmed	Range: Not Programmed, Programmed
	↑	RELAY NAME: Relay-1	Range: up to 20 alphanumeric characters

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

The **RELAY NAME** setting allows the user to uniquely identify a relay. This name appears on generated reports.

5.4 System setup

5.4.1 AC inputs

5.4.1.1 Current terminals

SETTINGS ⇒ SYSTEM SETUP ⇒ AC INPUTS ⇒ CURRENT TERMINAL F1(S8)

☒ CURRENT ☐ TERMINAL F1	↔	CT F1 PRIMARY: 65000 A	Range: 1 to 65000 A in steps of 1
	↑	CT F1 SECONDARY: 1 A	Range: 1 A, 5 A

This menu configures the AC current inputs. Upon power up, the B90 recognizes all the AC modules loaded in its chassis and populates the above menu accordingly.

The current terminals are denoted in the following format: Xa, where X = {F, L, S} and a = {1, 2,..., 8}. X represents the chassis slot containing the AC input module and a represents the AC channel of each module. For example, a B90 unit containing the F8H and L8K modules displays the following current inputs for configuration: F1, F2, F3, F4, F5, F6, F7, F8, L1, L2, L3, L4, L5, L6, and L7.

5.4.1.2 Voltage terminals

SETTINGS ⇒ SYSTEM SETUP ⇒ AC INPUTS ⇒ VOLTAGE TERMINAL F1(S8)

☒ VOLTAGE ☐ TERMINAL F1	↔	VT F1 SECONDARY: 66.4 V	Range: 50.0 to 240.0 V in steps of 0.1
---	---	----------------------------	--

↑

VT F1 RATIO:

1.00 :1

Range: 1.00 to 24000.00 :1 in steps of 1.00

This menu configures the AC voltage inputs. Upon power up, the B90 recognizes all the AC modules loaded in its chassis and populates the above menu accordingly.

The voltage terminals are denoted in the following format: Xa, where X = {F, L, S} and a = {5, 6, 7, 8}. X represents the chassis slot containing the AC input module and a represents the AC channel of each module. For example, a B90 unit containing the F8F and L8K modules displays the following voltage inputs: F5, F6, F7, F8, and L8.



The nominal **VT F1 SECONDARY** setting is the voltage across the relay input terminals when nominal voltage is applied to the VT primary.

5.4.2 Power system

SETTINGS ⇄ SYSTEM SETUP ⇄ POWER SYSTEM

■ POWER SYSTEM

■

⇄

NOMINAL FREQUENCY:

60 Hz

Range: 25 to 60 Hz in steps of 1

⇅

FREQUENCY AND PHASE REFERENCE:

F1

Range: available CT and VT channels

↑

FREQUENCY TRACKING:

Enabled

Range: Disabled, Enabled

NOMINAL FREQUENCY — Used as a default to set the digital sampling rate if the system frequency cannot be measured from available signals. This can 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.

FREQUENCY AND PHASE REFERENCE — Determines which AC signal is used for phase angle reference.

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

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

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

FREQUENCY TRACKING — Set to Disabled only in very unusual circumstances; consult the factory for special variable-frequency applications.

5.4.3 FlexCurves

5.4.3.1 Settings

SETTINGS ⇄ SYSTEM SETUP ⇄ FLEXCURVES ⇄ FLEXCURE A(D)

■ FLEXCURVE A

■

⇄

FLEXCURVE A TIME AT

0.00 xPKP: 0 ms

Range: 0 to 65535 ms in steps of 1

⇅

FLEXCURVE A TIME AT

0.05 xPKP: 0 ms

Range: 0 to 65535 ms in steps of 1

↓

↑

FLEXCURVE A TIME AT

20.00xPKP: 0 ms

Range: 0 to 65535 ms in steps of 1

FlexCurves A through D have settings for entering times to reset and operate at the following pickup levels: 0.00 to 0.98 and 1.03 to 20.00. This data is converted into two continuous curves by linear interpolation between data points. To enter a custom FlexCurve, enter the reset and operate times (using the **VALUE** keys) for each selected pickup point (using the **MESSAGE** up/down keys) for the required protection curve (A, B, C, or D).

Table 5-15: 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. Take care when setting the two points that are close to the multiple of pickup of 1; that is, 0.98 pu and 1.03 pu. It is recommended to set the two times to a similar value, otherwise the linear approximation can result in undesired behavior for the operating quantity that is close to 1.00 pu.

5.4.3.2 FlexCurve configuration with EnerVista software

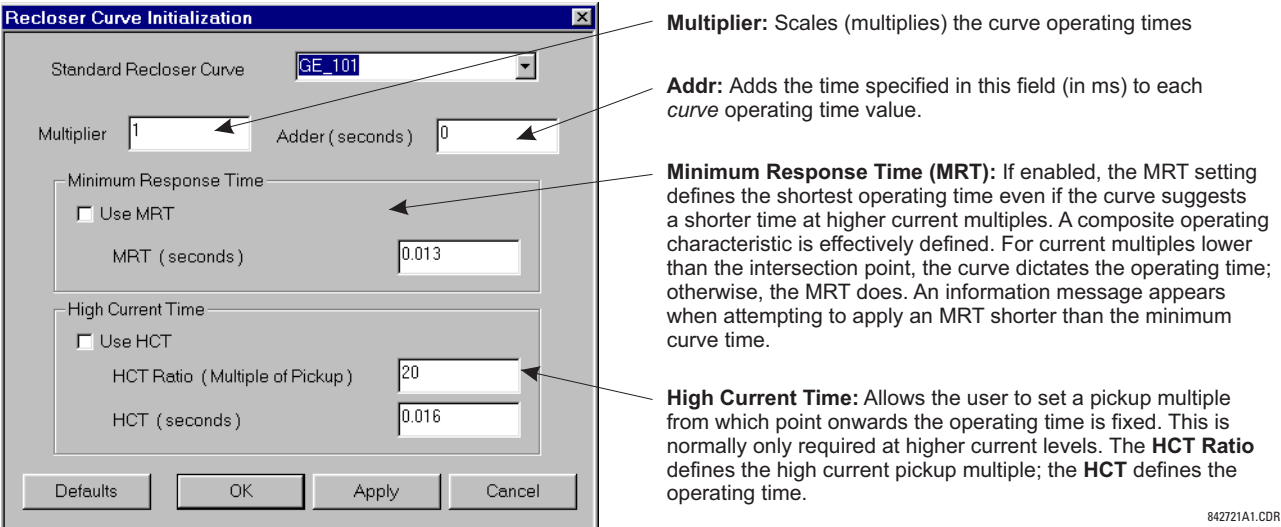
The EnerVista software allows for easy configuration and management of FlexCurves and their associated data points. Prospective FlexCurves can be configured from a selection of standard curves to provide the best approximate fit, then specific data points can be edited afterwards. Alternately, curve data can be imported from a specified file (.csv format) by selecting the EnerVista **Import Data From** setting (**Settings > System Setup > FlexCurves > FlexCurve**).

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.

5.4.3.3 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 here appears when the **Initialize From** setting in the EnerVista software is set to "Recloser Curve" and the **Initialize FlexCurve** button is clicked.

Figure 5-42: Recloser curve initialization



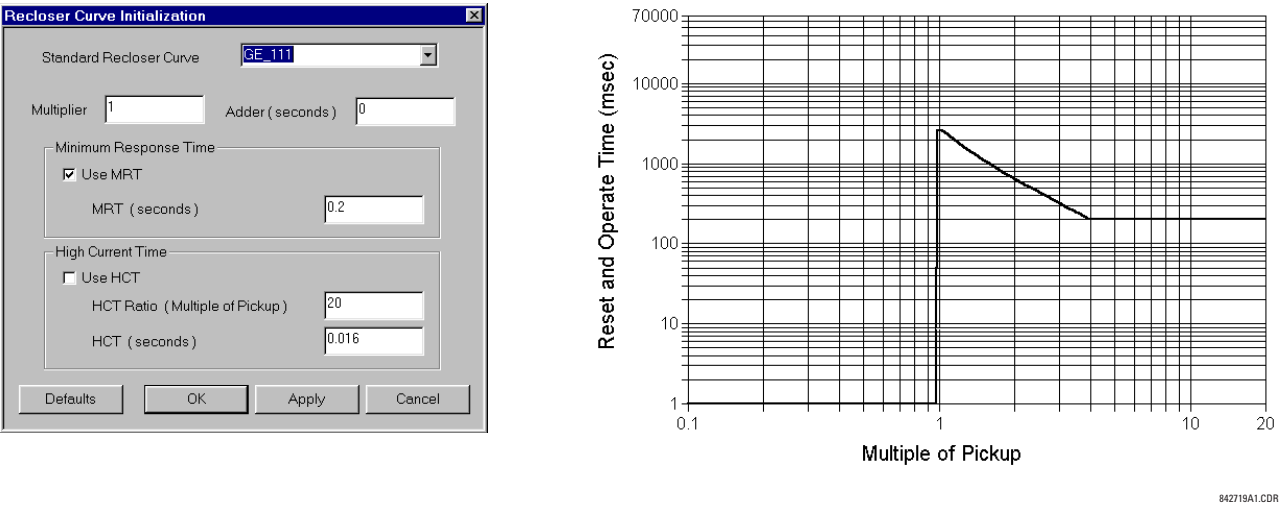
 The **Multiplier** and **Adder** settings only affect the curve portion of the characteristic and not the MRT and HCT settings. The HCT settings override the MRT settings for multiples of pickup greater than the HCT ratio.

5

5.4.3.4 Example

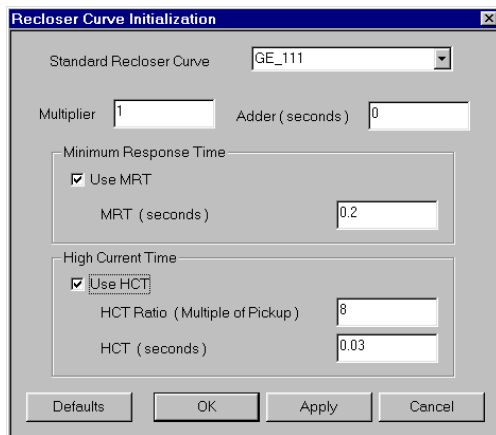
A composite curve can be created from the GE_111 standard with MRT = 200 ms and HCT initially disabled and then enabled at eight times pickup with an operating time of 30 ms. At approximately four times pickup, the curve operating time is equal to the MRT and from then onwards the operating time remains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

Figure 5-43: Composite recloser curve with HCT disabled



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

Figure 5-44: Composite recloser curve with HCT enabled



Recloser Curve Initialization

Standard Recloser Curve: GE_111

Multiplier: 1 Adder (seconds): 0

Minimum Response Time

☒ Use MRT

MRT (seconds): 0.2

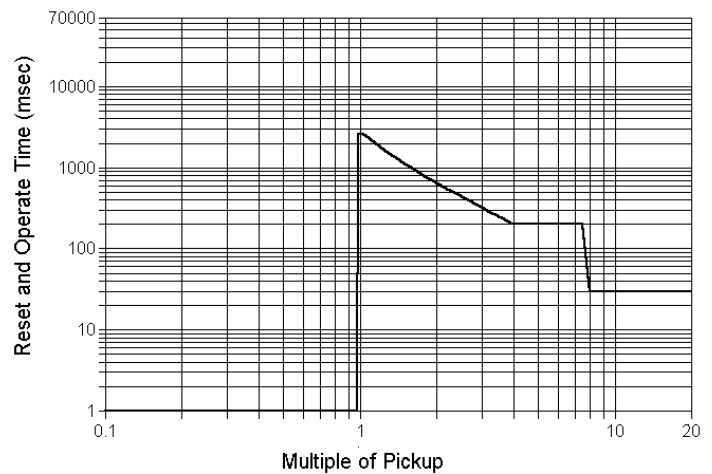
High Current Time

☒ Use HCT

HCT Ratio (Multiple of Pickup): 8

HCT (seconds): 0.03

Defaults OK Apply Cancel



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

5.4.3.5 Standard recloser curves

The following graphs display standard recloser curves available for the B90.

Figure 5-45: Recloser curves GE101 to GE106

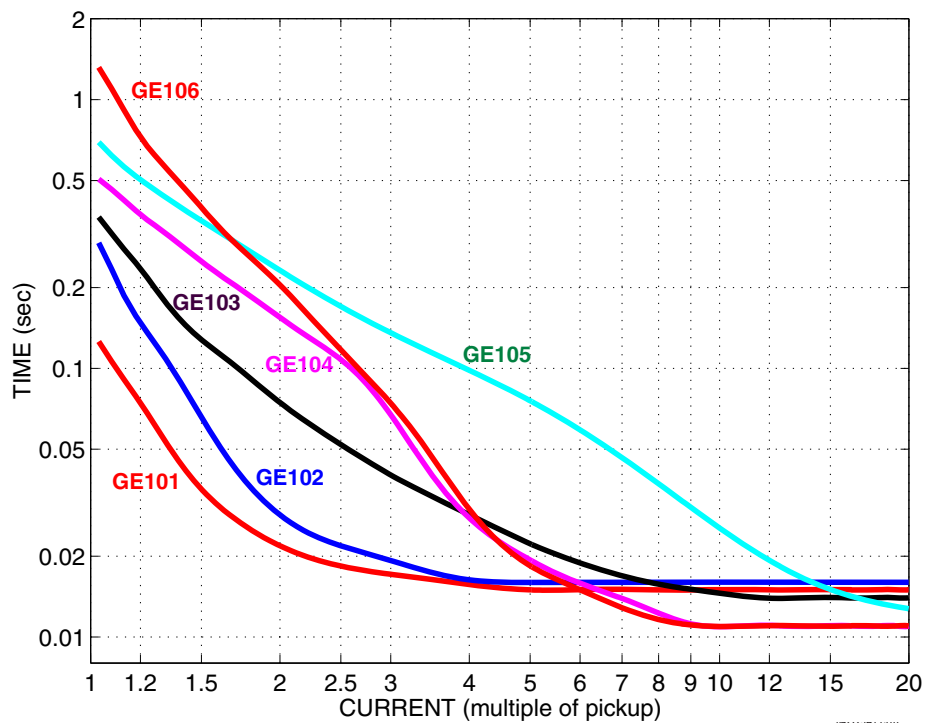


Figure 5-46: Recloser curves GE113, GE120, GE138, and GE142

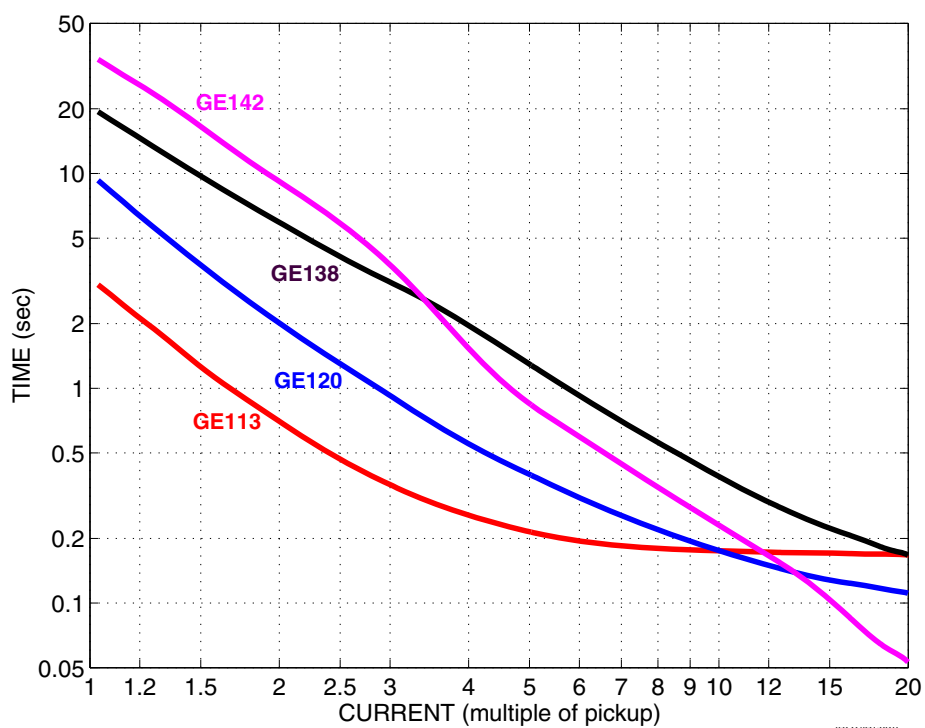


Figure 5-47: Recloser curves GE134, GE137, GE140, GE151, and GE201

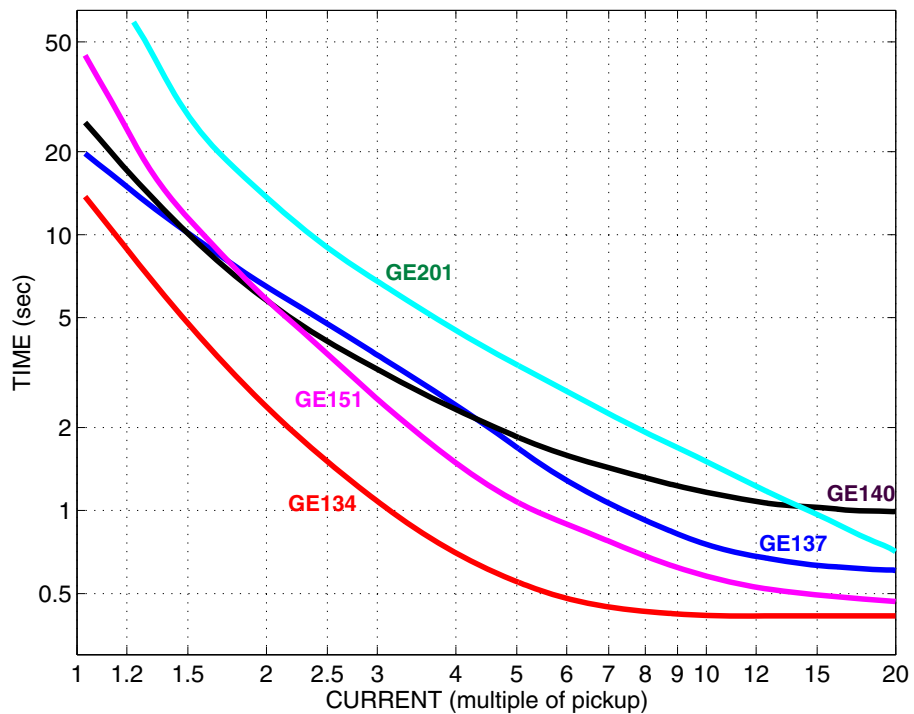


Figure 5-48: Recloser curves GE131, GE141, GE152, and GE200

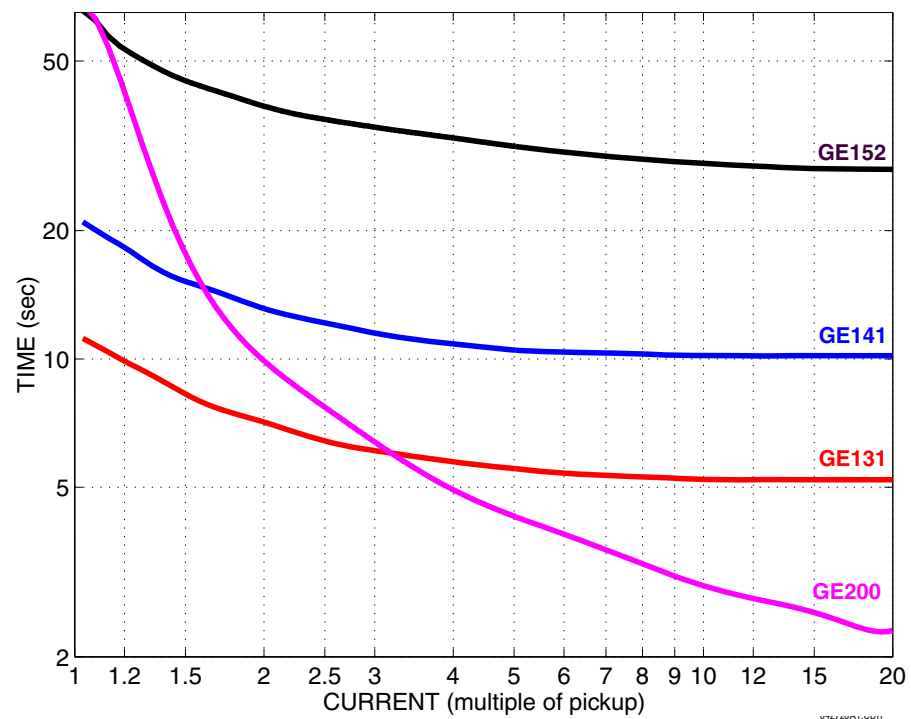


Figure 5-49: Recloser curves GE133, GE161, GE162, GE163, GE164, and GE165

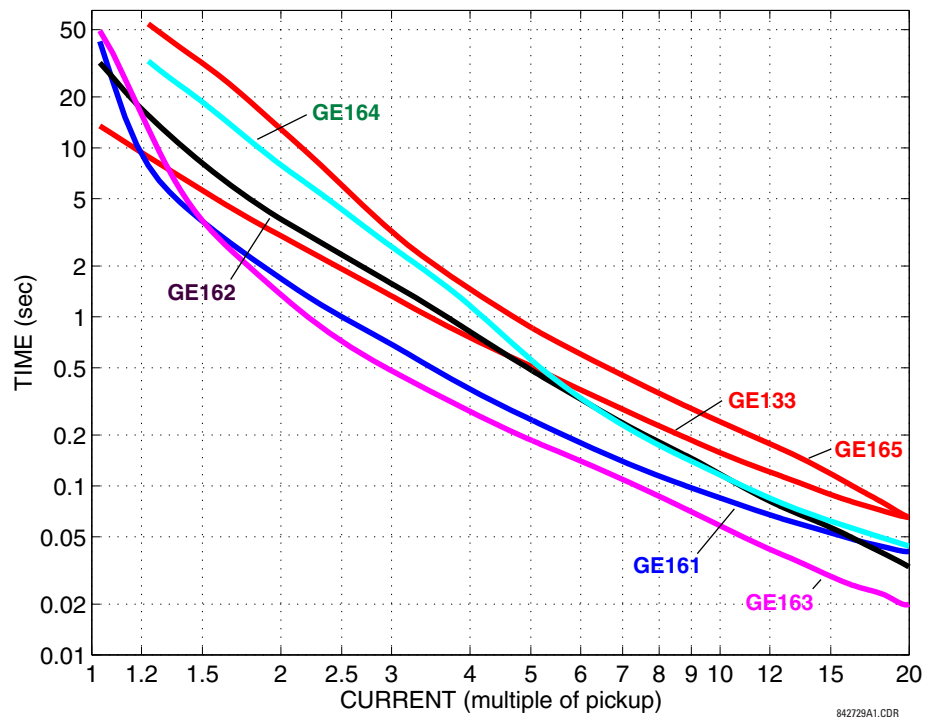


Figure 5-50: Recloser curves GE116, GE117, GE118, GE132, GE136, and GE139

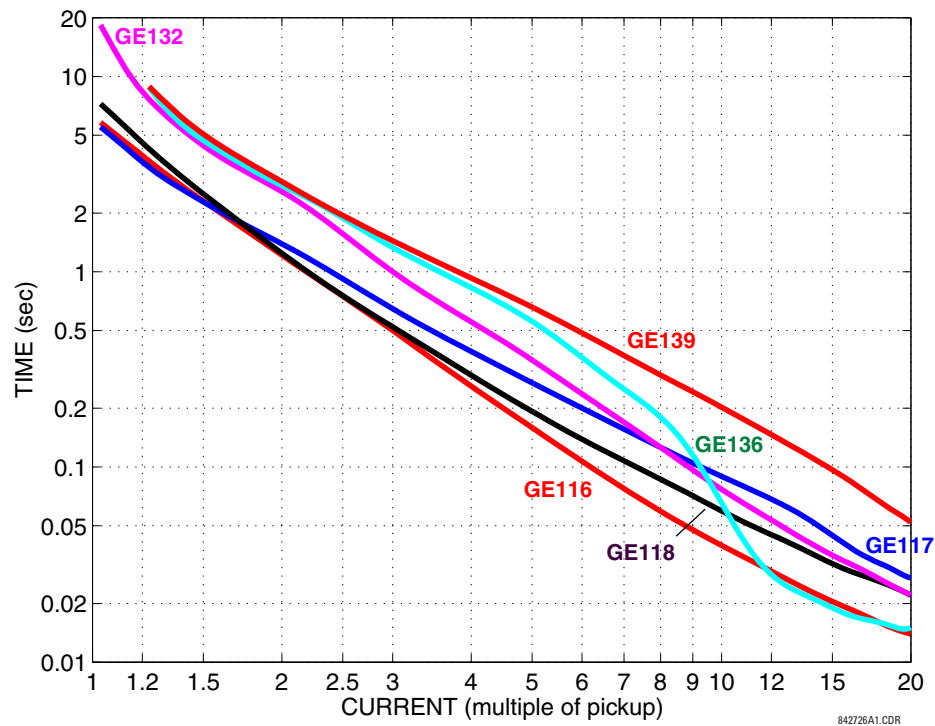


Figure 5-51: Recloser curves GE107, GE111, GE112, GE114, GE115, GE121, and GE122

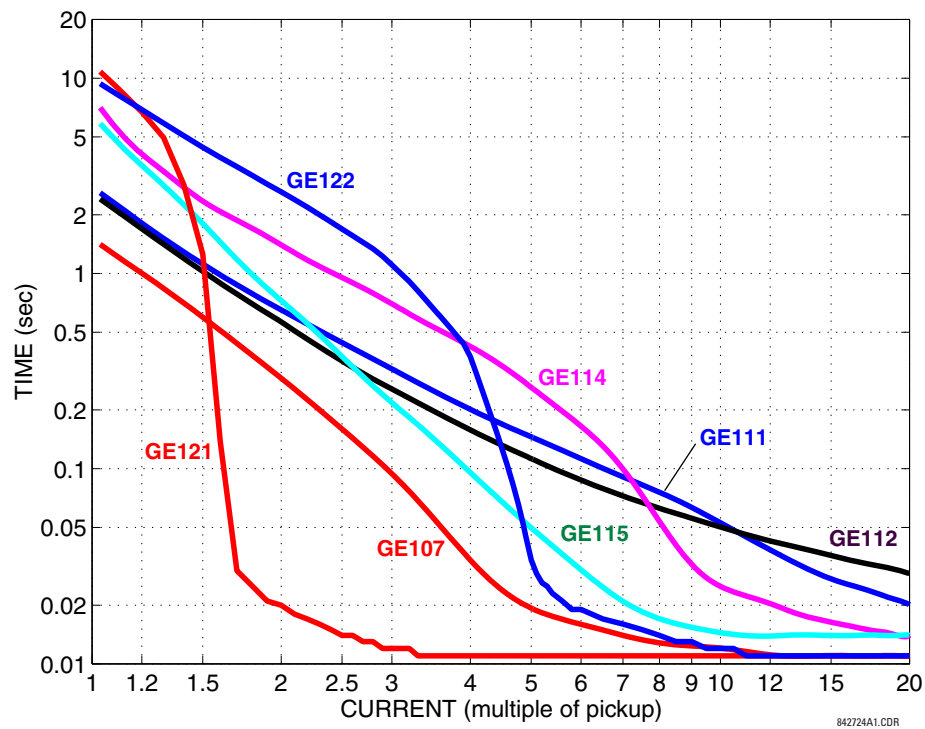
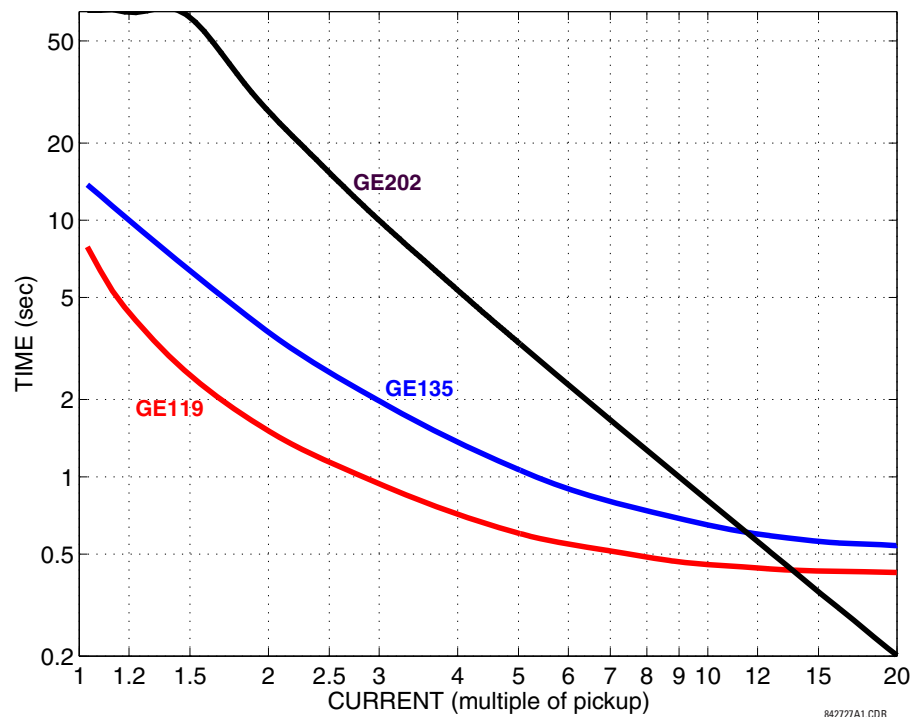


Figure 5-52: Recloser curves GE119, GE135, and GE202



5.4.4 Bus

SETTINGS ⇒ SYSTEM SETUP ⇒ BUS ⇒ BUS ZONE 1(6) ⇒ BUS ZONE 1(6) INPUT A(X)

■ BUS ZONE 1 INPUT A	↔	BUS 1A CT: F1	Range: available CT channels
	↕	BUS 1A DIRECTION: IN	Range: IN, OUT
	↑	BUS 1A STATUS: Off	Range: FlexLogic operand



The number of available zones and their size (maximum number of inputs) are optional and controlled by the software option portion of the order code. See the Order Codes section in chapter 2 for information on the maximum number of zones and inputs for a given B90 model.

Six bus differential zones are available. Each zone is associated with its own bus differential protection and CT trouble monitoring elements. A differential zone is defined by up to 24 pairs (inputs A to X) of current input-bus connection status values.

BUS 1A CT — This setting defines a current input to the zone. Selections include all the CT channels available in the relay as per configured hardware. The protected bus zone is uniquely identified as the portion of the bus between the selected current sources (CTs).

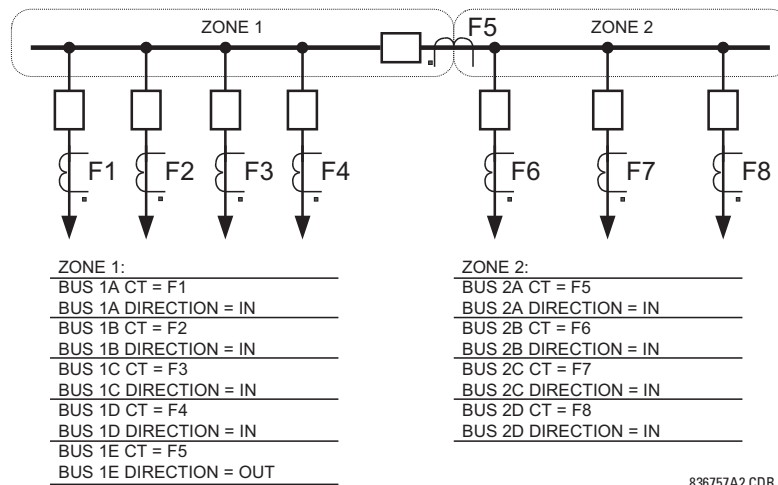
BUS 1A DIRECTION — This setting configures the CT orientation with respect to the protected zone. Bus differential and CT trouble decisions are based on current summation and thus correct orientation selection is important. The following figure shows a tie-breaker dividing a single bus into two sections, defined as zone 1 and zone 2. The tie-breaker CT (F5) is common to both zones and therefore the respective direction settings are opposite. The CT polarity dots are in relation to the protected zone and are terminated to the “common” of the tapped (1 A / 5 A) inputs. The polarity dots for the zone 2 CTs

face outward with respect to the bus; as such, the F5 to F8 direction settings are “IN”. Similarly, the F1 to F4 CTs for zone 1 are selected as “IN.” However, the polarity dot orientation for the F5 CT faces inward with respect to zone 1 and therefore the **BUS 1E DIRECTION** setting is “OUT.”

BUS 1A STATUS — This setting dynamically defines a connection status of a given feeder with respect to the differential zone (dynamic bus replica). If a given feeder is connected to the zone and its current included into differential calculations, the FlexLogic operand used for this setting is “On.” If the current is excluded, the FlexLogic operand is “Off.” Typically, this setting is an appropriately filtered position of an isolator, a breaker, or a tie-breaker.

In the case of an isolator connecting a feeder to a given section of a bus, the isolator monitoring feature produces a reliable isolator position operand (**ISOLATOR 1 POSITION**). Typically, the isolator monitoring feature is enabled in the fourth B90 IED and the **ISOLATOR 1 POSITION** status operand must be sent over direct input/output communications before it can be configured as a **BUS ZONE 1A(X) STATUS** setting.

Figure 5-53: Bus zone direction setting



For example, assume that B90 IED 4 is used for isolator monitoring while IEDs 1, 2, and 3 are used for protection. Consequently, the **B90 FUNCTION** setting of IED 4 must be set to “Logic” while **B90 FUNCTION** on the IEDs 1, 2 and 3 must be set to “Protection.” Normally open and closed auxiliary switches of a given isolator must be wired to the IED 4, and the Isolator feature must be enabled and configured appropriately.

Assume that the isolator shown as follows is monitored by the Isolator 1 feature. The **ISOLATOR 1 POSITION** is the FlexLogic operand asserted by the isolator 1 monitoring element. This operand must be configured to drive a direct output in order to send the connection status to IEDs 1, 2, and 3 where the bus replica is being utilized by differential protection. Assume bit 12 of the message originating at IED 4 is used for this purpose. This is achieved by applying the following settings:

For IED 4:

DIRECT OUTPUT DEVICE ID: “4” (this is the originating device)

DIRECT OUT 12 OPERAND: “**ISOLATOR 1 POSITION**” (this operand drives output number 12)

The above information is to be received by IEDs 1, 2, and 3. Assume direct input 68 is to reflect the isolator position.

For IEDs 1, 2, and 3:

DIRECT INPUT 68 DEVICE: “4” (message received from IED 4)

DIRECT INPUT 68 BIT NUMBER: “12” (using bit number 12)

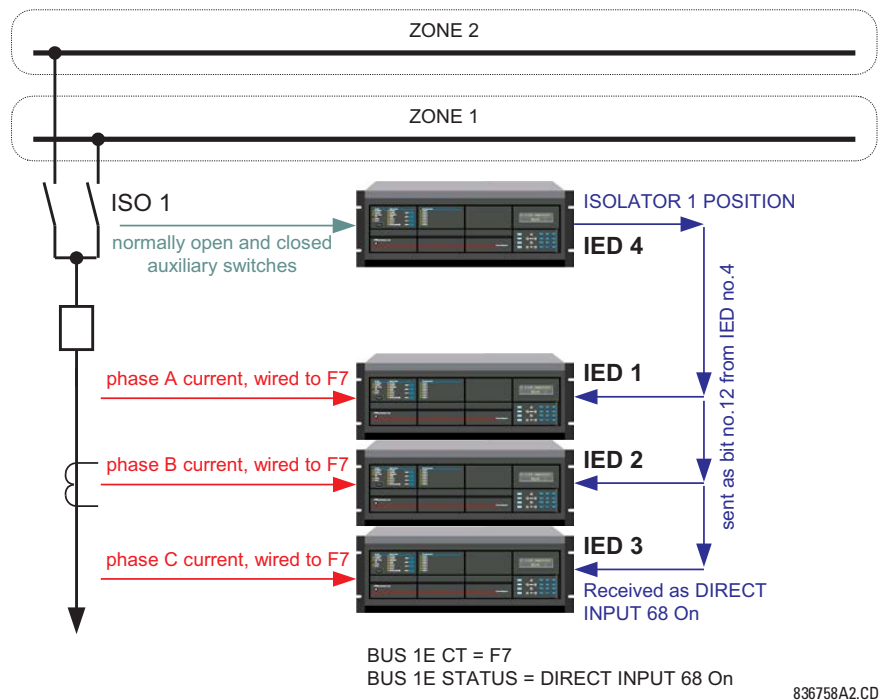
Once received, the isolator 1 status (known on IEDs 1, 2, and 3 as **DIRECT INPUT 68 On**) is used for bus configuration.

For IEDs 1, 2, and 3:

BUS 1E CT: “F7” (the current wired to the F7 terminal)

BUS 1E STATUS: “**DIRECT INPUT 68 On**”

Figure 5-54: Direct input and output sample configuration for dynamic bus replica



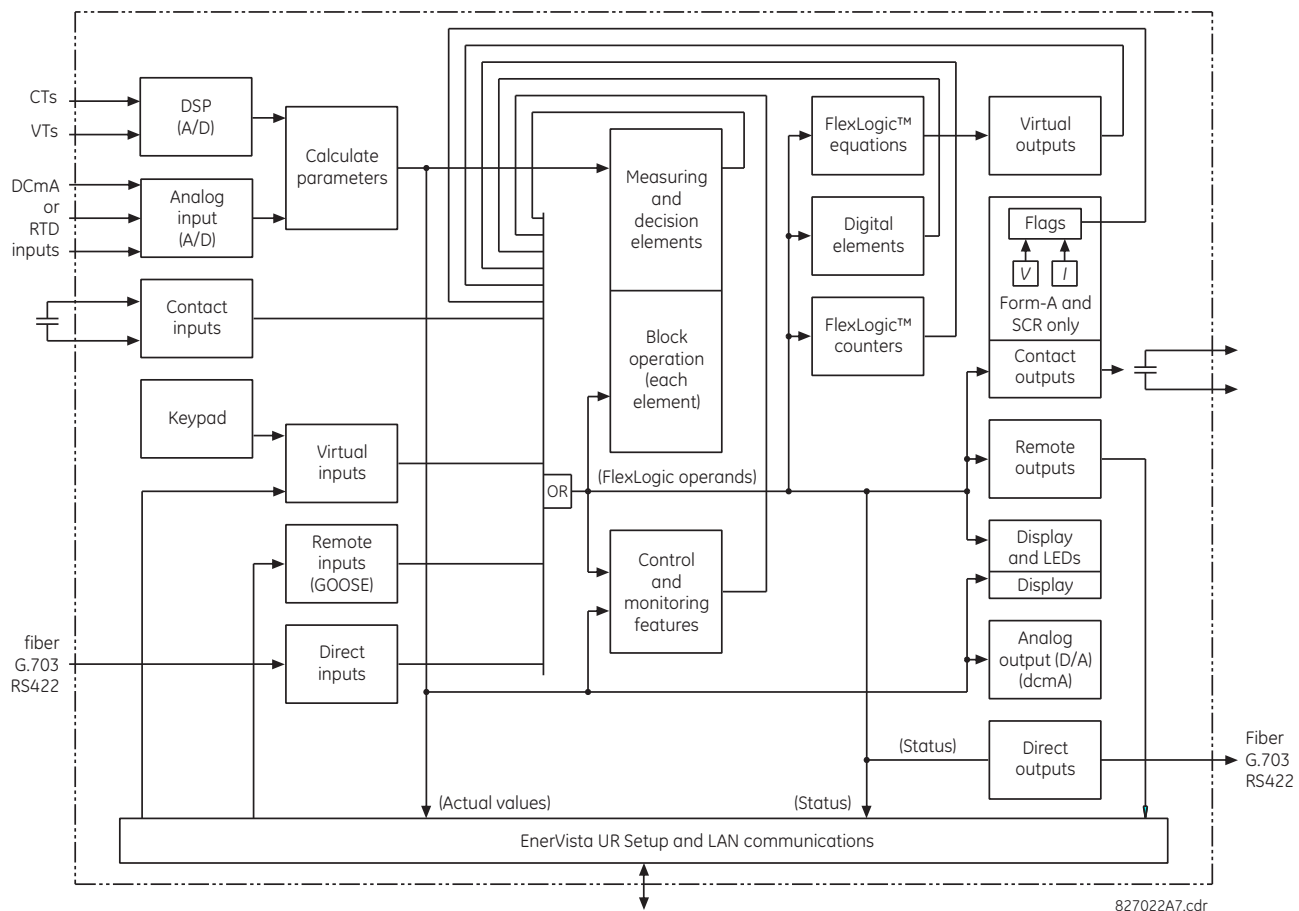
In the case of a breaker (or a tie-breaker), a breaker closed position with a dropout time of 40 to 60 ms is typically used as a connection status to avoid over-tripping or dead zones, depending on the relative position of the breaker and CT. See the Application of Settings chapter for details on configuring bus differential zones.

5.5 FlexLogic

5.5.1 FlexLogic operands

For flexibility, 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 contact input signals through elements or combinations of elements to contact outputs, is variable. The user has complete control of all variable logic through FlexLogic. In general, the system receives analog and digital inputs that it uses to produce analog and digital outputs. The figure shows major subsystems of a generic UR-series relay involved in this process.

Figure 5-55: UR architecture overview



The states of all digital signals used in the B90 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 wanted, 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 shown in the figure is required, it is implemented via FlexLogic. For example, 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 that 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 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, or flag set) or 0 (=OFF, or flag not set). Each equation is evaluated at least four times every power system cycle.

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

Table 5-16: B90 FlexLogic operand types

Operand type	State	Example of format	Characteristics [Input Is '1' (= ON) if...]
Contact Input	On	Cont Ip On	Voltage is applied presently to the input (external contact closed)
	Off	Cont Ip Off	Voltage is not applied presently to the input (external contact open)
Contact Output (type Form-A contact only)	Contact Closed	Cont Op 1 Closed	Contact output is closed
	Current On	Cont Op 1 Ion	Current is flowing through the contact
	Voltage On	Cont Op 1 VOn	Voltage exists across the contact
	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 that responds to rising values or below the pickup setting of an element that responds to falling values
	Dropout	PHASE TOC1 DPO	This operand is the logical inverse of the above PKP operand
	Operate	PHASE TOC1 OP	The tested parameter has been above/below the pickup setting of the element for the programmed delay time, or has been at logic 1 and is now at logic 0 but the reset timer has not finished timing
	Block	PHASE TOC1 BLK	The output of the comparator is set to the block function
Element (Digital)	Pickup	Dig Element 1 PKP	The input operand is at logic 1
	Dropout	Dig Element 1 DPO	This operand is the logical inverse of the above PKP operand
	Operate	Dig Element 1 OP	The input operand has been at logic 1 for the programmed pickup delay time, or has been at logic 1 for this period and is now at logic 0 but the reset timer has not finished timing
Fixed	On	On	Logic 1
	Off	Off	Logic 0
RxGOOSE Boolean	On	RxGOOSE Boolean 1 On	The RxGOOSE Boolean 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 (that is, evaluation of the equation that produces this virtual output results in a "1")

The following table lists alphabetically the operands available for the relay. The operands can be viewed online by entering the IP address of the relay in a web browser and accessing the Device Information Menu.

Table 5-17: B90 FlexLogic operands

Operand type	Operand syntax	Operand description
CONTROL PUSHBUTTONS	CONTROL PUSHBTN 1 ON CONTROL PUSHBTN 2 ON CONTROL PUSHBTN 3 ON CONTROL PUSHBTN 4 ON CONTROL PUSHBTN 5 ON CONTROL PUSHBTN 6 ON CONTROL PUSHBTN 7 ON	Control pushbutton 1 is being pressed Control pushbutton 2 is being pressed Control pushbutton 3 is being pressed Control pushbutton 4 is being pressed Control pushbutton 5 is being pressed Control pushbutton 6 is being pressed Control pushbutton 7 is being pressed
CYBERSENTRY	ROLE ADMIN ACT ROLE SUPERVISOR ACT ROLE ENGINEER ACT ROLE OPERATOR ACT ROLE OBSERVER ACT AUTHENTICATION FAIL UNAUTH FW ATTEMPT UNAUTH SETTING WRITE	Administrator role is active and is set to true when that is the case Supervisor role is active and is set to true when that is the case Engineer role is active and is set to true when that is the case Operator role is active and is set to true when that is the case Observer role is active and is set to true when that is the case Operand set for Failed Authentication self-test and alarm Operand set for firmware lock self-test and alarm Operand set for settings lock self-test and alarm
DIRECT DEVICES	DIRECT DEVICE 1On ↓ DIRECT DEVICE 16On DIRECT DEVICE 1Off ↓ DIRECT DEVICE 16Off	Flag is set, logic=1 ↓ Flag is set, logic=1 Flag is set, logic=1 ↓ Flag is set, logic=1
DIRECT INPUT/ OUTPUT CHANNEL MONITORING	DIR IO CH1 CRC ALARM DIR IO CH2 CRC ALARM DIR IO CH1 UNRET ALM DIR IO CH2 UNRET ALM	The rate of direct input messages received on channel 1 and failing the CRC exceeded the user-specified level The rate of direct input messages received on channel 2 and failing the CRC exceeded the user-specified level The rate of returned direct input/output messages on channel 1 exceeded the user-specified level (ring configurations only) The rate of returned direct input/output messages on channel 2 exceeded the user-specified level (ring configurations only)
ELEMENT: Breaker failure	BKRFAIL 1 RETRIP BKRFAIL 1 T1 OP BKRFAIL 1 T2 OP BKRFAIL 1 T3 OP BKRFAIL 1 TRIP OP BKRSUPV 1 SUPV OP BKRSUPV 1 HISET OP BKRSUPV 1 LOSET OP	Re-trip issued by the breaker failure 1 protection Timer 1 of the breaker failure 1 protection expired Timer 2 of the breaker failure 1 protection expired Timer 3 of the breaker failure 1 protection expired Breaker failure 1 has operated Overcurrent supervision of the breaker failure 1 operated High-set overcurrent supervision of the breaker failure 1 operated Low-set overcurrent supervision of the breaker failure 1 operated
	BKRFAIL 2 to 24 BKRSUPV 2 to 24	Same set of operands as shown for BKRFAIL1 Same set of operands as shown for BKRSUPV 1
ELEMENT: Bus differential	BUS 1 BIASED PKP BUS 1 BIASED DPO BUS 1 BIASED OP BUS 1 UNBIASED OP BUS 1 OP BUS 1 DIR BUS 1 SAT	The biased bus differential element for zone 1 has picked up The biased bus differential element for zone 1 has dropped out The biased bus differential element for zone 1 has operated The unbiased bus differential element for zone 1 has operated The bus differential element for zone 1 has operated The directional unit for the zone 1 bus differential element has issued permission to operate The saturation detector for the zone 1 bus differential element has detected external fault conditions
	BUS 2 to 6	Same set of operands as shown for BUS 1
ELEMENT: CT trouble	CT TROUBLE 1 OP CT TROUBLE 2 OP CT TROUBLE 3 OP CT TROUBLE 4 OP CT TROUBLE 5 OP CT TROUBLE 6 OP	CT trouble has been detected for bus differential zone 1 CT trouble has been detected for bus differential zone 2 CT trouble has been detected for bus differential zone 3 CT trouble has been detected for bus differential zone 4 CT trouble has been detected for bus differential zone 5 CT trouble has been detected for bus differential zone 6

Operand type	Operand syntax	Operand description
ELEMENT: Digital elements	Dig Element 1 PKP Dig Element 1 OP Dig Element 1 DPO	Digital Element 1 is picked up Digital Element 1 is operated Digital Element 1 is dropped out
	Dig Element 2 to 48	Same set of operands as shown for Dig Element 1
ELEMENT: End fault protection	EF1 1 PKP EF1 1 DPO EF1 1 OP	The first end fault protection element has picked up The first end fault protection element has dropped out The first end fault protection element has operated
	EF2 2 to 24	Same set of operands as shown for EF1 1
ELEMENT: Instantaneous overcurrent	IOC 1 PKP IOC 1 DPO IOC 1 OP	Instantaneous overcurrent 1 element has picked up Instantaneous overcurrent 1 element has dropped out Instantaneous overcurrent 1 element has operated
	IOC 2 to 24	Same set of operands as shown for IOC 1
ELEMENT: Isolator monitoring	ISOLATOR 1 POSITION ISOLATOR 1 ALARM ISOLATOR 1 BLOCK	Position of isolator 1 (ON = closed; OFF = open) Contact discrepancy detected for isolator 1 Blocking signal for substation switching operations set due to contact discrepancy of isolator 1 (acknowledgeable)
	ISOLATOR 2 to 48	Same set of operands as shown for ISOLATOR 1
ELEMENT: Non-volatile latches	LATCH 1 ON LATCH 1 OFF	Non-volatile latch 1 is ON (Logic = 1) Non-volatile latch 1 is OFF (Logic = 0)
	LATCH 2 to 16	Same set of operands as shown for LATCH 1
ELEMENT: Setting group	SETTING GROUP ACT 1 SETTING GROUP ACT 2 SETTING GROUP ACT 3 SETTING GROUP ACT 4 SETTING GROUP ACT 5 SETTING GROUP ACT 6	Setting group 1 is active Setting group 2 is active Setting group 3 is active Setting group 4 is active Setting group 5 is active Setting group 6 is active
ELEMENT: Time overcurrent	TOC 1 PKP TOC 1 DPO TOC 1 OP	The time overcurrent 1 element has picked up The time overcurrent 1 element has dropped out The time overcurrent 1 element has operated
	TOC 2 to 24	Same set of operands as shown for TOC 1
ELEMENT: Trip bus	TRIP BUS 1 PKP TRIP BUS 1 OP	Asserted when the trip bus 1 element picks up Asserted when the trip bus 1 element operates
	TRIP BUS 2 to 6	Same set of operands as shown for TRIP BUS 1
ELEMENT: Undervoltage	UNDERVOLTAGE 1 PKP UNDERVOLTAGE 1 DPO UNDERVOLTAGE 1 OP	The undervoltage 1 element has picked up The undervoltage 1 element has dropped out The undervoltage 1 element has operated
	UNDERVOLTAGE 2 to 12	Same set of operands as shown for UNDERVOLTAGE 1
FIXED OPERANDS	Off	Logic = 0. Does nothing and can 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	(does not appear unless ordered) (does not appear unless ordered)
	↓ Cont Ip 1 Off Cont Ip 2 Off	(does not appear unless ordered) (does not appear unless ordered)
	↓ Cont Ip 96 On Cont Ip 96 Off	(does not appear unless ordered) (does not appear unless ordered)
INPUTS/OUTPUTS: Contact outputs,	Cont Op 1 Closed Cont Op 1 IOn Cont Op 1 VOn	Contact output is closed Current is flowing through the contact Voltage exists across the contact (present for contact outputs equipped with monitoring)
	Cont Op 1 VOff	Voltage exists across the contact (present for contact outputs equipped with monitoring)
	Cont Op 2 to 64	Same set of operands as shown for Cont Op 1
INPUTS/OUTPUTS: Direct inputs	DIRECT INPUT 1 On	Flag is set, logic=1
	↓ DIRECT INPUT 96 On	Flag is set, logic=1

Operand type	Operand syntax	Operand description
INPUTS/OUTPUTS: RxGOOSE DPS	RxG DPS 1 BAD RxG DPS 1 INTERM	Asserted while the RxGOOSE double-point status input is in the bad state Asserted while the RxGOOSE double-point status input is in the intermediate state
	RxG DPS 1 OFF RxG DPS 1 ON	Asserted while the RxGOOSE double-point status input is off Asserted while the RxGOOSE double-point status input is on
	RxG DPS 2 to 5	Same set of operands as per RxG DPS 1
INPUTS/OUTPUTS: RxGOOSE Booleans	RxG Bool 1 On RxG Bool 2 On RxG Bool 3 On ↓ RxG Bool 128 On	Flag is set, logic=1 Flag is set, logic=1 Flag is set, logic=1 ↓ Flag is set, logic=1
INPUTS/OUTPUTS: Virtual inputs	Virt Ip 1 On Virt Ip 2 On Virt Ip 3 On ↓ Virt Ip 64 On	Flag is set, logic=1 Flag is set, logic=1 Flag is set, logic=1 ↓ Flag is set, logic=1
INPUTS/OUTPUTS: Virtual outputs	Virt Op 1 On Virt Op 2 On Virt Op 3 On ↓ Virt Op 96 On	Flag is set, logic=1 Flag is set, logic=1 Flag is set, logic=1 ↓ Flag is set, logic=1
LED INDICATORS: Fixed front panel LEDs	LED IN SERVICE LED TROUBLE LED TEST MODE LED TRIP LED ALARM LED PICKUP LED VOLTAGE LED CURRENT LED FREQUENCY ZONE 1 ZONE 2 ZONE 3 ZONE 4 OTHER	Asserted when the front panel IN SERVICE LED is on Asserted when the front panel TROUBLE LED is on Asserted when the front panel TEST MODE LED is on Asserted when the front panel TRIP LED is on Asserted when the front panel ALARM LED is on Asserted when the front panel PICKUP LED is on Asserted when the front panel VOLTAGE LED is on Asserted when the front panel CURRENT LED is on Asserted when the front panel FREQUENCY LED is on Asserted when the front panel OTHER LED is on Asserted when the front panel PHASE A LED is on Asserted when the front panel PHASE B LED is on Asserted when the front panel PHASE C LED is on Asserted when the front panel NEUTRAL/GROUND LED is on
LED INDICATORS: LED test	LED TEST IN PROGRESS	An LED test has been initiated and has not finished
LED INDICATORS: User-programmable LEDs	LED USER 1	Asserted when user-programmable LED 1 is on
	LED USER 2 to 48	The operand above is available for user-programmable LEDs 2 through 48
PASSWORD SECURITY	ACCESS LOC SETG OFF ACCESS LOC SETG ON ACCESS LOC CMND OFF ACCESS LOC CMND ON ACCESS REM SETG OFF ACCESS REM SETG ON ACCESS REM CMND OFF ACCESS REM CMND ON UNAUTHORIZED ACCESS	Asserted when local setting access is disabled Asserted when local setting access is enabled Asserted when local command access is disabled Asserted when local command access is enabled Asserted when remote setting access is disabled Asserted when remote setting access is enabled Asserted when remote command access is disabled Asserted when remote command access is enabled Asserted when a password entry fails while accessing a password protected level of the B90
RxGOOSE	RxGOOSE 1 On RxGOOSE 2 On RxGOOSE 3 On ↓ RxGOOSE 16 On	Flag is set, logic=1 Flag is set, logic=1 Flag is set, logic=1 ↓ Flag is set, logic=1
	RxGOOSE 1 Off RxGOOSE 2 Off RxGOOSE 3 Off ↓ RxGOOSE 16 Off	Flag is set, logic=1 Flag is set, logic=1 Flag is set, logic=1 ↓ Flag is set, logic=1

Operand type	Operand syntax	Operand description
RESETTING	RESET OP RESET OP (COMMS) RESET OP (OPERAND) RESET OP (PUSHBUTTON)	Reset command is operated (set by all three operands below) Communications source of the reset command Operand (assigned in the INPUTS/OUTPUTS ⇒ RESETTING menu) source of the reset command Reset key (pushbutton) source of the reset command
SELF-DIAGNOSTICS (See Relay Self-tests descriptions in Chapter 7: Commands and Targets)	ANY MAJOR ERROR ANY MINOR ERROR ANY SELF-TESTS BATTERY FAIL CLOCK UNSYNCHRONIZED DIRECT DEVICE OFF DIRECT RING BREAK EQUIPMENT MISMATCH FLEXLOGIC ERR TOKEN IRIG-B FAILURE LATCHING OUT ERROR MAINTENANCE ALERT FIRST ETHERNET FAIL PTP FAILURE RxGOOSE OFF RRTD COMM FAIL SECOND ETHERNET FAIL THIRD ETHERNET FAIL SNTP FAILURE SYSTEM EXCEPTION TEMP MONITOR UNIT NOT PROGRAMMED	Any of the major self-test errors generated (major error) Any of the minor self-test errors generated (minor error) Any self-test errors generated (generic, any error) The battery is not functioning. Replace as outlined in the Maintenance chapter. Relay is not synchronized to the international time standard A direct device is configured but not connected The Direct I/O settings is for a connection that is not in a ring The configuration of modules does not match the stored order code A FlexLogic equation is incorrect "Bad IRIG-B Signal" self-test. See Chapter 7: Commands and Targets. A difference is detected between the desired and actual latch contact state A subset of the minor self-test errors generated, see Chapter 7 Link failure detected. See description in Chapter 7: Commands and Targets. "Bad PTP Signal" self-test as described in Chapter 7 One or more GOOSE messages are not being received See description in Chapter 7: Commands and Targets See description in Chapter 7: Commands and Targets See description in Chapter 7: Commands and Targets SNTP server is not responding See description in Chapter 7: Commands and Targets Monitors ambient temperature and maximum operating temperature The product SETUP > INSTALLATION > RELAYS SETTINGS setting is not programmed
TEMPERATURE MONITOR	TEMP MONITOR	Asserted while the ambient temperature is greater than the maximum operating temperature (80°C)
USER-PROGRAMMABLE PUSHBUTTONS	PUSHBUTTON 1 ON PUSHBUTTON 1 OFF ANY PB ON	Pushbutton number 1 is in the "On" position Pushbutton number 1 is in the "Off" position Any of 12 pushbuttons is in the "On" position
	PUSHBUTTON 2 to 6, 12, or 16 depending on front panel	Same set of operands as PUSHBUTTON 1

Some operands can be re-named. These are the names of the breakers in the breaker control feature, the ID (identification) of contact inputs and outputs, the ID of virtual inputs, and the ID of virtual outputs. If the user changes the default name or ID of any of these operands, the assigned name appears in the relay list of operands. The default names are shown in the FlexLogic operands table.

The characteristics of the logic gates are tabulated in the following table, and the operators available in FlexLogic are listed in the FlexLogic operators table.

Table 5-18: 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 5-19: FlexLogic operators

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

5.5.2 FlexLogic rules

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

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

5.5.3 FlexLogic evaluation

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



FlexLogic provides built-in latches that by definition have a memory action, remaining in the set state after the set input has been asserted. These built-in latches are reset dominant, meaning that if logical "1" is applied to both set and reset entries simultaneously, then the output of the latch is logical "0." However, they are volatile, meaning that they reset upon removal of control power.

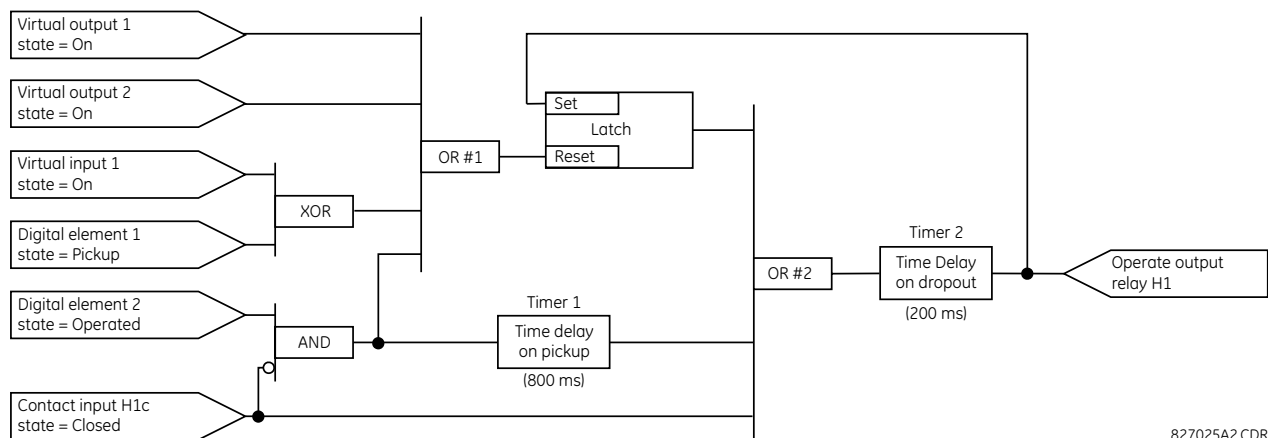
When making changes to FlexLogic entries in the settings, all FlexLogic equations are re-compiled whenever any new FlexLogic entry value is entered, and as a result of the re-compile all latches are reset automatically.

5.5.4 FlexLogic example

This section provides an example of logic implementation for a typical application. The sequence of steps is important to minimize the work to develop the relay settings. Note that the example in the following figure demonstrates the procedure, not to solve a specific application situation.

In the example, it is assumed that logic has already been programmed to produce virtual outputs 1 and 2, and is only a part of the full set of equations used. When using FlexLogic, it is important to make a note of each virtual output used; a virtual output designation (1 to 96) can be assigned only once.

Figure 5-56: Logic example



827025A2.CDR

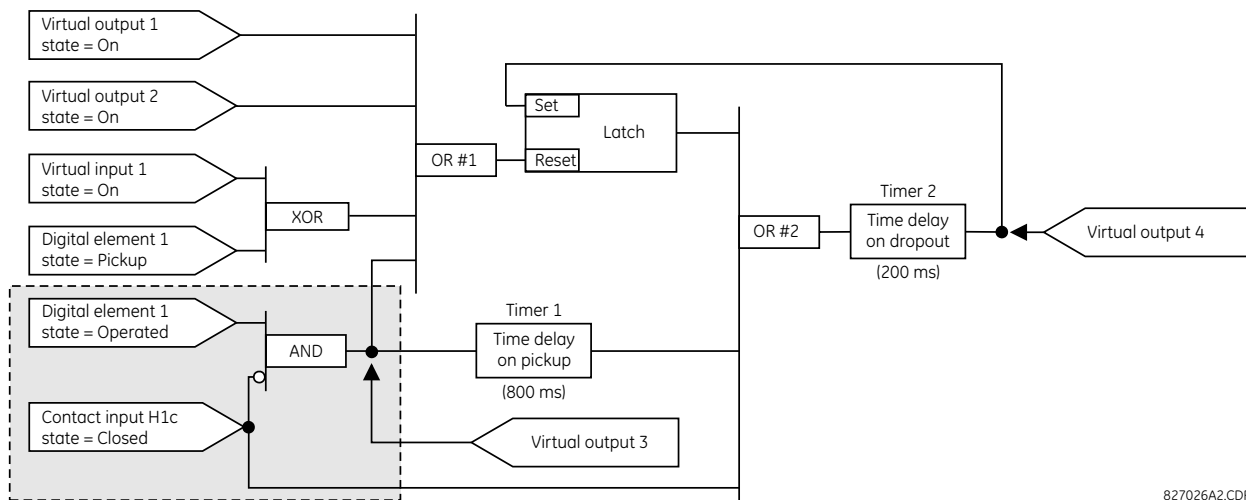
1. Inspect the example logic diagram to determine if the required logic can be implemented with the FlexLogic operators. If this is not possible, the logic must be altered until this condition is satisfied. Once done, count the inputs to each gate to verify that the number of inputs does not exceed the 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, 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 (that is, Virtual Output 3). The final output must also be assigned to a virtual output as virtual output 4, which is programmed in the contact output section to operate relay H1 (that is, contact output H1).

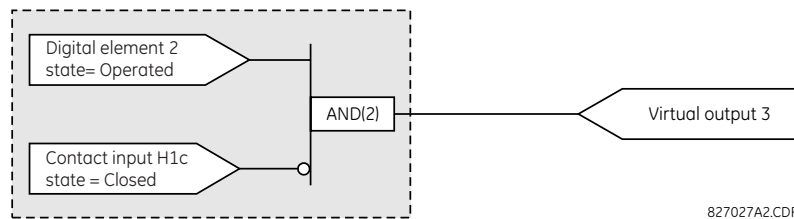
Therefore, the required logic can be implemented with two FlexLogic equations with outputs of virtual output 3 and virtual output 4, shown as follows.

Figure 5-57: Logic example with virtual outputs



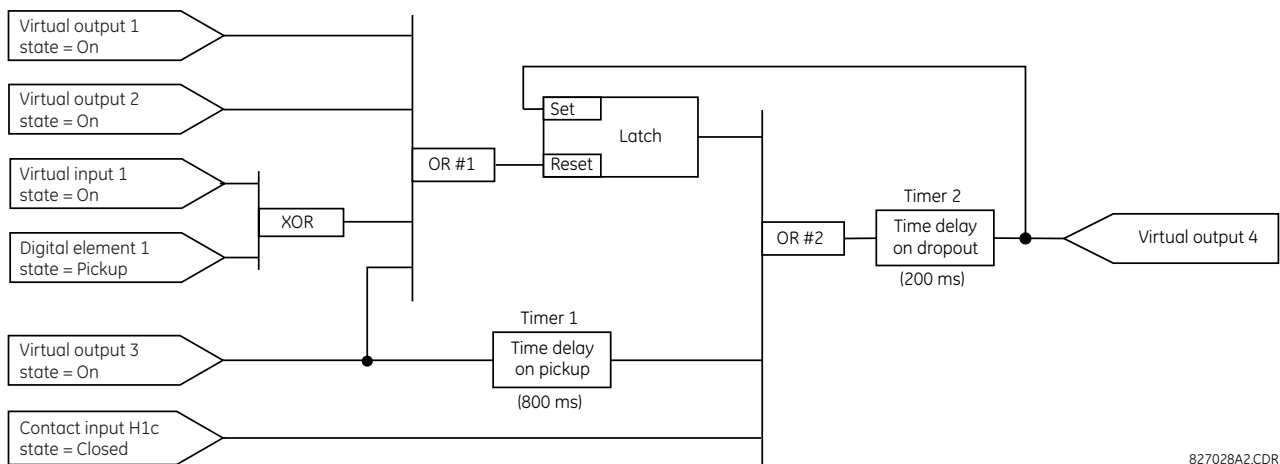
2. Prepare a logic diagram for the equation to produce virtual output 3, as this output is used as an operand in the virtual output 4 equation (create the equation for every output that is used as an operand first, so that when these operands are required they already have been evaluated and assigned to a specific virtual output). The logic for virtual output 3 is shown as follows with the final output assigned.

Figure 5-58: 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, shown as follows.

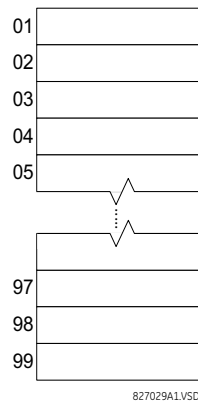
Figure 5-59: Logic for virtual output 4



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 outputs are 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 shown as follows.

Figure 5-60: FlexLogic worksheet



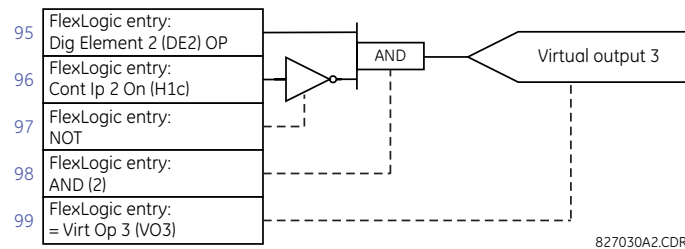
5. Following the procedure outlined, start with parameter 99, as follows:
 - 99: The final output of the equation is virtual output 3, which is created by the operator "= Virt Op n". This parameter is therefore "= Virt Op 3".
 - 98: The gate preceding the output is an AND, which in this case requires 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 operates 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 that 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 forms 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 produces the required logic by converting the set of parameters into a logic diagram. The result of this process is shown in the figure, which is compared to the logic for virtual output 3 diagram as a check.

Figure 5-61: FlexLogic equation for virtual output 3



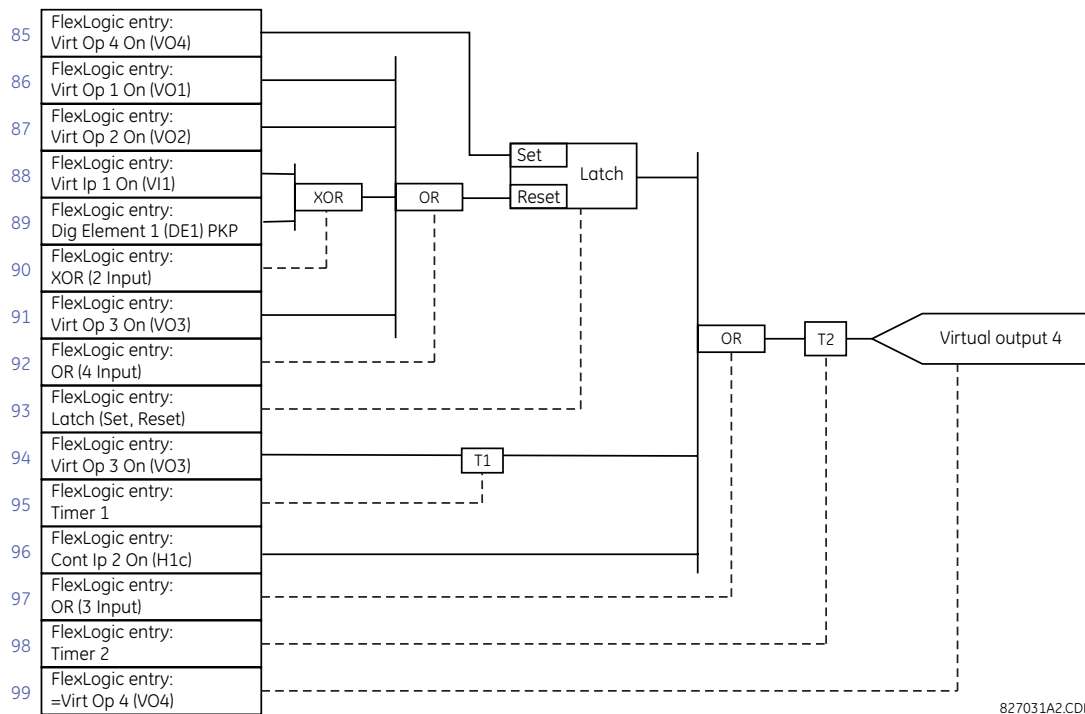
6. Repeating the process described for virtual output 3, select the FlexLogic parameters for Virtual Output 4.
 - 99: The final output of the equation is virtual output 4, which is parameter “= Virt Op 4”.
 - 98: The operator preceding the output is timer 2, which is operand “TIMER 2”. Note that the settings required for the timer are established in the timer programming section.
 - 97: The operator preceding timer 2 is OR #2, a 3-input OR, which is parameter “OR(3)”.
 - 96: The lowest input to OR #2 is operand “Cont Ip H1c On”.
 - 95: The center input to OR #2 is operand “TIMER 1”.
 - 94: The input to timer 1 is operand “Virt Op 3 On”.
 - 93: The upper input to OR #2 is operand “LATCH (S,R)”.
 - 92: There are two inputs to a latch, and the input immediately preceding the latch reset is OR #1, a 4-input OR, which is parameter “OR(4)”.
 - 91: The lowest input to OR #1 is operand “Virt Op 3 On”.
 - 90: The input just above the lowest input to OR #1 is operand “XOR(2)”.
 - 89: The lower input to the XOR is operand “DIG ELEM 1 PKP”.
 - 88: The upper input to the XOR is operand “Virt Ip 1 On”.
 - 87: The input just below the upper input to OR #1 is operand “Virt Op 2 On”.
 - 86: The upper input to OR #1 is operand “Virt Op 1 On”.
 - 85: The last parameter is used to set the latch, and is operand “Virt Op 4 On”.

The equation for virtual output 4 is:

```
[85] Virt Op 4 On
[86] Virt Op 1 On
[87] Virt Op 2 On
[88] Virt Ip 1 On
[89] DIG ELEM 1 PKP
[90] XOR(2)
[91] Virt Op 3 On
[92] OR(4)
[93] LATCH (S,R)
[94] Virt Op 3 On
[95] TIMER 1
[96] Cont Ip H1c On
[97] OR(3)
[98] TIMER 2
[99] = Virt Op 4
```

Now check that the selection of parameters produce the required logic by converting the set of parameters into a logic diagram. The result is shown in the figure, which is compared to the logic for virtual output 4 diagram as a check.

Figure 5-62: 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 are used as inputs to operators are created before needed. In cases where a lot of processing is required to perform logic, this can be difficult to achieve, but in most cases does not cause problems as all logic is calculated at least four times per power frequency cycle. The possibility of a problem caused by sequential processing emphasizes the necessity to test the performance of FlexLogic before it is placed in service. In the following equation, virtual output 3 is used as an input to both latch 1 and timer 1 as arranged in the following order:

```

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

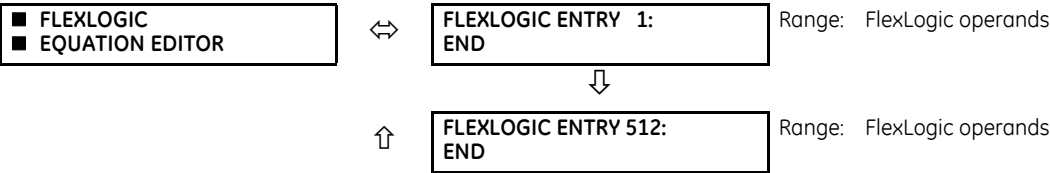
8. Always test the logic after it is loaded into the relay, in the same way as has been used in the past. Testing can be

simplified by placing an "END" operator within the overall set of FlexLogic equations. The equations are evaluated up to the first "END" operator.

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

5.5.5 FlexLogic equation editor

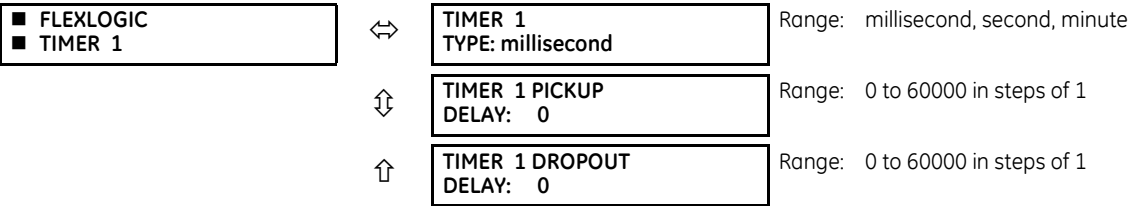
SETTINGS ⇒ FLEXLOGIC ⇒ FLEXLOGIC EQUATION EDITOR



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 is never set to '1'. Press the +/- key when editing FlexLogic equations to quickly scan through the major parameter types.

5.5.6 FlexLogic timers

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



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

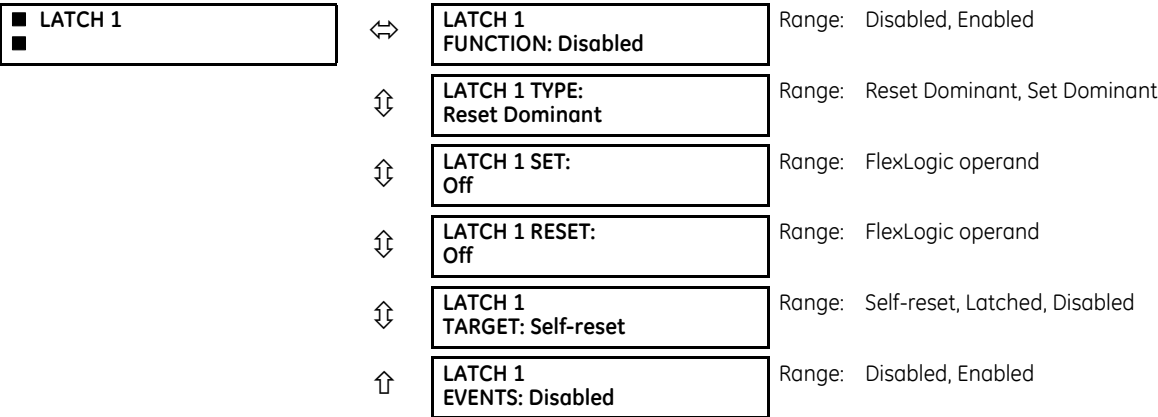
TIMER 1 TYPE — Selects the time measurement unit.

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

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

5.5.7 Non-volatile latches

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



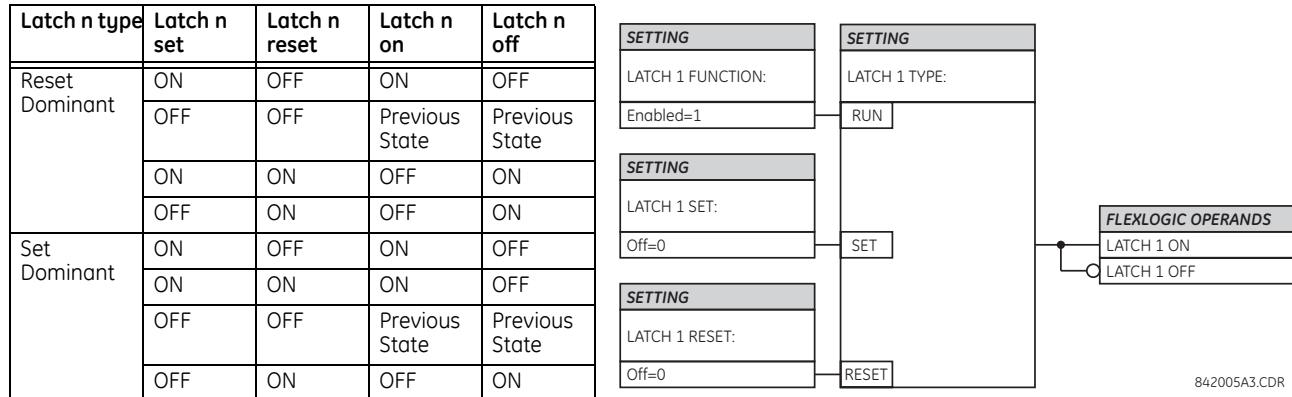
The non-volatile latches provide a permanent logical flag that is stored safely and do not reset upon restart after the relay is powered down. Typical applications include sustaining operator commands or permanently blocking relay functions, such as Autorecloser, until a deliberate interface action resets the latch.

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 5-63: Non-volatile latch operation table (N = 1 to 16) and logic



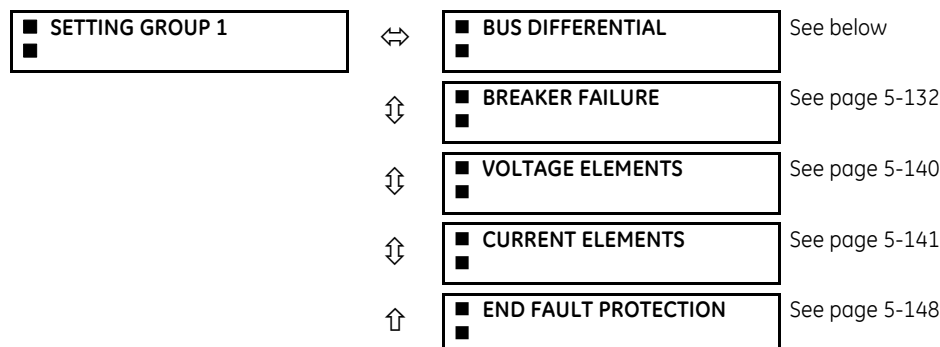
5.6 Grouped elements

5.6.1 Overview

Each protection element can be assigned up to six sets of settings with designations 1 to 6. The performance of these elements is defined by the active setting group at a given time. Multiple setting groups allow the user to conveniently change protection settings for different operating situations (for example, altered power system configuration or season of the year). The active setting group can be preset or selected in the **SETTING GROUPS** menu (see the Control Elements section later in this chapter). See also the Introduction to Elements section at the beginning of this chapter.

5.6.2 Setting group 1

SETTINGS ⇌ GROUPED ELEMENTS ⇌ SETTING GROUP 1(6)



Each of the six setting group menus is identical. Setting group 1 (the default active group) is active automatically when no other group is active.

If the device incorrectly switches to group 1 after power cycling, upgrade the firmware to version 7.31 or later to correct this issue.

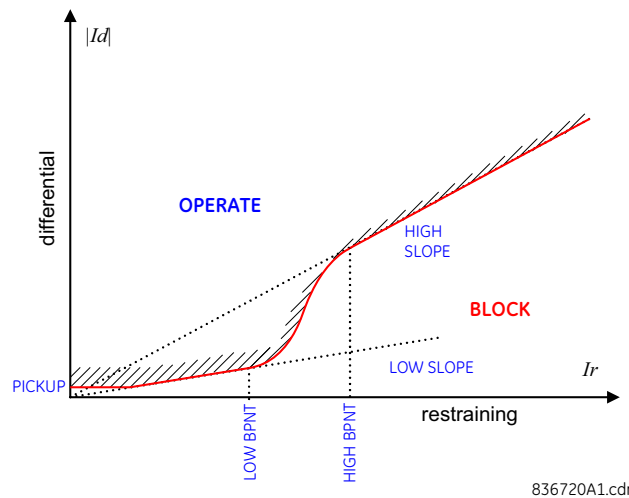
5.6.3 Bus differential

SETTINGS ⇒ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ BUS DIFFERENTIAL ⇒ BUS ZONE 1(6) DIFFERENTIAL

BUS ZONE 1 DIFFERENTIAL	↔	BUS ZONE 1 DIFF FUNCTION: Disabled	Range: Disabled, Enabled
	⇅	BUS ZONE 1 DIFF PICKUP: 0.100 pu	Range: 0.050 to 6.000 pu in steps of 0.001
	⇅	BUS ZONE 1 DIFF LOW SLOPE: 25%	Range: 15 to 100% in steps of 1
	⇅	BUS ZONE 1 DIFF LOW BPNT: 2.00 pu	Range: 1.00 to 30.00 pu in steps of 0.01
	⇅	BUS ZONE 1 DIFF HIGH SLOPE: 60%	Range: 50 to 100% in steps of 1
	⇅	BUS ZONE 1 DIFF HIGH BPNT: 8.00 pu	Range: 1.00 to 30.00 pu in steps of 0.01
	⇅	BUS ZONE 1 DIFF HIGH SET: 15.00 pu	Range: 0.10 to 99.99 pu in steps of 0.01
	⇅	BUS ZONE 1 DIFF SEAL-IN: 0.400 s	Range: 0.000 to 65.535 s in steps of 0.001
	⇅	BUS ZONE 1 DIFF SUPV: On	Range: FlexLogic operand
	⇅	BUS ZONE 1 DIFF TRIP: Off	Range: FlexLogic operand
	⇅	BUS ZONE 1 DIFF BLK: Off	Range: FlexLogic operand
	⇅	BUS ZONE 1 DIFF TARGET: Latched	Range: Self-reset, Latched, Disabled
	↑	BUS ZONE 1 DIFF EVENTS: Disabled	Range: Disabled, Enabled

Up to six zones of bus differential protection are provided, depending on the software options. The operation of these elements is completely dependent on the dynamic bus replica, which must be defined first. Both restrained (biased) and unrestrained (unbiased, instantaneous) bus differential protection functions are provided for each bus differential zone. The biased bus differential function has a dual-slope operating characteristic (see figure below) operating in conjunction with saturation detection and a directional comparison principle (see the logic diagram in this section).

Figure 5-64: Biased differential operating characteristic



The protected zone input current with the highest magnitude is used as the restraining signal. Stability during heavy external faults is achieved by dynamic CT saturation detection and current flow direction supervision without affecting sensitivity and speed of operation for internal faults.

The differential operating characteristic is divided into two regions. In the region of low differential currents and lower slope, the element operates on a 2-out-of-2 basis, applying both the differential and current directional tests. In the region of high differential currents, the element operates on a dynamic 1-out-of-2 / 2-out-of-2 basis. If the differential current is in this region and CT saturation is detected, both the differential and current directional tests are applied. If CT saturation is ruled out by the saturation detector, the differential protection principle alone is capable of causing the element to operate.

The saturation detector is an integral part of the bus differential element. It has no settings but uses some of the differential characteristic parameters. The flags indicating CT saturation are available on a per phase basis as FlexLogic operands.

The directional principle is an integral part of the biased bus differential element and has no associated settings. The directional element dynamically identifies what appears to be the faulted circuit and compares its current angle with that of the sum of the remaining currents of the protected zone. The element declares a bus fault if the angle is less than 90°. Directional indicating flags signal operation on a per-phase basis and are available as FlexLogic operands.

The unbiased bus differential function checks the magnitude of the differential current against an adjustable threshold. Neither the bias nor the directional principles apply. The operation of the unbiased differential function is associated with separate output operands.

The bus differential protection feature is available only when **PRODUCT SETUP ⇒ B90 FUNCTION ⇒ B90 FUNCTION** is set to "Protection".

Operation of this element is completely dependent on the dynamic bus replica which must be first defined under bus zone 1. The bus differential element 1 protects the differential zone defined as bus zone 1.

BUS ZONE 1 DIFF PICKUP — This setting defines the minimum differential current required for operation of the biased bus differential protection element. This setting is chosen based on the maximum magnitude of the differential current that might be seen under no-load conditions. This setting prevents relay maloperation in the situation when the bus carries little power and the restraining signal is too low to provide enough bias in the first slope region of the differential characteristic.

This setting can also be set above the maximum load level to ensure security during CT trouble conditions. However, voltage supervision or a check-zone are better alternatives.

BUS ZONE 1 DIFF LOW SLOPE — This setting defines the percentage bias for the restraining currents, from zero to the lower breakpoint (**LOW BPNT**). This setting determines the sensitivity of the relay for low current internal faults. The value chosen needs to be high enough to accommodate the spurious differential current resulting from inaccuracy of the CTs operating

in their linear mode, i.e. in load conditions and during distant external faults. When adjusting this setting, it must be kept in mind that the restraining signal used by the biased bus differential protection element is created as the maximum of all the input currents.

BUS ZONE 1 DIFF LOW BPNT — This setting defines the lower breakpoint of the dual-slope operating characteristic. The percentage bias applied for the restraining current from zero to the value specified as **LOW BPNT** is given by the **LOW SLOPE** setting. This setting needs to be set above the maximum load current. The **LOW BPNT** can be moved to the AC current under which all the CTs are guaranteed to transform without saturation. This includes the effect of residual magnetism. When adjusting this setting, keep in mind that the restraining signal is created as the maximum of all the input currents.

BUS ZONE 1 DIFF HIGH SLOPE — This setting defines the percentage bias for the restraining currents above the higher breakpoint (**HIGH BPNT**). This setting affects stability of the relay for heavy external faults. Traditionally, the value chosen for this setting needs to be high enough to accommodate the spurious differential current resulting from saturation of the CTs during heavy external faults. This requirement can be considerably relaxed in favor of sensitivity and speed of operation as the relay detects CT saturation and upon detection applies the directional principle to prevent maloperation. When adjusting this setting, keep in mind that the restraining signal is created as the maximum of all the input currents.

BUS ZONE 1 DIFF HIGH BPNT — This setting defines the higher breakpoint of the dual-slope operating characteristic. The percentage bias applied for the restraining current above the value specified as **HIGH BPNT** is given by the **HIGH SLOPE** setting. The **HIGH BPNT** setting needs to be set below the minimum AC current that is likely to saturate the weakest CT feeding the relay. When adjusting this setting, it must be kept in mind the restraining signal is created as the maximum of all the input currents.

The dual-slope operating characteristic of the biased bus differential protection element is shaped to ensure true percentage bias for high restraining currents (see the following figure). This means that the straight line defining the upper slope intersects the origin of the differential-restraining plane and a discontinuity appears between the low and high slope regions (between the **LOW BPNT** and **HIGH BPNT** settings). This discontinuity is handled by approximating the operate/no-operate boundary of the characteristic using a certain connection function. This ensures smooth transition of the slope from **LOW SLOPE** (lower value) to **HIGH SLOPE** (higher value).

The following parameters of the biased operating characteristic are used by the saturation detector: **LOW SLOPE**, **HIGH SLOPE**, and **HIGH BPNT**. The saturation detector uses these settings to detect specific relations between the differential and restraining currents. The values of these settings are selected based on the aforementioned criteria related to the art of bus differential protection.

BUS ZONE 1 DIFF HIGH SET — This setting defines the minimum differential current required for operation of the unbiased bus differential protection function. This setting is based on the maximum magnitude of the differential current that might be seen during heavy external faults causing deep CT saturation. When selecting this setting, keep in mind that the unbiased bus differential protection function uses the full-cycle Fourier measuring algorithm and applies it to pre-filtered samples of the input currents. As a result, the transient measuring errors including the effect of the DC component are below 2%. During heavy CT saturation when the currents are significantly distorted, the magnitude of the differential current as measured by the relay and used by the unbiased bus differential function is significantly lower than both the peak values of the waveform and the true RMS value. The measured magnitude practically reflects the power system frequency component alone. This allows for lower values of the **HIGH SET** setting.

The unbiased (high set) differential function can be virtually disabled by setting its operating threshold, **HIGH SET**, very high.

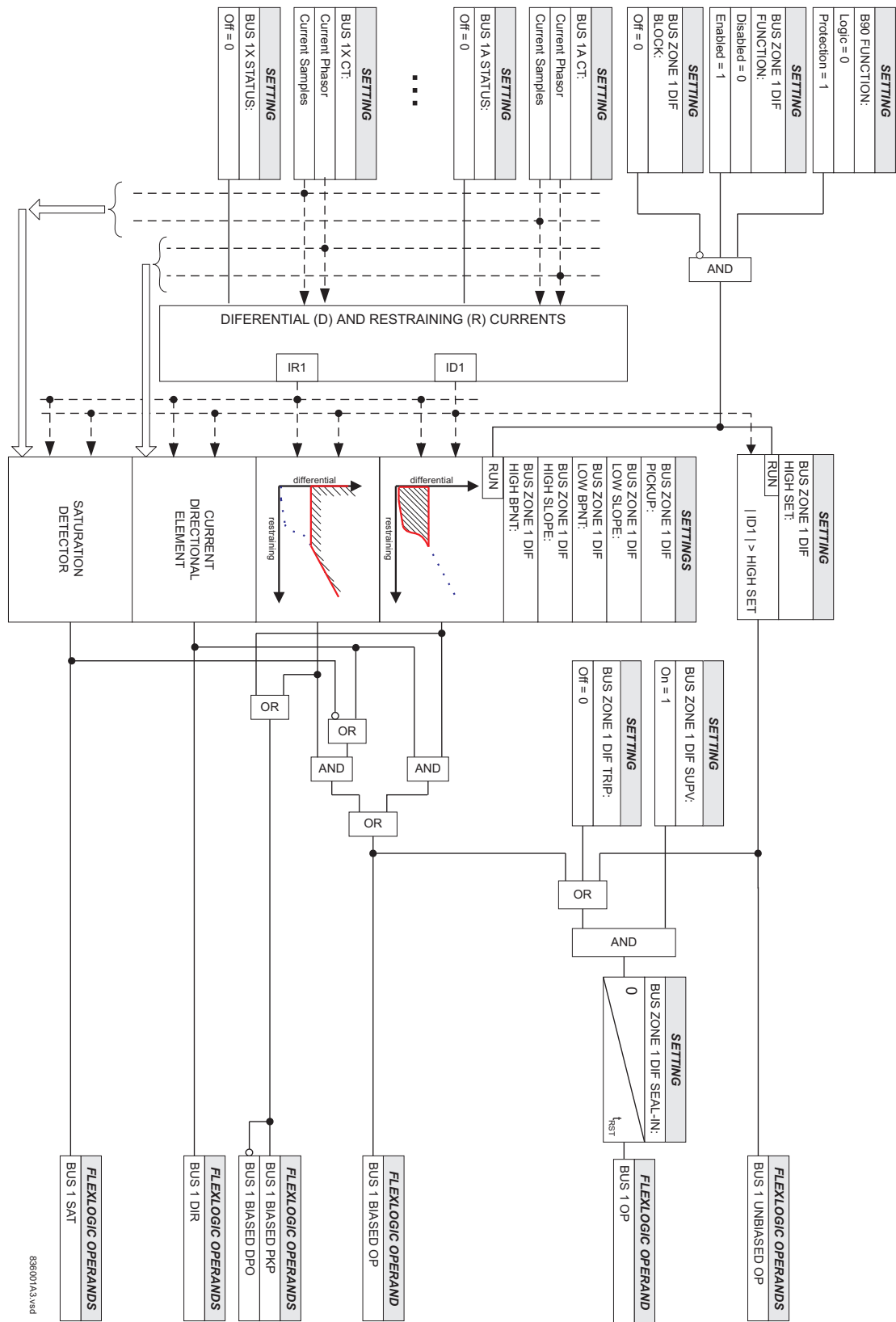
BUS ZONE 1 DIFF SEAL-IN — This setting defines the drop-out time of the seal-in timer applied to the **BUS 1 OP** FlexLogic operand.

BUS ZONE 1 DIFF SUPV — This setting specifies a FlexLogic operand that supervises operation of the element. Typical applications include undervoltage condition and overall (check) zone. In a sense the setting is similar to the blocking input, but does not stop the element from running. This is important for saturation detector, as the latter requires some historical data. The Bus Differential element shall not be supervised from the blocking input. The blocking input (**BUS ZONE 1 DIFF BLK** setting) is meant to block the element permanently, not dynamically from a fault depended condition such as undervoltage.

BUS ZONE 1 DIFF TRIP — This setting specifies a FlexLogic operand that forces operation of the zone. Typical applications include forced trip of the healthy phase from the faulted phase, or a trip command from the BF function to isolate the entire zone of busbar protection.

More information on the bus zone differential settings can be found in the Application of Settings chapter.

Figure 5-65: Bus zone 1 differential logic



5.6.4 Breaker failure (ANSI 50BF)

SETTINGS ⇒ DOWN GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ DOWN BREAKER FAILURE 1(24)

■ BREAKER FAILURE			
⇔	⇔	■ BREAKER FAILURE ■ CURRENT SUPV 1	
		⇔	BF1 CURRENT SUPV FUNCTION: Disabled Range: Disabled, Enabled
		⇕	BF1 CT: F1 Range: Available current channels
		⇕	BF1 AMP SUPV PICKUP: 1.050 pu Range: 0.001 to 30.000 pu in steps of 0.001
		⇕	BF1 AMP HISET PICKUP: 1.050 pu Range: 0.001 to 30.000 pu in steps of 0.001
	↑	BF1 AMP LOSET PICKUP: 1.050 pu	Range: 0.001 to 30.000 pu in steps of 0.001
⇕	⇕	■ BREAKER FAILURE 1	
		⇔	BF1 FUNCTION: Disabled Range: Disabled, Enabled
		⇕	BF1 INITIATE: Off Range: FlexLogic operand
		⇕	BF1 USE AMP SUPV: Yes Range: Yes, No
		⇕	BF1 USE SEAL-IN: Yes Range: Yes, No
		⇕	BF1 AMP SUPV OP A: Off Range: FlexLogic operand
		⇕	BF1 AMP SUPV OP B: Off Range: FlexLogic operand
		⇕	BF1 AMP SUPV OP C: Off Range: FlexLogic operand
		⇕	BF1 USE TIMER 1: Yes Range: Yes, No
		⇕	BF1 TIMER 1 PICKUP DELAY: 0.000 s Range: 0.000 to 65.535 s in steps of 0.001
		⇕	BF1 USE TIMER 2: Yes Range: Yes, No
		⇕	BF1 TIMER 2 PICKUP DELAY: 0.000 s Range: 0.000 to 65.535 s in steps of 0.001
		⇕	BF1 USE TIMER 3: Yes Range: Yes, No
		⇕	BF1 TIMER 3 PICKUP DELAY: 0.000 s Range: 0.000 to 65.535 s in steps of 0.001
		⇕	BF1 BKR POS1: Off Range: FlexLogic operand
		⇕	BF1 BKR POS2: Off Range: FlexLogic operand

⇅	BF1 BKR TEST ON: Off	Range: FlexLogic operand
⇅	BF1 AMP HISET OP A: Off	Range: FlexLogic operand
⇅	BF1 AMP HISET OP B: Off	Range: FlexLogic operand
⇅	BF1 AMP HISET OP C: Off	Range: FlexLogic operand
⇅	BF1 AMP LOSET OP A: Off	Range: FlexLogic operand
⇅	BF1 AMP LOSET OP B: Off	Range: FlexLogic operand
⇅	BF1 AMP LOSET OP C: Off	Range: FlexLogic operand
⇅	BF1 LOSET TIME DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 1
⇅	BF1 TRIP DROPOUT TIME DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 1
⇅	BF1 RETRIP TIME DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 1
⇅	BF1 BLOCK: Off	Range: FlexLogic operand
⇅	BF1 TARGET: Self-Reset	Range: Self-Reset, Latched, Disabled
↑	BF1 EVENTS: Disabled	Range: Enabled, Disabled
⇅	■ BREAKER FAILURE ■ CURRENT SUPV 2	
⇅	■ BREAKER FAILURE 2 ■	
	↓	
⇅	■ BREAKER FAILURE ■ CURRENT SUPV 24	
↑	■ BREAKER FAILURE 24 ■	

The breaker failure feature has two parts: breaker failure current supervision and breaker failure logic. Breaker failure current supervision acts upon current levels and is available if the **PRODUCT SETUP ⇒ B90 FUNCTION ⇒ B90 FUNCTION** setting is "Protection." Breaker failure logic is based on status information and is available if the **PRODUCT SETUP ⇒ B90 FUNCTION ⇒ B90 FUNCTION** setting is "Logic." The Breaker failure element requires B90 fiber optic interconnection and proper configuration of the breaker failure and direct input/output settings. See the Application of Settings chapter for details.

5.6.4.1 Breaker failure protection

In general, breaker failure schemes expect that the breaker receiving the trip command opens within a set time. If it does not, upstream or adjacent breakers are tripped to effectively clear the fault. This widespread tripping usually interrupts power to a larger section of the power system than the initial trip. A higher level of security is required due to the effect on system safety and stability.

The breaker failure scheme is intended for three-pole operation but can be used with single-pole tripping if certain conditions are satisfied (see the note below). The operation of the breaker failure element includes three stages: initiation, identification of a breaker failure condition, and output (or response).



The Breaker Failure can be used with single-pole tripping schemes if the HISET and LOSET current elements are set below the lowest expected fault current and above the highest expected load current.

NOTE

5.6.4.2 Stage 1: Initiation

The breaker failure scheme is initiated by a FlexLogic operand representing the protection trip signal initially sent to the breaker. This signal does not include other breaker commands that are not indicative of a fault in the protected zone. The initiating signal should be sealed-in if primary fault detection can reset before the fault is cleared. The seal-in is supervised by current level, so it resets 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.

Breaker failure scheme 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 initiate for a breaker that has very little or no current flowing through it, which may be the case for transformer faults or ring bus where unequal current division between ring bus circuit breakers can delay the failed breaker clearing time until the healthy ring breaker has operated. For those situations where it is required to maintain breaker fail coverage for fault levels below the **BF1 AMP SUPV PICKUP** setting, a current supervised initiate should not be used. This feature should be used for those situations where coordinating margins can be reduced when high speed reclosing is used. If this choice is made the current supervision pickup level must be lower than the minimum fault current flowing through the breaker.

Immediately after scheme initiation it sends again a trip signal to the breaker (re-trip). This is intended to reduce the possibility of widespread tripping that results from a declaration of a failed breaker.

5.6.4.3 Stage 2: Determination of a breaker failure condition

Improved flexibility is achieved by providing three timers or stages (Timers 1, 2, and 3) as shown in the Breaker Failure Logic diagram. Each stage is individually enabled and asserts its individual operand.

Only a breaker auxiliary contact (fast-operating) or current supervision (if enabled) can reset Timer 1 (early stage). If Timer 1 expires, it implies that current is still flowing or the breaker (position status) is still closed; that is, the breaker failed to open. The Timer 2 (main stage) logic is not supervised by breaker status, only by current. An output is issued if current is detected after the Timer 2 delay interval. This stage detects the condition where a breaker opens mechanically but fails to interrupt fault current.

The HISET and LOSET settings discriminate between the pre- and post-tripping current variation for breakers that employ opening resistors. If the current level is between HISET and LOSET, a time delay (**BF x LOSET TIME DELAY**) is added. For currents above the HISET value, the **BFxx LOSET TIME DELAY** timer is bypassed.

The **BF x LOSET TIME DELAY** is based on the time that breaker resistor limited current can flow through the circuit after the breaker interruption time. Both current detectors provide fast operating time for small multiples of the pickup setting.

The Timer 3 (slow stage) is supervised by breaker status (auxiliary contact) and control switch status, the latter indicating if the breaker is in/out of service. This mode is typically used during maintenance. There is no current level check for this stage since this is associated with small currents. Timer 3 is typically set with a longer time.

5.6.4.4 Stage 3: Output

The outputs from the scheme 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 face plate TRIP LED

5.6.4.5 Breaker failure settings

BF1 INITIATE — This setting selects the FlexLogic operand that initiates three-pole tripping of the breaker. Although this scheme is designed for three-pole tripping, it can be used with single-pole tripping schemes if the HISET and LOSET current elements are set to be sensitive to the lowest expected fault value but insensitive to the highest expected load on the protected line.

BF1 USE AMP SUPV — If set to "Yes", the element is initiated if current flowing through the breaker is above the supervision pickup level.

BF1 USE SEAL-IN — If set to "Yes", the element is sealed-in if current flowing through the breaker is above the supervision pickup level.

BF1 AMP SUPV OP A through C — This setting selects the B90 Remote Inputs that represent operation of the current supervision elements on phase A, B, or C.

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 **BKR POS1** 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 UR relays, which use a Fourier transform, the calculated current magnitude ramps-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 shows a margin of two cycles; this interval is considered the minimum appropriate for most applications.

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 — This setting selects the FlexLogic operand that represents the protected breaker early-type auxiliary switch contact (52/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 — This setting selects the FlexLogic operand that represents the protected breaker normal type auxiliary switch contact (52/a). This may be a multiplied contact.

BF1 BKR TEST ON — This setting selects the FlexLogic operand that represents the breaker In-Service/Out-of-Service switch, set to the Out-of-Service position.

BF1 LOSET TIME DELAY — This setting represents the pickup delay for current detection after opening resistor insertion. Typically this is based on the time while the breaker resistor current can flow through the circuit after the breaker interrupting time.

BF1 TRIP DROPOUT TIME 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 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 RETRIP TIME DELAY — This setting is used to set a delay before asserting the re-trip operand.

BF1 CT — This setting selects the currents that will be used in Breaker Failure scheme BF1 for current supervision (AMP SUPV, HISET and LOSET elements).

BF1 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 guarantee correct operation.

BF1 AMP HISET PICKUP — This setting is used to set the phase current fault detection level. Generally this setting detects the lowest expected fault current on the protected breaker, before a breaker-opening resistor is inserted.

BF1 AMP LOSET PICKUP — This setting is used to set the phase current fault detection level. Generally this setting detects the lowest expected fault current on the protected breaker, after a breaker opening resistor is inserted approximately 90% of resistor current).

Figure 5-66: Breaker failure current supervision logic

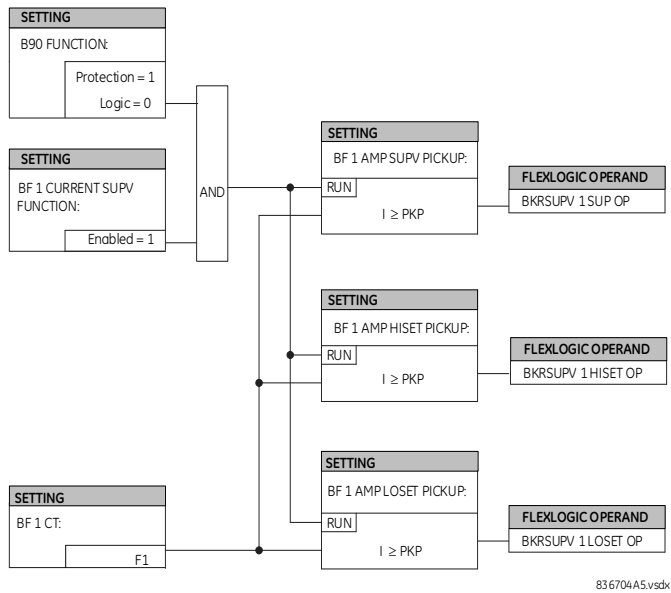
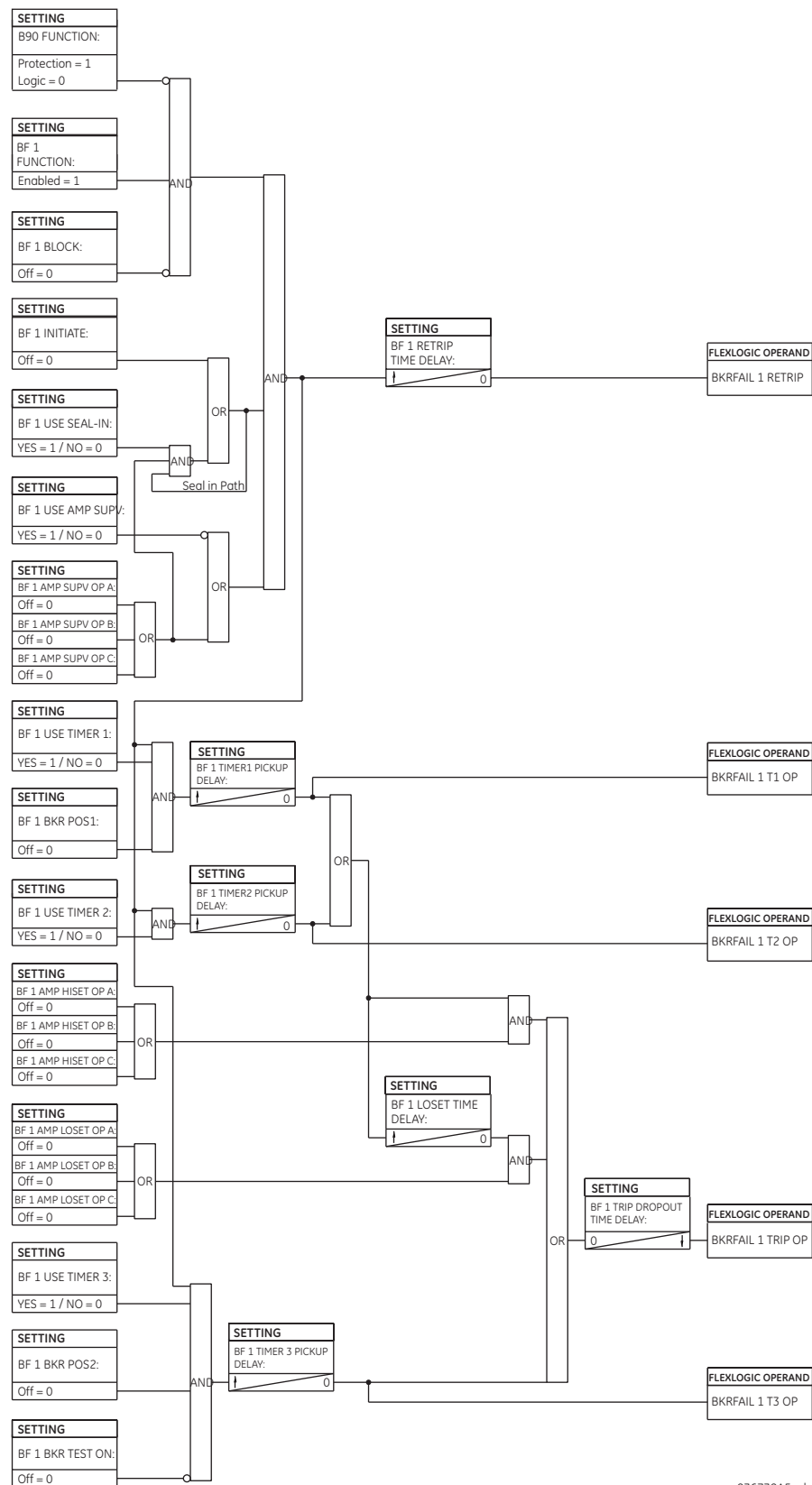


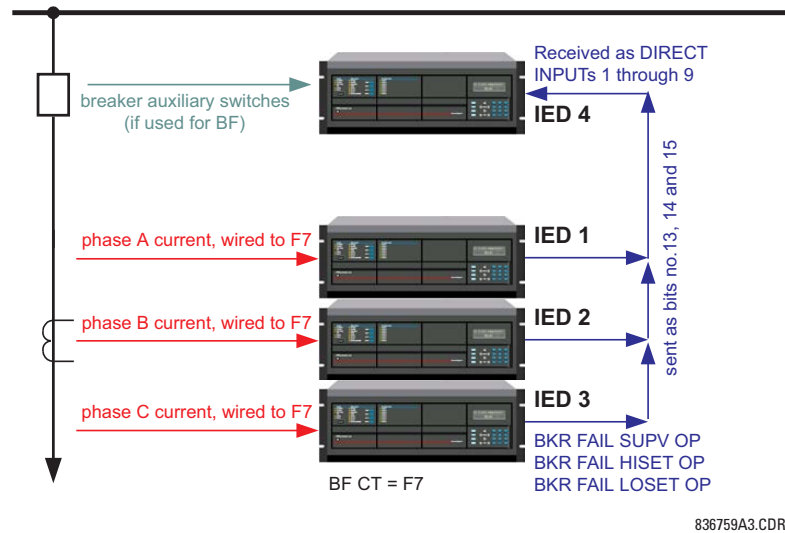
Figure 5-67: Breaker failure logic



5.6.4.6 Application example

For illustration, assume the F7 current is monitored for Breaker Failure protection of a given breaker as shown.

Figure 5-68: Direct I/O sample configuration for breaker failure protection



The Protection IEDs 1, 2, and 3 (**B90 FUNCTION** set to "Protection") send the Breaker Fail current supervision flags over the Direct I/O communications. Assume bits 13, 14, and 15 are used for this purpose as follows:

For IED 1:

- DIRECT OUTPUT DEVICE ID:** "1" (this is an originating device)
- DIRECT OUT 13 OPERAND:** "BKRSUPV 3 SUPV OP" (this operand drives output number 13)
- DIRECT OUT 14 OPERAND:** "BKRSUPV 3 HISET OP" (this operand drives output number 14)
- DIRECT OUT 15 OPERAND:** "BKRSUPV 3 LOSET OP" (this operand drives output number 15)

For IED 2:

- DIRECT OUTPUT DEVICE ID:** "2" (this is an originating device)
- DIRECT OUT 13 OPERAND:** "BKRSUPV 3 SUPV OP" (this operand drives output number 13)
- DIRECT OUT 14 OPERAND:** "BKRSUPV 3 HISET OP" (this operand drives output number 14)
- DIRECT OUT 15 OPERAND:** "BKRSUPV 3 LOSET OP" (this operand drives output number 15)

For IED 3:

- DIRECT OUTPUT DEVICE ID:** "3" (this is an originating device)
- DIRECT OUT 13 OPERAND:** "BKRSUPV 3 SUPV OP" (this operand drives output number 13)
- DIRECT OUT 14 OPERAND:** "BKRSUPV 3 HISET OP" (this operand drives output number 14)
- DIRECT OUT 15 OPERAND:** "BKRSUPV 3 LOSET OP" (this operand drives output number 15)

The above nine flags must be received at the IED 4. Assume Direct Inputs 1 through 9 are to be used for this purpose. This is accomplished with the following settings.

For IED 4:

- DIRECT INPUT 1 DEVICE:** "1" (message received from IED 1)
- DIRECT INPUT 1 BIT NUMBER:** "13" (this is BKRSUPV 3 SUPV OP for Phase A)
- DIRECT INPUT 2 DEVICE:** "1" (message received from IED 1)
- DIRECT INPUT 2 BIT NUMBER:** "14" (this is BKRSUPV 3 HISET OP for Phase A)
- DIRECT INPUT 3 DEVICE:** "1" (message received from IED 1)
- DIRECT INPUT 3 BIT NUMBER:** "15" (this is BKRSUPV 3 LOSET OP for Phase A)
- DIRECT INPUT 4 DEVICE:** "2" (message received from IED 2)
- DIRECT INPUT 4 BIT NUMBER:** "13" (this is BKRSUPV 3 SUPV OP for Phase B)
- DIRECT INPUT 5 DEVICE:** "2" (message received from IED 2)
- DIRECT INPUT 5 BIT NUMBER:** "14" (this is BKRSUPV 3 HISET OP for Phase B)

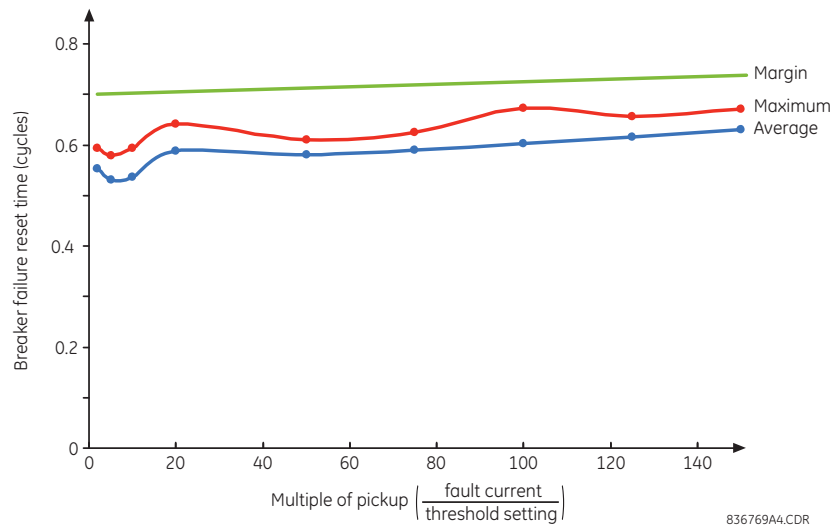
DIRECT INPUT 6 DEVICE: "2" (message received from IED 2)
DIRECT INPUT 6 BIT NUMBER: "15" (this is BKRSUPV 3 LOSET OP for Phase B)
DIRECT INPUT 7 DEVICE: "3" (message received from IED 3)
DIRECT INPUT 7 BIT NUMBER: "13" (this is BKRSUPV 3 SUPV OP for Phase C)
DIRECT INPUT 8 DEVICE: "3" (message received from IED 3)
DIRECT INPUT 8 BIT NUMBER: "14" (this is BKRSUPV 3 HISET OP for Phase C)
DIRECT INPUT 9 DEVICE: "3" (message received from IED 3)
DIRECT INPUT 9 BIT NUMBER: "15" (this is BKRSUPV 3 LOSET OP for Phase C)

The received flags are now to be configured for in the Breaker Failure 3 logic as follows:

BF 3 AMP SUPV OP A: "Direct Input 1 On"
BF 3 AMP HISET OP A: "Direct Input 2 On"
BF 3 AMP LOSET OP A: "Direct Input 3 On"
BF 3 AMP SUPV OP B: "Direct Input 4 On"
BF 3 AMP HISET OP B: "Direct Input 5 On"
BF 3 AMP LOSET OP B: "Direct Input 6 On"
BF 3 AMP SUPV OP C: "Direct Input 7 On"
BF 3 AMP HISET OP C: "Direct Input 8 On"
BF 3 AMP LOSET OP C: "Direct Input 9 On"

The B90 current supervision elements reset in less than 0.7 of a power cycle up to the multiple of pickup of 100 (threshold set at 0.01 of the actual fault current) as in the following figure.

Figure 5-69: Breaker failure overcurrent supervision reset time



As the overcurrent supervising flags must be sent via Direct I/Os to the B90 IEDs that perform the BF functionality, an extra delay is introduced. Consequently, the following is recommended for coordinating the BF time:

$$\text{Total BF Reset Time} = 0.7 \text{ of a power cycle} + 0.2 \text{ of a power cycle} \times \text{Direct I/O bridge count}$$

Eq. 5-3

where

0.7 of a power cycle = the reset of the BF overcurrent elements

Direct I/O bridge count = the number of "bridges" between the source and destination of the Direct I/O messages (Direct I/O delay)

For example, in the four-IED application example shown earlier, IED 2 is two "bridges" away from IED 4; therefore, the Total BF Reset Time is $0.7 + 2 \times 0.2 = 1.1$ of a power system cycle.

$$\begin{aligned} \text{Total BF Reset Time} &= 0.7 \text{ of a power cycle} + 0.2 \text{ of a power cycle} \times \text{Direct I/O bridge count} \\ &= 0.7 + 2 \times 0.2 = 1.1 \text{ of a power cycle} \end{aligned} \quad (\text{EQ 0.1})$$

Note that a message delivery time of 0.2 of a cycle per "bridge" applies when the **DIRECT I/O DATA RATE** is set to 128 kbps.

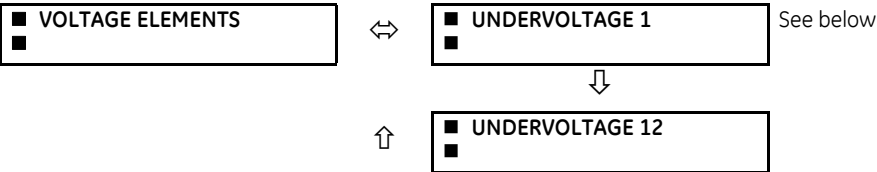


The relay uses sophisticated algorithms to speed up the reset time of the breaker failure overcurrent supervision. Caution must be paid when testing the B90 for BF reset times. In particular, the current must be interrupted in a way resembling the actual breaker operation (zero-crossing).

5.6.5 Voltage elements

5.6.5.1 Menu

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



5.6.5.2 Undervoltage (ANSI 27)

SETTINGS ⇒ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ VOLTAGE ELEMENTS ⇒ UNDERVOLTAGE 1(12)

■ UNDERVOLTAGE 1	⇔	UNDERVOLTAGE 1 FUNCTION: Disabled	Range: Disabled, Enabled
	⇕	UNDERVOLTAGE 1 VT: F5	Range: Available voltage channels
	⇕	UNDERVOLTAGE 1 PICKUP: 0.800 pu	Range: 0.000 to 3.000 pu in steps of 0.001
	⇕	UNDERVOLTAGE 1 MIN VOLTAGE: 0.000 pu	Range: 0.000 to 1.000 pu in steps of 0.001
	⇕	UNDERVOLTAGE 1 PKP DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
	⇕	UNDERVOLTAGE 1 RST DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
	⇕	UNDERVOLTAGE 1 BLK: Off	Range: FlexLogic operand
	⇕	UNDERVOLTAGE 1 TARGET: Self-Reset	Range: Self-Reset, Latched, Disabled
	⇕	UNDERVOLTAGE 1 EVENTS: Disabled	Range: Enabled, Disabled

The undervoltage element supervises (low-voltage check) current based main protection (that is, differential, breaker failure, end fault, and time overcurrent backup protection). The B90 accepts phase-to-ground or phase-to-phase voltage input configurations. If the intention is to operate all three phases for any one phase voltage collapse, appropriate FlexLogic operand exchanges must occur between the B90s using fiber optic communications (direct inputs and outputs).

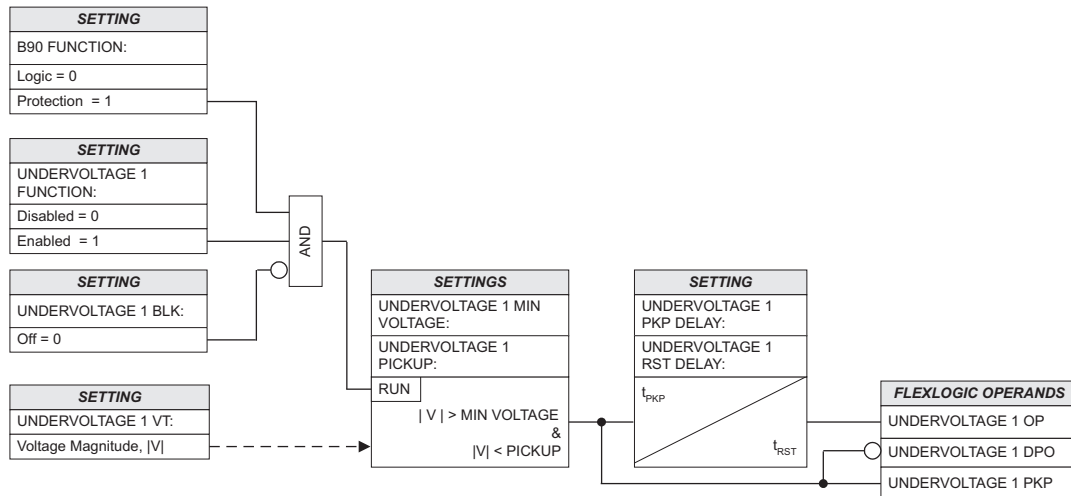
The undervoltage element also accepts the neutral voltage (3V0) from an open-corner delta VT arrangement. In this case, the FlexLogic output is inverted to accomplish the 3V0 overvoltage functionality.

Application of the Undervoltage element is beneficial during CT trouble conditions. A low-voltage check prevents maloperation of the main protection until the CT trouble element (differential current alarm) operates. The CT Trouble element is user-configurable to block selected protection functions indefinitely. Voltage supervision alone does not guarantee security because a CT trouble may be followed by an external fault causing a low-voltage condition.

Voltage pickup is set in per-unit values. The nominal voltage as entered in the **SYSTEM SETUP ⇒ AC INPUTS ⇒ ⚡ VOLTAGE BANK ## ⇒ ⚡ VT ## SECONDARY** setting corresponds to 1 pu. The minimum voltage setting (**UNDervoltage 1 MIN VOLTAGE**) specifies the minimum voltage required for element operation. This setting discriminates between undervoltage conditions for energized and de-energized circuits. If the element is used for low-voltage supervision, set this value to zero.

The Undervoltage element is enabled only when **PRODUCT SETUP ⇒ B90 FUNCTION ⇒ B90 FUNCTION** is set to “Protection”. One element is available per each voltage input of the relay.

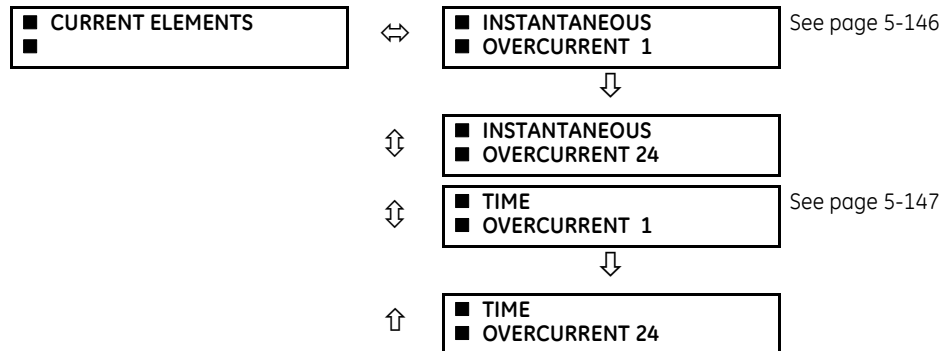
Figure 5-70: Undervoltage logic



5.6.6 Current elements

5.6.6.1 Menu

SETTINGS ⇒ ⚡ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ ⚡ CURRENT ELEMENTS



5.6.6.2 Inverse TOC curve characteristics

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

Table 5-20: Overcurrent curve types

IEEE	IEC	GE type IAC	Other
IEEE Extremely Inverse	IEC Curve A (BS142)	IAC Extremely Inverse	I^2t
IEEE Very Inverse	IEC Curve B (BS142)	IAC Very Inverse	Definite Time
IEEE Moderately Inverse	IEC Curve C (BS142)	IAC Inverse	
	IEC Short Inverse	IAC Short Inverse	

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 operates. 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.

The URs calculate operate time corresponding to the values in the range of 1.03 to 20 multiples of the pickup current. Above 20 multiples of the pickup current, URs clamp the operate time to the value at a multiple of 20, resulting in the flat part of the characteristics. Reset time is calculated in the range of 0 to 0.97 multiples of the pickup current.

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 curves. The IEEE curves are derived from the operate and reset time equations.

$$T = \text{TDM} \times \left[\frac{A}{\left(\frac{I}{I_{\text{pickup}}} \right)^p - 1} + B \right], T_{\text{RESET}} = \text{TDM} \times \left[\frac{t_r}{1 - \left(\frac{I}{I_{\text{pickup}}} \right)^2} \right] \quad \text{Eq. 5-4}$$

where

T = operate time (in seconds)

TDM = Multiplier setting

I = input current

I_{pickup} = Pickup Current setting

A, B, p = constants defined in the table

T_{RESET} = reset time in seconds (assuming energy capacity is 100% and RESET is "Timed")

t_r = characteristic constant defined in the table

Table 5-21: 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 5-22: 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

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
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 IEC curves are derived by the operate and reset time equations.

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

Eq. 5-5

5

where

T = operate time (in seconds)

TDM = Multiplier setting

I = input current

I_{pickup} = Pickup Current setting

K, E = constants defined in the table

t_r = characteristic constant defined in the table

T_{RESET} = reset time in seconds (assuming energy capacity is 100% and RESET is "Timed")

Table 5-23: 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 5-24: 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

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
0.80	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 Inverse										
0.05	0.153	0.089	0.056	0.044	0.038	0.034	0.031	0.029	0.027	0.026
0.10	0.306	0.178	0.111	0.088	0.075	0.067	0.062	0.058	0.054	0.052
0.20	0.612	0.356	0.223	0.175	0.150	0.135	0.124	0.115	0.109	0.104
0.40	1.223	0.711	0.445	0.351	0.301	0.269	0.247	0.231	0.218	0.207
0.60	1.835	1.067	0.668	0.526	0.451	0.404	0.371	0.346	0.327	0.311
0.80	2.446	1.423	0.890	0.702	0.602	0.538	0.494	0.461	0.435	0.415
1.00	3.058	1.778	1.113	0.877	0.752	0.673	0.618	0.576	0.544	0.518

IAC curves

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

$$T = \text{TDM} \times \left(A + \frac{B}{(I/I_{\text{pkp}}) - C} + \frac{D}{((I/I_{\text{pkp}}) - C)^2} + \frac{E}{((I/I_{\text{pkp}}) - C)^3} \right), \quad T_{\text{RESET}} = \text{TDM} \times \left[\frac{t_r}{1 - (I/I_{\text{pkp}})^2} \right] \quad \text{Eq. 5-6}$$

where

T = operate time (in seconds)

TDM = Multiplier setting

I = Input current

I_{pkp} = Pickup Current setting

A to E = constants defined in the table

t_r = characteristic constant defined in the table

T_{RESET} = reset time in seconds (assuming energy capacity is 100% and RESET is "Timed")

Table 5-25: 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 curve shape	A	B	C	D	E	t_r
IAC Short Inverse	0.0428	0.0609	0.6200	-0.0010	0.0221	0.222

Table 5-26: GE type 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

I^2t curves

The I^2t curves are derived as follows:

$$T = TDM \times \left[\frac{100}{\left(\frac{I}{I_{pickup}} \right)^2} \right], \quad T_{RESET} = TDM \times \left[\frac{100}{\left(\frac{I}{I_{pickup}} \right)^{-2}} \right] \quad \text{Eq. 5-7}$$

where

T = Operate time (in seconds)

TDM = Multiplier setting

I = Input current

I_{pickup} = Pickup Current setting

T_{RESET} = reset time in seconds (assuming energy capacity is 100% and RESET is "Timed")

Table 5-27: I^2t curve trip times

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

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. The definite time curve shapes are defined as follows:

$$T = \text{TDM in seconds, when } I > I_{pickup} \quad \text{Eq. 5-8}$$

$$T_{RESET} = \text{TDM in seconds} \quad \text{Eq. 5-9}$$

where

T = Operate Time (in seconds)

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)

5.6.6.3 Instantaneous overcurrent (ANSI 50)

SETTINGS ⇒ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ CURRENT ELEMENTS ⇒ INSTANTANEOUS OVERCURRENT 1(24)

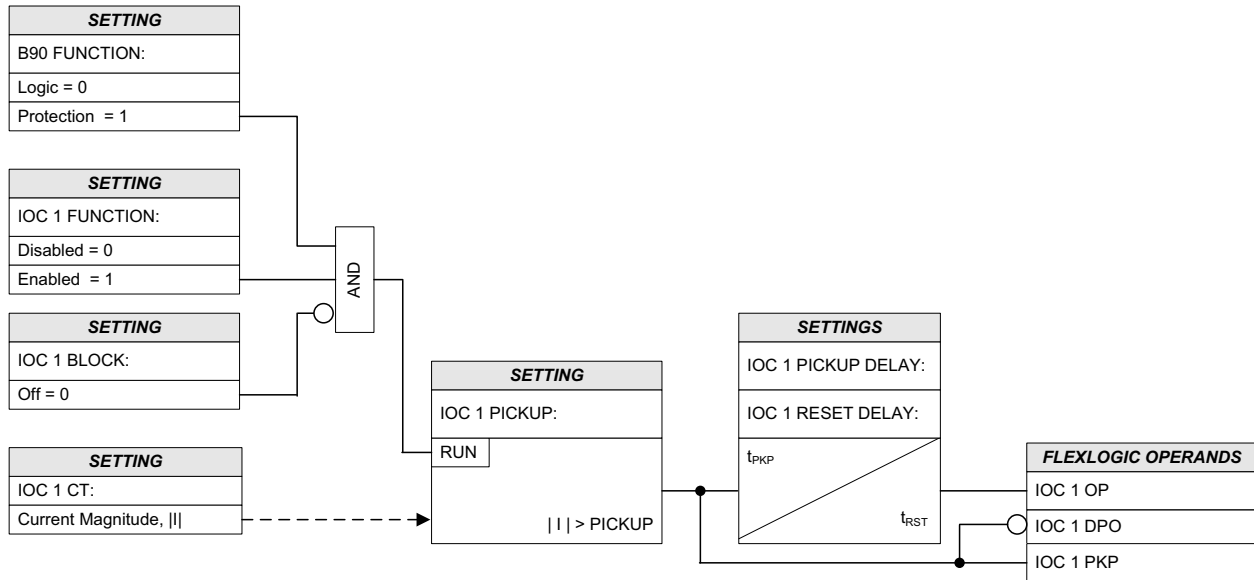
■ INSTANTANEOUS ■ OVERCURRENT 1	↔	IOC1 FUNCTION: Disabled	Range: Disabled, Enabled
	↕	IOC1 CT: F1	Range: Available current channels
	↕	IOC1 PICKUP: 1.200 pu	Range: 0.001 to 30.000 pu in steps of 0.001
	↕	IOC1 PICKUP DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
	↕	IOC1 RESET DELAY: 0.000 s	Range: 0.000 to 65.535 s in steps of 0.001
	↕	IOC1 BLOCK: Off	Range: FlexLogic operand
	↕	IOC1 TARGET: Self-Reset	Range: Self-Reset, Latched, Disabled
	↑	IOC1 EVENTS: Disabled	Range: Disabled, Enabled

The instantaneous overcurrent element is used primarily for supervising main protection trip commands on a per-breaker basis (that is, differential, breaker failure, and end fault protection). It responds to a single-phase current. If the intention is to allow three-phase tripping if any phase current is above the threshold, the appropriate FlexLogic operands are passed between the IEDs using the B90 fiber optic communications (Direct I/Os).

Instantaneous Overcurrent supervision can also be used to prevent tripping feeders with low currents or for definite time backup protection.

The pickup setting is specified in per unit values. The nominal current as entered under **SYSTEM SETUP ⇒ AC INPUTS ⇒ CURRENT BANK XY ⇒ CT XY SECONDARY** is 1 p.u. The element can be effectively enabled only when **B90 FUNCTION** is set to "Protection". One instantaneous overcurrent element is available per each CT input of the relay.

Figure 5-71: Instantaneous overcurrent logic



836005A1.vsd

5.6.6.4 Time overcurrent (ANSI 51)

SETTINGS ⇒ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ CURRENT ELEMENTS ⇒ TIME OVERCURRENT 1(24)

■ TIME	⇔	TOC1 FUNCTION: Disabled	Range: Disabled, Enabled
■ OVERCURRENT 1	⇕	TOC1 CT: F1	Range: Available current channels
	⇕	TOC1 PICKUP: 1.200 pu	Range: 0.000 to 30.000 pu in steps of 0.001
	⇕	TOC1 CURVE: IEEE Mod Inv	Range: see OVERCURRENT CURVE TYPES table
	⇕	TOC1 TD MULTIPLIER: 1.00	Range: 0.00 to 600.00 in steps of 1
	⇕	TOC1 RESET: Instantaneous	Range: Instantaneous, Timed
	⇕	TOC1 BLOCK: Off	Range: FlexLogic operand
	⇕	TOC1 TARGET: Self-Reset	Range: Self-Reset, Latched, Disabled

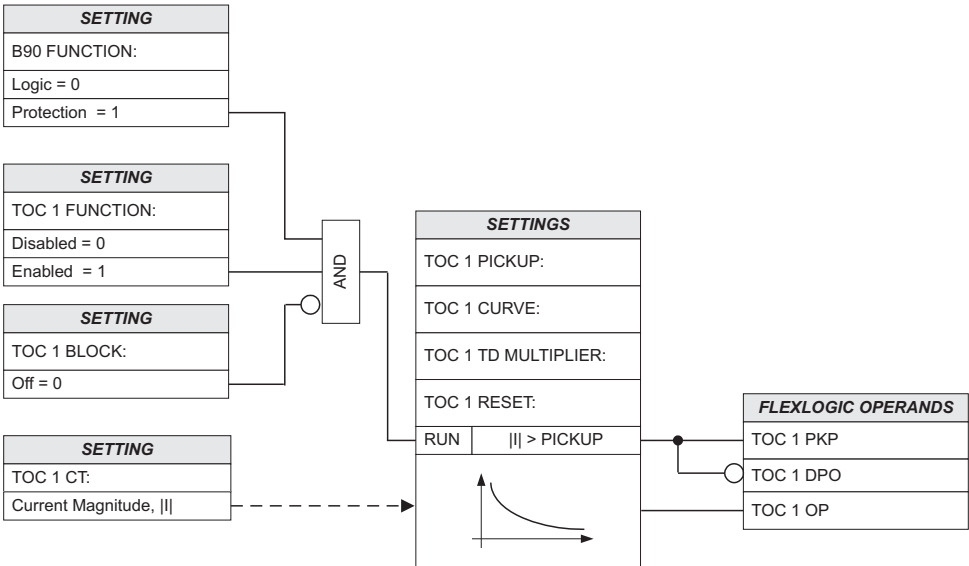
↑

TOC1 EVENTS:
Disabled

Range: Disabled, Enabled

The Time Overcurrent (TOC) element is provided for backup protection with a choice of inverse time curves. The element is enabled only when **PRODUCT SETUP ⇒ B90 FUNCTION ⇒ B90 FUNCTION** is set to "Protection". One TOC element is available per each CT input.

Figure 5-72: Time overcurrent logic



5.6.7 End fault protection

SETTINGS ⇒ GROUPED ELEMENTS ⇒ SETTING GROUP 1(6) ⇒ END FAULT PROTECTION 1(24)

■ END FAULT
■ PROTECTION 1

⇔

EFP1 FUNCTION:
Disabled

Range: Disabled, Enabled

⇕

EFP1 CT:
F1

Range: Available current channels

⇕

EFP1 PICKUP:
1.200 pu

Range: 0.000 to 30.000 pu in steps of 0.001

⇕

EFP1 BREAKER OPEN:
Off

Range: FlexLogic operand

⇕

EFP1 BKR DELAY:
0.400 s

Range: 0.000 to 65.535 s in steps of 0.001

⇕

EFP1 MANUAL CLOSE:
Off

Range: FlexLogic operand

⇕

EFP1 PICKUP DELAY:
0.040 s

Range: 0.000 to 65.535 s in steps of 0.001

⇕

EFP1 BLOCK:
Off

Range: FlexLogic operand

⇕

EFP1 TARGET:
Self-reset

Range: Self-reset, Latched, Disabled

↑

EFP1 EVENTS:
Disabled

Range: Disabled, Enabled

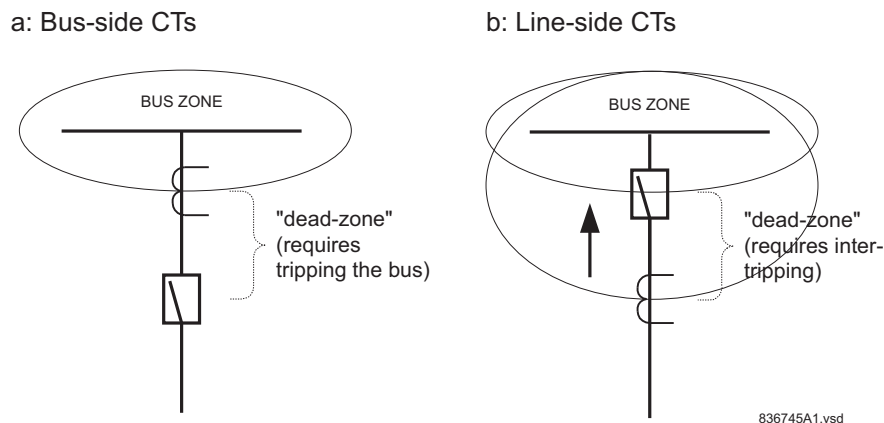
The End Fault Protection (EFP) element operates for dead-zone faults; i.e., faults between the CT and an open feeder breaker. Since a bus protection zone terminates on the CTs, faults between the CT and breaker require special consideration.

With a bus-side CT (Part A of the figure below), a fault between the open CB and CT is outside the bus zone but can only be cleared by tripping the bus zone protection. In this case EFP trips the bus zone protection once the current exceeds a user-programmable threshold, effectively clearing the fault.

With a line-side CT (Part B of the figure below), the zone is reduced once the breaker opens. Otherwise, the bus protection may issue an unnecessary widespread trip in the case of a fault between the open CB and CT. The zone is shortened using the breaker position with a short drop-out delay as a connection status for the associated current. Once the bus zone moves and terminates on the CB, a dead-zone is created between the CB and CT. In this case, the EFP is used; upon operation, the EFP will trip the remote breaker.

The EFP element arms when the feeder breaker opens and resets when a manual breaker CLOSE command is issued. To avoid race conditions, a user-programmable time delay for the breaker OPEN signal is provided. Once armed, the element operates when the current exceeds a user-programmable threshold. The output must be configured to either send an inter-trip or trip the bus zone protection depending on the CT orientation with respect to the breaker.

Figure 5-73: Application of end fault protection element



EFP1 PICKUP — Specifies the current level recognized by an armed EFP scheme as fault current in the protected dead-zone. Although it can be set very low (above the noise level), set above the maximum load current for extra security.

EFP1 BREAKER OPEN — This setting is a FlexLogic operand indicating an open breaker. The operand shall be "On" when the breaker is open. Typically, this setting is a position of an appropriately wired input contact of the B90.

EFP1 BKR DELAY — This setting specifies a timed delay between the breaker position being declared as open by the EFP1 BREAKER OPEN setting and the moment the EFP scheme is armed. Set this delay long enough to avoid spurious operation due to a delay between the breaker position and decaying of the breaker current. The current ramp down period of the B90 for the purpose of setting the EFP is 1.3 of a power system cycle.

EFP1 MANUAL CLOSE — This setting is a FlexLogic operand indicating a close command for the breaker. This operand shall be "On" when the breaker is ordered to close. Typically this setting is a position of an appropriately wired input contact of the B90.

EFP1 PICKUP DELAY — This setting allows extra security when tripping the bus from the EFP element. This timer shall be set longer than the maximum delay between the breaker closing and picking up some current and the **EFP MANUAL CLOSE** signal. If the manual close signal, **EFP MANUAL CLOSE**, arrives before the timer expires, the element resets and misoperation due to signal transit times is avoided.

EFP1 BLOCK — This setting dynamically block/unblocks the element. A typical application is a by-pass isolator as shown below. When the isolator is closed, the current does not necessarily indicate on a fault between the CB and CT and the element shall be blocked. Therefore, the close status of the isolator shall be used as the block setting.

Figure 5-74: End fault protection and bypass isolators

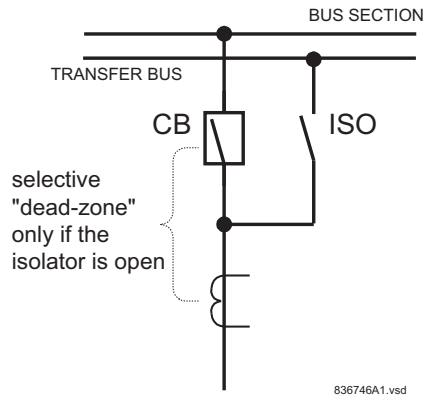
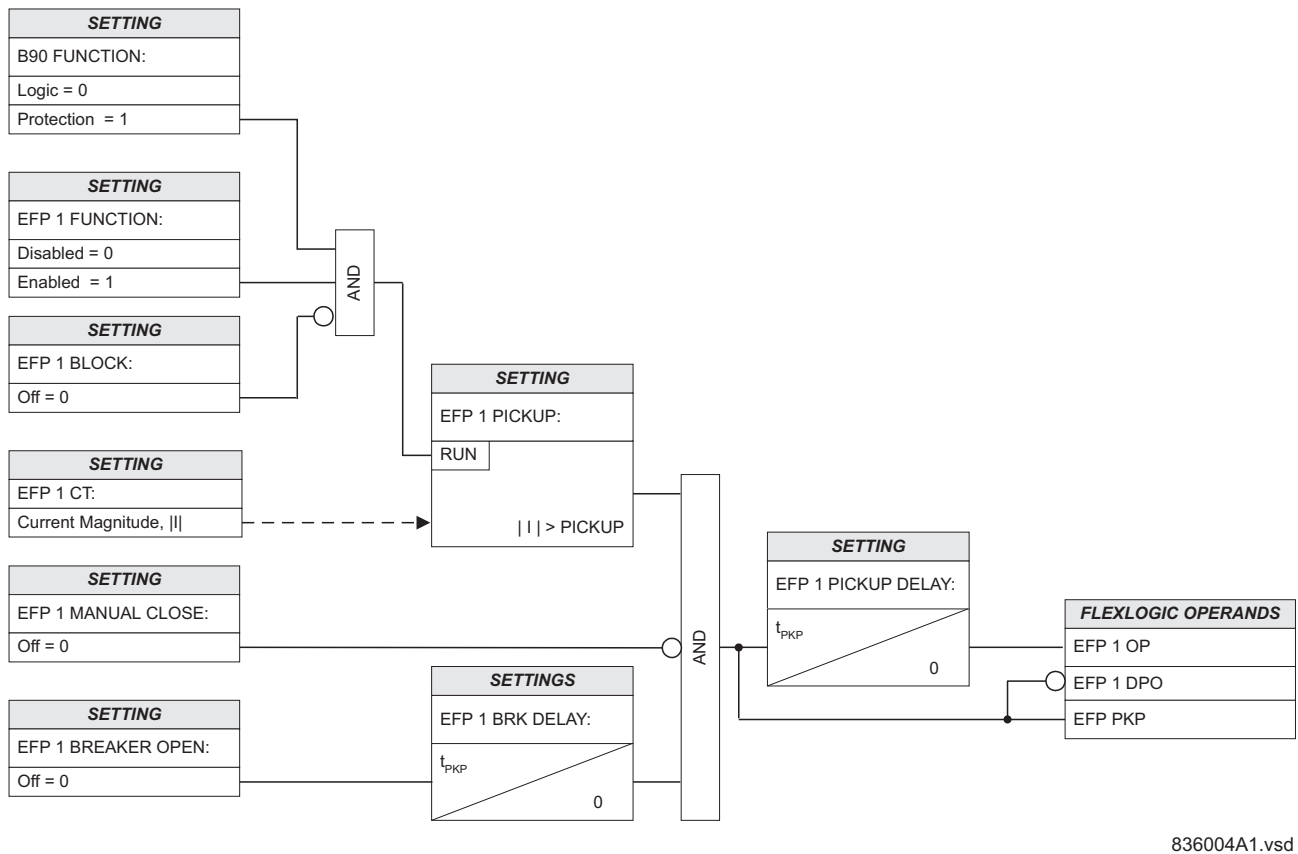


Figure 5-75: End fault protection logic



5.7 Control elements

5.7.1 Overview

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

5.7.2 Trip bus

SETTINGS ⇒ CONTROL ELEMENTS ⇒ TRIP BUS ⇒ TRIP BUS 1(6)

■ TRIP BUS 1 ■	⇔	TRIP BUS 1 FUNCTION: Disabled	Range: Enabled, Disabled
	⇕	TRIP BUS 1 BLOCK: Off	Range: FlexLogic operand
	⇕	TRIP BUS 1 PICKUP DELAY: 0.00 s	Range: 0.00 to 600.00 s in steps of 0.01
	⇕	TRIP BUS 1 RESET DELAY: 0.00 s	Range: 0.00 to 600.00 s in steps of 0.01
	⇕	TRIP BUS 1 INPUT 1 Off	Range: FlexLogic operand
	↓		
	⇕	TRIP BUS 1 INPUT 16 Off	Range: FlexLogic operand
	⇕	TRIP BUS 1 LATCHING: Disabled	Range: Enabled, Disabled
	⇕	TRIP BUS 1 RESET: Off	Range: FlexLogic operand
	⇕	TRIP BUS 1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
	↑	TRIP BUS 1 EVENTS: Disabled	Range: Enabled, Disabled

The trip bus element allows aggregating outputs of protection and control elements without using FlexLogic and assigning them a simple and effective manner. Each trip bus can be assigned for either trip or alarm actions. Simple trip conditioning such as latch, delay, and seal-in delay are available.

The easiest way to assign element outputs to a trip bus is through the EnerVista software under **Settings > Protection Summary**. Navigate to a specific protection or control protection element and check the bus box by hovering over the blank check box and selecting an option that displays. Once the desired element is selected for a specific bus, a list of element operate-type operands are displayed and can be assigned to a trip bus. If more than one operate-type operand is required, it can be assigned directly from the trip bus menu.

Figure 5-76: Trip bus fields in the protection summary

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

Save Restore Default Reset VIEW ALL mode

GROUPED ELEMENTS	TB1	TB2	TB3	TB4	TB5	GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5	GROUP 6
Current Differential	☐	☐	☐	☐	☐	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Stub Bus	☐	☐	☐	☐	☐	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Line Pickup	☐	☐	☐	☐	☐	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Phase Distance Z 1	☐	☐	☐	☐	☐	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Phase Distance Z 2	☐	☐	☐	☐	☐	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Phase Distance Z 3	☐	☐	☐	☐	☐	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Ground Distance Z 1	☐	☐	☐	☐	☐	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Ground Distance Z 2	☐	☐	☐	☐	☐	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Ground Distance Z 3	☐	☐	☐	☐	☐	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Power Swing	☐	☐	☐	☐	☐	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Load Encroachment	☐	☐	☐	☐	☐	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Phase TOC 1	☐	☐	☐	☐	☐	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Phase TOC 2	☐	☐	☐	☐	☐	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Phase TOC 3	☐	☐	☐	☐	☐	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Phase TOC 4	☐	☐	☐	☐	☐	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled

Quick Connect Device

The following settings are available.

TRIP BUS 1 BLOCK — The trip bus output is blocked when the operand assigned to this setting is asserted.

TRIP BUS 1 PICKUP DELAY — This setting specifies a time delay to produce an output depending on how output is used.

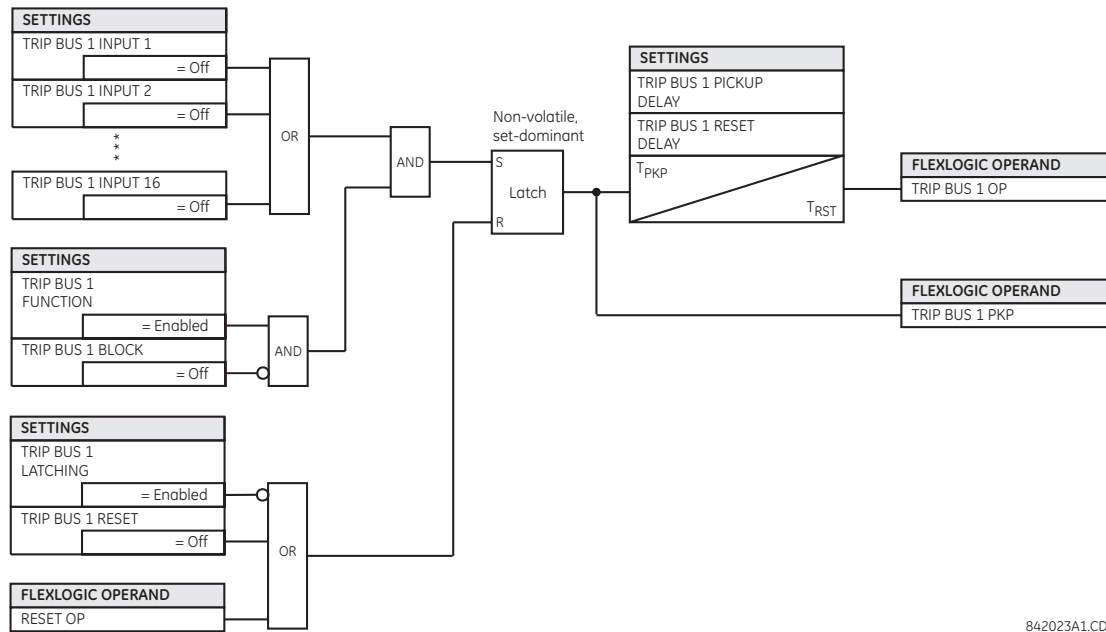
TRIP BUS 1 RESET DELAY — This setting specifies a time delay to reset an output command. Set the time delay long enough to allow the breaker or contactor to perform a required action.

TRIP BUS 1 INPUT 1 to TRIP BUS 1 INPUT 16 — These settings select a FlexLogic operand to be assigned as an input to the trip bus.

TRIP BUS 1 LATCHING — This setting enables or disables latching of the trip bus output. This is typically used when lockout is required or user acknowledgement of the relay response is required.

TRIP BUS 1 RESET — The trip bus output is reset when the operand assigned to this setting is asserted. Note that the [RESET OP](#) operand is pre-wired to the reset gate of the latch. As such, a reset command from the front panel interface or via communications resets the trip bus output.

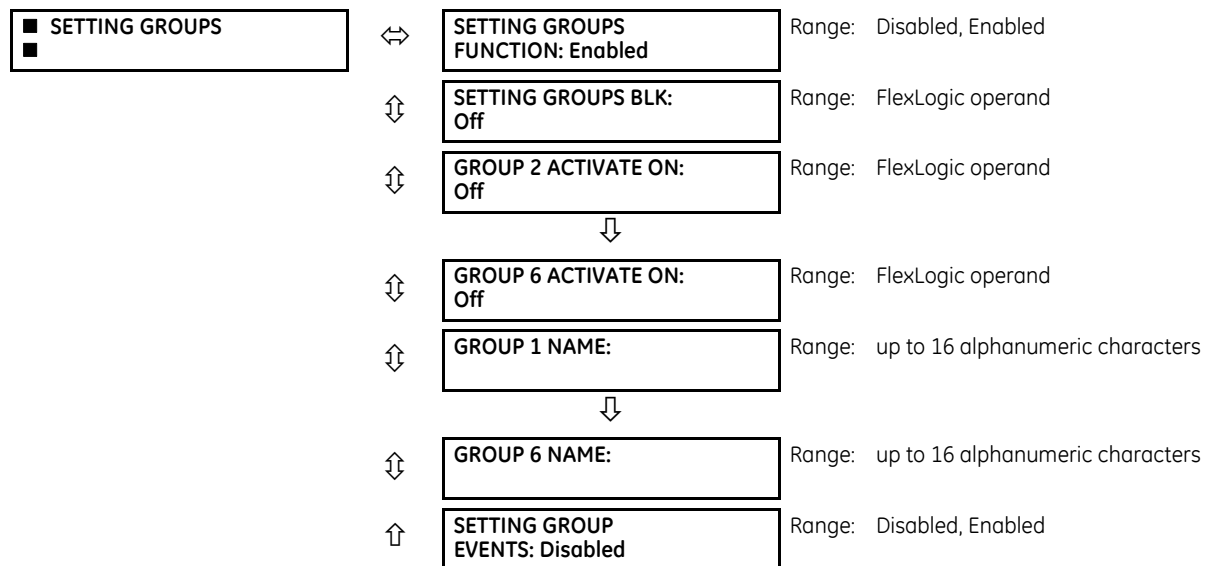
Figure 5-77: Trip bus logic



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5.7.3 Setting groups

SETTINGS ⇌ CONTROL ELEMENTS ⇌ SETTING GROUPS



The setting groups menu controls the activation and deactivation of up to six possible groups of settings in the **GROUPED ELEMENTS** settings menu. The active setting group can be indicated on the front display of the UR by configuring User-Programmable LEDs to display the state of the [SETTING GROUP ACT](#) FlexLogic operands.

On a setting group change, protection elements are blocked temporarily to allow the relay to re-initialize with the new settings. The duration of the block depends on relay configuration and can last up to four cycles. The actual block duration on the group switching can be verified by the [PROTSUPV](#) operand.

SETTING GROUPS FUNCTION — When Enabled, allows setting groups other than group 1 (the default active group) to be activated. The default setting group is forced active while the **SETTING GROUPS FUNCTION** setting is Disabled.

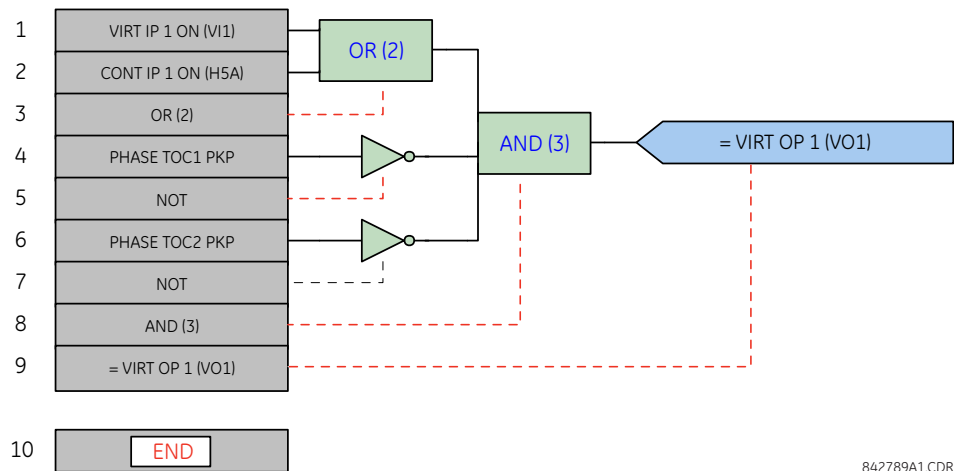
SETTING GROUPS BLK — Prevents the active setting group from changing when the selected FlexLogic operand is "On." This can be useful in applications where it is undesirable to change the settings under certain conditions, such as during a control sequence.

GROUP 2 ACTIVATE ON to GROUP 6 ACTIVATE ON — Selects a FlexLogic operand which, when set, makes 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 that is activated by its **ACTIVATE ON** parameter takes priority over the lower-numbered groups. There is no activate on setting for group 1 (the default active group), because group 1 automatically becomes active if no other group is active.

SETTING GROUP 1 NAME to SETTING GROUP 6 NAME — Allows the user to assign a name to each of the six settings groups. Once programmed, this name appears on the second line of the **GROUPED ELEMENTS ⇒ SETTING GROUP 1(6)** menu display.

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

Figure 5-78: Example of FlexLogic control of a setting group



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A setting group selection can also be made by the IEC 61850 MMS service SelectActiveSG to the control block @Master/LLN0.SGCB. The priority scheme mentioned makes active the highest numbered group selected by SelectActiveSG or the **GROUP ACTIVATE ON** settings. The SelectActiveSG selection has a default value of 1, so until a higher SelectActiveSG selection is received, the **GROUP ACTIVATE ON** settings control the active group.

The most recent SelectActiveSG selection is preserved while the UR is powered down or reset.

If it becomes necessary to cancel the SelectActiveSG selection without using a SelectActiveSG service request, change the **SETTING GROUPS FUNCTION** setting to Disabled. This resets the SelectActiveSG selection to 1.

5.7.4 Digital elements

SETTINGS ⇒ ⚡ CONTROL ELEMENTS ⇒ ⚡ DIGITAL ELEMENTS ⇒ DIGITAL ELEMENT 1(48)

■ DIGITAL ELEMENT 1	↔	DIGITAL ELEMENT 1 FUNCTION: Disabled	Range: Disabled, Enabled
	↕	DIG ELEM 1 NAME: Dig Element 1	Range: 16 alphanumeric characters
	↕	DIG ELEM 1 INPUT: Off	Range: FlexLogic operand

↕	DIG ELEM 1 PICKUP DELAY: 0.000 s	Range: 0.000 to 999999.999 s in steps of 0.001
↕	DIG ELEM 1 RESET DELAY: 0.000 s	Range: 0.000 to 999999.999 s in steps of 0.001
↕	DIGITAL ELEMENT 1 PICKUP LED: Enabled	Range: Disabled, Enabled
↕	DIG ELEM 1 BLOCK: Off	Range: FlexLogic operand
↕	DIGITAL ELEMENT 1 TARGET: Self-reset	Range: Self-reset, Latched, Disabled
↑	DIGITAL ELEMENT 1 EVENTS: Disabled	Range: Disabled, Enabled



Digital elements run once per power system cycle.

As such they can easily fail to react to an input signal or a block signal with a duration less than one power system cycle. This also means that digital element output can react up to one power system cycle later than the pickup and reset delay settings indicate.

Do not use digital elements with transient signals, such as communications commands. Do not use digital elements where random delays of up to one cycle cannot be tolerated, such as in high speed protection.

There are 48 identical digital elements available, numbered 1 to 48. A digital element can monitor any FlexLogic operand and present a target message and/or enable events recording depending on the output operand state. The digital element settings include a name to 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.

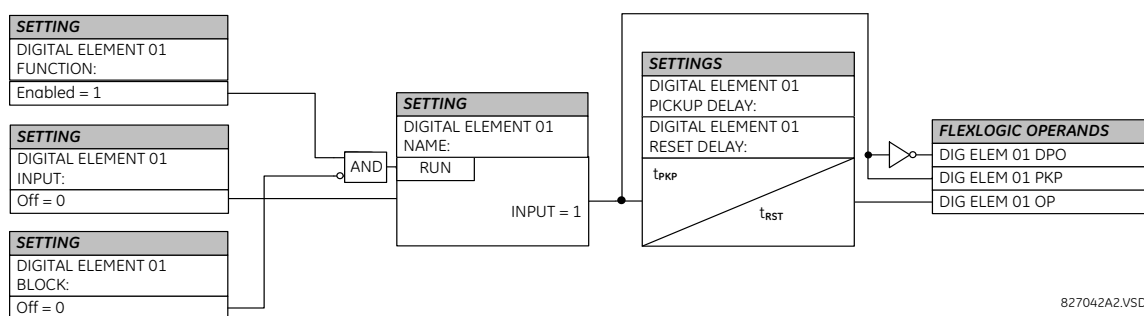
DIGITAL ELEMENT 1 INPUT — Selects a FlexLogic operand to be monitored by the digital element.

DIGITAL ELEMENT 1 PICKUP DELAY — Sets the required time delay from element pickup to element operation. If a pickup delay is not required, set to "0." To avoid nuisance alarms, set the delay greater than the operating time of the breaker.

DIGITAL ELEMENT 1 RESET DELAY — Sets the time delay to reset. If a reset delay is not required, set to "0."

DIGITAL ELEMENT 1 PICKUP LED — This setting enables or disabled the digital element pickup LED. When set to "Disabled," the operation of the pickup LED is blocked.

Figure 5-79: Digital element logic



Circuit monitoring applications

Some versions of the digital input modules include an active voltage monitor circuit connected across form-A contacts. The voltage monitor circuit limits the trickle current through the output circuit (see technical specifications for form-A).

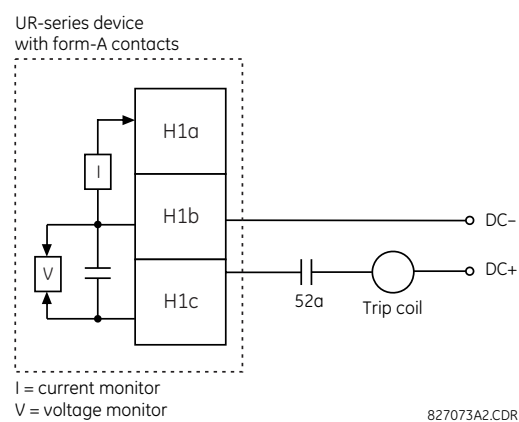
As long as the current through the voltage monitor is above a threshold (see technical specifications for form-A), the **Cont Op 1 VOn** FlexLogic operand is set (for contact input 1—corresponding operands exist for each contact output). If the output circuit has a high resistance or the DC current is interrupted, the trickle current drops below the threshold and the **Cont Op 1 VOff** FlexLogic operand is 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 that 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 falls below the monitor threshold, and an alarm is declared.

In most breaker control circuits, the trip coil is connected in series with a breaker auxiliary contact that is open when the breaker is open (see figure). To prevent unwanted alarms in this situation, the trip circuit monitoring logic must include the breaker position.

Figure 5-80: Trip circuit example 1



Assume the output contact H1 is a trip contact. Using the contact output settings, this output is given an ID name; for example, "Cont Op 1." Assume a 52a breaker auxiliary contact is connected to contact input H5a to monitor breaker status. Using the contact input settings, this input is given an ID name, for example, "Cont Ip 1," and is set "On" when the breaker is closed. The settings to use digital element 1 to monitor the breaker trip circuit are indicated (EnerVista example shown).

Digital Elements // D60_500.urs : C:\Document...	
Save Restore Default Reset	
PARAMETER	DIGITAL ELEMENT 1
Function	Enabled
Digital Element 1 Name	Bkr Trip Cct Out
Input	Cont Op 1 VOff (H1)
Pickup Delay	0.200 s
Reset Delay	0.100 s
Pickup Led	Enabled
Block	Cont Ip 1 Off(H5a)
Target	Self-reset
Events	Enabled
D60_500.urs Control Elements	

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 following figure). This can be achieved by connecting a suitable resistor (see figure) across the auxiliary contact in the trip circuit. In this case, it is not required to supervise the monitoring circuit with the breaker position – the **BLOCK** setting is selected to “Off.” In this case, the settings are as follows (EnerVista example shown).

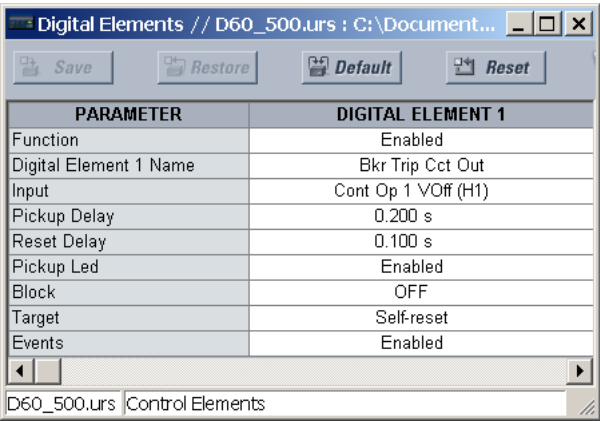
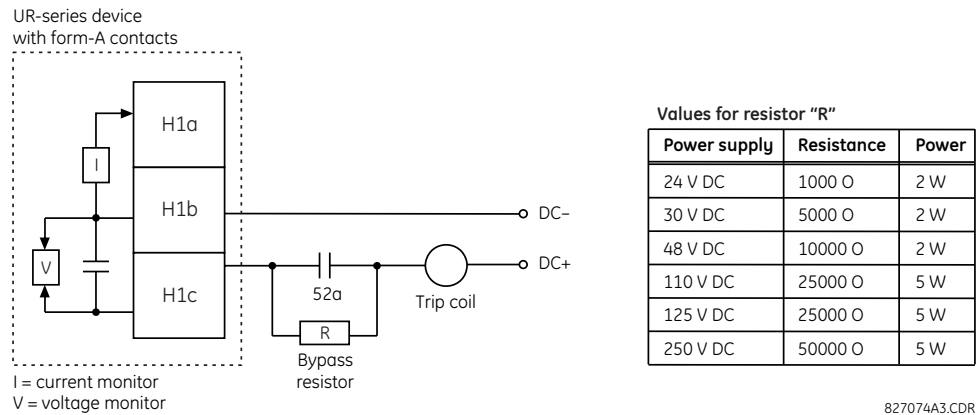


Figure 5-81: Trip circuit example 2

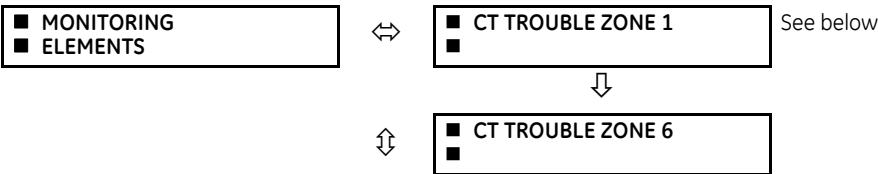


The wiring connection for two examples above is applicable to both form-A contacts with voltage monitoring and solid-state contact with voltage monitoring.

5.7.5 Monitoring elements

5.7.5.1 Menu

SETTINGS ⇌ CONTROL ELEMENTS ⇌ MONITORING ELEMENTS



↑

■ BUS REPLICA

■

See page 5-159

5.7.5.2 CT trouble zone (ANSI 50/74)

SETTINGS ⇄ CONTROL ELEMENTS ⇄ MONITORING ELEMENTS ⇄ CT TROUBLE ZONE 1(6)

■ CT TROUBLE ZONE 1

■

↔

CT TROUBLE ZONE 1
FUNCTION: Disabled

Range: Disabled, Enabled

↕

CT TROUBLE ZONE 1
PICKUP: 0.100 pu

Range: 0.020 to 2.000 pu in steps of 0.001

↕

CT TROUBLE ZONE 1
DELAY: 1.0 s

Range: 1.0 to 60.0 s in steps of 0.1

↕

CT TROUBLE ZONE 1
TARGET: Self-reset

Range: Self-reset, Latched, Disabled

↑

CT TROUBLE ZONE 1
EVENTS: Disabled

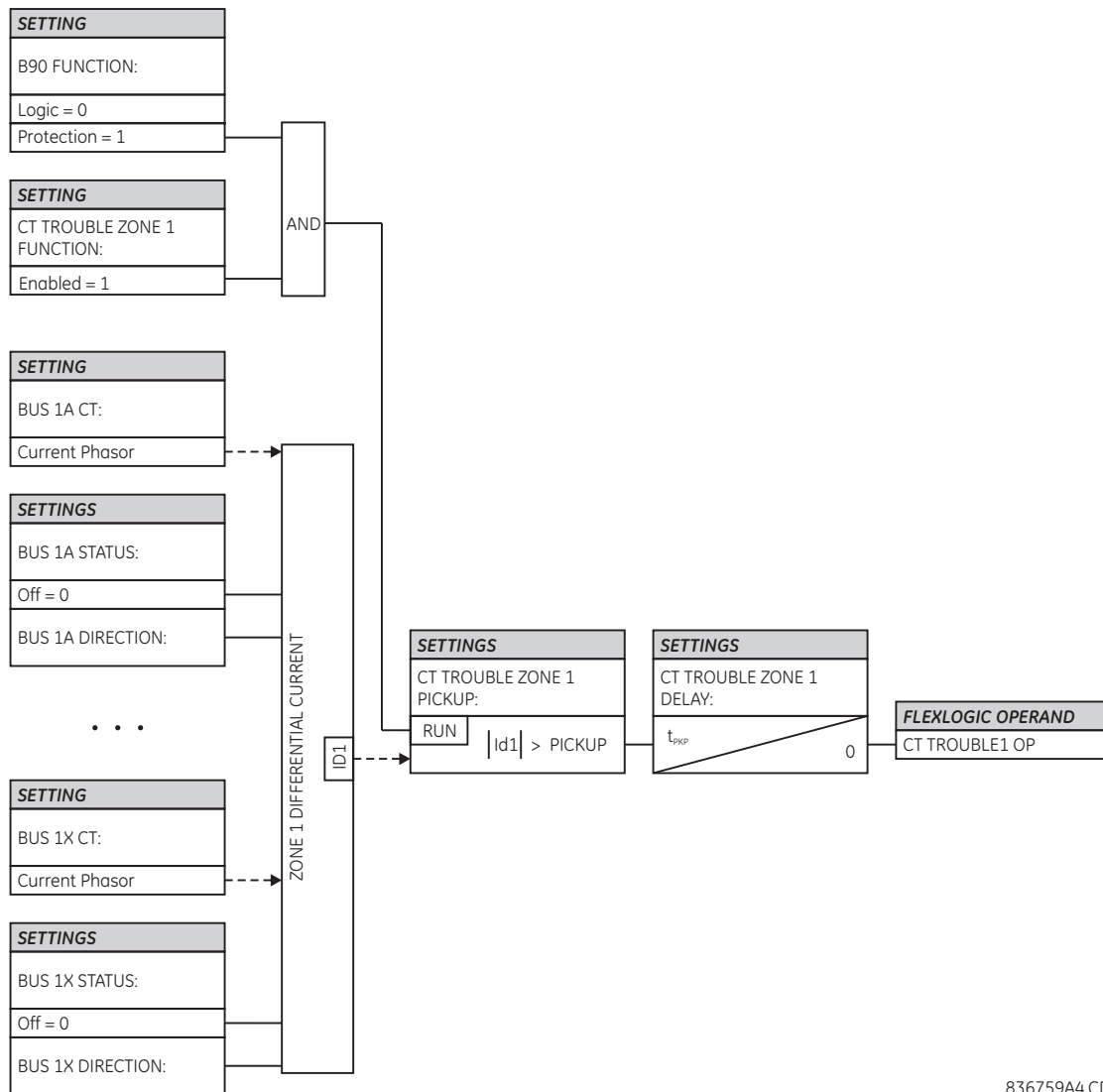
Range: Disabled, Enabled

The CT Trouble feature is available only when **PRODUCT SETUP ⇄ B90 FUNCTION ⇄ B90 FUNCTION** is set to "Protection".

This element uses the differential current calculated in accordance with the bus configuration programmed under Bus Zone 1. Operation of this element is therefore completely dependent on the dynamic bus replica, which must be defined first. The bus differential zones are defined using the path **SETTINGS ⇄ SYSTEM SETUP ⇄ BUS**. The CT Trouble element 1 detects CT problems in any of the circuits actually connected to the differential zone defined as Bus Zone 1.

The **CT TROUBLE ZONE 1 PICKUP** setting specifies the differential current level that defines an abnormal bus state. If the differential current in a given phase remains above this level for the time interval defined by the **CT TROUBLE ZONE 1 DELAY** setting, CT Trouble is declared for the given phase by setting the appropriate FlexLogic output operand. The operand may be configured to raise an alarm and block the bus differential function for the corresponding zone of protection.

Figure 5-82: CT trouble logic



5.7.5.3 Bus replica isolator monitoring

SETTINGS ⇌ CONTROL ELEMENTS ⇌ MONITORING ELEMENTS ⇌ BUS REPLICA ⇌ ISOLATOR 1(48)

■ ISOLATOR 1	⇌	ISOLATOR 1 FUNCTION: Disabled	Range: Disabled, Enabled
■	⇌	ISOLATOR 1 OPEN: Off	Range: FlexLogic operand
	⇌	ISOLATOR 1 CLOSED: Off	Range: FlexLogic operand
	⇌	ISOLATOR 1 ALARM DELAY: 0.05 s	Range: 0.00 to 120.00 s in steps of 0.05
	⇌	ISOLATOR 1 RESET: Off	Range: FlexLogic operand
	⇌	ISOLATOR 1 TARGET: Self-Reset	Range: Self-Reset, Latched, Disabled

↑

ISOLATOR 1

EVENTS: Disabled

Range: Disabled, Enabled

Bus protection zone discrimination depends heavily on reliable isolator position feedback. Therefore, two isolator auxiliary contacts – normally open and normally closed – must confirm the status of the isolator via the B90 contact inputs.

This element responds to both normally open and normally closed auxiliary contacts of an isolator or a tie-breaker in order to assert the actual position of the isolator for the dynamic bus image. The element asserts two extra output operands indicating "isolator alarm" (auxiliary contact discrepancy), and "block switching operations in the substation." The operation of the element is summarized in the following table.

Table 5-28: Isolator monitoring logic

Isolator open auxiliary contact	Isolator closed auxiliary contact	Isolator position	Alarm	Block switching
Off	On	CLOSED	No	No
Off	Off	LAST VALID	After time delay until acknowledged	Until Isolator Position is valid
On	On	CLOSED		
On	Off	OPEN	No	No

The position of an isolator is indicated by the **ISOLATOR N POSITION** FlexLogic operand (On = Closed, Off = Open). This operand is used as a circuit connection status for the bus configuration. When "On", the related current is associated with a given differential zone; when "Off", the current is excluded from differential calculations.

An isolator alarm FlexLogic operand, **ISOLATOR 1 ALARM**, is asserted after a settable time delay if the auxiliary contacts of the isolator do not match (open-open, closed-closed instead of open-closed or closed-open), yielding an undefined isolator position. The operand may be used to block user-selected protection functions and may be reset manually or remotely via the resetting input operand.

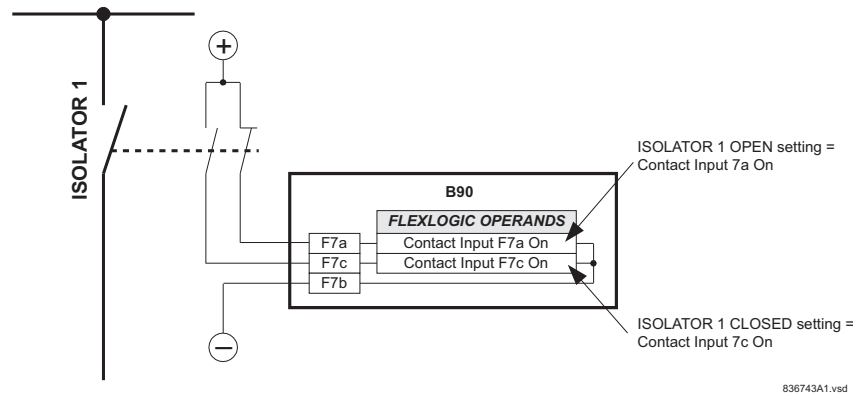
The **ISOLATOR 1 BLOCK** operand is asserted as long as the isolator position is invalid. This operand may be used to block switching operations in the substation. Typically, breakers and isolators that control currents flowing through a given isolator shall be blocked from operation as long as isolator position is not resolved.

The element is effectively enabled only when **PRODUCT SETUP ⇒ B90 FUNCTION ⇒ B90 FUNCTION** is set to "Logic." See the Application of Settings chapter for details on the usage of the Bus Replica element.

ISOLATOR 1 OPEN — This setting specifies a FlexLogic operand that represents an auxiliary contact of the monitored isolator. Typically this setting is a status of an appropriately wired input contact ("On" = isolator open).

ISOLATOR 1 CLOSED — This setting indicates a FlexLogic operand that represents an auxiliary contact of the monitored isolator. Typically this setting is a status of an appropriately wired input contact ("On" = isolator closed).

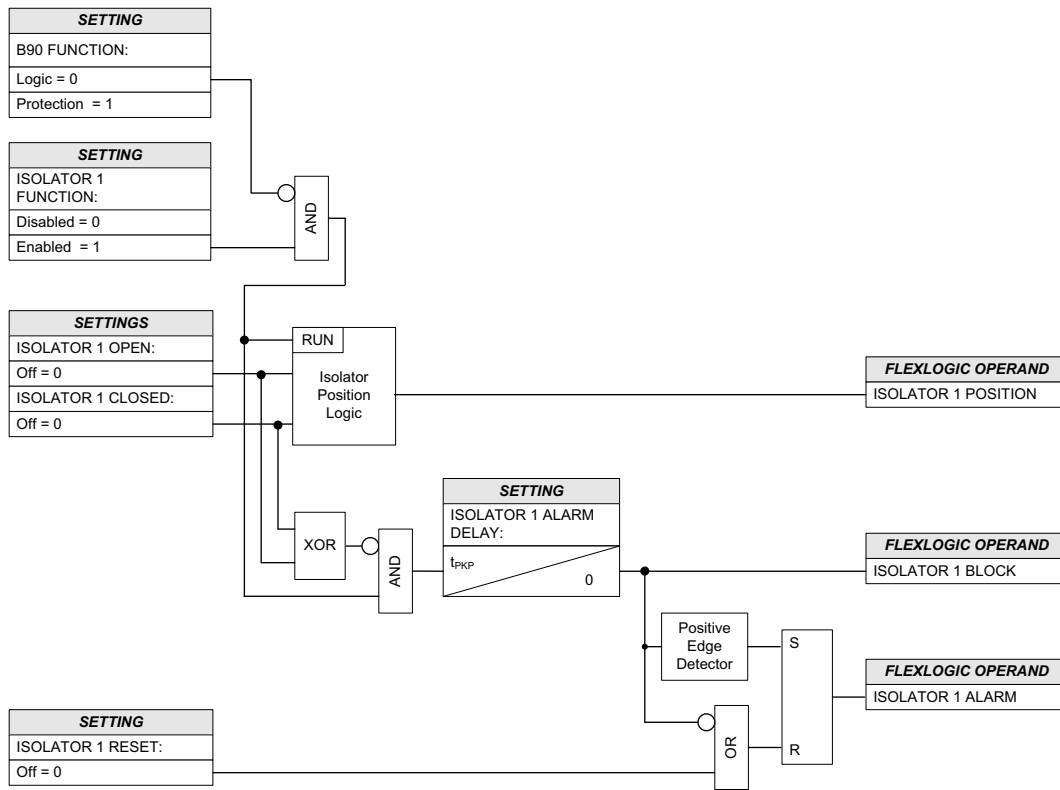
Figure 5-83: Typical isolator open/closed settings



ISOLATOR 1 ALARM DELAY — This setting specifies a time delay after which an isolator alarm is issued by asserting the operand assigned to **ISOLATOR 1 ALARM**. Set the delay longer than the slowest operation (transition) time of the isolator.

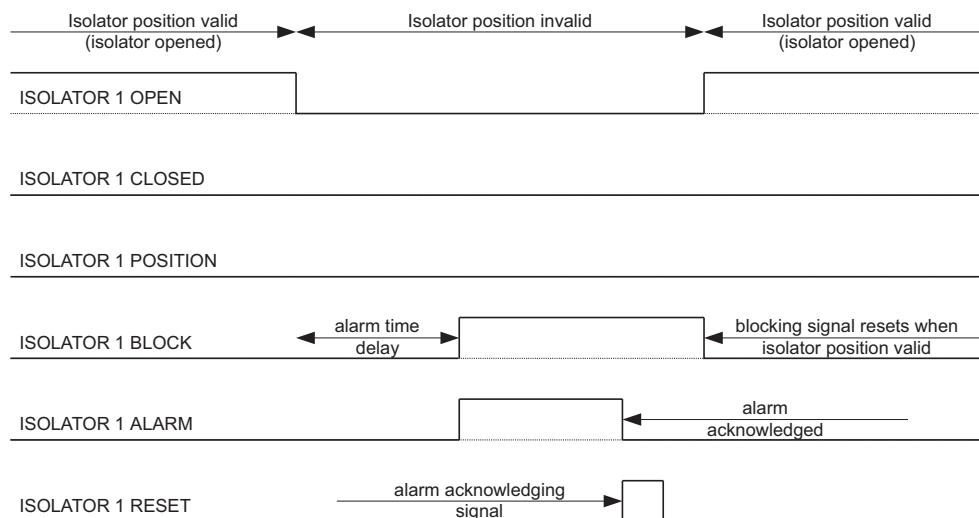
ISOLATOR 1 RESET — This setting indicates a FlexLogic operand that acknowledges the isolator alarm. Once the alarm is acknowledged, the **ISOLATOR 1 ALARM** is reset. If the latter operand was configured to block protection, the blocking is removed once the alarm is acknowledged. The acknowledge pulse must last at least 50 ms to take effect.

Figure 5-84: Isolator monitoring logic



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Figure 5-85: Isolator monitoring sample timing diagram

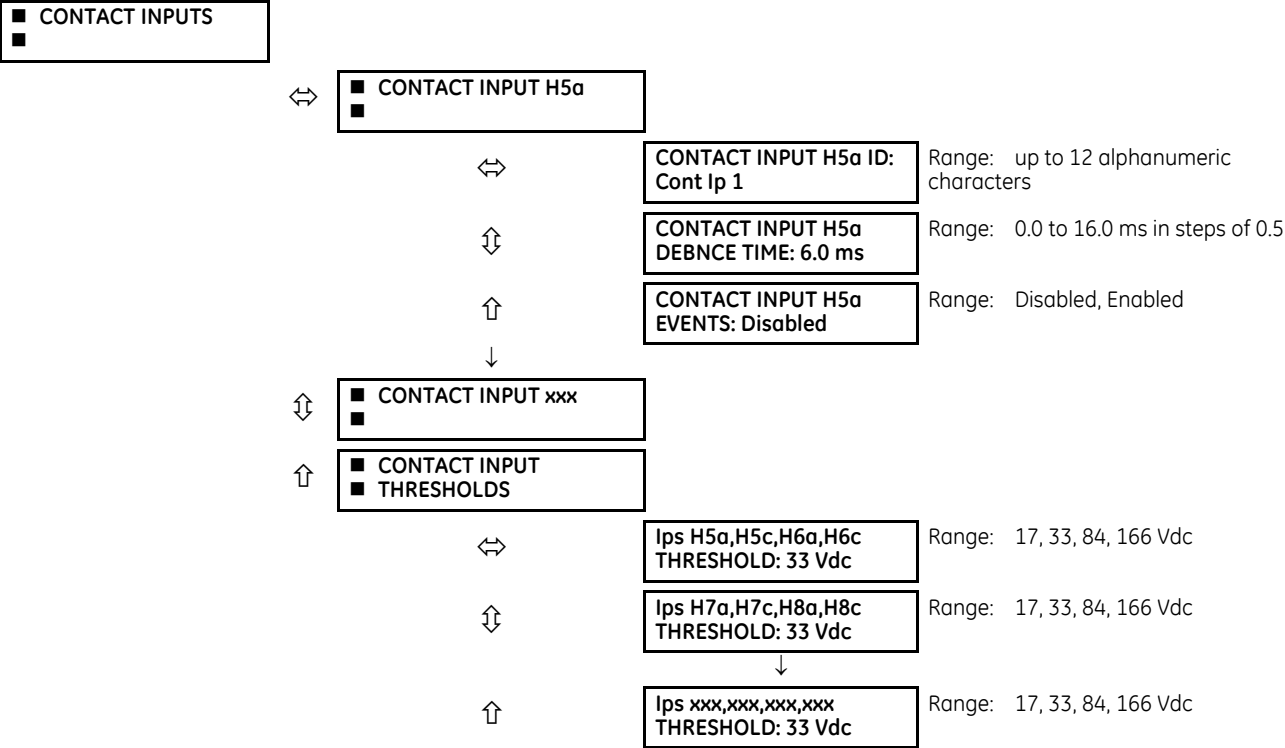


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5.8 Inputs/outputs

5.8.1 Contact inputs

SETTINGS ⇒ INPUTS/OUTPUTS ⇒ CONTACT INPUTS



Contact inputs and outputs are digital signals associated with connections to hard-wired contacts. Wet and dry contacts are supported.

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 can be assigned to a contact input for diagnostic, setting, and event recording purposes. The **CONTACT IP X On** (Logic 1) FlexLogic operand corresponds to contact input “X” being closed, while **CONTACT IP X Off** corresponds to contact input “X” being open. The **CONTACT INPUT DEBNCE TIME** defines the time required for the contact to overcome ‘contact bouncing’ conditions. As this time differs for different contact types and manufacturers, set it as a maximum contact debounce time (per manufacturer specifications) plus some margin to ensure proper operation. If **CONTACT INPUT EVENTS** is set to “Enabled,” every change in the contact input state triggers an event.

A raw status is scanned for all Contact Inputs synchronously at the constant rate of 0.5 ms as shown in the following figure. 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 B90 to validate the new contact state. In the following figure, 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 (de-bounced), 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 figure).

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 that follows). 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.

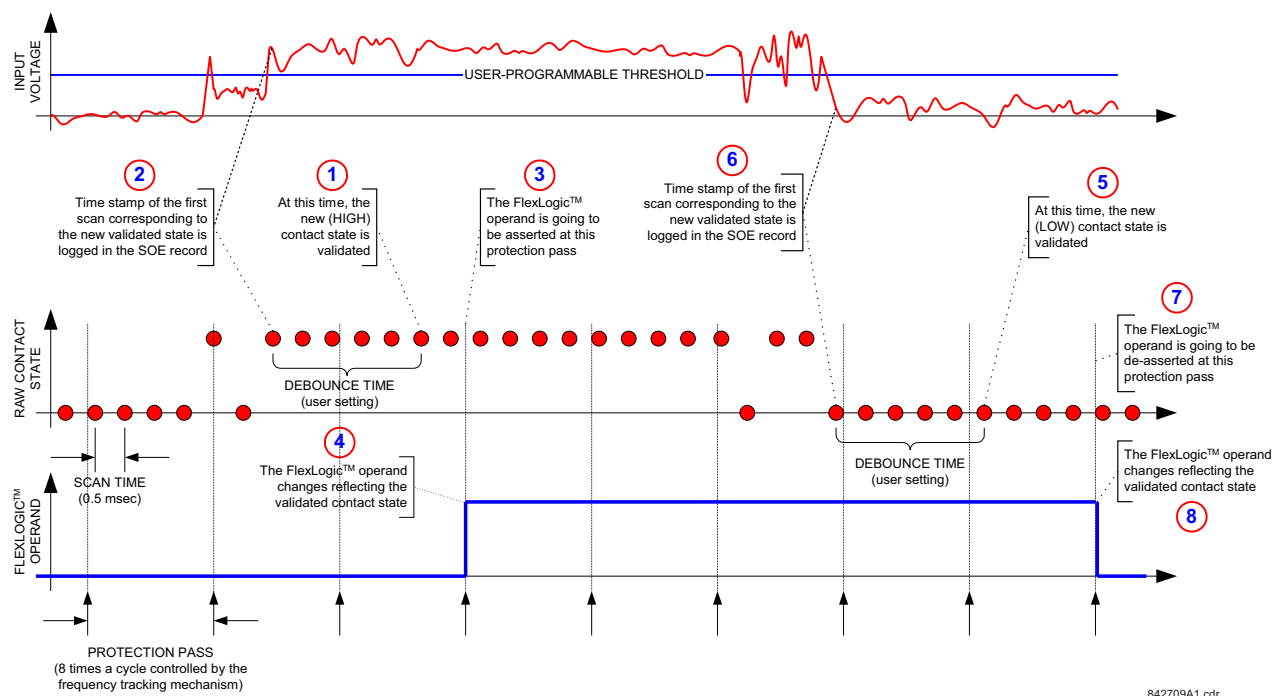
The FlexLogic operand response time to the contact input change is equal to the debounce time setting plus up to one protection pass (variable and depending on system frequency if frequency tracking enabled). If the change of state occurs just after a protection pass, the recognition is delayed until 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 1 ms.

For example, eight 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 shown). 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) and HIGH-LOW (marks no. 5, 6, 7, and 8) transitions.

Figure 5-86: 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 is selected according to the following criteria: 17 for 24 V sources, 33 for 48 V sources, 84 for 110 to 125 V sources and 166 for 250 V sources.

For example, to use contact input H5a as a status input from the breaker 52b contact to seal-in the trip relay and record it in the Event Records menu, make the following settings changes:

CONTACT INPUT H5a ID: "Breaker Closed (52b)"
CONTACT INPUT H5a EVENTS: "Enabled"

Note that the 52b contact is closed when the breaker is open and open when the breaker is closed.

5.8.2 Virtual inputs

SETTINGS ⇄ INPUTS/OUTPUTS ⇄ VIRTUAL INPUTS ⇄ VIRTUAL INPUT 1(64)

■ VIRTUAL INPUT 1 ■	⇄	VIRTUAL INPUT 1 FUNCTION: Disabled	Range: Disabled, Enabled
	⇅	VIRTUAL INPUT 1 ID: Virt Ip 1	Range: up to 12 alphanumeric characters
	⇅	VIRTUAL INPUT 1 TYPE: Latched	Range: Self-Reset, Latched
	⇅	VIRTUAL INPUT 1 EVENTS: Disabled	Range: Disabled, Enabled

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

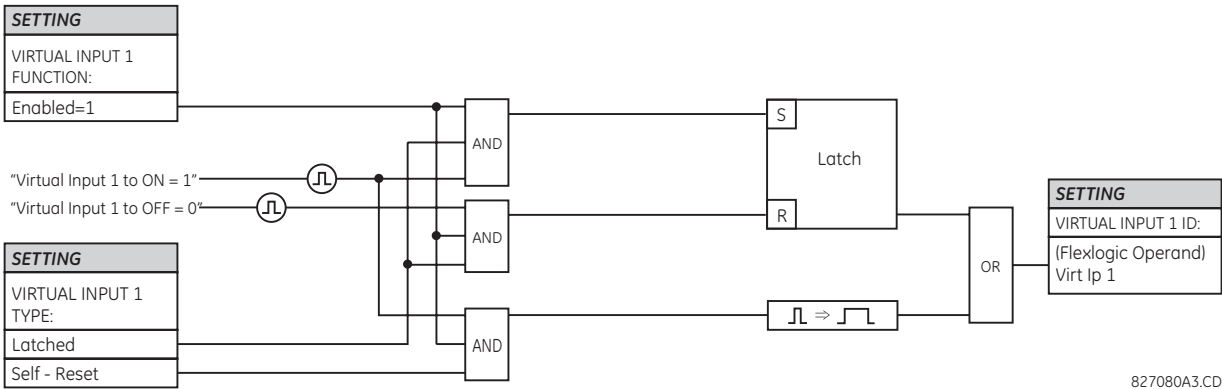
There are 64 virtual inputs that can be individually programmed to respond to input signals from the keypad (via the **COMMANDS** menu) and communications protocols. All virtual input operands are defaulted to “Off” (logic 0) unless the appropriate input signal is received.

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

There are two types of operation: self-reset and latched. If **VIRTUAL INPUT x type** is “Self-Reset,” when the input signal transits from off to on, the output operand is set to on for only one evaluation of the FlexLogic equations and then return to off. If set to “Latched,” the virtual input sets the state of the output operand to the same state as the most recent received input.

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 likely needs to be lengthened in time. A FlexLogic timer with a delayed reset can perform this function.

Figure 5-87: Virtual inputs logic



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5.8.3 Contact outputs

5.8.3.1 Digital outputs

SETTINGS ⇒↓ INPUTS/OUTPUTS ⇒↓ CONTACT OUTPUTS ⇒↓ CONTACT OUTPUT H1

■ CONTACT OUTPUT H1 ■	↔	CONTACT OUTPUT H1 ID Cont Op 1	Range: up to 12 alphanumeric characters
	↕	OUTPUT H1 OPERATE: Off	Range: FlexLogic operand
	↕	OUTPUT H1 SEAL-IN: Off	Range: FlexLogic operand
	↑	CONTACT OUTPUT H1 EVENTS: Enabled	Range: Disabled, Enabled

A contact inputs and outputs are digital signals associated with connections to hard-wired contacts. Wet and dry contacts are supported.

Upon startup of the relay, the main processor determines from an assessment of the modules installed in the chassis which contact outputs are available and then presents the settings for only these outputs. Where the contact input is non-latching, the settings are as shown.

An ID can be assigned to each contact output. The signal that can **OPERATE** a contact output can be any FlexLogic operand (virtual output, element state, contact input, or virtual input). An additional FlexLogic operand can be used to **SEAL-IN** the relay. Any change of state of a contact output can be logged as an Event if programmed to do so.

For example, the trip circuit current is monitored by providing a current threshold detector in series with some Form-A contacts (see the trip circuit example in the Digital Elements section). The monitor sets a flag (see the specifications for Form-A). The name of the FlexLogic operand set by the monitor, consists of the output relay designation, followed by the name of the flag; for example, [Cont OP 1 IO_n](#).

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 using the [Cont OP 1 IO](#) 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"

Figure 5-88: Contact input/output module type 6A contact 1 logic



5.8.3.2 Latching outputs

SETTINGS ⇒ INPUTS/OUTPUTS ⇒ CONTACT OUTPUTS ⇒ CONTACT OUTPUT H1a

CONTACT OUTPUT H1a	⇔	OUTPUT H1a ID L-Cont Op 1	Range: up to 12 alphanumeric characters
	⇕	OUTPUT H1a OPERATE: Off	Range: FlexLogic operand
	⇕	OUTPUT H1a RESET: Off	Range: FlexLogic operand
	⇕	OUTPUT H1a TYPE: Operate-dominant	Range: Operate-dominant, Reset-dominant
	↑	OUTPUT H1a EVENTS: Disabled	Range: Disabled, Enabled

The latching output contacts are mechanically bi-stable and controlled by two separate (open and close) coils. As such they retain their position even if the relay is not powered up. The relay recognizes all latching output contact cards and populates the setting menu accordingly. On power up, the relay reads positions of the latching contacts from the hardware before executing any other functions of the relay (such as protection and control features or FlexLogic).

The latching output modules, either as a part of the relay or as individual modules, are shipped from the factory with all latching contacts opened. It is highly recommended to double-check the programming and positions of the latching contacts when replacing a module.

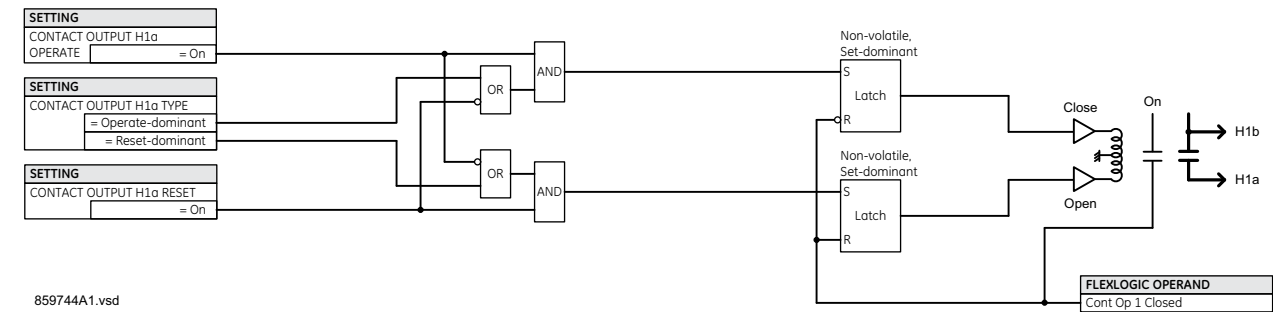
Since the relay asserts the output contact and reads back its position, it is possible to incorporate self-monitoring capabilities for the latching outputs. If any latching outputs exhibits a discrepancy, the LATCHING OUTPUT ERROR self-test error is declared. The error is signaled by the **LATCHING OUT ERROR** FlexLogic operand, event, and target message.

OUTPUT H1a OPERATE — This setting specifies a FlexLogic operand to operate the ‘close coil’ of the contact. The relay seals-in this input to safely close the contact. Once the contact is closed and the **RESET** input is logic 0 (off), any activity of the **OPERATE** input, such as subsequent chattering, does not have any effect. With both the **OPERATE** and **RESET** inputs active (logic 1), the response of the latching contact is specified by the **OUTPUT H1a TYPE** setting.

OUTPUT H1a RESET — This setting specifies a FlexLogic operand to operate the ‘trip coil’ of the contact. The relay seals-in this input to safely open the contact. Once the contact is opened and the **OPERATE** input is logic 0 (off), any activity of the **RESET** input, such as subsequent chattering, does not have any effect. With both the **OPERATE** and **RESET** inputs active (logic 1), the response of the latching contact is specified by the **OUTPUT H1a TYPE** setting.

OUTPUT H1a TYPE — This setting specifies the contact response under conflicting control inputs; that is, when both the **OPERATE** and **RESET** signals are applied. With both control inputs applied simultaneously, the contact closes if set to “Operate-dominant” and opens if set to “Reset-dominant.”

Figure 5-89: Contact input/output module type 4L contact 1 logic



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 are applied.

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

OUTPUT H1a OPERATE: "PUSHBUTTON 1 ON"

OUTPUT H1a RESET: "PUSHBUTTON 2 ON"

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

PUSHBUTTON 1 FUNCTION: "Self-reset"

PUSHBTN 1 DROP-OUT TIME: "0.00 s"

PUSHBUTTON 2 FUNCTION: "Self-reset"

PUSHBTN 2 DROP-OUT TIME: "0.00 s"

Application example 2

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

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

OUTPUT H1a OPERATE: "VO1"

OUTPUT H1a RESET: "VO2"

OUTPUT H1c OPERATE: "VO2"

OUTPUT H1c RESET: "VO1"

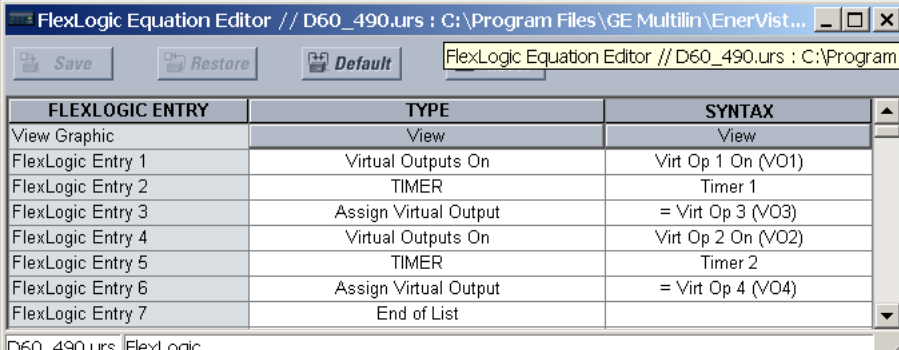
Since the two physical contacts in this example are mechanically separated and have individual control inputs, they do not operate at exactly the same time. A discrepancy in the range of a fraction of a maximum operating time can occur.

Therefore, a pair of contacts programmed to be a multi-contact relay do 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.

Write the following FlexLogic equation (EnerVista example shown).



FLEXLOGIC ENTRY	TYPE	SYNTAX
View Graphic	View	View
FlexLogic Entry 1	Virtual Outputs On	Virt Op 1 On (VO1)
FlexLogic Entry 2	TIMER	Timer 1
FlexLogic Entry 3	Assign Virtual Output	= Virt Op 3 (VO3)
FlexLogic Entry 4	Virtual Outputs On	Virt Op 2 On (VO2)
FlexLogic Entry 5	TIMER	Timer 2
FlexLogic Entry 6	Assign Virtual Output	= Virt Op 4 (VO4)
FlexLogic Entry 7	End of List	

Set both timers (Timer 1 and Timer 2) to 20 ms pickup and 0 ms dropout.

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

OUTPUT H1a OPERATE: "VO1"

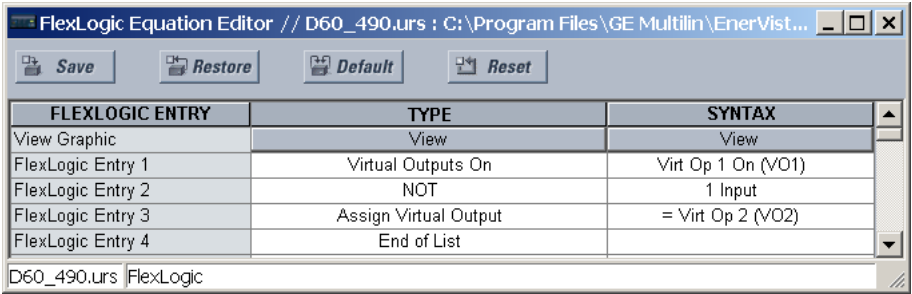
OUTPUT H1a RESET: "VO4"

OUTPUT H1c OPERATE: "VO2"

OUTPUT H1c RESET: "VO3"

Application example 4

A latching contact H1a is to be controlled from a single virtual output VO1. The contact is to remain closed as long as VO1 is high, and is to remain opened when VO1 is low. Program the relay as follows.
Write the following FlexLogic equation (EnerVista example shown).



FLEXLOGIC ENTRY	TYPE	SYNTAX
View Graphic	View	View
FlexLogic Entry 1	Virtual Outputs On	Virt Op 1 On (VO1)
FlexLogic Entry 2	NOT	1 Input
FlexLogic Entry 3	Assign Virtual Output	= Virt Op 2 (VO2)
FlexLogic Entry 4	End of List	

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

OUTPUT H1a OPERATE: "VO1"
OUTPUT H1a RESET: "VO2"

5.8.4 Virtual outputs

SETTINGS ⇒ INPUTS/OUTPUTS ⇒ VIRTUAL OUTPUTS ⇒ VIRTUAL OUTPUT 1(96)

■ VIRTUAL OUTPUT 1

↔

VIRTUAL OUTPUT 1 ID
Virt Op 1

↕

VIRTUAL OUTPUT 1
EVENTS: Disabled

Range: up to 12 alphanumeric characters

Range: Disabled, Enabled

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

There are 96 virtual outputs that can be assigned using FlexLogic. If not assigned, the output is forced to 'OFF' (Logic 0). An ID also can 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 is programmed as follows:

VIRTUAL OUTPUT 1 ID: "Trip"
VIRTUAL OUTPUT 1 EVENTS: "Disabled"

5.8.5 Resetting

SETTINGS ⇒ INPUTS/OUTPUTS ⇒ RESETTING

■ RESETTING

↔

RESET OPERAND:
Off

Range: FlexLogic operand

Some events can be programmed to latch the faceplate LED event indicators, target messages, and/or graphical panel annunciator windows. Once set, the latching mechanism holds 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 where the initiating condition has cleared. The **RESET** command can be sent from the faceplate **RESET** button, a remote device via a communications channel, or any selected operand.

The three sources of **RESET** commands each activates the **RESET OP** FlexLogic operand. Each individual source of a **RESET** command also creates its individual operand **RESET OP (PUSHBUTTON)**, **RESET OP (COMMS)**, or **RESET OP (OPERAND)** to identify the source of the command. Each of these three operands generates an event in the event record when activated. The **RESET OPERAND** setting here selects the operand that activates the **RESET OP (OPERAND)** operand.

5.8.6 Direct inputs and outputs

5.8.6.1 Direct inputs

SETTINGS ⇌ INPUTS/OUTPUTS ⇌ DIRECT INPUTS ⇌ DIRECT INPUT 1(96)

■ DIRECT INPUT 1 ■	↔	DIRECT INPUT 1 NAME: Dir Ip 1	Range: up to 12 alphanumeric characters
	↕	DIRECT INPUT 1 DEVICE ID: 0	Range: 0 to 16
	↕	DIRECT INPUT 1 BIT NUMBER: 0	Range: 0 to 96
	↕	DIRECT INPUT 1 DEFAULT: Off	Range: On, Off, Latest/On, Latest/Off
	↑	DIRECT INPUT 1 EVENTS: Disabled	Range: Enabled, Disabled

These settings specify how the direct input information is processed.

DIRECT INPUT 1 NAME — This setting allows the user to assign a descriptive name to the direct input.

DIRECT INPUT 1 DEVICE ID — Represents the source of direct input 1. The specified direct input is driven by the device identified here.

DIRECT INPUT 1 BIT NUMBER — The bit number to extract the state for direct input 1. Direct Input 1 is driven by the bit identified as **DIRECT INPUT 1 BIT NUMBER**. This corresponds to the direct output number of the sending device.

DIRECT INPUT 1 DEFAULT — Represents the state of the direct input when the associated direct device is offline. The following choices are available:

- On — Defaults the input to Logic 1
- Off — Defaults the input to Logic 0
- Latest/On — Freezes the input in case of lost communications. When the latest state is not known, such as after relay power-up but before the first communication exchange, the input defaults to Logic 1. When communication resumes, the input becomes fully operational.
- Latest/Off — Freezes the input in case of lost communications. When the latest state is not known, such as after relay power-up but before the first communication exchange, the input defaults to Logic 0. When communication resumes, the input becomes fully operational.

5.8.6.2 Direct outputs

SETTINGS ⇌ INPUTS/OUTPUTS ⇌ DIRECT OUTPUTS ⇌ DIRECT OUTPUT 1(96)

■ DIRECT OUTPUT 1 ■	↔	DIRECT OUT 1 NAME: Dir Out 1	Range: up to 12 alphanumeric characters
	↕	DIRECT OUT 1 OPERAND: Off	Range: FlexLogic operand
	↑	DIRECT OUTPUT 1 EVENTS: Disabled	Range: Enabled, Disabled

DIRECT OUT 1 NAME — This setting allows the user to assign a descriptive name to the direct output.

DIR OUT 1 OPERAND — This sets the FlexLogic operand that determines the state of this direct output.

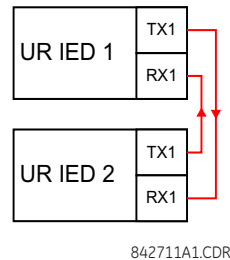
5.8.6.3 Application examples

The examples introduced in the earlier Direct Inputs and Outputs section (part of the Product Setup section) are continued here to illustrate usage of the direct inputs and outputs.

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

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

Figure 5-90: Input and output extension via direct inputs and outputs



Assume that contact input 1 from UR IED 2 is to be used by UR IED 1. The following settings are 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:

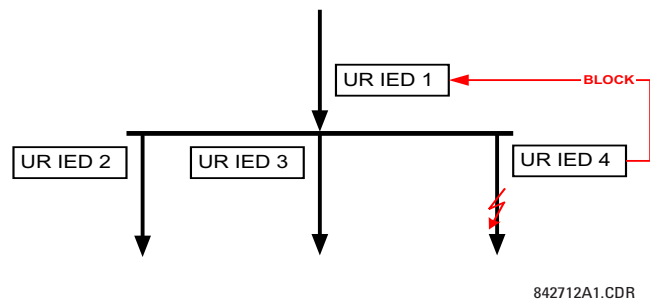
DIRECT OUT 12 OPERAND = "Cont Ip 1 On"

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.

Figure 5-91: Sample interlocking busbar protection scheme



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

The following settings are 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"

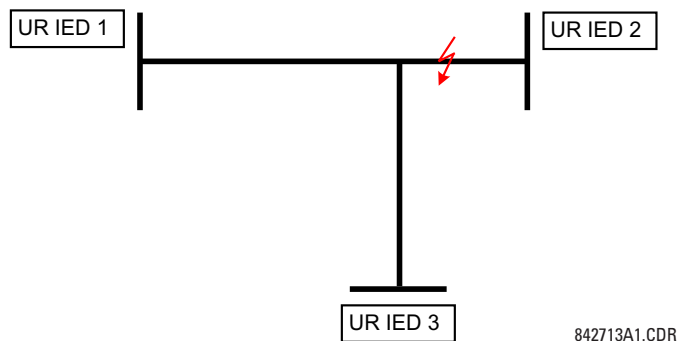
DIRECT INPUT 9 DEFAULT STATE: select "On" for security, select "Off" for dependability

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 3: Pilot-aided schemes

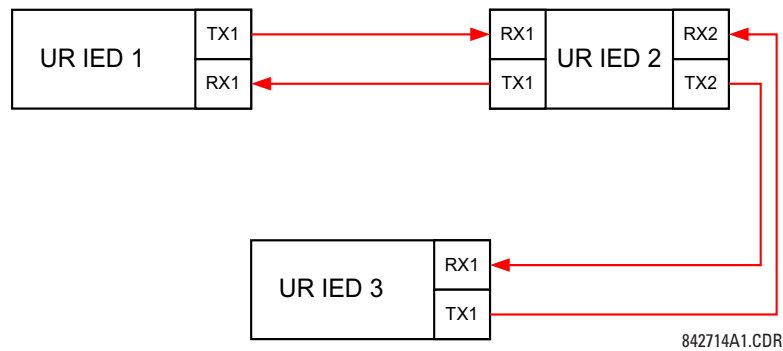
Consider a three-terminal line protection application shown in the following figure.

Figure 5-92: Three-terminal line application



Assume the Hybrid Permissive Overreaching Transfer Trip (Hybrid POTT) scheme is applied using the architecture shown as follows. The scheme output operand [HYB POTT TX1](#) is used to key the permission.

Figure 5-93: Single-channel open-loop configuration



In this architecture, Devices 1 and 3 do not communicate directly. Therefore, Device 2 must act as a 'bridge'. The following settings are applied:

UR IEC 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:

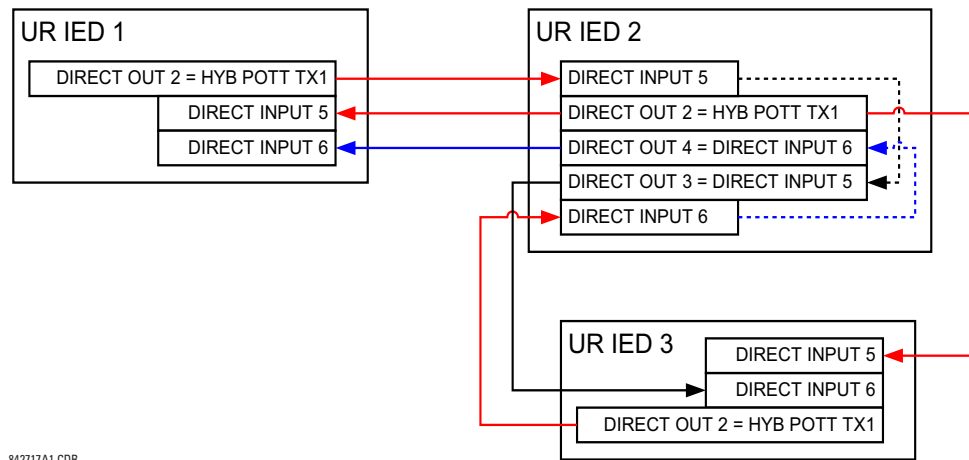
DIRECT OUT 2 OPERAND: "HYB POTT TX1"
DIRECT INPUT 5 DEVICE ID: "2"
DIRECT INPUT 5 BIT NUMBER: "2" (this is a message from IED 2)
DIRECT INPUT 6 DEVICE ID: "2"
DIRECT INPUT 6 BIT NUMBER: "3" (effectively, this is a message from IED 1)

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)

The figure shows the signal flow among the three IEDs.

Figure 5-94: Signal flow for direct input and output



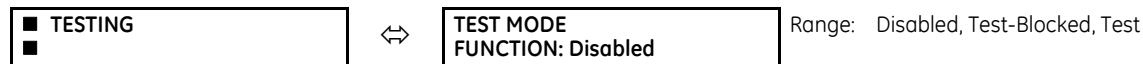
842717A1.CDR

In three-terminal applications, both the remote terminals must grant permission to trip. Therefore, at each terminal, direct inputs 5 and 6 are ANDed in FlexLogic and the resulting operand configured as the permission to trip (**HYB POTT RX1** setting).

5.9 Testing

5.9.1 Test mode function

SETTINGS ⇌ TESTING ⇌ TEST MODE FUNCTION



The B90 provides a test facility to verify the functionality of contact inputs and outputs, some communication functions and the phasor measurement unit (where applicable), using simulated conditions. It is accessible in the software.

The test mode can be in any of three states: Disabled, Test-Blocked, or Test.

The Disabled mode is intended for normal in service operation; relay protection, control and communication function is normal. Test features are disabled, except channel tests and phasor measurement unit tests remain usable when provided.

The Test-Blocked mode is intended to allow the relay to be quickly placed in a state where the relay cannot negatively impact the power system or other parts of the substation automation system. This is to allow changing settings, loading new firmware, changing hardware modules, and changing communication connections. As far as practical all relay output signals are blocked. Contact outputs are de-energized, latching outputs are frozen. Commands to HardFiber Bricks are blocked. GOOSE transmissions have their "simulation" flag (also known as "test" flag) set, which results in the messages not being accepted by compliant receiving devices that do not have a "Sim" data attribute set. The quality attribute of values that can be output via IEC 61850 MMS services are set to "invalid," which results in the values not being used for operational purposes by compliant receiving devices. Direct I/O channel tests and PMU tests are usable on applicable models.

The Test mode is intended for testing involving forcing relay operation by test signal injection and verifying correct relay output. This mode is also for tests to verify the relay outputs (both contact and communications) have the intended impact on specific power system devices or on specific other substation automation devices. Contact outputs can be selectively enabled or forced as described in the following two sections. Shared outputs to Bricks have their test mode flag raised, which results in their value only being accepted by relays also in forcible/test mode. GOOSE transmissions have the "simulation" flag set, which results in these only being accepted by other devices that have their "Sim" data attribute set.

The "Sim" data attribute in the relay is set, so that if GOOSE messages are received with the "simulation" flag set, these are used in place of the normal messages. The quality attribute of values that are output via IEC 61850 MMS services are set to "valid" + "test," which signals that the values are not to be used for operational purposes.

Otherwise, the UR remains fully operational while in Test mode, allowing for various testing procedures. In particular, the protection and control elements, and FlexLogic function normally. Other than the IEC 61850 protocol, communications based inputs and outputs remain fully operational. The test procedure must take this into account. Direct I/O channel tests and PMU tests are usable on applicable models.

The test mode can be selected either through the front panel, through EnerVista UR Setup, or through IEC 61850 control to LLN0.Mod. LLN0.Mod.ctlVal "on" selects Disabled, "test/blocked" selects Test-Blocked, and "test" selects Test. The **TEST MODE FUNCTION** setting can only be changed by a direct user command. Following a restart, power up, settings upload, or firmware upgrade, the test mode remains at the last programmed value. This allows a UR that has been placed in test-blocked mode to remain isolated during testing and maintenance activities.

5.9.2 Test mode forcing

SETTINGS ⇒ ⚙ TESTING ⇒ TEST MODE FORCING

■ TESTING

⇔

TEST MODE FORCING:
On

Range: FlexLogic operand

When in Test mode, the operand selected by the **TEST MODE FORCING** setting dictates further response of the UR to testing conditions, as described in the following two sections.

The test mode state is indicated on the relay faceplate by a combination of the Test Mode LED indicator, the In-Service LED indicator, and by the critical fail relay, as shown in the following table.

Table 5-29: Test mode operation

TEST MODE FUNCTION	In-service LED	Test mode LED	Critical fail relay	TEST MODE FORCING	Contact input and output behavior
Disabled	Unaffected	Off	Normal	No effect	Normal
Test-Blocked	Off	On	De-energized	No effect	Contact outputs disabled
Test	Off	Flashing	De-energized	Off	Normal
				On	Controlled by forcing features



On restart, the **TEST MODE FORCING** setting and the force contact input and force contact output settings revert to their default states.

5.9.3 Force contact inputs

SETTINGS ⇒ ⚙ TESTING ⇒ ⚙ FORCE CONTACT INPUTS

■ FORCE CONTACT
■ INPUTS

⇔

FORCE Cont Ip 1
:Normal

Range: Normal, Open, Closed

⇕

FORCE Cont Ip 2
:Normal

Range: Normal, Open, Closed

⇕

FORCE Cont Ip xx
:Normal

Range: Normal, Open, Closed

The force contact inputs feature provides a method of performing checks on the function of all contact inputs. While in Test mode, the relay contact inputs can be pre-programmed to respond in the following ways:

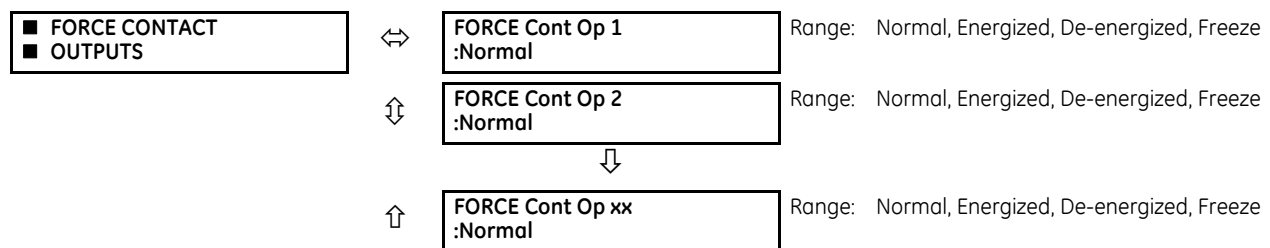
- If set to “Normal,” the input remains fully operational. It is controlled by the voltage across its input terminals and can be turned on and off by external circuitry. Select this value if a given input must be operational during the test. This includes, for example, an input initiating the test, or being a part of a user pre-programmed test sequence.
- If set to “Open,” the input is forced to report as opened (Logic 0) while the operand selected by **TEST MODE FORCING** setting is On, regardless of the voltage across the input terminals. While the selected operand is Off, the input behaves as it does when in service.
- If set to “Closed,” the input is forced to report as closed (Logic 1) while the operand selected by **TEST MODE FORCING** setting is On regardless of the voltage across the input terminals. While the selected operand is Off, the input behaves as it does when in service.



On restart, the **TEST MODE FORCING** setting and the force contact input and force contact output settings revert to their default states.

5.9.4 Force contact outputs

SETTINGS ⇌ TESTING ⇌ FORCE CONTACT OUTPUTS



The force contact outputs feature provides a method of performing checks on the function of all contact outputs.

While in Test mode, the relay contact outputs can be pre-programmed to respond in the following ways:

- If set to “Normal,” the contact output remains fully operational. It operates when its control operand is logic 1 and resets when its control operand is logic 0.
- If set to “Energized,” the output closes and remains closed while the operand selected by the **TEST MODE FORCING** setting is On, regardless of the status of the operand configured to control the output contact. While the selected operand is Off, the output behaves as it does when in service.
- If set to “De-energized,” the output opens and remains opened while the operand selected by the **TEST MODE FORCING** setting is On, regardless of the status of the operand configured to control the output contact. While the selected operand is Off, the output behaves as it does when in service.
- If set to “Freeze,” the output retains its position at the instant before the **TEST MODE FUNCTION** was Test and the operand selected by the **TEST MODE FORCING** setting was On, regardless of later changes in the status of the operand configured to control the output contact. While the selected operand is Off, the output behaves as it does when in service.



On restart, the **TEST MODE FORCING** setting and the force contact input and force contact output settings revert to their default states.

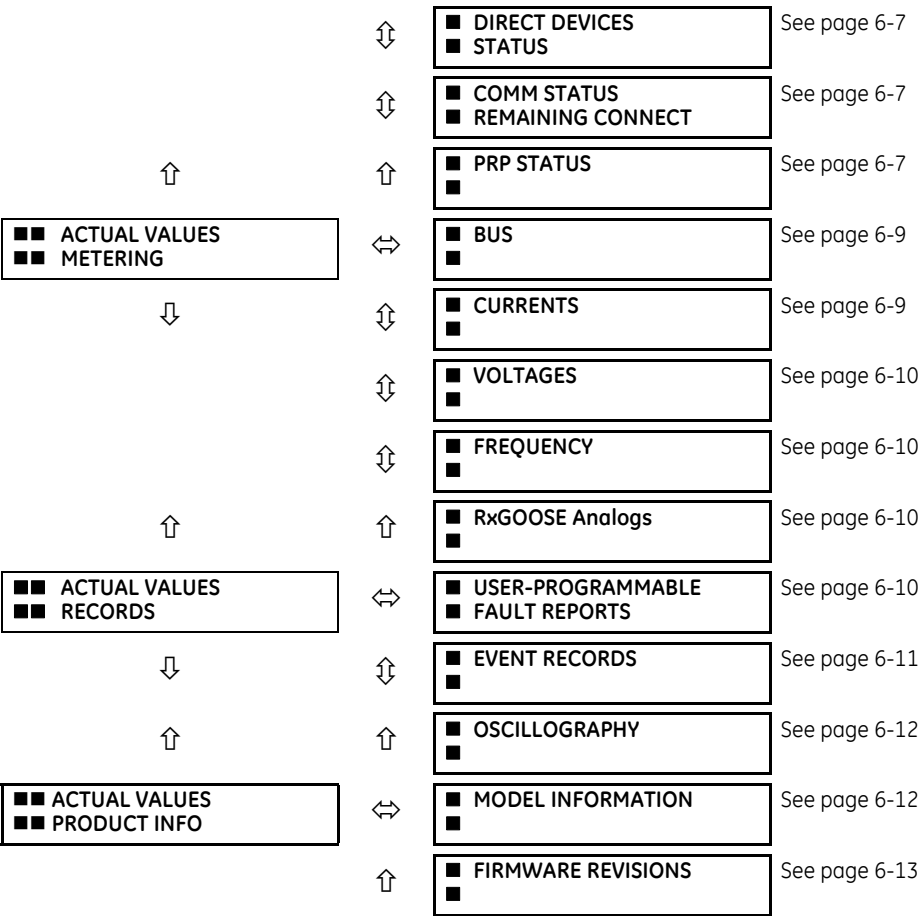
B90 Low Impedance Bus Differential System

Chapter 6: Actual values

This chapter outlines viewing of data on the front panel and in the software.

6.1 Actual Values menu

■ ACTUAL VALUES ■ STATUS	↔	■ CONTACT INPUTS ■	See page 6-2
↓	↕	■ VIRTUAL INPUTS ■	See page 6-3
	↕	■ RxGOOSE BOOLEAN ■ INPUTS	See page 6-3
	↕	■ RxGOOSE DPS INPUTS ■	See page 6-3
	↕	■ CONTACT OUTPUTS ■	See page 6-3
	↕	■ VIRTUAL OUTPUTS ■	See page 6-4
	↕	■ RxGOOSE STATUS ■	See page 6-4
	↕	■ RxGOOSE ■ STATISTICS	See page 6-4
	↕	■ FLEX STATES ■	See page 6-5
	↕	■ ETHERNET ■	See page 6-5
	↕	■ REAL TIME CLOCK ■ SYNCHRONIZING	See page 6-5
	↕	■ DIRECT INPUTS ■	See page 6-6

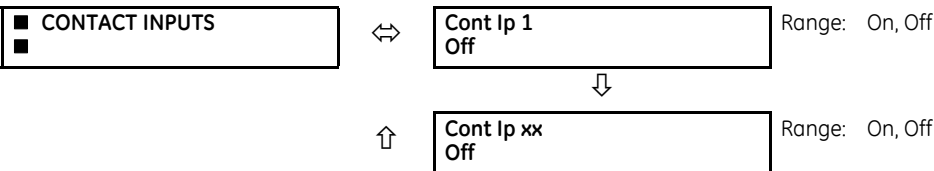


For status reporting, 'On' represents Logic 1 and 'Off' represents Logic 0.

6.2 Status

6.2.1 Contact inputs

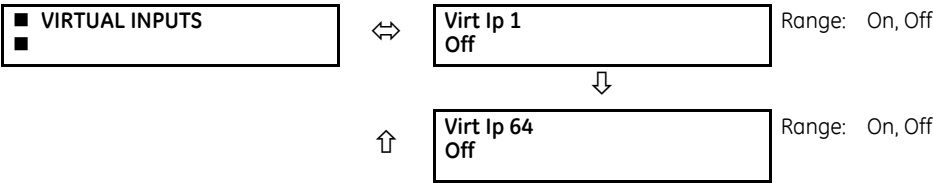
ACTUAL VALUES ⇒ STATUS ⇒ CONTACT INPUTS



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

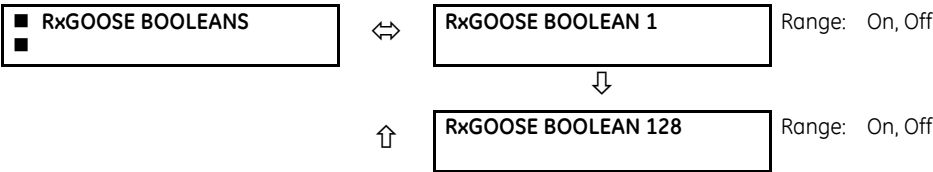
ACTUAL VALUES ⇒ STATUS ⇒ ↓ VIRTUAL INPUTS



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

6.2.3 RxGOOSE boolean inputs

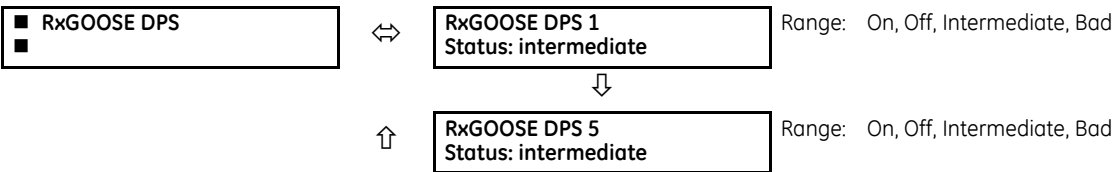
ACTUAL VALUES ⇒ STATUS ⇒ ↓ RxGOOSE BOOLEANS



The B90 is provided with optional IEC 61850 capability. This feature is specified as a software option at the time of ordering. See the Order Codes section of chapter 2 for details.

6.2.4 RxGOOSE DPS inputs

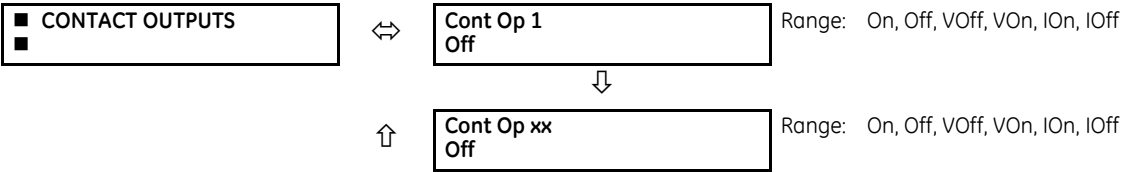
ACTUAL VALUES ⇒ STATUS ⇒ ↓ RxGOOSE DPS



The B90 is provided with optional IEC 61850 capability. This feature is specified as a software option at the time of ordering. See the Order Codes section of chapter 2 for details.

6.2.5 Contact outputs

ACTUAL VALUES ⇒ STATUS ⇒ ↓ CONTACT OUTPUTS

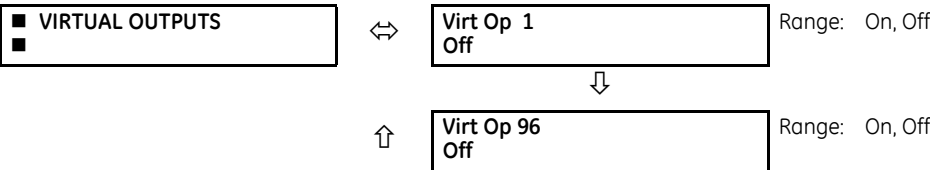


The present state of the contact outputs is shown here. The first line of a message display indicates the ID of the contact output. For example, 'Cont Op 1' refers to the contact output in terms of the default name-array index. The second line of the display indicates the logic state of the contact output.

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

6.2.6 Virtual outputs

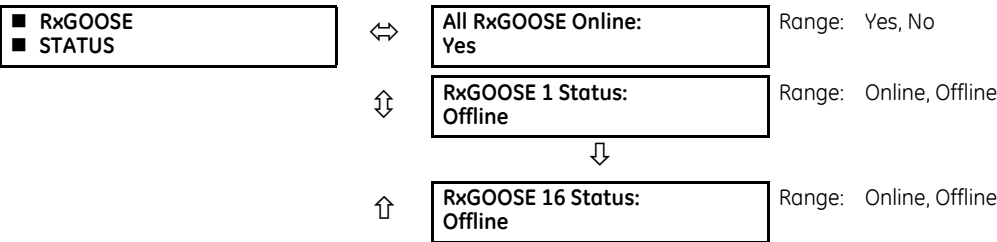
ACTUAL VALUES ⇒ STATUS ⇒↕ VIRTUAL OUTPUTS



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

6.2.7 RxGOOSE status

ACTUAL VALUES ⇒ STATUS ⇒↕ RxGOOSE STATUS



6

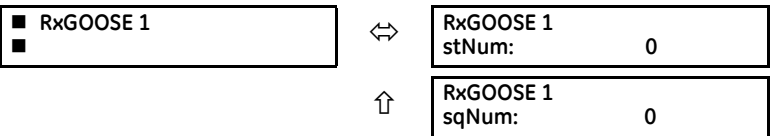


The B90 is provided with optional IEC 61850 capability. This feature is specified as a software option at the time of ordering. See the Order Codes section of chapter 2 for details.

The **All RxGOOSE Online** actual value does not consider RxGOOSE that are not configured or are not used by any RxGOOSE Input.

6.2.8 RxGOOSE statistics

ACTUAL VALUES ⇒ STATUS ⇒↕ RxGOOSE STATISTICS ⇒↕ RxGOOSE 1(16)



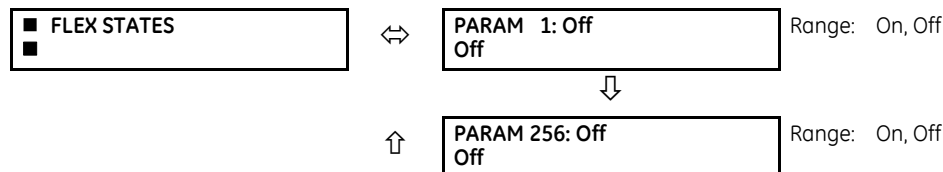
The B90 is provided with optional IEC 61850 capability. This feature is specified as a software option at the time of ordering. See the Order Codes section of chapter 2 for details.

stNum — State number. The most recently received value in GOOSE message field stNum. The publisher increments stNum each time that the state of one or more of the GOOSE message members is sent with a revised value.

sqNum — Sequence number. The most recently received value in GOOSE message field sqNum. The publisher sets sqNum to zero each time the state of one or more of the GOOSE message members is sent with a new value, and it increments it whenever a GOOSE message is resent without any member value change.

6.2.9 Flex States

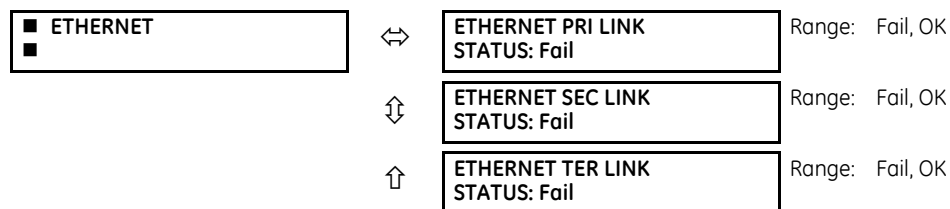
ACTUAL VALUES ⇒ STATUS ⇒ FLEX STATES



There are 256 FlexState™ bits available. The second line value indicates the state of the given FlexState bit.

6.2.10 Ethernet

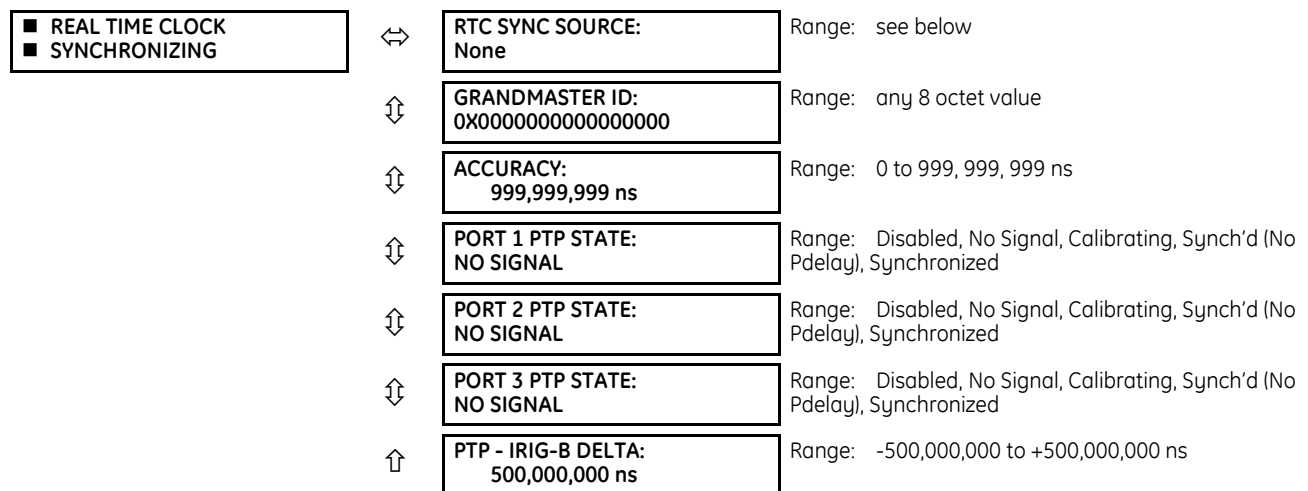
ACTUAL VALUES ⇒ STATUS ⇒ ETHERNET



These values indicate the status of the first, second, and third Ethernet links.

6.2.11 Real time clock synchronizing

ACTUAL VALUES ⇒ STATUS ⇒ REAL TIME CLOCK SYNCHRONIZING





This item displays when the product includes an IEEE 1588 software option.

RTC SYNC SOURCE actual value is the time synchronizing source the relay is using at present. Possible sources are: Port 1 PTP Clock, Port 2 PTP Clock, Port 3 PTP Clock, IRIG-B, SNTP, and None. An actual value displays when the relay includes the IEEE 1588 software option.

The **GRANDMASTER ID** is the grandmasterIdentity code being received from the present PTP grandmaster, if any. When the relay is not using any PTP grandmaster, this actual value is zero. The grandmasterIdentity code is specified by PTP to be globally unique, so one can always know which clock is grandmaster in a system with multiple grandmaster-capable clocks.

ACCURACY is the estimated maximum time error at present in the RTC, considering the quality information imbedded in the received time signal. The value 999,999,999 indicates that the magnitude of the estimated error is one second or more, or that the error cannot be estimated.

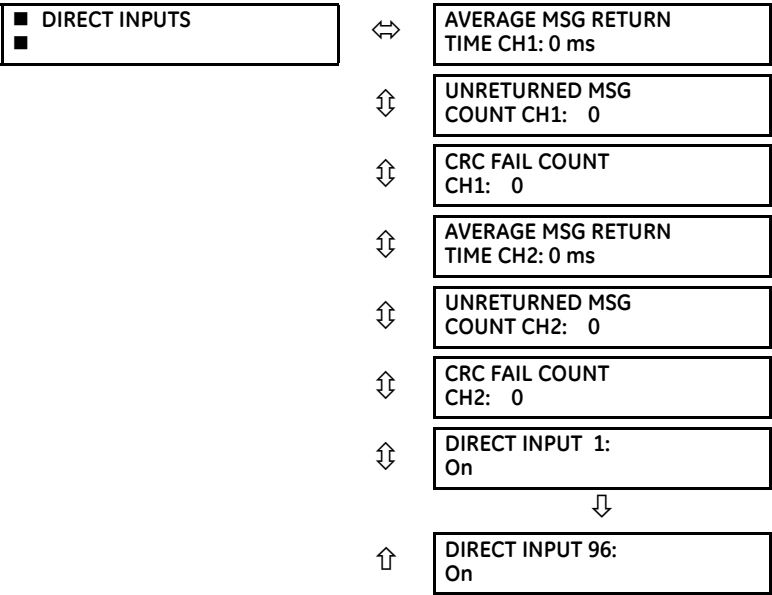
PORT 1...3 PTP STATE is the present state of the port's PTP clock. The PTP clock state is:

- **DISABLED** is the port's function setting is Disabled
- **NO SIGNAL** if enabled but no signal from an active master has been found and selected
- **CALIBRATING** if an active master has been selected but lock is not at present established
- **SYNCH'D (NO PDELAY)** if the port is synchronized, but the peer delay mechanism is non-operational
- **SYNCHRONIZED** if synchronized

PTP - IRIG-B DELTA is the time difference, measured in nanoseconds, between the fractional seconds portion of the time being received via PTP and that being received via IRIG-B. A positive value indicates that PTP time is fast compared to IRIG-B time.

6.2.12 Direct inputs

ACTUAL VALUES ⇌ STATUS ⇌ DIRECT INPUTS



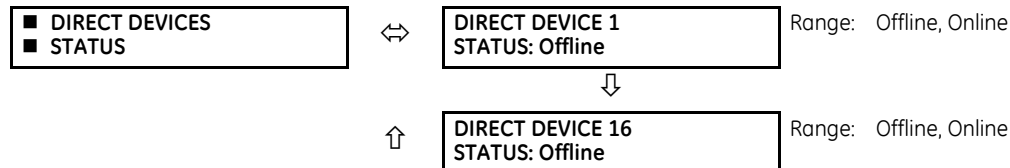
The **AVERAGE MSG RETURN TIME** is the time taken for direct output messages to return to the sender in a direct input/output ring configuration (this value is not applicable for non-ring configurations). This is a rolling average calculated for the last ten messages. There are two return times for dual-channel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

The **UNRETURNED MSG COUNT** values (one per communications channel) count the direct output messages that do not make the trip around the communications ring. The **CRC FAIL COUNT** values (one per communications channel) count the direct output messages that have been received but fail the CRC check. High values for either of these counts can indicate on a problem with wiring, the communication channel, or one or more relays. The **UNRETURNED MSG COUNT** and **CRC FAIL COUNT** values can be cleared using the **CLEAR DIRECT I/O COUNTERS** command.

The **DIRECT INPUT 1** to **DIRECT INPUT (96)** values represent the state of each direct input.

6.2.13 Direct devices status

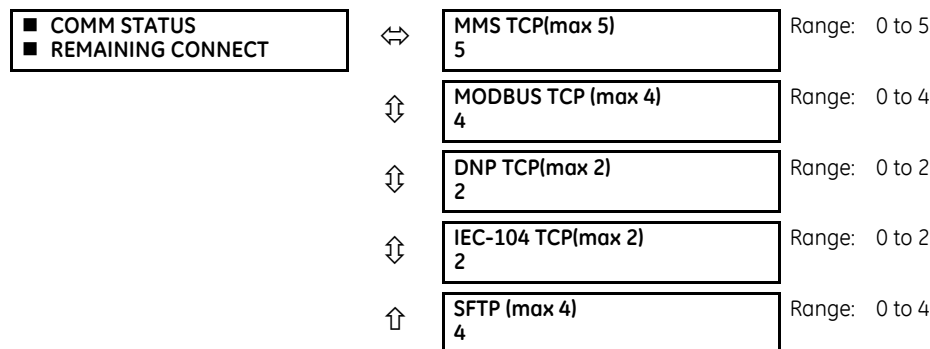
ACTUAL VALUES ⇒ STATUS ⇒ ⇅ DIRECT DEVICES STATUS



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

6.2.14 Remaining connection status

ACTUAL VALUES ⇒ STATUS ⇒ ⇅ COMM STATUS REMAINING CONNECT



These values specify the remaining number of TCP connections still available for each protocol. The display depends on the options applicable to your device. Each time a connection is used, the remaining number of connections decrements. When released, the remaining number of connections increments. If no connection is made over the specific protocol, the number equals the maximum number available for the specific protocol.

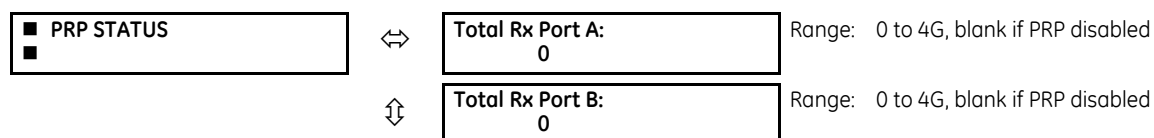
For example, the maximum number of Modbus TCP connections is 4. Once an EnerVista session is opened on a computer connected to the UR over Ethernet, the Modbus TCP status shows 3. If the EnerVista application is closed, the Modbus TCP status shows 4.

MMS TCP — The number of IEC 61850 connections remaining.

6.2.15 Parallel Redundancy Protocol (PRP)

The Parallel Redundancy Protocol (PRP) defines a redundancy protocol for high availability in substation automation networks.

ACTUAL VALUES ⇒ STATUS ⇒ ⇅ PRP



↕	Mismatches Port A: 0	Range: 0 to 4G, blank if PRP disabled
↕	Mismatches Port B: 0	Range: 0 to 4G, blank if PRP disabled
↑	Total Errors: 0	Range: 0 to 4G, blank if PRP disabled



The B90 is provided with optional PRP capability. This feature is specified as a software option at the time of ordering. See the Order Codes section in chapter 2 for details.

Total Received Port A is a counter for total messages received (either from DANPs or from SANs) on Port A.

Total Received Port B is a counter for total messages received (either from DANPs or from SANs) on Port B.

Total Errors is a counter for total messages received with an error (bad port code, frame length too short).

Mismatches Port A is a counter for total messages received with an error on Port A (PRP frame, but port received through and LAN ID in the frame do not match).

Mismatches Port B is a counter for total messages received with an error on Port B (PRP frame, but port received through and LAN ID in the frame do not match).

6.3 Metering

6.3.1 Metering conventions

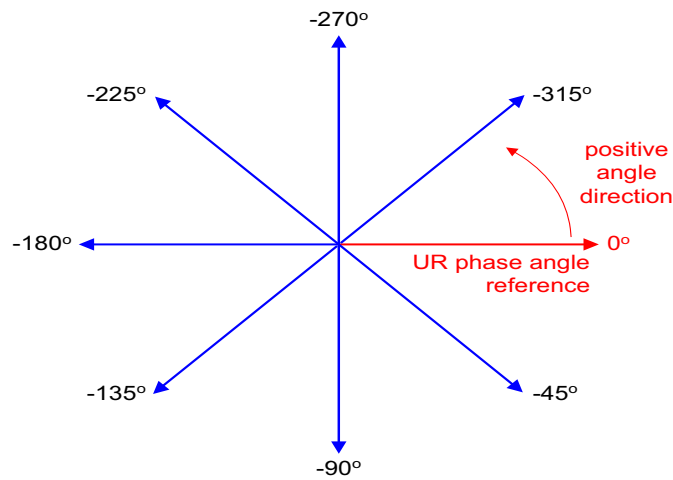
6.3.1.1 UR convention for measuring phase angles

All phasors calculated by URs and used for protection, control and metering functions are rotating phasors that maintain the correct phase angle relationships with each other at all times.

For display and oscillography purposes, all phasor angles in a given relay are referred to an AC input channel pre-selected by the **SETTINGS** ⇒ **SYSTEM SETUP** ⇒ **POWER SYSTEM** ⇒ **FREQUENCY AND PHASE REFERENCE** setting. This setting defines a particular AC signal source to be used as the reference.

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. The figure illustrates this.

Figure 6-1: UR phase angle measurement convention



827845A1.CDR

6.3.2 Bus zone

ACTUAL VALUES ⇄ METERING ⇄ BUS ⇄ BUS ZONE 1(6)

■ BUS ZONE 1 ■	⇄	BUS ZONE 1 DIFF: 0.000 A 0.0°
	↑	BUS ZONE 1 REST: 0.000 A 0.0°

These values display the differential and restraint currents phasors for each bus zone. The magnitudes are displayed in primary amperes.



There is no cutoff level applied to the differential and restraint currents computed by the B90. Therefore, a small differential current reflecting CT inaccuracies and bus leakage current can be present during balanced conditions. This is done to achieve a more accurate differential balance and to provide a direct indication of the real differential current, as excluding small currents or not accounting for CT errors can impose significant unaccounted differential current. It is advisable to set the minimum pickup for 87B protection greater than the maximum differential current during normal load conditions.

6

6.3.3 Currents

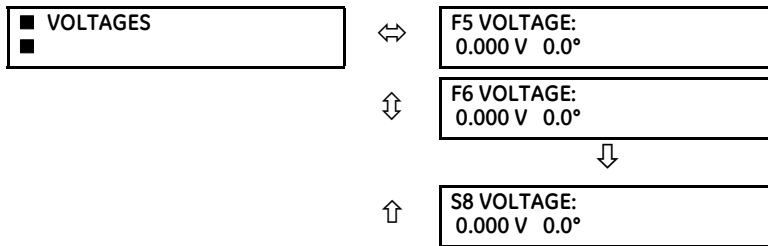
ACTUAL VALUES ⇄ METERING ⇄ CURRENTS

■ CURRENTS ■	⇄	F1 CURRENT: 0.000 A 0.0°
	⇄	F2 CURRENT: 0.000 A 0.0°
	↓	
	↑	S8 CURRENT: 0.000 A 0.0°

The metered current values for each terminal are displayed in this menu.

6.3.4 Voltages

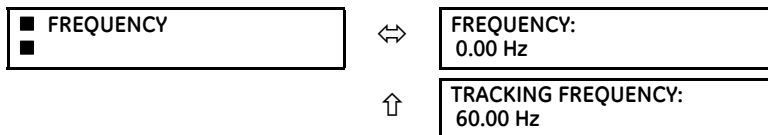
ACTUAL VALUES ⇨ METERING ⇨ VOLTAGES



This menu displays the metered voltage values for each terminal.

6.3.5 Frequency

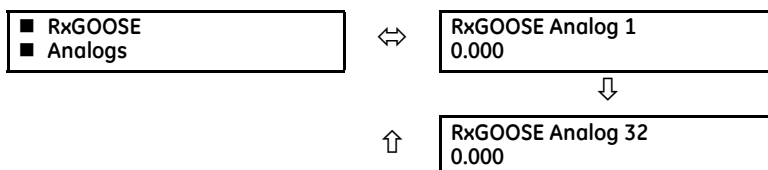
ACTUAL VALUES ⇨ METERING ⇨ FREQUENCY



This menu displays the metered frequency value and the tracking frequency. The frequency is tracked based on the selection of the reference source with the **FREQUENCY AND PHASE REFERENCE** setting in the **SETTINGS ⇨ SYSTEM SETUP ⇨ POWER SYSTEM** menu. See the Power System section of chapter 5 for details.

6.3.6 RxGOOSE analogs

ACTUAL VALUES ⇨ METERING ⇨ RxGOOSE Analogs



The B90 is provided with optional GOOSE communications capability. This feature is specified as a software option at the time of ordering. See the Order Codes section of chapter 2 for details.

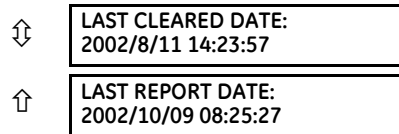
The RxGOOSE Analog values display in this menu. The RxGOOSE Analog values are received via IEC 61850 GOOSE messages sent from other devices.

6.4 Records

6.4.1 User-programmable fault reports

ACTUAL VALUES ⇨ RECORDS ⇨ USER PROGRAMMABLE FAULT REPORTS

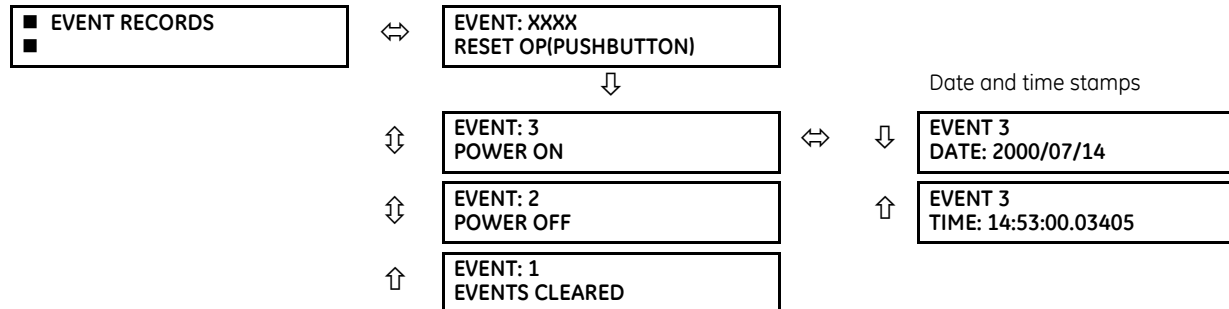




This menu displays the user-programmable fault report actual values. See the User-Programmable Fault Report section in chapter 5 for information on this feature.

6.4.2 Event records

ACTUAL VALUES ⇌ RECORDS ⇌ EVENT RECORDS

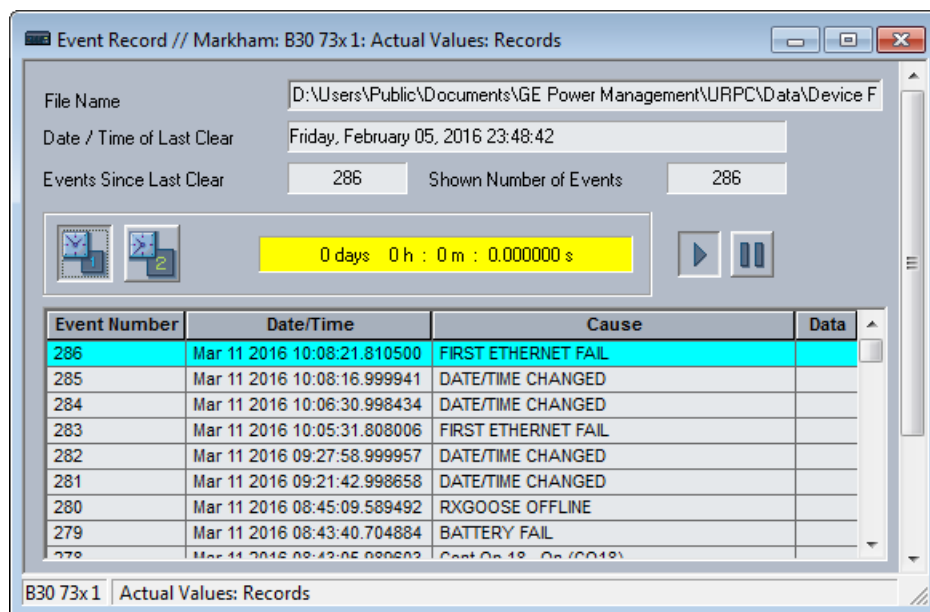


The event records menu shows the contextual data associated with up to the last 1024 events, listed in chronological order from most recent to oldest. When all 1024 event records have been filled, the oldest record is removed as a new record is added. Each event record shows the event identifier/sequence number, cause, and date/time stamp associated with the event trigger. See the **COMMANDS ⇌ CLEAR RECORDS** menu for clearing event records.

Only major output operands generate events, not every operand. Elements that assert output per phase, for example, log operating phase output only without asserting the common three-phase operand event.

The event records are also viewable in the software and in a web browser. The figure shows the event records in the software. To view them in a web browser, enter the IP address of the device.

Figure 6-2: Event records viewed in EnerVista software



6.4.3 Oscillography

ACTUAL VALUES ⇨ ⬇ RECORDS ⇨ ⬇ OSCILLOGRAPHY

■ OSCILLOGRAPHY	↔	FORCE TRIGGER? No	Range: No, Yes
	↕	NUMBER OF TRIGGERS: 0	
	↕	AVAILABLE RECORDS: 0	
	↕	CYCLES PER RECORD: 0	
	⬆	LAST CLEARED DATE: 2000/07/14 15:40:16	

This menu allows the user to view the number of triggers involved and number of oscillography traces available. The cycles per record value is calculated to account for the fixed amount of data storage for oscillography. See the Oscillography section of chapter 5 for details.

A trigger can be forced here at any time by setting “Yes” to the FORCE TRIGGER? command. See the **COMMANDS ⇨ ⬇ CLEAR RECORDS** menu for information on clearing the oscillography records.

6.5 Product information

6.5.1 Model information

ACTUAL VALUES ⇨ ⬇ PRODUCT INFO ⇨ MODEL INFORMATION

■ MODEL INFORMATION	↔	ORDER CODE LINE 1: B90-A00-AAA-A0A-A0A	Range: standard GE order code format (lines 1 to 4)
	↕	ORDER CODE LINE 2: A0A-A0A-A0A	Range: up to 20 alphanumeric characters
	↕	ORDER CODE LINE 3:	Range: up to 20 alphanumeric characters
	↕	ORDER CODE LINE 4:	Range: up to 20 alphanumeric characters
	↕	SERIAL NUMBER:	Range: standard GE serial number format
	↕	ETHERNET MAC ADDRESS 000000000000	Range: standard Ethernet MAC address format
	↕	MANUFACTURING DATE:	Range: YYYY/MM/DD HH:MM:SS
	↕	OPERATING TIME: 0:00:00	Range: operating time in HH:MM:SS
	↕	CT/ VT ADVANCED DIAG ACTIVE: No	Range: Yes, No
	⬆	LAST SETTING CHANGE: 1970/01/01 23:11:19	Range: YYYY/MM/DD HH:MM:SS

The order code, serial number, Ethernet MAC address, date and time of manufacture, and operating time are shown here. The rear panel on the device contains similar information.

ETHERNET MAC ADDRESS — UR devices with firmware 7.0x and above have three Ethernet ports that can be used on three networks. The MAC address displays for port 1. The MAC address for port 2 is one higher. The MAC address for port 3 is one higher than port 2. In redundant mode, the MAC addresses for ports 2 and 3 are the same as port 2.

6.5.2 Firmware revisions

ACTUAL VALUES ⇌ PRODUCT INFO ⇌ FIRMWARE REVISIONS

■ FIRMWARE REVISIONS ■	↔	B90 Relay REVISION: 7.3x	Range: 0.00 to 655.35 Revision number of the application firmware.
	↕	MODIFICATION FILE NUMBER: 0	Range: 0 to 65535 (ID of the MOD FILE) Value is 0 for each standard firmware release.
	↕	BOOT PROGRAM REVISION: 7.01	Range: 0.00 to 655.35 Revision number of the boot program firmware.
	↕	FRONT PANEL PROGRAM REVISION: 2.01	Range: 0.00 to 655.35 Revision number of faceplate program firmware.
	↕	COMPILE DATE: 2013/09/15 04:55:16	Range: YYYY/MM/DD HH:MM:SS Date and time when product firmware was built.
	↕	BOOT DATE: 2013/09/15 16:41:32	Range: YYYY/MM/DD HH:MM:SS Date and time when the boot program was built.
	↕	FPGA PROGRAM: REVISION: 01.05	Range: 0.00 to 655.35 Revision number for FPGA.
	↑	FPGA DATA: 2013/09/15 16:41:32	Range: YYYY/MM/DD HH:MM:SS Date and time when the FPGA was built.

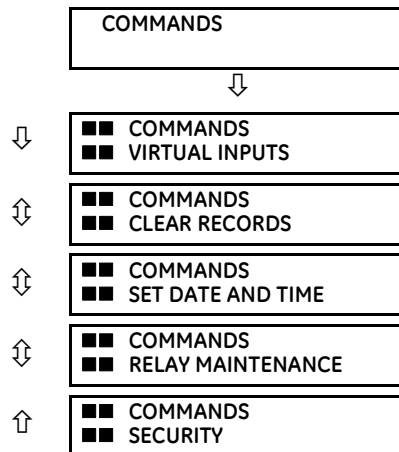
The shown data is illustrative only. A modification file number of 0 indicates that, currently, no modifications have been installed.

B90 Low Impedance Bus Differential System

Chapter 7: Commands and targets

This chapter outlines the Commands and Targets menus and self-tests/error messages. Commands related to the IEC 61850 protocol are outlined in the IEC 61850 section of the Settings chapter. Log/error messages for IEC 61850 are outlined in the UR Series Communications Guide.

7.1 Commands menu



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

COMMAND
EXECUTED

7.1.1 Virtual inputs

COMMANDS ⇨ VIRTUAL INPUTS

■ ■ COMMANDS
■ ■ VIRTUAL INPUTS

⇔

Virt Ip 1
Off

Range: Off, On

⇕

Virt Ip 2
Off

Range: Off, On

↓

⇕

Virt Ip 64
Off

Range: Off, On

The states of up to 64 virtual inputs are changed here. The first line of the display indicates the ID of the virtual input. The second line indicates the current or selected status of the virtual input. This status is a state off (logic 0) or on (logic 1).

7.1.2 Clear records

COMMANDS ⇨ CLEAR RECORDS

■ ■ COMMANDS
■ ■ CLEAR RECORDS

⇔

CLEAR USER FAULT
REPORTS? No

Range: No, Yes

⇕

CLEAR EVENT RECORDS?
No

Range: No, Yes

⇕

CLEAR OSCILLOGRAPHY?
No

Range: No, Yes

⇕

CLEAR UNAUTHORIZED
ACCESS? No

Range: No, Yes

⇕

CLEAR DIRECT I/O
COUNTERS? No

Range: No, Yes.
Valid only for units with Direct Input/Output module.

⇕

CLEAR ALL RELAY
RECORDS? No

Range: No, Yes

This menu contains commands for clearing historical data such as the event records. Data is cleared by changing a command setting to “Yes” and pressing the **ENTER** key. After clearing data, the command setting automatically reverts to “No.”

7.1.3 Set date and time

COMMANDS ⇨ SET DATE AND TIME

■ ■ COMMANDS
■ ■ SET DATE AND TIME

⇔

SET DATE AND TIME:
2000/01/14 13:47:03

Range: YYYY/MM/DD HH:MM:SS

The date and time can be entered on the faceplate keypad. 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 and date take effect when the **ENTER** key is pressed.

When the relay is synchronizing to an external time source such as PTP, IRIG-B, or SNTP, the manually entered time is overwritten.

The timescale of the entered time is local time, including daylight savings time where and when applicable.

7.1.4 Relay maintenance

COMMANDS ⇌ RELAY MAINTENANCE

■■ COMMANDS ■■ RELAY MAINTENANCE	⇌	PERFORM LAMP TEST? No	Range: No, Yes
	⇌	UPDATE ORDER CODE? No	Range: No, Yes
	⇌	REBOOT RELAY? No	Range: No, Yes
	⇌	SERVICE COMMAND: 0	Range: 0, 101, 20511
	⇌	SAVE VOLATILE DATA?: No	Range: No, Yes

This menu contains commands for relay maintenance purposes. Commands for the lamp test and order code are activated by changing a command setting to “Yes” and pressing the **ENTER** key. The command setting then automatically reverts to “No.” The service command is activated by entering a numerical code and pressing the **ENTER** key.

PERFORM LAMP TEST — Turns on all faceplate LEDs and display pixels for a short duration.

UPDATE ORDER CODE — This 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 displays.

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 displays.

REBOOT RELAY — Restarts the relay so that changes to configuration settings can take effect. In most cases, if changes are made to the configuration settings these changes do not take effect unless the relay is rebooted.



With the CyberSentry option, the Administrator or Operator role can initiate the Reboot Relay command.

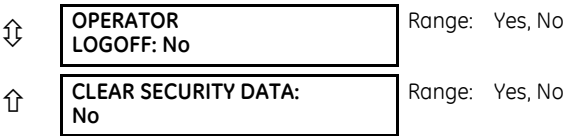
SERVICE COMMAND — Performs specific B90 service actions. Presently, there are two service actions available. Code “20511” returns all settings to their factory default value and restarts the relay (you then re-enter IP addresses, restart, set unit to “Programmed”). Code “101” is used to clear factory diagnostic information stored in the non-volatile memory. If a code other than these two is entered, the command is ignored and no action is taken. Various self-checking diagnostics are performed in the background while the B90 is running, and diagnostic information is stored on the non-volatile memory from time to time based on the self-checking result. Although the diagnostic information is cleared before the B90 is shipped from the factory, the user can want to clear the diagnostic information for themselves under certain circumstances. For example, you clear diagnostic information after replacement of hardware. Once the diagnostic information is cleared, all self-checking variables are reset to their initial state and diagnostics restart from scratch.

SAVE VOLATILE DATA — Saves this data to compact flash memory prior to shutdown. This allows the saved data to be as recent as possible instead of relying on the periodic timer to save the data.

7.1.5 Security

COMMANDS ⇌ SECURITY

■■ SECURITY ■■	⇌	ADMINISTRATOR LOGOFF: No	Range: Yes, No
	⇌	ENGINEER LOGOFF: No	Range: Yes, No



With the CyberSentry option, this setting is available to enable or disable the following commands.

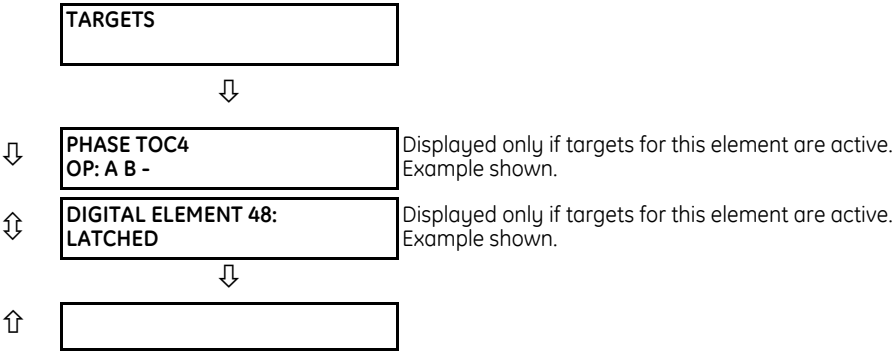
ADMINISTRATOR LOGOFF — Selecting ‘Yes’ allows the Supervisor to forcefully logoff an administrator session.

ENGINEER LOGOFF — Selecting ‘Yes’ allows the Supervisor to forcefully logoff an engineer session.

OPERATOR LOGOFF — Selecting ‘Yes’ allows the Supervisor to forcefully logoff an operator session.

CLEAR SECURITY DATA — Selecting ‘Yes’ allows the Supervisor to forcefully clear all the security logs and clears all the operands associated with the self-tests.

7.2 Targets menu



A target enables the EnerVista UR Setup software to monitor automatically and display the status of any active target messages of all the devices inserted into that site.

Each B90 element with a **TARGET** setting has a target message that when activated by its element is displayed in sequence with any other currently active target messages in the **TARGETS** menu. In the example shown, the Phase TOC4 and Digital Element 48 target settings are active and so have their targets displayed. The down arrow below the two elements indicates that there can be other active elements beyond these two.

For more information, see the description of target messages in the next section, and the Introduction to Elements section in the Settings chapter for instructions on **TARGET** setting.

When no targets are active, the display reads **NO ACTIVE TARGETS**.

7.2.1 Target messages

When there are no active targets, the first target to become active causes 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 again defaults back to the target message.

The range of variables for the target messages is described below. Phase information is included if applicable. If a target message status changes, the status with the highest priority displays.

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.

7.2.2 Relay self-tests

7.2.2.1 Description

The relay performs a number of self-test diagnostic checks to ensure device integrity. The two types of self-tests (major and minor) are listed in the following tables. When either type of error occurs, the Trouble LED Indicator turns on and a target message displays. 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 de-energizes
- All other output relays de-energize and are prevented from further operation
- The faceplate In Service LED indicator turns off
- A RELAY OUT OF SERVICE event is recorded

7.2.2.2 Major self-test error messages

The major self-test errors are outlined in this section.

INCOMPATIBLE H/W: Contact Factory (xxx)

- *Latched target message:* Yes.
- *Description of problem:* One or more installed hardware modules is not compatible with the B90 order code.
- *How often the test is performed:* Module dependent.
- *What to do:* Contact the factory and supply the failure code noted in the display. The “xxx” text identifies the failed module (for example, F8L).

EQUIPMENT MISMATCH: with 2nd line detail

- *Latched target message:* No.
- *Description of problem:* The configuration of modules does not match the order code stored in the B90. For example, “Card F8L Missing” means that hardware module 8L is missing from slot F inside the UR device.
- *How often the test is performed:* On power up. Afterwards, the backplane is checked for missing cards every five seconds.
- *What to do:* Check all modules against the order code, ensure they are inserted properly, and cycle control power. If the problem persists, contact the factory.

FLEXLOGIC ERROR: with 2nd line detail

- *Latched target message:* No.
- *Description of problem:* A FlexLogic equation is incorrect.
- *How often the test is performed:* The test is event driven, performed whenever FlexLogic equations are modified.
- *What to do:* Finish all equation editing and use self tests to debug any errors.

UNIT NOT PROGRAMMED: Check Settings

- *Latched target message:* No.

- *Description of problem:* The **PRODUCT SETUP** ⇒ **INSTALLATION** ⇒ **RELAY SETTINGS** setting indicates the B90 is not programmed.
- *How often the test is performed:* On power up and whenever the **PRODUCT SETUP** ⇒ **INSTALLATION** ⇒ **RELAY SETTINGS** setting is altered.
- *What to do:* Program all settings and then set **PRODUCT SETUP** ⇒ **INSTALLATION** ⇒ **RELAY SETTINGS** to “Programmed.”

MODULE FAILURE ___:
Contact Factory (xxx)

- *Latched target message:* Yes.
- *Description of problem:* Module hardware failure detected. Module Failures 1 to 11 are major. The system can reboot for four of these, as follows.
MODULE FAILURE 06 — Event message reads SYSTEM INTEGRITY RECOVERY 06 when a reboot was required and otherwise MODULE FAILURE 06 when a failure was detected
MODULE FAILURE 07 — Event message reads SYSTEM INTEGRITY RECOVERY 07 when a reboot was required and otherwise MODULE FAILURE 07 when a failure was detected
MODULE FAILURE 08 — Event message reads SYSTEM INTEGRITY RECOVERY 08 when a reboot was required and otherwise MODULE FAILURE 08 when a failure was detected
MODULE FAILURE 11 — Event message reads SYSTEM INTEGRITY RECOVERY 11 when a reboot was required and otherwise MODULE FAILURE 11 when a failure was detected
- *How often the test is performed:* Module dependent.
- *What to do:* Contact the factory and supply the failure code noted in the display. The “xxx” text identifies the failed module (for example, F8L).

7.2.2.3 Minor self-test error messages

Most of the minor self-test errors can be disabled. See the settings in the User-programmable Self-tests section in chapter 5.

MODULE FAILURE ___:
Contact Factory (xxx)

- *Latched target message:* Yes.
- *Description of problem:* Module hardware failure detected. Module Failures 12 and 31 to 33 are minor.
- *How often the test is performed:* Module dependent.
- *What to do:* Contact the factory and supply the failure code noted in the display. The “xxx” text identifies the failed module (for example, F8L).

For Module Failure 31, a new process card hardware is available. The process card hardware has been enhanced to support new features, such as fast distance protection, Synchrophasors Frequency, and Rate of Change of Frequency calculations to conform to C37.118 - 2005 standard. The new functionality leveraging the hardware is supported with firmware revision 7.25 and above. When using an older revision of the process card with a new firmware revision (7.25), Module Failure 31 indicates the limited functionality. If your application requires the new functionality, then new process card hardware is required and otherwise you can continue using the existing hardware. To know the revision of your hardware, contact the factory.

MAINTENANCE ALERT:
Replace Battery

- *Latched target message:* Yes.
- *Description of problem:* The battery is weak or not functioning. It powers the real time clock. This message displays as Battery Fail in the event records. When the battery weakness reaches a critical level, the message displays persistently on the front panel and no front panel key navigation is possible.
- *How often the test is performed:* The battery is monitored every five seconds. The error message displays after 60 seconds if the problem persists.

- *What to do:* Replace the battery as outlined in the Maintenance chapter.

**MAINTENANCE ALERT:
Direct I/O Ring Break**

- *Latched target message:* No.
- *Description of problem:* Direct input and output settings are configured for a ring, but the connection is not in a ring.
- *How often the test is performed:* Every second.
- *What to do:* Check direct input and output configuration and wiring.

**MAINTENANCE ALERT:
Bad IRIG-B Signal**

- *Latched target message:* No.
- *Description of problem:* A bad IRIG-B input signal has been detected.
- *How often the test is performed:* Monitored whenever an IRIG-B signal is received.
- *What to do:* Ensure the following:
 - The IRIG-B cable is properly connected.
 - Proper cable functionality (that is, check for physical damage or perform a continuity test).
 - The IRIG-B receiver is functioning.
 - Check the input signal level (it can be less than specification).
 If none of these apply, then contact the factory.

**MAINTENANCE ALERT:
Bad PTP Signal**

- *Latched target message:* No.
- *Description of problem:* No PTP enabled port has good PTP signal input.
- *How often the test is performed:* Activated when no acceptable signal is being received.
- *What to do:* Ensure the following:
 - The Ethernet cable(s) are properly connected.
 - At least one PTP grandmaster-capable clock is functioning.
 - If a strict power profile (PP) is enabled, that entire network is PP compliant.
 - The network is delivering PTP messages to the relay.

**MAINTENANCE ALERT:
SNTP Failure**

- *Latched target message:* No.
- *Description of problem:* The SNTP server is not responding.
- *How often the test is performed:* Every 10 to 60 seconds.
- *What to do:* Check that Ethernet cable(s) are properly connected. Check that configuration for the SNTP server corresponds to the actual server settings. Check connectivity to the server (ping the server IP address).

**MAINTENANCE ALERT:
4L Discrepancy**

- *Latched target message:* No.
- *Description of problem:* A discrepancy has been detected between the actual and desired state of a latching contact output of an installed type “4L” module.
- *How often the test is performed:* Upon initiation of a contact output state change.
- *What to do:* Verify the state of the output contact and contact the factory if the problem persists.

**MAINTENANCE ALERT:
GGIO Ind xxx oscill**

- *Latched target message:* No.
- *Description of problem:* A data item in a configurable GOOSE data set is oscillating.
- *How often the test is performed:* Upon scanning of each configurable GOOSE data set.
- *What to do:* The "xxx" text denotes the data item that has been detected as oscillating. Evaluate all logic pertaining to this item.

**DIRECT I/O FAILURE:
COMM Path Incomplete**

- *Latched target message:* No.
- *Description of problem:* A direct device is configured but not connected.
- *How often the test is performed:* Every second.
- *What to do:* Check direct input and output configuration and wiring.

**RxGOOSE FAIL:
Missing messages**

- *Latched target message:* No.
- *Description of problem:* One or more RxGOOSE messages are not being received.
- *How often the test is performed:* The self-test is activated when no message is received within the expected time interval, which is the time-to-live time in the previous message. This time can be from milliseconds to minutes.
- *What to do:* Check GOOSE setup.

**RXGOOSE OFFLINE:
COMM Path Incomplete**

- *Latched target message:* No.
- *Description of problem:* One or more GOOSE devices are not responding.
- *How often the test is performed:* Event driven. The test is performed when a device programmed to receive GOOSE messages stops receiving. This can be from 1 to 60 seconds, depending on GOOSE packets.
- *What to do:* Check GOOSE setup.

**TEMP MONITOR:
OVER TEMPERATURE**

- *Latched target message:* Yes.
- *Description of problem:* The ambient temperature is greater than the maximum operating temperature (+80°C).
- *How often the test is performed:* Every hour.
- *What to do:* Remove the B90 from service and install in a location that meets operating temperature standards.

**SYSTEM EXCEPTION:
Press RESET Key**

- *Latched target message:* Yes.
- *Description of problem:* Abnormal restart from modules being removed or inserted while the B90 is powered-up, when there is an abnormal DC supply, or as a result of internal relay failure.
- *How often the test is performed:* Event driven.
- *What to do:* Contact the factory.

FIRST ETHERNET FAIL**SECOND ETHERNET FAIL****THIRD ETHERNET FAIL**

- *Latched target message:* Yes.
- *Description of problem:* A link loss detection on an Ethernet port. The link loss is due to unplugging the cable or the switch port being down.
- *How often the test is performed:*
- *What to do:* Check the connection.

WRONG TRANSCEIVER

- *Latched target message:* Yes.
- *Description of problem:* The type of SFP does not match the CPU type.
T-type CPU = All ports support fiber SFPs only
U-type CPU = Maintenance port needs RJ45 SFP and the other two ports fiber SFPs
V-type CPU = All ports support RJ45 SFPs only
- *What to do:* A web page "SFP Transceiver Information" is provided. This page displays the type of the SFP in it. This data is to be used with the CPU type to know the cause of the problem.

SFP MODULE x FAIL

- *Latched target message:* No.
- *Description of problem:* A faulty SFP or unplugging the SFP would generate this self test.
- *What to do:* The web page "SFP Transceiver Information" described in the previous section applies for this self test as well. The "SFP Module Fail" has higher priority and it suppresses the "Ethernet Fail" target message. The "SFP MODULE FAIL FUNCTION" setting enables/disables this self test. The target for this self test is priority-based, with the third one being the highest priority. For example, if all three SFP modules fail, then the third SFP target is activated. If the third SFP module failure resolves, then the second SFP target is activated.

AUTHENTICATION FAIL

- *Latched target message:* No.
- *Description of problem:* The number of failures threshold was exceeded.
- *What to do:* Wait for the lockout interval and try to authenticate again.

FIRMWARE LOCK

- *Message:* "Unauthorized firmware attempt"
- *Latched target message:* No.
- *Description of problem:* A firmware upgrade operation was attempted while the lock relay setting was enabled.
- *What to do:* Ask the Supervisor to unlock the relay and try again.

SETTING LOCK

- *Message:* "Unauthorized setting write"
- *Latched target message:* No.
- *Description of problem:* A setting write was attempted while the lock relay setting was enabled.
- *What to do:* Ask the Supervisor to unlock the settings and try again.

SERVER UNAVAILABLE

- *Message:* "An attempt to contact the Radius server has failed"
- *Latched target message:* No.
- *Description of problem:* The RADIUS authentication server is unavailable.
- *What to do:* Verify network connectivity and try again.

**STORAGE MEDIA ALARM:
Self Test Error**

- *Description of problem:* The CPU module fails to read from or write to the Compact Flash (CF) card inside the module. The CF card stores certain non-volatile data, such as event records, oscillography and datalogger records, fault report values, and non-volatile actual values. Settings are not stored in CF and hence are unaffected by this self-test.
- *Latched target message:* No.
- *How often the test is performed:* On power up. Afterwards, every time the CPU accesses the CF card for reading or writing.
- *What to do:* Contact the factory.

**VOLTAGE MONITOR:
with 2nd line detail**

- *Description of problem:* The relay detected a problem with the internal voltage rails for longer than 25 seconds.
- *Latched target message:* Yes.
- *How often the test is performed:* Every five seconds.
- *What to do:* Contact GE customer service.

B90 Low Impedance Bus Differential System

Chapter 8: Application of settings

This chapter provides example(s) of use.

8.1 Overview

8.1.1 Introduction

This chapter provides an example of setting calculations for a sample bus. The selected example includes various bus configurations to clarify a number of typical situations. Both the bus configuration and numerical data used are not meant to reflect any specific utility practice or design standards.

It is also assumed that the CTs have been selected without considering a B90 application, but the UR settings are to be calculated for proper relay application. The CT data used in this example are kept to a minimum and in a generic form. The CT data does not reflect any particular notation or national standards.

The analysis provided in this chapter has been performed with the following goals:

- The limits of linear operation of the CTs considering zero remanent flux have been determined in order to select the high breakpoint settings of the biased differential characteristic
- The limits of linear operation of the CTs considering a remanent flux of 80% have been determined in order to select the low breakpoint settings of the biased differential characteristic
- Saturation of the CTs has been analyzed in order to select the higher slope of the biased differential characteristic and the high set differential overcurrent setting

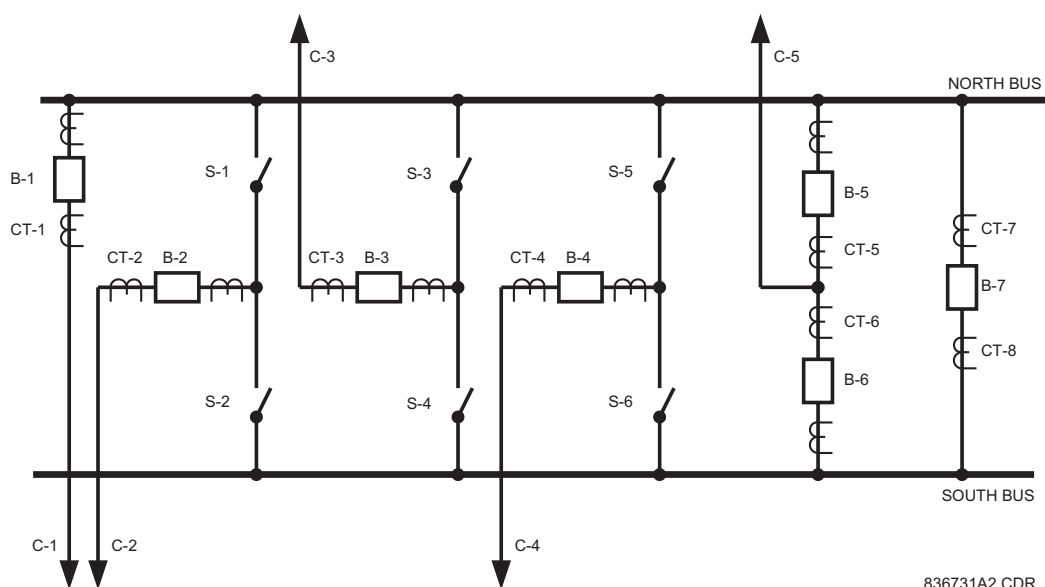
The analysis tools and safety margins applied are examples only and do not reflect any particular protection philosophy.

Typically, for the CT saturation related calculations, it is sufficient to consider the weakest (most prone to saturation) CT connected to the bus and the total bus fault current combined with the longest time constant among all the circuits connected to the bus. This chapter provides more detailed analysis (see the Slopes and High Set Threshold section) in order to illustrate the idea of using setting groups to enhance the B90 performance when the bus configuration changes (see the Enhancing Relay Performance section).

8.1.2 Sample busbar and data

The figure shows a double bus arrangement with North and South buses. This station has five circuits (C-1 through C-5) and a tiebreaker (B-7). Circuit C-1 is connected to the North bus; circuits C-2, C-3 and C-4 can be routed to either bus via switches S-1 through S-6; circuit C-5 can be connected to either bus via breakers B-5 and B-6.

Figure 8-1: Sample bus configuration



The table shows the assumed short circuit contributions of the connected circuits and their DC time constants.

Table 8-1: Basic fault data of the connected circuit

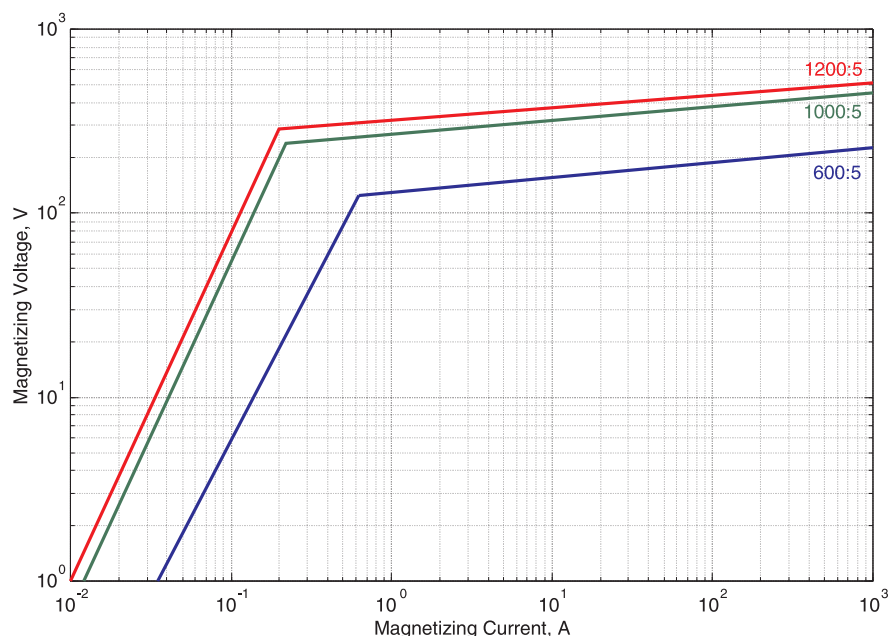
Circuit	I _{FAULT} (kA)	T _{DC} (ms)
C-1	0.00	N/A
C-2	0.00	N/A
C-3	6.00	5
C-4	5.00	30
C-5	3.00	40

The basic CT data is presented in the following table. The magnetizing characteristics of the three different types of CTs used in this example are shown in the following figure.

Table 8-2: Basic CT data

CT	Ratio	V _{sat} (V)	R _{CTsec} (Ω)	Leads (m)
CT-1	600:5	144	0.34	210
CT-2	600:5	144	0.34	205
CT-3	1200:5	288	0.64	200
CT-4	1000:5	240	0.54	200
CT-5, CT-6	1000:5	240	0.54	180
CT-7, CT-8	1200:5	288	0.64	200

Figure 8-2: Approximate CT magnetizing characteristics



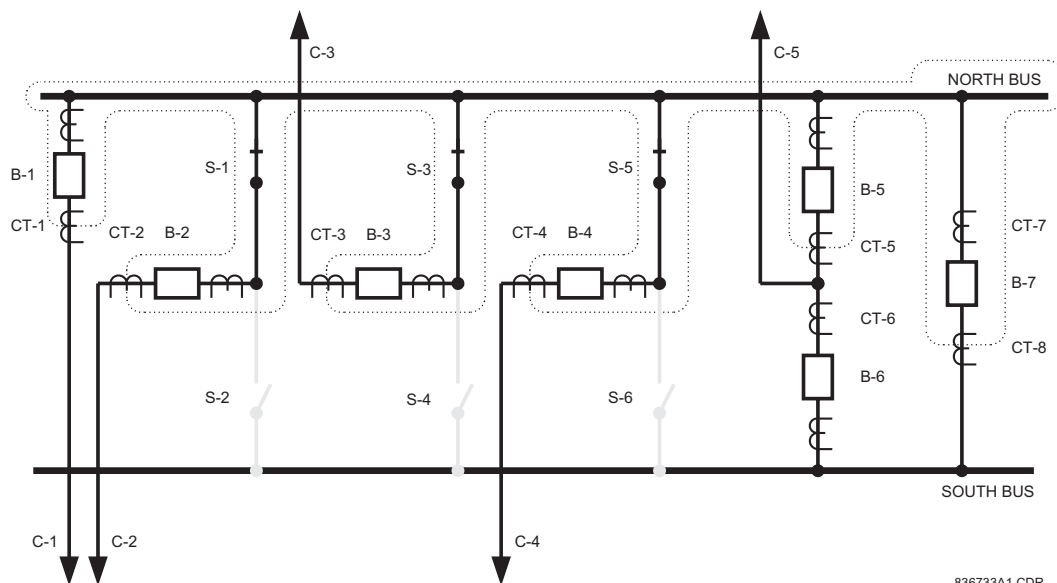
836732A4.CDR

8.2 Zoning and dynamic bus replica

8.2.1 North bus zone

With reference to the following diagram, the North bus differential zone is bounded by the following CTs: CT-1, CT-2 (if S-1 closed), CT-3 (if S-3 closed), CT-4 (if S-5 closed), CT-5 and CT-8. The North bus protection is to operate the following breakers: B-1, B-2 (if S-1 closed), B-3 (if S-3 closed), B-4 (if S-5 closed), B-5 and B-7.

Figure 8-3: North bus zone

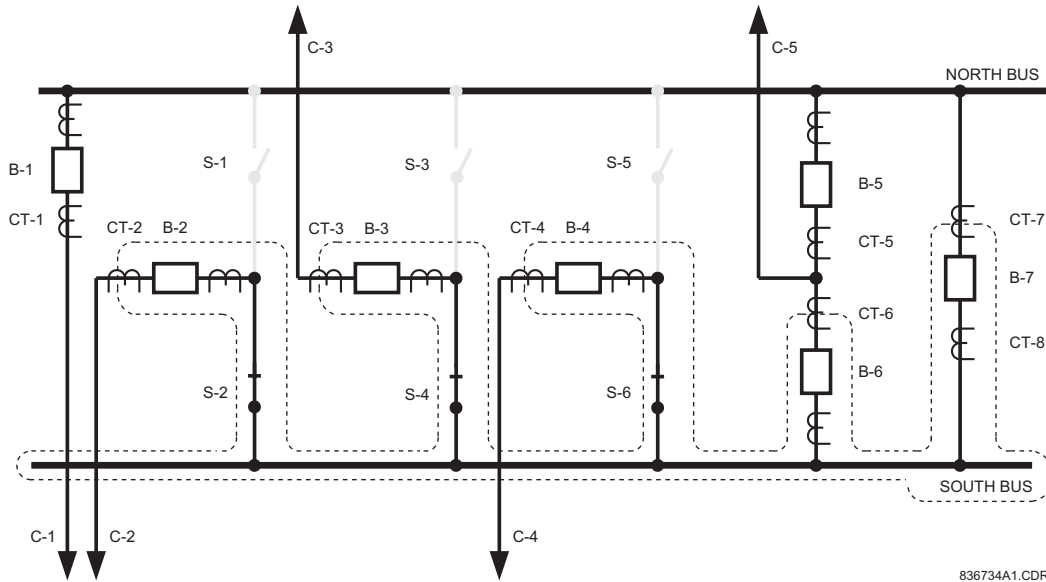


836733A1.CDR

8.2.2 South bus zone

The South bus differential zone is bounded by the following CTs: CT-2 (if S-2 closed), CT-3 (if S-4 closed), CT-4 (if S-6 closed), CT-6 and CT-7. The South bus protection is to operate the following breakers: B-2 (if S-2 closed), B-3 (if S-4 closed), B-4 (if S-6 closed), B-6 and B-7.

Figure 8-4: South bus zone



8.3 Biased characteristic breakpoints

8.3.1 Description

The limits of linear operation of the CTs need to be found in order to set the breakpoints of the biased differential characteristic. The settings for the North and South bus relays are analyzed simultaneously from this point on as the two differential zones share some CTs and the results of computations apply to both the relays.

For microprocessor-based relays it is justified to assume the burden of the CTs to be resistive. The limits of the linear operation of a CT, neglecting the effects of the DC component and residual magnetism, can be approximated as follows:

$$I_{\max} = \frac{V_{\text{sat}}}{R_s} \quad \text{Eq. 8-1}$$

where

$I_{\max}$ is the maximum secondary current transformed without saturation (AC component only, no residual magnetism),

R_s is the total burden resistance

V_{sat} is the saturation voltage of the CT

The total burden resistance depends on both the fault type and connection of the CTs. For single-line-to-ground faults and CTs connected in Wye, the burden resistance is calculated as:

$$R_s = 2R_{\text{lead}} + R_{\text{CTsec}} + R_{\text{relay}} \quad \text{Eq. 8-2}$$

where

R_{lead} is the lead resistance (one way, hence the factor of 2)

R_{CTsec} is the secondary CT resistance

R_{relay} is the relay input resistance

Assuming $0.003 \Omega/\text{m}$ lead resistance and approximating the B90 input resistance for the 5A input CTs as $0.2 \text{ VA} / (5 \text{ A})^2$ or 0.008Ω , the limits of the linear operation of the CTs have been calculated and presented in the Limits of Linear Operations of the CTs table.

8.3.2 High breakpoint

As an external fault can happen on any of the connected circuits, threatening saturation of any of the CTs, take the minimum value of the linear operation limit as the **HIGH BPNT** setting. The limit of linear operation that neglects both the residual magnetism and the effect of the DC component should be the base for setting the higher breakpoint of the biased differential characteristic.

The B90 requires the breakpoints to be entered as 'pu' values. The relay uses the largest primary current of the CTs bounding the bus differential zone as a base for the pu settings. Both the North and South buses have the largest primary current of the CTs of 1200 A (CT-7 and CT-8), thus upon configuration of the relays, 1200 A is automatically selected as base for the pu quantities. With a given I_{base} current, the limits of linear operation have been recalculated to pu values as follows:

$$I_{\text{max(pu)}} = \frac{I_{\text{max(secondary)}}}{I_{\text{base}}} \times \text{CT ratio} \quad \text{Eq. 8-3}$$

Table 8-3: Limits of linear operation of the CTS

CT	$R_s (\Omega)$	$I_{\text{max}} (\text{A sec})$	$I_{\text{max}} (\text{pu})$ (no remanence)	$I_{\text{max}} (\text{pu})$ (80% remanence)
CT-1	1.61	89.55	8.96	1.79
CT-2	1.58	91.25	9.13	1.83
CT-3	1.85	155.84	31.17	6.23
CT-4	1.75	137.30	22.88	4.58
CT-5, CT-6	1.63	147.42	24.57	4.91
CT-7, CT-8	1.85	155.84	31.17	6.23

The third and fourth columns of the table have the following significance.

If an external fault occurs on circuit C-1, then CT-1 carries the fault current. As the fault current is higher than any of the other currents, the current supplied by CT-1 is used as the restraint signal. CT-1 is guaranteed to saturate if the current exceeds 89.55 A secondary, or 17.9 times its rated current, or 8.96 pu of the bus differential zone. Consequently, considering CT-1, the value of 8.96 pu is used as the higher breakpoint of the characteristic.

Considering CTs that can be connected (depending on the positions of the switches) to the North bus, the **HIGH BPNT** for the North bus zone is selected as the minimum of (8.96, 9.13, 31.17, 22.88, 24.57, 31.17), or 8.96 pu.

Considering CTs that can be connected (depending on the positions of the switches) to the South bus, the **HIGH BPNT** for the South bus zone is selected as the minimum of (9.13, 31.17, 22.88, 24.57, 31.17), or 9.13 pu.

8.3.3 Low breakpoint

The DC component in the primary current can saturate a given CT even with the AC current below the suggested value of the higher breakpoint. The relay copes with this threat by using the Saturation Detector and applying a 2-out-of-2 operating principle upon detecting saturation.

The residual magnetism (remanence) left in the core of a CT can limit the linear operation of the CT significantly. It is justified to assume that the residual flux can be as high as 80% of the saturation level leaving only 20% to accommodate the flux component created by the primary current. This phenomenon can be reflected by reducing the saturation voltage in the calculations by the factor of $100\% / 20\%$, or 5. This, in turn, is equivalent to reducing the limit of linear operation by the factor of 5, hence the last column in the Limits of Linear Operations of the CTs table.

For example, if the residual flux left in the core of the CT-1 is as high as 80% of its saturation level, the CT saturates at 17.92 A secondary, or 3.58 times its rated current, or at 1.79 pu of the bus differential zone.

The reduced limit of linear operation is used as the lower breakpoint of the biased differential characteristic (the **LOW BPNT** setting). In this way the interval spanning from the lower to higher breakpoints covers the indistinct area of possible saturation due to the random factor of residual magnetism.

The **LOW BPNT** is set at 1.79 pu for the North bus zone, and at 1.83 pu for the South bus zone.

A combination of very high residual magnetism and a DC component with a long time constant can saturate a given CT even with the AC current below the suggested value of the lower breakpoint. The relay copes with this threat by using a 2-out-of-2 operating mode for low differential currents.

8.4 Slopes and high set threshold

8.4.1 Description

To set the higher slope and threshold of the high set (unbiased) differential operation, external faults must be analyzed. Consider an external fault for the North bus relay. It is justified to assume bus configurations that give maximum stress to the maximum number of CTs. For this purpose we assume the tie breaker, B-7 closed; all the circuitry capable of supplying the fault current to be in service; moreover, they are connected to the South bus in order to analyze the CT-7 and CT-8 carrying the fault current.

8.4.2 External faults on C-1

The following table presents the results of analysis of an external fault on circuit C-1 (C-1 is connected to the North bus; C-3, C-4, and C-5 are connected to the South bus).

For security reasons, it has been assumed that the fault current being a sum of several contributors (C-3, C-4, and C-5 in this case) has a time constant of the DC component of the maximum among the time constants of the contributors. The fault current is supplied from circuits C-3, C-4, and C-5 connected to the South bus, thus through CT-3, CT-4, and CT-6. The current passes through the tie breaker threatening saturation of CT-7 and CT-8.

By comparing the secondary currents (column 3 in the table below) with the limits of linear operation for the CTs (column 4 in the Limits of Linear Operations of the CTs table earlier), it is concluded that CT-1 will saturate during this fault, producing a spurious differential signal for the North bus zone differential protection. All other CTs do not saturate due to the AC components. The amount of the spurious differential current (magnetizing current of CT-1) can be calculated using the burden, magnetizing characteristic and primary current of the noted CT by solving the following equations:

$$\begin{aligned} I_{\text{relay}} &= \sqrt{I_s^2 - I_{\text{magnetizing}}^2} \\ I_{\text{relay}} \times R_s &= V_{\text{magnetizing}} \end{aligned} \quad \text{Eq. 8-4}$$

For $I_s = 116.67 \text{ A}$, $R_s = 1.61 \Omega$ and the characteristic shown earlier in the Approximate CT Magnetizing Characteristics figure, the solution is $I_{\text{magnetizing}} = 29.73 \text{ A}$, $I_{\text{relay}} = 112.8 \text{ A}$.

The magnetizing current of the saturated CT-1 appears to the differential element protecting the North bus as a differential signal of 29.73 A, while the restraint signal is the maximum of the bus currents (112.8 A in this case). Consequently, the higher slope of the characteristic should not be lower than 29.73 A / 112.8 A, or 26%, and the pickup of the high set differential elements should not be lower than 29.73 A, or 2.97 pu.

The CTs identified as operating in the linear mode as far as the AC components are considered can, however, saturate due to the DC components. Saturation does not occur if $V_{\text{sat}} > I_s \times R_s \times (1 + \omega \times T_{\text{dc}})$, where ω is radian system frequency ($2\pi f$).

If the above condition is violated, CT time-to-saturate for a full DC saturation can be estimated as follows. The CT saturation factor K_s capability curve is defined as

$$K_s = \frac{\omega \times T_1 \times T_2}{T_1 - T_2} \left[e^{-t/T_1} - e^{-t/T_2} \right] - \sin(\omega t) \quad \text{Eq. 8-5}$$

where

T_1 is a primary system time constant

T_2 is the secondary CT time constant, which can be estimated by the following equation:

$$T_2 = \frac{V_s \times N}{20 \times (\omega \times R_s)} \quad \text{Eq. 8-6}$$

where

N is the CT ratio

V_s is the CT voltage at 10 A exciting current obtained from the CT excitation curve

CT limiting factor K_{S_LIM} is defined by the following equation:

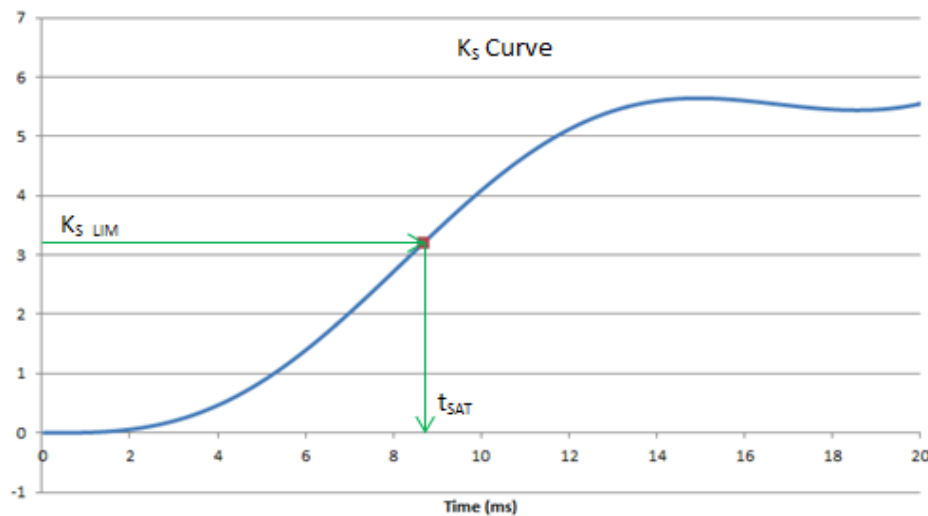
$$K_{S_LIM} = \frac{V_s \times N}{I_p \times R_s} \quad \text{Eq. 8-7}$$

where

I_p is the maximum CT primary fault current

The figure illustrates the K_s CT saturation capability curve and K_{S_LIM} limiting factor.

Figure 8-5: Determining CT time-to-saturate



CT time-to-saturate (t_{SAT}) is determined as a projection of the intersection of the K_s CT saturation capability curve and K_{S_LIM} CT limiting factor, as shown in the figure.

Practically, CT time-to-saturate can be obtained by either of the following methods:

- Method 1 — Download the "CT Time-to-Saturate Estimator.xlsm" spreadsheet from the GE Multilin web site, located under Support > Support Documents > B90 Low Impedance Bus Differential System. Enter the required system and CT parameters to obtain the CT time-to-saturate.
- Method 2
 - Define several time instances $t_1, t_2 \dots t_n$
 - Use equation 8-5 to calculate the corresponding $K_{S1}, K_{S2} \dots K_{Sn}$
 - Calculate K_{S_LIM} using equation 8-7
 - Compare each K_s value with K_{S_LIM} . If K_s at the given time instance t_i is less than K_{S_LIM} , it means that true t_{SAT} is greater than t_i , otherwise it is less than t_i

Columns 6 and 7 of the table below summarize the DC saturation threat for the fault on C-1. CT-4, CT-6, CT-7, and CT-8 can saturate due to the DC components and can generate spurious differential signal for both the North and South bus relays depending on the bus configuration. The saturation does not occur before 5.02 ms and is detected by the Saturation Detector.

The transient saturation of the CTs due to the DC component can be neglected when setting the slopes of the characteristic as the saturation is detected and the relay uses the current directional principle. It must, however, be taken into account when setting the high set (unbiased) differential element.

Table 8-4: External fault calculations on C-1

CT	I_{FAULT} (kA)	I_{FAULT} (A sec)	T_{DC} (ms)	AC saturation	DC saturation	t_{SAT} (ms)
CT-1	14.0	116.67	40	Yes	Yes	5.02
CT-2	0	0.00	N/A	No	No	N/A
CT-3	6.0	25.00	5	No	No	N/A
CT-4	5.0	25.00	30	No	Yes	26.37
CT-6	3.0	15.00	40	No	Yes	61.50
CT-7, CT-8	14.0	58.33	40	No	Yes	9.44

8.4.3 External faults on C-2

The following table presents the results of analysis of an external fault on circuit C-2 (C-2 is connected to the North bus; C-3, C-4 and C-5 are connected to the South bus).

By comparing the secondary currents (column 3 in the following table) with the limits of linear operation for the CTs (column 4 shown earlier in the Limits of Linear Operations of the CTs table) it is concluded that CT-2 will saturate during this fault producing a spurious differential signal. All other CTs do not saturate due to the AC components. The amount of the spurious differential current (magnetizing current of CT-2) can be calculated using the burden, magnetizing characteristic, and the primary current of the said CT.

For $I_s = 116.67$ A, $R_s = 1.23 \Omega$ and the characteristic shown earlier in the Approximate CT Magnetizing Characteristics figure, the solution is $I_{\text{magnetizing}} = 27.69$ A, $I_{\text{relay}} = 113.3$ A.

The magnetizing current of the saturated CT-2 appears to the differential element protecting the North bus as a differential signal of 27.69 A, while the restraint signal is the maximum of the bus currents (113.3 A). Consequently, the higher slope of the characteristic should not be lower than 27.69 A / 113.3 A, or 24% and the pickup of the high-set differential elements should not be lower than 27.69 A, or 2.77 pu.

Columns 6 and 7 of the following table summarize the DC saturation threat for the fault on C-2. CT-4, CT-6, CT-7, and CT-8 can saturate due to the DC components and can generate spurious differential signal for both the North and South bus relays depending on the bus configuration. The saturation does not occur before 5.06 ms and is detected by the Saturation Detector.

Table 8-5: External fault calculations on C-2

CT	I_{FAULT} (kA)	I_{FAULT} (A sec)	T_{DC} (ms)	AC saturation	DC saturation	t_{SAT} (ms)
CT-1	0	0.00	N/A	No	No	N/A
CT-2	14.0	116.67	40	Yes	Yes	5.06
CT-3	6.0	25.00	5	No	No	N/A
CT-4	5.0	25.00	30	No	Yes	26.37
CT-6	3.0	15.00	40	No	Yes	61.50
CT-7, CT-8	14.0	58.33	40	No	Yes	9.44

8.4.4 External faults on C-3

The following table presents the results of analysis of an external fault on circuit C-3 (C-3 is connected to the North bus; C-4 and C-5 are connected to the South bus).

By comparing the secondary currents (column 3 in the table below) with the limits of linear operation for the CTs (column 4 in the Limits of Linear Operations of the CTs table shown earlier), it is concluded that none of the CTs saturate due to the AC currents during this fault.

Columns 6 and 7 of the table below summarize the DC saturation threat for the fault on C-3. CT-3, CT-4, CT-6, CT-7, and CT-8 can saturate due to the DC components and can generate a spurious differential signal for both the North and South bus relays depending on the bus configuration. The saturation does not occur before 23.68 ms and is detected by the Saturation Detector.

Table 8-6: Calculations for the external faults on C-3

CT	I_{FAULT} (kA)	I_{FAULT} (A sec)	T_{DC} (ms)	AC saturation	DC saturation	t_{SAT} (ms)
CT-1	0	0.00	N/A	No	No	N/A
CT-2	0	0.00	N/A	No	No	N/A
CT-3	8.0	33.33	40	No	Yes	23.68
CT-4	5.0	25.00	30	No	Yes	26.37
CT-6	3.0	15.00	40	No	Yes	61.50
CT-7, CT-8	8.0	33.33	40	No	Yes	23.68

8.4.5 External faults on C-4

The following table presents the results of analysis of an external fault on circuit C-4 (C-4 is connected to the North bus; C-3 and C-5 are connected to the South bus).

By comparing the secondary currents (column 3 in the table below) with the limits of linear operation for the CTs (column 4 in the Limits of Linear Operations of the CTs table shown earlier), it is concluded that none of the CTs saturate due to the AC currents during this fault.

Columns 6 and 7 of the following table summarize the DC saturation threat for the fault on C-4. CT-4, CT-6, CT-7, and CT-8 can saturate due to the DC components and can generate a spurious differential signal for both the North and South bus relays depending on the bus configuration. The saturation does not occur before 10.03 ms and is detected by the Saturation Detector.

Table 8-7: External fault calculations on C-4

CT	I_{FAULT} (kA)	I_{FAULT} (A sec)	T_{DC} (ms)	AC saturation	DC saturation	t_{SAT} (ms)
CT-1	0	0.00	N/A	No	No	N/A
CT-2	0	0.00	N/A	No	No	N/A
CT-3	6.0	25.00	5	No	No	N/A
CT-4	9.0	45.00	40	No	Yes	10.03
CT-6	3.0	15.00	40	No	Yes	61.50
CT-7, CT-8	9.0	37.50	40	No	Yes	22.23

8.4.6 External faults on C-5

The following table presents the results of analysis of an external fault on circuit C-5 (C-5 is connected to the North bus; C-3 and C-4 are connected to the South bus).

By comparing the secondary currents (column 3 in the table below) with the limits of linear operation for the CTs (column 4 in the Limits of Linear Operations of the CTs table shown earlier), it is concluded that none of the CTs saturate due to the AC currents during this fault.

Columns 6 and 7 of the following table summarize the DC saturation threat for the fault on C-5. CT-4, CT-5, CT-7, and CT-8 can saturate due to the DC components and can generate a spurious differential signal for both the North and South bus relays depending on the bus configuration. The saturation does not occur before 9.45 ms and is detected by the Saturation Detector.

Table 8-8: External fault calculations on C-5

CT	I_{FAULT} (kA)	I_{FAULT} (A sec)	T_{DC} (ms)	AC saturation	DC saturation	t_{SAT} (ms)
CT-1	0	0.00	N/A	No	No	N/A
CT-2	0	0.00	N/A	No	No	N/A

CT	I_{FAULT} (kA)	I_{FAULT} (A sec)	T_{DC} (ms)	AC saturation	DC saturation	t_{SAT} (ms)
CT-3	6.0	25.00	5	No	No	N/A
CT-4	5.0	25.00	30	No	Yes	26.37
CT-5	11.0	55.00	30	No	Yes	9.45
CT-7, CT-8	11.0	45.83	30	No	Yes	11.54

8.5 Bus differential settings

8.5.1 Description

Taking the previous analysis from this chapter into account, the settings have been calculated as follows.

Table 8-9: North bus differential protection settings

Setting	Value	Comments
PICKUP	0.1 pu	Default value. Lower or higher values can be entered upon security/dependability requirements. The pu value is for the base of 1200A. This means the actual pickup is 120 A primary.
LOW SLOPE	25%	Default value. Lower or higher values can be entered upon security/dependability requirements.
LOW BPNT	1.79 pu	None of the CTs saturate for AC currents below 1.79 pu even with 80% remanence. The DC component, however, combined with the remanence can saturate some CTs even for currents below 1.79 pu. The B90 copes with saturation using the current directional principle.
HIGH SLOPE	60%	Default value. Lower or higher values can be entered upon security/dependability requirements. The value of 60% ensures that the differential characteristic alone (without the directional principle) work correctly under AC saturation of the CTs (26% of spurious differential during the fault on C-1 saturating CT-1).
HIGH BPNT	8.96	None of the CTs saturate for AC currents below 8.96 pu. The DC component, however, can saturate some CTs even for currents below 8.96 pu. The B90 copes with saturation using the current directional principle.
HIGH SET	5.94	The maximum spurious differential current is 2.97 pu. Due to limited accuracy of analysis and the effect of DC saturation a security factor of 2 has been adopted. The highest internal fault current is 14kA, or 11.67 pu giving a good chance to clear a number of faults by the unbiased differential operation.

Table 8-10: South bus differential protection settings

Setting	Value	Comments
PICKUP	0.1 pu	Default value. Lower or higher values can be entered upon security/dependability requirements. The pu value is for the base of 1200A. This means the actual pickup is 120 A primary.
LOW SLOPE	25%	Default value. Lower or higher values can be entered upon security/dependability requirements.
LOW BPNT	1.83 pu	None of the CTs saturate for AC currents below 1.83 pu even with 80% remanence. The DC component, however, combined with the remanence can saturate some CTs even for currents below 1.83 pu. The B90 copes with saturation using the current directional principle.
HIGH SLOPE	60%	Default value. Lower or higher values can be entered upon security/dependability requirements. The value of 60% ensures that the differential characteristic alone (without the directional principle) work correctly under AC saturation of the CTs (24% of spurious differential during the fault on C-2 saturating CT-2).
HIGH BPNT	9.13 pu	None of the CTs saturate for AC currents below 9.13 pu. The DC component, however, can saturate some CTs even for currents below 9.13 pu. The B90 copes with saturation using the current directional principle.
HIGH SET	5.54	The maximum spurious differential current is 2.77 pu. Due to limited accuracy of analysis and the effect of DC saturation a security factor of 2 has been adopted. The highest internal fault current is 14kA, or 11.67 pu giving a good chance to clear a number of faults by the unbiased differential operation.

8.6 Enhancing relay performance

8.6.1 Using setting groups

In the example of the South bus, CT-2 is the weakest (most prone to saturation) CT dictating values of some settings. However, CT-2 may not be a part of the South bus protection zone if the S-2 switch is opened. As the position of the switch must be provided for the dynamic bus replica, the status of the switch can be re-used to control the setting groups and apply more sensitive settings if the weakest CT is not part of the bus zone at a given time. For example, if the S-2 switch is opened while the S-6 switch is closed, the CT-4 becomes the weakest CT connected to the South bus. The higher breakpoint (**HIGH BPNT**) could be increased to 22.88 pu (fourth column of the Limits of Linear Operations of the CTs table). The lower breakpoint (**LOW BPNT**) could be increased to 4.58 pu (fifth column of the Limits of Linear Operations of the CTs table). The higher slope (**HIGH SLOPE**) could be decreased as no AC saturation is possible for the South bus CTs (see the external fault calculation tables for each circuit).

The concept could be implemented by using:

- FlexLogic to process the status signals in order to identify the weakest CT
- Setting Groups to switch dynamically from one setting group to another (adaptive settings)

This approach can be extended for buses that do not require the dynamic bus replica mechanism. This can include approximation of the total bus fault current using positions of all switches and breakers and optimizing the settings depending on the amount of stress imposed on the CTs in any particular bus configuration.

B90 Low Impedance Bus Differential System

Chapter 9: Theory of operation

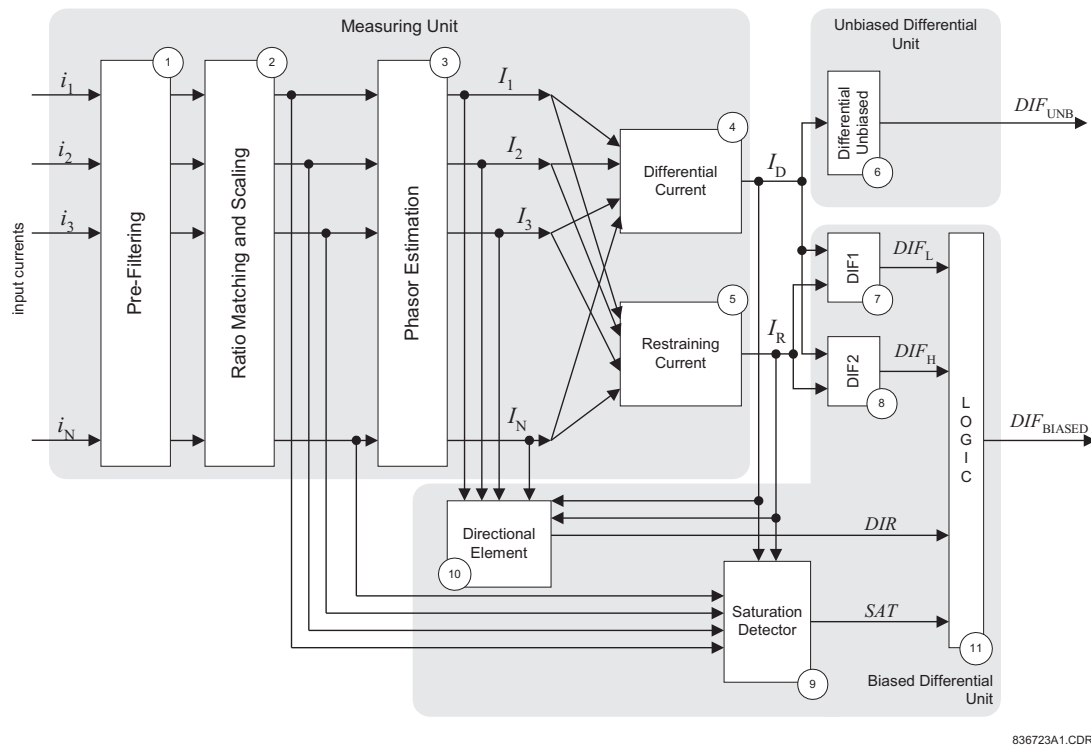
This chapter outlines advanced information on operation.

9.1 Introduction

9.1.1 Bus differential protection

The figure shows that input currents defining (through the dynamic bus replica) the bus differential zone are received by the B90 from current transformers (CTs) associated with the power system.

Figure 9-1: Bus differential protection block diagram



The currents are digitally pre-filtered (Block 1) in order to remove the decaying DC components and other signal distortions.

The filtered input signals are brought to a common scale taking into account the transformation ratios of the connected CTs (Block 2). See the Dynamic Bus Replica section in this chapter.

Phasors of the differential zone currents are estimated digitally (Block 3), and the differential (Block 4) and restraining (Block 5) signals are calculated. See the Differential Principle section.

The magnitude of the differential signal is compared with a threshold, and an appropriate flag indicating operation of the unbiased bus differential protection is produced (Block 6).

The magnitudes of the differential and restraining currents are compared and two auxiliary flags that correspond to two specifically shaped portions of the differential operating characteristic (DIF_1 and DIF_2) are produced (blocks 7 and 8). The characteristic is split in order to enhance performance of the relay by applying diverse security measures for each of the regions. See the Differential Principle section.

The directional element (Block 10) supervises the biased differential characteristic when necessary. The current directional comparison principle is used that processes phasors of all the input currents as well as the differential and restraining currents. See the Directional Principle section.

The saturation detector (Block 9) analyzes the differential and restraining currents as well as the samples of the input currents. This block sets its output flag upon detecting CT saturation. See the Saturation Detector section.

The output logic (Block 11) combines the differential, directional, and saturation flags into the biased differential operation flag. The applied logic enhances performance of the relay while keeping an excellent balance between dependability/speed and security. See the Output Logic and Examples section.

9.2 Dynamic bus replica

9.2.1 Dynamic bus replica mechanism

The bus differential zones of the B90 allow for protecting bus sections that include circuits that are switchable between different sections. Proper relay operation is achieved by associating a status signal with each input current. This mechanism is referred to as a dynamic bus replica.

The dynamic bus zone is programmed as a number of CT input–status–direction entries.

The status signal of a given CT input–status pair of the dynamic bus replica is a FlexLogic operand created to indicate whether or not the associated circuit (current) is connected to the protected bus zone. Normally, the status signals are to be created from input contacts wired to appropriate auxiliary contacts of isolator switches or breakers.

9.2.2 CT ratio matching

The B90 allows for using CTs with various rated secondary currents and transformation ratios. Scaling to a common base is performed internally by the relay. The maximum allowable ratio mismatch is 32:1. For proper setting of the differential characteristic, it is imperative to understand the common base used by the relay.

The B90 scales the secondary currents to the maximum primary current among the CTs defining a given bus differential zone: 1 per unit corresponds to the highest rated primary current.

The scaling base is selected automatically by the relay during the configuration phase and is not affected by the dynamic aspect of the bus differential zone. This means that even though the circuit containing the CT with the maximum rated primary current is not connected to a given bus zone at a given time, the scaling base does not change.

9.2.2.1 Example 1

Assume that the CTs installed in the circuit defining the BUS ZONE 1 have the following ratings:

- 1A CT: 600:5
- 1B CT: 500:1
- 1C CT: 600:5
- 1D CT: 1000:5
- 1E CT: 500:1
- 1F CT: 600:5

The maximum of 600, 500, 600, 1000, 500, and 600 is 1000 A, which is selected as the base upon configuration of the BUS ZONE 1. 1 per unit (pu) represents 1000 A primary.

9.3 Differential principle

9.3.1 Biased differential characteristic

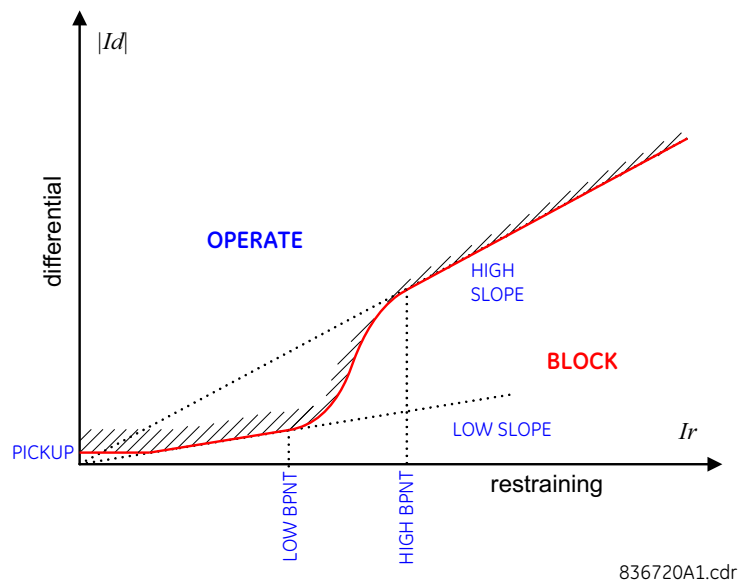
The B90 uses a dual-slope dual-breakpoint operating characteristic as shown in the following figure.

The **PICKUP** setting is provided to cope with spurious differential signals when the bus carries a light load and there is no effective restraining signal.

The first breakpoint (**LOW BPNT**) is provided to specify the limit of guaranteed linear operation of the CTs in the most unfavorable conditions, such as high residual magnetism left in the magnetic cores or multiple autoreclosure shots. This point defines the upper limit for the application of the first slope (**LOW SLOPE**).

The second breakpoint (**HIGH BPNT**) is provided to specify the limits of operation of the CTs without any substantial saturation. This point defines the lower limit for the application of the second slope (**HIGH SLOPE**).

Figure 9-2: Biased operating characteristic



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The higher slope used by the B90 acts as an actual percentage bias regardless of the value of the restraining signal. This is so because the boundary of the operating characteristic in the higher slope region is a straight line intersecting the origin of the 'differential - restraining' plane. The advantage of having a constant bias specified by the **HIGH SLOPE** setting creates an obstacle of a discontinuity between the first and second slopes. This is overcome by using a smooth approximation (cubic spline) of the characteristic between the lower and higher breakpoints. Consequently, the characteristic ensures

- A constant percentage bias of **LOW SLOPE** for restraining currents below the lower breakpoint of **LOW BPNT**,
- A constant percentage bias of **HIGH SLOPE** for restraining currents above the higher breakpoint of **HIGH BPNT**, and
- A smooth transition from the bias of **LOW SLOPE** to **HIGH SLOPE** between the breakpoints

9.3.2 Differential and restraining currents

The differential current is produced as a sum of the phasors of the input currents of a differential bus zone taking into account the status signals of the currents, for example applying the dynamic bus replica of the protected zone. The differential current is scaled to the maximum rated primary current. The scaling must be taken into account when setting the **PICKUP** value of the biased differential characteristic and the **HIGH SET** operating point of the unbiased differential function.

The restraining current is produced as a maximum of the magnitudes of the phasors of the zone input currents taking into account the status signals of the currents, for example applying the dynamic bus replica of the protected bus zone. The restraining current is scaled to the maximum rated primary current. The scaling must be taken into account when setting the breakpoints of the biased differential characteristic.

The "maximum of" definition of the restraining signal biases the relay toward dependability without jeopardizing security as the relay uses additional means to cope with CT saturation on external faults. An additional benefit of this approach is that the restraining signal always represents a physical — compared to an "average" or "sum of" — current flowing through the CT that is most likely to saturate during given external fault. This brings more meaning to the breakpoint settings of the operating characteristic.

The following example is provided with respect to the breakpoint settings.

9.3.2.1 Example 2

Proceed with the previous example and assume that taking into account the relevant factors such as properties of the CTs themselves, resistance of the leads, and burden of the CTs, the following primary currents are guaranteed to be transformed without significant saturation:

- 1A CT: 6.0 kA
- 1B CT: 7.5 kA
- 1C CT: 5.0 kA
- 1D CT: 13.0 kA
- 1E CT: 8.0 kA
- 1F CT: 9.0 kA

As having the lowest primary current guaranteeing operation without saturation, the CT associated with the 1C input is most exposed to saturation. During an external fault on the 1C circuit, the 1C CT carries the fault current contributed by potentially all the remaining circuits. The fault current is higher than any contributing current, and therefore, the current of the 1C CT becomes the restraining signal for the biased differential characteristic for external faults on the 1C circuit. Consequently, the higher breakpoint of the differential characteristic (**HIGH BPNT**) needs to be set no higher than 5000 A, where 1000 A = 5 pu (1000 A is the base unit as outlined in the previous the example).

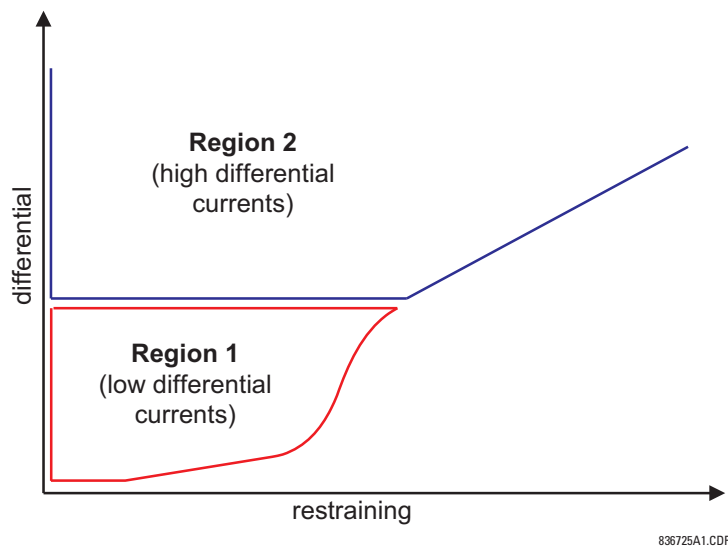
The same approach applies to the setting of the lower breakpoint, **LOW BPNT**.

9.3.3 Enhanced security

To enhance the performance of the B90, the differential characteristic is divided into two regions having diverse operating modes, as shown in following figure.

The first region applies to comparatively low differential currents and has been introduced to deal with CT saturation on low-current external faults. Certain distant external faults can cause CT saturation due to extremely long time constants of the DC component or multiple autoreclosure shots. The saturation, however, is difficult to detect in such cases. Additional security via the “directional check” is permanently applied to this region without regard to the saturation detector.

Figure 9-3: Two regions of differential character



The second region includes the remaining portion of the differential characteristic and applies to comparatively high differential currents. If, during an external fault, the spurious differential current is high enough so that the differential-restraining current trajectory enters the second region, then saturation is guaranteed to be detected by the saturation detector.

The B90 operates in the 2-out-of-2 mode in the first region of the differential characteristic. Both differential and directional principles (Differential Principle and Directional Principle) must confirm an internal fault in order for the biased differential element to operate.

The relay operates in the dynamic 1-out-of-2 / 2-out-of-2 mode in the second region of the differential characteristic. If the saturation detector (see the Saturation Detector section) does not detect CT saturation, the differential protection principle alone is capable of operating the biased differential element. If CT saturation is detected, both differential and directional principles must confirm an internal fault in order for the biased differential element to operate.

Because of diverse operating modes in the first and second regions of the differential characteristic, the user gains double control over the dependability and security issues. The first level includes slopes and breakpoints of the characteristic with regard to the amount of the bias. The second level includes control over the split between the first and second regions of the characteristic.

9.4 Directional principle

9.4.1 Current directional protection

For better security, the B90 uses the current directional protection principle to dynamically supervise the main current differential function. The directional principle is in effect permanently for low differential currents (region 1 in the Two Regions of Differential Characteristic figure) and is switched on dynamically for large differential currents (region 2 in the same figure) by the saturation detector (see the Saturation Detector section) upon detecting CT saturation.

The directional principle responds to a relative direction of the fault currents. This means that a reference signal, such as bus voltage, is not required. The directional principle declares that

- If all of the fault currents flow in one direction, the fault is internal, or
- If at least one fault current flows in an opposite direction compared with the sum of the remaining currents, the fault is external

The directional principle is implemented in two stages.

First, based on the magnitude of a given current, it is determined whether the current is a fault current. If so, its relative phase relation has to be considered. The angle check must not be initiated for the load currents as the direction is out of the bus even during internal faults. The auxiliary comparator of this stage applies an adaptable threshold. The threshold is a fraction of the restraining current. The current from a particular feeder is used for bus directional comparison if its magnitude is greater than $\max(K \times I_{\text{restraint}}, 0.1 \text{ pu})$ or it is greater than 2 times its CT rating. For bus zones with two feeders, $K = 0.2$. For bus zones with three to six feeders, $K = 0.8 / (N - 1)$. For bus zones with more than six feeders, $K = 0.16$.

Second, for the selected fault currents, the phase angle between a given current and the sum of all the remaining currents is checked. The sum of all the remaining currents is the differential current less the current under consideration. Therefore, for each, say the p th, current to be considered, the angle between the I_p and $I_D - I_p$ phasors is to be checked.

Ideally, during external faults, the said angle is close to 180° (as shown); and close to 0 degrees during internal faults.

Figure 9-4: Directional principle operation during external faults

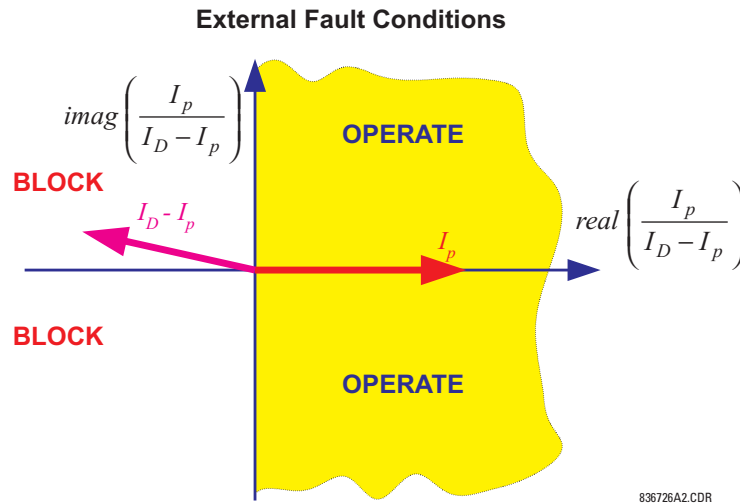
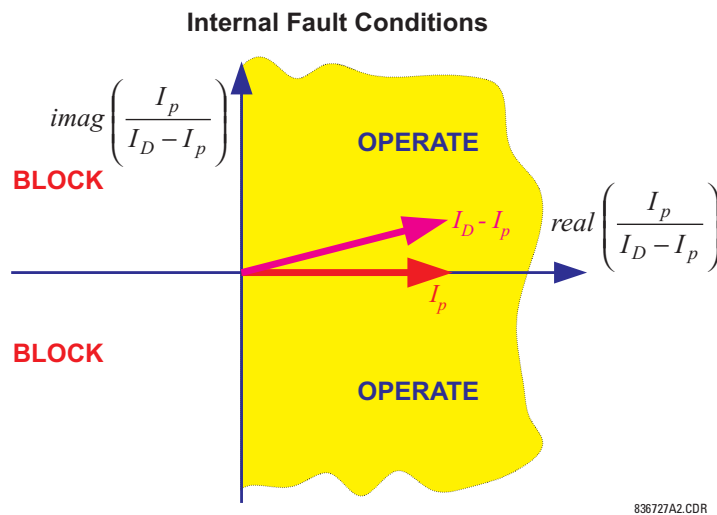


Figure 9-5: Directional principle operation during internal faults



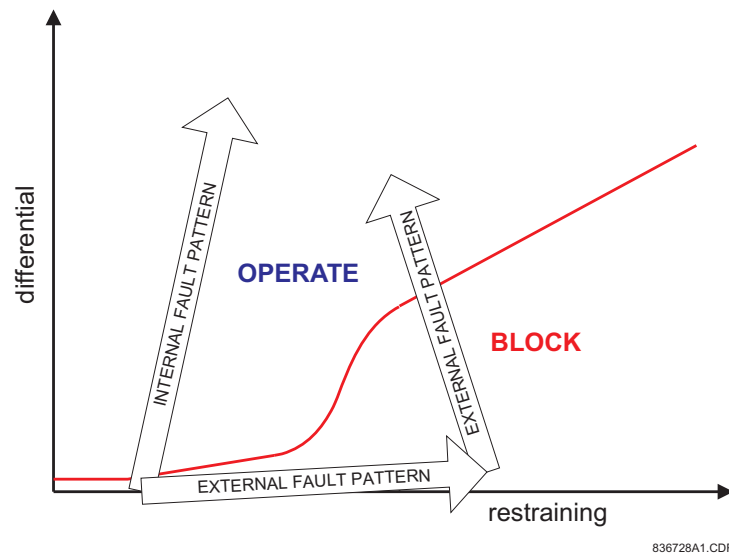
The B90 implementation calculates the maximum angle for the considered currents and compares it against a fixed threshold of 90°. The flag indicating whether the directional protection principle is satisfied is available as the FlexLogic operand [BUS 1\(4\) DIR A/B/C](#).

9.5 Saturation detector

9.5.1 CT saturation detection

The saturation detector of the B90 takes advantage of the fact that any CT operates correctly for a short period of time, even under very large primary currents that would subsequently cause a very deep saturation. As a result, in the case of an external fault, the differential current stays very low during the initial period of linear operation of the CTs while the restraining signal develops rapidly. Once one or more CTs saturate, the differential current increases. The restraining signal, however, yields by at least a few milliseconds. During internal faults, both the differential and restraining currents develop simultaneously. This creates characteristic patterns for the differential - restraining trajectory, as shown.

Figure 9-6: CT saturation detection internal and external fault patterns



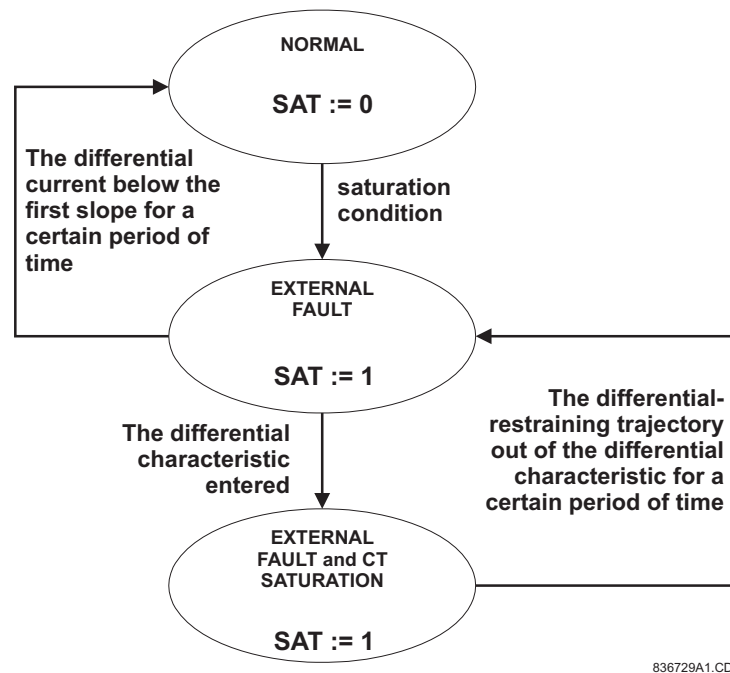
The CT saturation condition is declared by the saturation detector when the magnitude of the restraining signal becomes larger than the higher breakpoint (**HIGH BPNT**) and at the same time the differential current is below the first slope (**LOW SLOPE**). The said condition is of a transient nature and requires a seal-in. A special logic in the form of a “state machine” is used for this purpose as depicted in the following figure on saturation detector state machine.

As the phasor estimator introduces a delay into the measurement process, the aforementioned saturation test fails to detect CT saturation occurring very fast. In order to cope with very fast CT saturation, another condition is checked that uses relations between the signals at the waveform level. The basic principle is similar to that described. Additionally, the sample-based stage of the saturation detector uses the time derivative of the restraining signal (di/dt) to better trace the saturation pattern shown in the following figure.

The saturation detector is capable of detecting saturation occurring in approximately 3 ms from fault inception. The saturation detector, although having no dedicated settings, uses the main differential characteristic for proper operation. This must be kept in mind when setting the characteristic as its parameters must retain their original meaning.

The operation of the saturation detector is available as the FlexLogic operand [BUS 1\(4\) SAT A/B/C](#).

Figure 9-7: Saturation detector state machine



9.6 Output logic and examples

9.6.1 Output logic

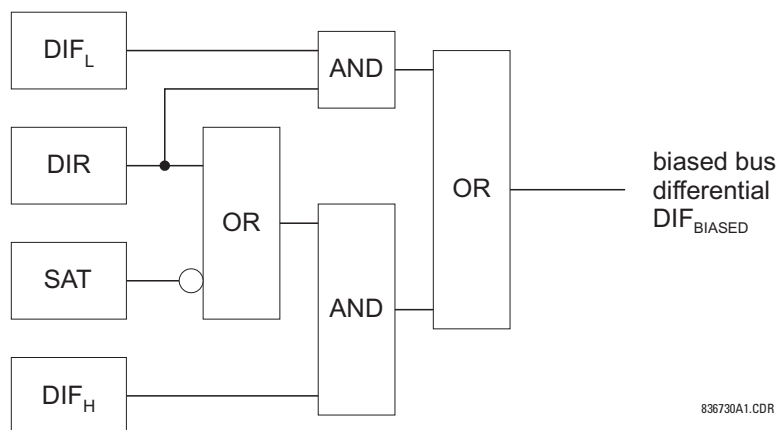
The biased differential characteristic uses the output logic shown in the following figure.

For low differential signals, the biased differential element operates on the 2-out-of-2 basis utilizing both the differential and directional principles.

For high differential signals, the directional principle is included only if demanded by the saturation detector (dynamic 1-out-of-2 / 2-out-of-2 mode). Typically, the directional principle is slower, and by avoiding using it when possible, the B90 gains speed.

The dynamic inclusion/exclusion of the directional principle is not applied for the low differential currents but is included permanently only because it is comparatively difficult to reliably detect CT saturation occurring when the currents are small, for example saturation due to extremely long time constant of the DC component or due to multiple autoreclosure actions.

Figure 9-8: Output logic of biased differential protection



9.6.2 Internal and external fault example

Two examples of relay operation are presented: an external fault with heavy CT saturation and an internal fault.

The protected bus includes six circuits connected to CT terminals F1, F5, M1, M5, U1, and U5, respectively. The circuits F1, F5, M1, M5, and U5 are capable of feeding some fault current; the U1 circuit supplies a load. The F1, F5, and U5 circuits are significantly stronger than the F5 and M1 connections.

The M5 circuit contains the weakest (most prone to saturation) CT of the bus.

The first of the following figures presents the bus currents and the most important logic signals for the case of an external fault. Despite very fast and severe CT saturation, the B90 remains stable.

The second figure presents the same signals but for the case of an internal fault. The B90 trips in 10 ms (fast form-C output contact).

Figure 9-9: External fault example

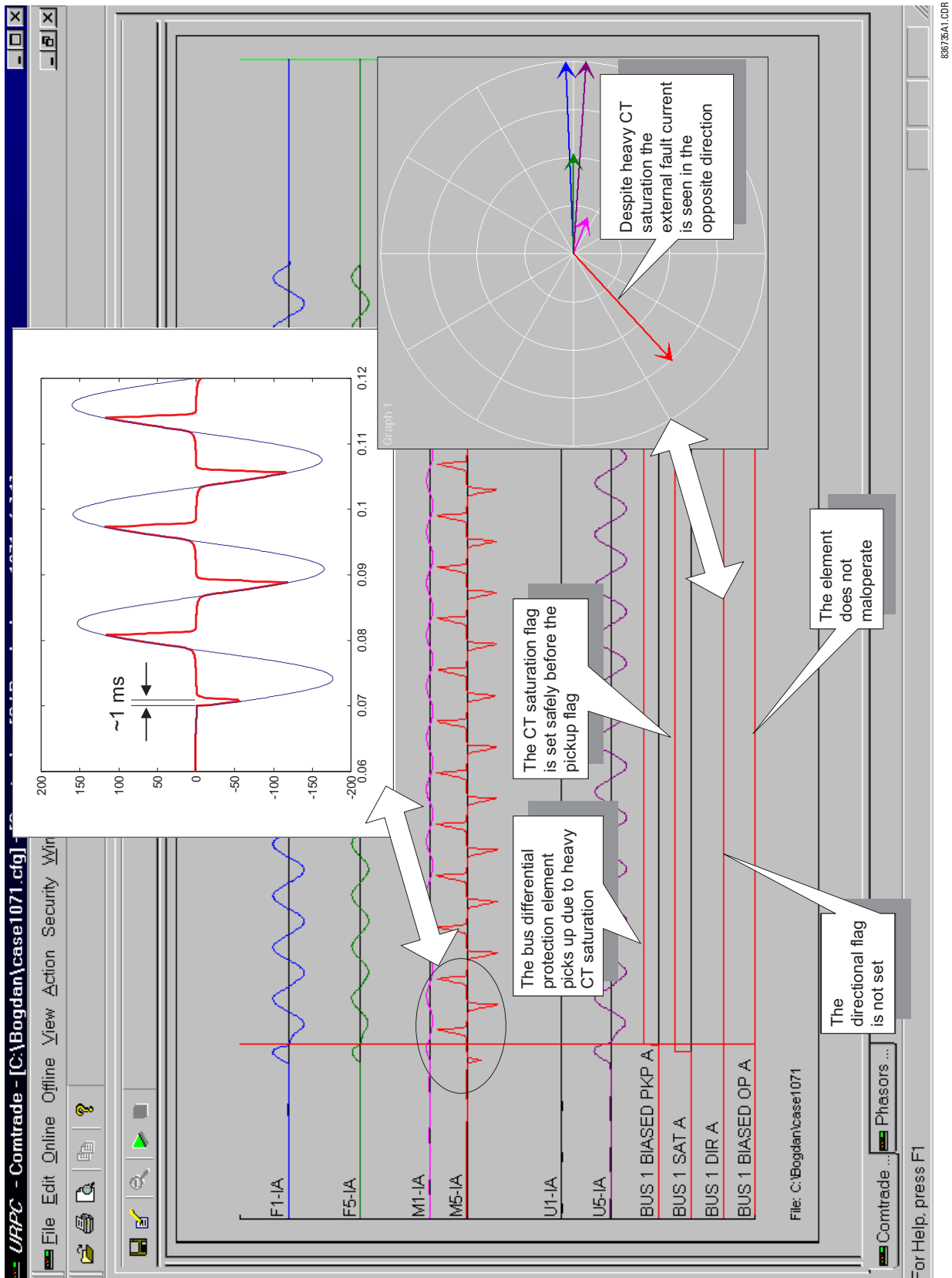
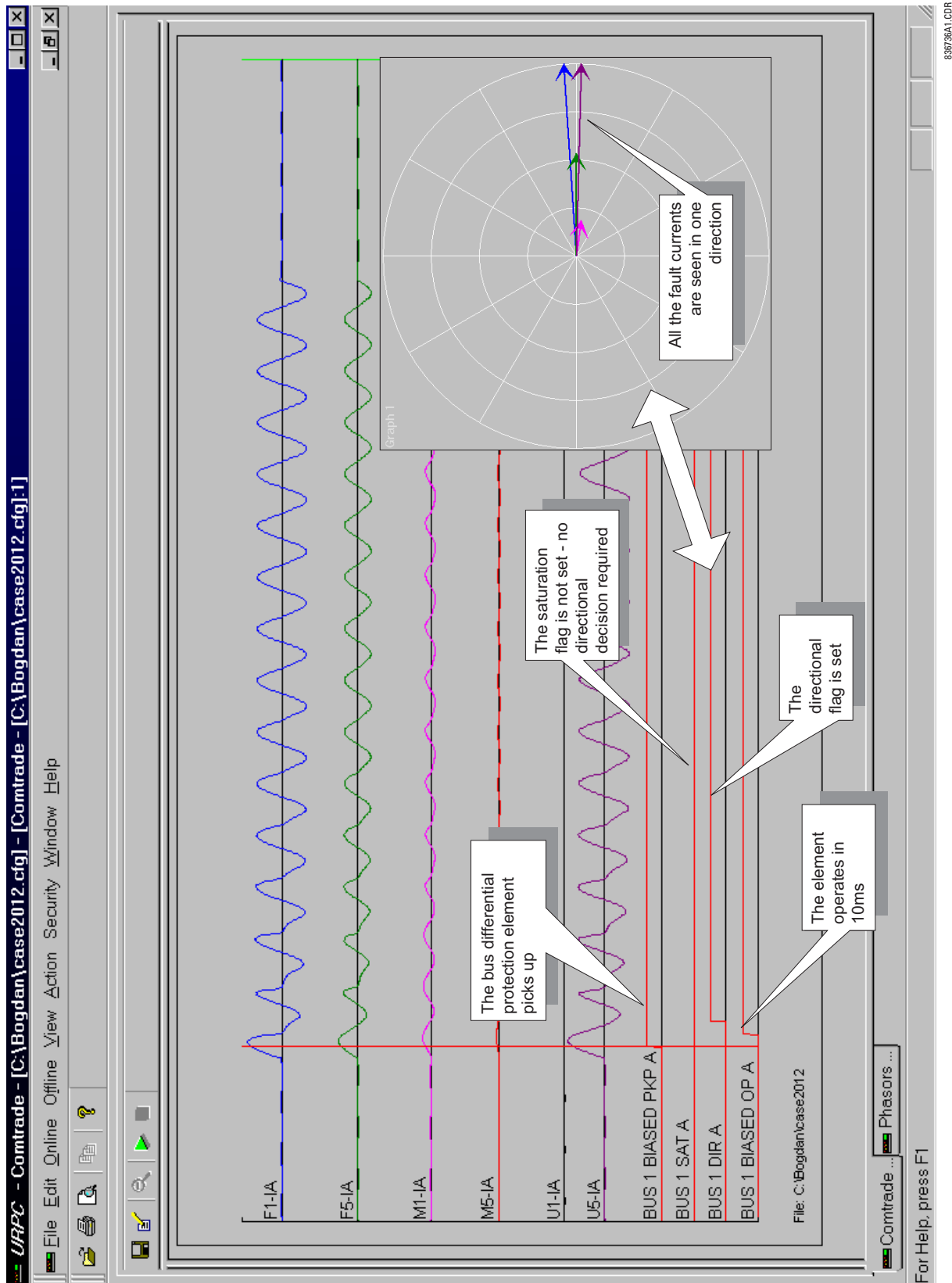


Figure 9-10: Internal fault example



B90 Low Impedance Bus Differential System

Chapter 10: Maintenance

This chapter outlines maintenance, repair, storage, and disposal of the hardware and software.

10.1 General maintenance

The B90 requires minimal maintenance. As a microprocessor-based relay, its characteristics do not change over time. Expected service life is 20 years for UR devices manufactured June 2014 or later when applied in a controlled indoors environment and electrical conditions within specification.

While the B90 performs continual self-tests, it is recommended that maintenance be scheduled with other system maintenance. This maintenance can involve in-service, out-of-service, or unscheduled maintenance.

10.1.1 In-service maintenance

1. Visual verification of the analog values integrity, such as voltage and current (in comparison to other devices on the corresponding system).
2. Visual verification of active alarms, relay display messages, and LED indications.
3. LED test.
4. Visual inspection for any damage, corrosion, dust, or loose wires.
5. Event recorder file download with further events analysis.

10.1.2 Out-of-service maintenance

1. Check wiring connections for firmness.
2. Analog values (currents, voltages, RTDs, analog inputs) injection test and metering accuracy verification. Calibrated test equipment is required.
3. Protection elements setting verification (analog values injection or visual verification of setting file entries against relay settings schedule).
4. Contact inputs and outputs verification. This test can be conducted by direct change of state forcing or as part of the system functional testing.
5. Visual inspection for any damage, corrosion, or dust.
6. Event recorder file download with further events analysis.
7. LED Test and pushbutton continuity check.

NOTICE

To avoid deterioration of electrolytic capacitors, power up units that are stored in a de-energized state once per year, for one hour continuously.

10.1.3 Unscheduled maintenance (system interruption)

1. View the event recorder and oscillography or fault report for correct operation of inputs, outputs, and elements.

10.2 Back up and restore settings

Back up a copy of the in-service settings for each commissioned UR device, so as to revert to the commissioned settings after inadvertent, unauthorized, or temporary setting changes are made, after the settings defaulted due to firmware upgrade, or when the device has to be replaced. This section describes how to backup settings to a file and how to use that file to restore the settings to the original relay or to a replacement relay.

10.2.1 Back up settings

UR device settings can be saved in a backup URS file using the EnerVista UR Setup software. The URS file is the standard UR settings file. For an introduction to settings files in the URS format, see the beginning of the Interfaces chapter. When the IEC 61850 option is present, the settings can alternatively be saved in a backup IID file either using the EnerVista UR Setup software in online mode or by using any of the supported file transfer protocols. The IID file is one of several IEC 61850 Substation Configuration Language (SCL) file types; see the IEC 61850 chapter in the UR Series Communications Guide for an introduction to SCL.

"TBD" displays when a setting in a modeled element is configured with a non-modeled operand. For example, Phase IOC is modeled in a firmware release, while the LED operands are not modeled. If the block setting of the Phase IOC is configured with LED operands, its displays as TBD in IID and CID files, the web interface, or in an MMS client.

The options that display in the EnerVista software when right-clicking depend on device options.

To save a settings file in the URS format:

1. In EnerVista, connect to the device in the Online Window area.
2. Right-click the device name in the Online Window area and select **Read Device Settings**. A window opens.
3. Select or enter a file name and location, and click the **Receive** button. A .urs file is created in the Offline Window area.

To save settings in the IID format in EnerVista:

1. In EnerVista, connect to the device in the Online Window area.
2. Right-click the device name in the Online Window area and select **Read IID File**. The option is not present when the device does not have the IEC 61850 option. A window opens when successful.
3. Select or enter a file name and location, and click the **Receive** button. A .iid file is created.

To save settings in the IID format using TFTP:

1. On a computer on the same subnetwork as the UR device, open a command window.
2. Enter

```
TFTP <IP address> GET ur.iid <destination>
```

where

<IP address> is the IP address of the UR device

ur.iid is the internal name of the IID file in the UR device

<destination> is the path and file name of the IID file. If omitted, the file is saved as ur.iid in the command window default directory.

An example is


```
TFTP 192.168.1.101 GET ur.iid Feeder1.iid
```

10.2.2 Restore settings

UR device settings can be restored to the values they were at when a URS backup file was created using the EnerVista UR Setup software. When the IEC 61850 option is present, the settings can alternatively be to the values they were at when an IID type backup was created either using the EnerVista UR Setup software in online mode or by using any of the supported file transfer protocols. Note that TFTP cannot be used here, as TFTP "put" mode is disabled for security reasons.

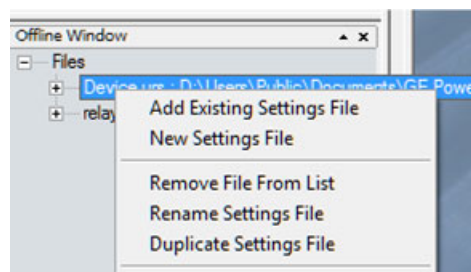
To restore completely, a few settings need to be entered manually either via EnerVista UR Setup or via the UR device front panel. If the restore operation is to be via Ethernet, first the UR device must have its IP address settings entered via the front panel. These are located at **SETTINGS** ⇒ **PRODUCT SETUP** ⇒ **COMMUNICATIONS** ⇒ **NETWORK 1(3)** and **SETTINGS** ⇒ **PRODUCT SETUP** ⇒ **COMMUNICATIONS** ⇒ **IPv4 ROUTE TABLE 1(6)** ⇒ **DEFAULT IPv4 ROUTE** ⇒ **GATEWAY ADDRESS**.

When importing a file, it cannot have a blank numeric value. All numeric values must be non-blank, otherwise the file is rejected.

To restore settings from a URS file:

1. In EnerVista, connect to the device in the Online Window area.
2. Right-click the .urs file in the Offline Window area and select **Add Existing Settings File** to locate a file, and/or drag-and-drop the file from the Offline Window area to the device in the Online Window area.

Figure 10-1: Restoring a URS settings file

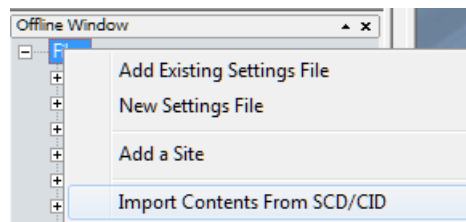


3. Manually copy the remaining settings, outlined as follows.

To restore settings from an IID file using EnerVista software:

1. In Windows, make a copy of the .iid backup file, and change the extension to .cid on the new copy.
2. In the Online Window area of the UR EnerVista Setup software, connect to the device to establish communication.
3. In the Offline Window area, right-click **Files** and select **Import Contents From SCD/CID**.

Figure 10-2: Importing a CID file



4. Navigate to and select the file with .cid extension. When prompted, enter a file name to give to an intermediate URS file. The URS file is added to the Offline Window area.
5. Drag the imported file in the Offline Window to the device in the Online Window.
6. Manually copy the remaining settings, outlined as follows.

To restore settings from an IID using SFTP:

1. Close EnerVista UR Setup software.
2. In Windows, make a copy of the .iid backup file, and change the extension to .cid on the new copy.
3. On a computer on the same subnetwork as the UR device, open an SFTP client application, such as WinSCP. Note that TFTP cannot be used here.
4. Use the device's IP address as the host name.
5. If the device has the CyberSentry option, use the User Name of "Administrator" or "Engineer," and the password programmed for the selected role. The default password is "ChangeMe1#" (without quotation marks). Log in to the device.
6. If the device does not have the CyberSentry option, use the User Name of "Setting," and the password programmed for the Setting role. The default password is "ChangeMe1#" (without quotation marks). Log in to the device.
7. Upload the backup file copy with the .cid extension. WinSCP uses drag-and-drop or copy-and-paste for this file transfer.
8. Manually copy the remaining settings, outlined as follows.

To manually copy remaining settings:

1. Settings listed in section 4.1.2 Settings Files are not transferred to the UR device with settings files. Enter them manually either via the front panel or via EnerVista UR Setup software. The values that these settings had at the time the backup was created are contained within the backup file, accessed through EnerVista UR Setup software.

10.3 Upgrade firmware

The firmware of the B90 device can be upgraded, locally or remotely, using the EnerVista software. Instructions are outlined here and in the Help file under the topic "Upgrading Firmware."

Upgrades are possible for the same release (such as 7.01 to 7.02) and from one firmware version to another (such as 7.2 to 7.3). When upgrading to another firmware version, check the release notes on the GE Multilin website for compatibility.

If you are upgrading from version 7.0 or 7.1 to 7.2 or later, some CPU modules require a new boot version. Update this first.

To upgrade the firmware:

1. If required, download the boot file and/or firmware from <http://www.gegridolutions.com/app/ViewFiles.aspx?prod=urfamily&type=7>. The boot file is a .bin file.
2. Navigate to **Settings > Product Setup > Security** and ensure that the **Remote Setting Authorized** and **Local Setting Authorized** settings are "ON." On the front panel of the device, the path is **Settings ⇒ Product Setup ⇒ Security ⇒ Dual Permission Security Access**.

If using CyberSentry security, also ensure that the relay and firmware are not locked under the **Settings > Product Setup > Security > Supervisory** settings. A Supervisor role is required for these settings.

3. In EnerVista, back up the device settings by right-clicking the device and selecting **Read Device Settings**. In the window that displays, select an existing file to overwrite, or enter a name for a new settings file and optionally a location for the new file. Click the **Receive** button to start the backup.

If an "Incompatible device order codes or versions" message displays, it means that you are trying to overwrite a file for another product. You access the **Convert Settings File** option by right-clicking the file in the **Offline Window** area at the lower left.

4. In EnerVista, navigate to **Maintenance > Update Firmware**.

First select the boot file if applicable, locating the .bin file, and proceed. Restart the device, the EnerVista software, and refresh the order code in EnerVista under the **Device Setup** button.

To update the firmware, click **Maintenance > Update Firmware**, select the firmware update by locating the file, and proceed with the update.

When asked if upgrading over the Internet, the difference is the flash memory buffer size each time the software sends data to the relay. Yes means that the flash memory buffer size is 256 bytes. No means that it is 1024 bytes, which is faster.

If an "Unable to put relay in flash mode" message displays, set the **Settings > Product Setup > Security > Dual Permission Security Access > Remote Setting Authorized** and **Local Setting Authorized** settings to "ON" and try again.

When the update is finished, restart the device by clicking **Maintenance > Reboot Relay Command**, restart the EnerVista software, and refresh the order code in EnerVista under the **Device Setup** button. As the device is starting up, verify the boot and firmware version, or in EnerVista check them under **Actual Values > Product Info > Firmware Revisions**. The boot version is not the same as the firmware revision, and the firmware revision reflects the UR release, for example firmware revision 7.3 is UR release 7.3.

5. Set the device to "programmed" under **Settings > Product Setup > Installation**.
6. If you changed the **Remote Setting Authorized**, the **Local Setting Authorized** settings, or relay lock settings, return them to their previous settings.
7. To apply any previously saved settings, right-click the saved settings file in the **Offline Window** area and select **Write to Device**.



NOTE

Modbus addresses assigned to firmware modules, features, settings, and corresponding data items (that is, default values, minimum/maximum values, data type, and item size) can 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.

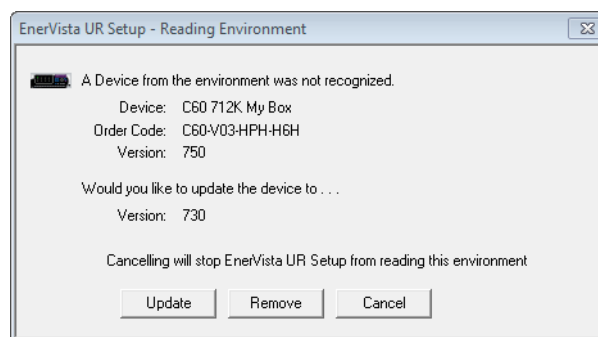
10.4 Upgrade software

The latest EnerVista software and firmware can be downloaded from <http://www.gegridsolutions.com/app/ViewFiles.aspx?prod=urfamily&type=7>

After upgrading, check the version number under **Help > About**. If the new version does not display, try uninstalling the software and reinstalling the new versions.

A message can display in the EnerVista software upon launch that "a device from the environment was not recognized." This means that a device is online and its firmware version conflicts with the software version. In the example shown, a C60 with firmware version 7.5x is online, but the software version is 7.3x. Updating removed incompatible files and changes the device to version 7.3x, after which you need to make the order codes consistent as outlined next.

Figure 10-3: Mismatch in order code between software and device



To make the order codes consistent:

1. In EnerVista, click the **Device Setup** button. The window opens.

2. Expand the entry for the UR device.
3. Click the **Read Order Code** button. The order code and version of the device are populated to the software.
4. Click the **OK** button to save the change.

10.5 Replace module

This section outlines how to replace a module.

WARNING

Withdraw or insert a module only when control power has been removed from the unit, and be sure to insert only the correct module type into a slot, else personal injury, damage to the unit or connected equipment, or undesired operation can result.

NOTICE

To avoid damage to the equipment, use proper electrostatic discharge protection (for example, a static strap) 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. Replace modules only with like modules in their original factory configured slots.

To replace a module:

1. Open the enhanced faceplate to the left once the thumb screw has been removed. This allows for easy access of the modules for withdrawal. The new wide-angle hinge assembly in the enhanced front panel opens completely and allows easy access to all modules in the B90.

Figure 10-4: Modules inside relay with front cover open (enhanced faceplate)



842812A1.CDR

The basic faceplate can be opened to the left once the black plastic sliding latch on the right side has been pushed up, as shown below.

Figure 10-5: Removing module (basic faceplate)



842760A1.CDR

2. With power to the unit off, disconnect individually the connections at the front and back of the module before removing the module from the chassis.
For any Process Card/process bus module in slot H for use with a HardFiber Brick, also remove the two screws at the back that attach the module to the chassis.
3. To properly remove a module, pull simultaneously the ejector/inserters clips, located at the top and bottom of the module. Record the original location of the module to ensure that the same or replacement module is inserted into the correct slot. While modules with current input provide automatic shorting of external CT circuits, for CT/VT modules it is recommended to short/isolate external circuits accordingly for maximum safety.
4. To properly insert a module, ensure that the correct module type is inserted into the correct slot position. The ejector/inserters 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 is fully inserted.



The new CT/VT modules can only be used with new CPUs; similarly, old CT/VT modules can only be used with old CPUs. In the event that there is a mismatch between the CPU and CT/VT module, the relay does not function and a DSP ERROR or HARDWARE MISMATCH error displays.

10.6 Battery

A battery powers the real time clock on startup of the device.

When required, the battery can be replaced. The battery type is 3 V cylindrical.

The power supply module contains the battery. The power supply modules were upgraded in 2014 to SH/SL from RH/RL, but the order code when purchasing a UR with redundant power supply remained as RH/RL so that customers can continue to use the same order codes. The order code can read RH or RL, while the module inside the unit reads SH or SL. The order code for replacement redundant power supply modules was changed to SH/SL. To determine which procedure to use, see the power supply module or use the photographs here.

10.6.1 Replace battery for RH/RL power supply

When required, the battery can be replaced. The power supply module contains the battery.



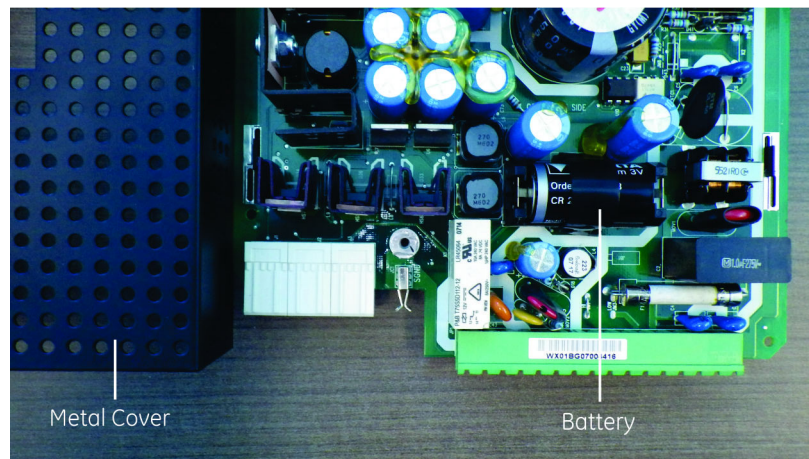
To avoid injury, ensure that the unit has been powered off for a minimum of three minutes before replacing the battery.

Risk of fire if battery is replaced with incorrect type or polarity.

To replace the battery:

1. Turn off the power to the unit.
2. Wait a minimum of three minutes to ensure that there is no power to the battery.
3. As outlined in the previous section, open the unit by sliding up the plastic latch on the right side of the front panel (basic front panel) or unscrewing the panel (enhanced front panel).
4. For the basic front panel, it needs to be removed in order to access the power supply module, which is typically in the first slot on the left side and blocked by the hinge of the front panel. To remove the front panel, unscrew its bracket on the front left side of the unit.
5. Simultaneously pull the ejector clips at the top and bottom of the power supply module and remove the module.
6. Unscrew the screw that attaches the metal cover to the module.
7. Slide the metal cover away from the clips about 1 cm (1/4 inch) and remove the cover.
8. Unclip the black plastic holder that keeps the battery in place. The plastic clips into the socket at the bottom on both sides. Use a flat-head screwdriver if you cannot unclip the plastic with your fingers.
9. Observe the + and - polarity of the battery and replace it with the same polarity as marked on the battery holder. Replace the battery with the identical make and model. For example, do not use a rechargeable battery.

Figure 10-6: Battery location on RH/RL power supply module



859718A1.cdr

10. Reinstall the battery clip and the metal cover, and reinsert the power supply module into the unit.
11. Power on the unit.
12. Dispose of the old battery as outlined in the next section.

10.6.2 Replace battery for SH/SL power supply

When required, the battery can be replaced. The power supply module contains the battery.



To avoid injury, ensure that the unit has been powered off for a minimum of three minutes before replacing the battery.

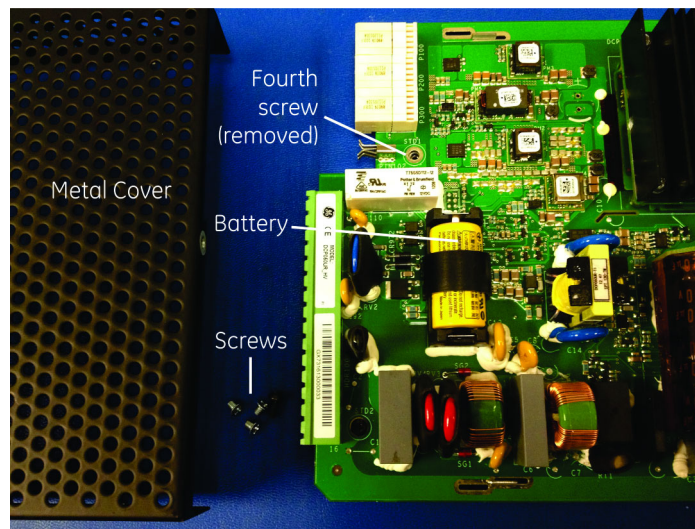
Risk of fire if battery is replaced with incorrect type or polarity.

To replace the battery:

1. Turn off the power to the unit.

2. Wait a minimum of three minutes to ensure that there is no power to the battery.
3. As outlined in the previous section, open the unit by sliding up the plastic latch on the right side of the front panel (basic front panel) or unscrewing the panel (enhanced front panel).
4. For the basic front panel, it needs to be removed in order to access the power supply module, which is typically in the first slot on the left side and blocked by the hinge of the front panel. To remove the front panel, unscrew the bracket on the left side of the unit.
5. Remove the power supply module by simultaneously pulling the ejector clips at the top and bottom of the module and sliding it out.
6. Unscrew all four screws (not three) that attach the metal cover to the module. The fourth screw is at the back end of the module, on the opposite side from the clips, beside the white electronics part (see figure).
7. Slide the metal cover away from the clips about 0.5 cm (1/8 inch) and remove the cover.
8. Unclip the black plastic holder that keeps the battery in place. The plastic clips into the socket at the bottom on both sides—pull the plastic away from the battery. Use a flat-head screwdriver if you cannot unclip the plastic with your fingers.
9. Replace the battery with the identical make and model. For example, do not use a rechargeable battery. Observe the + and - polarity of the battery and replace it with the same polarity as marked on the battery holder.

Figure 10-7: Battery location on SH/SL power supply module



859717A1.cdr

10. Reinstall the battery holder and the metal cover, and reinsert the power supply module into the unit.
11. Power on the unit.
12. Dispose of the old battery as outlined in the next section.

10.6.3 Dispose of battery



10.6.3.1 EN Battery disposal

This product contains a battery that cannot be disposed of as unsorted municipal waste in the European Union. See the product documentation for specific battery information. The battery is marked with this symbol, which may include lettering to indicate cadmium (Cd), lead (Pb), or mercury (Hg). For proper recycling return the battery to your supplier or to a designated collection point. For more information see: www.recyclethis.info.

10.6.3.2 CS Nakládání s bateriemi

Tento produkt obsahuje baterie, které nemohou být zneškodněny v Evropské unii jako netříděný komunální odpad. Viz dokumentace k produktu pro informace pro konkrétní baterie. Baterie je označena tímto symbolem, který může zahrnovat i uvedena písmena, kadmium (Cd), olovo (Pb), nebo rtuť (Hg). Pro správnou recyklaci baterií vraťte svémudodavateli nebo na určeném sběrném místě. Pro více informací viz: www.recyclethis.info.

10.6.3.3 DA Batteri affald

Dette produkt indeholder et batteri som ikke kan bortskaffes sammen med almindeligt husholdningsaffald i Europa. Se produktinformation for specifikke informationer om batteriet. Batteriet er forsynet med indgraveret symboler for hvad batteriet indeholder: kadmium (Cd), bly (Pb) og kviksølv (Hg). Europæiske brugere af elektrisk udstyr skal aflevere kasserede produkter til genbrug eller til leverandøren. Yderligere oplysninger findes på webstedet www.recyclethis.info.

10.6.3.4 DE Entsorgung von Batterien

Dieses Produkt beinhaltet eine Batterie, die nicht als unsortierter städtischer Abfall in der europäischen Union entsorgt werden darf. Beachten Sie die spezifischen Batterie-Informationen in der Produktdokumentation. Die Batterie ist mit diesem Symbol gekennzeichnet, welches auch Hinweise auf möglicherweise enthaltene Stoffe wie Kadmium (Cd), Blei (Pb) oder Quecksilber (Hektogramm) darstellt. Für die korrekte Wiederverwertung bringen Sie diese Batterie zu Ihrem lokalen Lieferanten zurück oder entsorgen Sie das Produkt an den gekennzeichneten Sammelstellen. Weitere Informationen hierzu finden Sie auf der folgenden Website: www.recyclethis.info.

10.6.3.5 EL Απόρριψη μπαταριών

Αυτό το προϊόν περιέχει μια μπαταρία που δεν πρέπει να απορρίπτεται σε δημόσια συστήματα απόρριψης στην Ευρωπαϊκή Κοινότητα. Δείτε την τεκμηρίωση του προϊόντος για συγκεκριμένες πληροφορίες που αφορούν τη μπαταρία. Η μπαταρία είναι φέρει σήμανση με αυτό το σύμβολο, το οποίο μπορεί να περιλαμβάνει γράμματα για να δηλώσουν το κάδμιο (Cd), τον μόλυβδο (Pb), ή τον υδράργυρο (Hg). Για την κατάλληλη ανακύκλωση επιστρέψτε την μπαταρία στον προμηθευτή σας ή σε καθορισμένο σημείο συλλογής. Για περισσότερες πληροφορίες δείτε: www.recyclethis.info.

10.6.3.6 ES Eliminacion de baterias

Este producto contiene una batería que no se pueda eliminar como basura normal sin clasificar en la Unión Europea. Examine la documentación del producto para la información específica de la batería. La batería se marca con este símbolo, que puede incluir siglas para indicar el cadmio (Cd), el plomo (Pb), o el mercurio (Hg). Para el reciclaje apropiado, devuelva este producto a su distribuidor ó deshágase de él en los puntos de reciclaje designados. Para mas información : www.recyclethis.info.

10.6.3.7 ET Patareide kõrvaldamine

Käesolev toode sisaldab patareisid, mida Euroopa Liidus ei tohi kõrvaldada sorteerimata olmejäätmetena. Andmeid patareide kohta vaadake toote dokumentatsioonist. Patareid on märgistatud käesoleva sümboliga, millel võib olla kaadmiumi (Cd), pliid (Pb) või elavhõbedat (Hg) tähistavad tähed. Nõuetekohaseks ringlusse võtmiseks tagastage patarei tarnijale või kindlaksmääratud vastuvõtupunkti. Lisainformatsiooni saab Internetist aadressil: www.recyclethis.info.

10.6.3.8 FI Paristoje ja akkujen hävittäminen

Tuote sisältää pariston, jota ei saa hävittää Euroopan Unionin alueella talousjätteen mukana. Tarkista tuoteselosteesta tuotteen tiedot. Paristo on merkitty tällä symbolilla ja saattaa sisältää kadmiumia (Cd), lyijyä (Pb) tai elohopeaa (Hg). Oikean kierrätystavan varmistamiseksi palauta tuote paikalliselle jälleenmyyjälle tai palauta se paristojen keräyspisteeseen. Lisätietoja sivuilla www.recyclethis.info.

10.6.3.9 FR Élimination des piles

Ce produit contient une batterie qui ne peuvent être éliminés comme déchets municipaux non triés dans l'Union européenne. Voir la documentation du produit au niveau des renseignements sur la pile. La batterie est marqué de ce symbole, qui comprennent les indications cadmium (Cd), plomb (Pb), ou mercure (Hg). Pour le recyclage, retourner la batterie à votre fournisseur ou à un point de collecte. Pour plus d'informations, voir: www.recyclethis.info.

10.6.3.10 HU Akkumulátor hulladék kezelése

Ezen termék akkumulátort tartalmaz, amely az Európai Unió belül csak a kijelölt módon és helyen dobható ki. A termékben illetve a mellékelt ismertetőn olvasható a kadmium (Cd), ólom (Pb) vagy higany (Hg) tartalomra utaló betűjelzés. A hulladék akkumulátor leadható a termék forgalmazójánál új akkumulátor vásárlásakor, vagy a kijelölt elektronikai hulladékdudvarokban. További információ a www.recyclethis.info oldalon.

10.6.3.11 IT Smaltimento batterie

Questo prodotto contiene una batteria che non può essere smaltita nei comuni contenitori per lo smaltimento rifiuti, nell'Unione Europea. Controllate la documentazione del prodotto per le informazioni specifiche sulla batteria. La batteria è contrassegnata con questo simbolo e può includere alcuni caratteri ad indicare la presenza di cadmio (Cd), piombo (Pb) oppure mercurio (Hg). Per il corretto smaltimento, potete restituirli al vostro fornitore locale, oppure rivolgervi e consegnarli presso i centri di raccolta preposti. Per maggiori informazioni vedere: www.recyclethis.info.

10.6.3.12 LT Baterijų šalinimas

Šios įrangos sudėtyje yra baterijų, kurias draudžiama šalinti Europos Sąjungos viešose nerūšiuotų atliekų šalinimo sistemose. Informaciją apie baterijas galite rasti įrangos techninėje dokumentacijoje. Baterijos žymimos šiuo simboliu, papildomai gali būti nurodoma kad baterijų sudėtyje yra kadmio (Cd), švino (Pb) ar gyvsidabrio (Hg). Eksploatavimui nebetinkamas baterijas pristatykite į tam skirtas surinkimo vietas arba grąžinkite jas tiesioginiam tiekėjui, kad jos būtų tinkamai utilizuotos. Daugiau informacijos rasite šioje interneto svetainėje: www.recyclethis.info.

10.6.3.13 LV Bateriju likvidēšana

Šis produkts satur bateriju vai akumulatoru, kuru nedrīkst izmest Eiropas Savienībā esošajās sadzīves atkritumu sistēmās. Sk. produkta dokumentācijā, kur ir norādīta konkrēta informācija par bateriju vai akumulatoru. Baterijas vai akumulatora marķējumā ir šis simbols, kas var ietvert burtus, kuri norāda kadmiju (Cd), svīnu (Pb) vai dzīvsudrabu (Hg). Pēc ekspluatācijas laika beigām baterijas vai akumulatori jānodod piegādātājam vai specializētā bateriju savākšanas vietā. Sīkāku informāciju var iegūt vietnē: www.recyclethis.info.

10.6.3.14 NL Verwijderen van batterijen

Dit product bevat een batterij welke niet kan verwijderd worden via de gemeentelijke huisvuilscheiding in de Europese Gemeenschap. Gelieve de product documentatie te controleren voor specifieke batterij informatie. De batterijen met deze label kunnen volgende indicaties bevatten cadium (Cd), lood (Pb) of kwik (Hg). Voor correcte vorm van kringloop, geef je de producten terug aan jou locale leverancier of geef het af aan een gespecialiseerde verzamelpunt. Meer informatie vindt u op de volgende website: www.recyclethis.info.

10.6.3.15 NO Retur av batteri

Dette produkt inneholder et batteri som ikke kan kastes med usortert kommunalt søppel i den Europeiske Unionen. Se produktdokumentasjonen for spesifikk batteriinformasjon. Batteriet er merket med dette symbolet som kan inkludere symboler for å indikere at kadmium (Cd), bly (Pb), eller kvikksølv (Hg) forekommer. Returner batteriet til leverandøren din eller til et dedikert oppsamlingspunkt for korrekt gjenvinning. For mer informasjon se: www.recyclethis.info.

10.6.3.16 PL Pozbywanie się zużytych baterii

Ten produkt zawiera baterie, które w Unii Europejskiej mogą być usuwane tylko jako posegregowane odpady komunalne. Dokładne informacje dotyczące użytych baterii znajdują się w dokumentacji produktu. Baterie oznaczone tym symbolem mogą zawierać dodatkowe oznaczenia literowe wskazujące na zawartość kadmu (Cd), ołowiu (Pb) lub rtęci (Hg). Dla zapewnienia właściwej utylizacji, należy zwrócić baterie do dostawcy albo do wyznaczonego punktu zbiórki. Więcej informacji można znaleźć na stronie internetowej www.recyclethis.info.

10.6.3.17 PT Eliminação de Baterias

Este produto contém uma bateria que não pode ser considerado lixo municipal na União Europeia. Consulte a documentação do produto para obter informação específica da bateria. A bateria é identificada por meio de este símbolo, que pode incluir a rotulagem para indicar o cádmio (Cd), chumbo (Pb), ou o mercúrio (Hg). Para uma reciclagem apropriada envie a bateria para o seu fornecedor ou para um ponto de recolha designado. Para mais informação veja: www.recyclethis.info.

10.6.3.18 RU Утилизация батарей

Согласно европейской директиве об отходах электрического и электронного оборудования, продукты, содержащие батареи, нельзя утилизировать как обычные отходы на территории ЕС. Более подробную информацию вы найдете в документации к продукту. На этом символе могут присутствовать буквы, которые означают, что батарея содержит кадмий (Cd), свинец (Pb) или ртуть (Hg). Для надлежащей утилизации по окончании срока эксплуатации пользователь должен вернуть батареи локальному поставщику или сдать в специальный пункт приема. Подробности можно найти на веб-сайте: www.recyclethis.info.

10.6.3.19 SK Zaobchádzanie s batériami

Tento produkt obsahuje batériu, s ktorou sa v Európskej únii nesmie nakladať ako s netriedeným komunálnym odpadom. Dokumentácia k produktu obsahuje špecifické informácie o batérii. Batéria je označená týmto symbolom, ktorý môže obsahovať písmená na označenie kadmia (Cd), olova (Pb), alebo ortuti (Hg). Na správnu recykláciu vráťte batériu vášmu lokálnemu dodávateľovi alebo na určené zberné miesto. Pre viac informácií pozrite: www.recyclethis.info.

10.6.3.20 SL Odlaganje baterij

Ta izdelek vsebuje baterijo, ki je v Evropski uniji ni dovoljeno odstranjevati kot nesortiran komunalni odpad. Za posebne informacije o bateriji glejte dokumentacijo izdelka. Baterija je označena s tem simbolom, ki lahko vključuje napise, ki označujejo kadmij (Cd), svinec (Pb) ali živo srebro (Hg). Za ustrezno recikliranje baterijo vrnite dobavitelju ali jo odstranite na določenem zbirališču. Za več informacij obiščite spletno stran: www.recyclethis.info.

10.6.3.21 SV Kassering av batteri

Denna produkt innehåller ett batteri som inte får kastas i allmänna sophanteringssystem inom den europeiska unionen. Se produktdokumentationen för specifik batteriinformation. Batteriet är märkt med denna symbol, vilket kan innebära att det innehåller kadmium (Cd), bly (Pb) eller kvicksilver (Hg). För korrekt återvinning skall batteriet returneras till leverantören eller till en därför avsedd deponering. För mer information, se: www.recyclethis.info.

10.6.3.22 TR Pil Geri Dönüşümü

Bu ürün Avrupa Birliği genel atık sistemlerine atılmaması gereken pil içermektedir. Daha detaylı pil bilgisi için ürünün kataloğunu inceleyiniz. Bu sembolle işaretlenmiş piller Kadmiyum(Cd), Kurşun(Pb) ya da Civa(Hg) içerebilir. Doğru geri dönüşüm için ürünü yerel tedarikçinize geri veriniz ya da özel işaretlenmiş toplama noktalarına atınız. Daha fazla bilgi için: www.recyclethis.info.

10.6.3.23 Global contacts

North America	905-294-6222
Latin America	+55 11 3614 1700
Europe, Middle East, Africa	+(34) 94 485 88 00
Asia	+86-21-2401-3208
India	+91 80 41314617

From GE Part Number 1604-0021-A1, GE Publication Number GEK-113574

10.7 Clear files and data after uninstall

The unit can be decommissioned by turning off power to the unit and disconnecting the wires to it.

To clear files and settings in the UR:

1. On the UR front panel, navigate to **COMMANDS** ⇒ **RELAY MAINTENANCE** ⇒ **SERVICE COMMAND**, enter the value 20511, and press the **ENTER** key. The relay restarts and clears the UR.
2. Clear the flash memory using the **SETTINGS** ⇒ **PRODUCT SETUP** ⇒ **CLEAR RELAY RECORDS** command.

To clear files and settings on the computer:

1. Uninstall the EnerVista UR Setup software.
2. Find and delete the following UR files:
 - .URS, .CID, and .ICD settings
 - .EVT event records
 - .CFG and .DAT COMTRADE

10.8 Repairs

The battery and modules inside the case can be replaced without return of the device to the factory. The firmware and software can be upgraded without return of the device to the factory.

Fuses in the power supply module are not field-replaceable.

Files can be requested for use by technical support staff, for example the Service Report (click the icon in the software) or under **Maintenance > Retrieve File**, as outlined elsewhere in this document.

For issues not solved by troubleshooting, the process to return the device to the factory for repair is as follows:

- Contact a GE Grid Solutions Technical Support Center. Contact information is found in the first chapter.
- Obtain a Return Materials Authorization (RMA) number from the Technical Support Center.
- Verify that the RMA and Commercial Invoice received have the correct information.
- Tightly pack the unit in a box with bubble wrap, foam material, or styrofoam inserts or packaging peanuts to cushion the item(s). You may also use double boxing whereby you place the box in a larger box that contains at least 5 cm of cushioning material.
- Ship the unit by courier or freight forwarder, along with the Commercial Invoice and RMA, to the factory.

GE GRID SOLUTIONS
650 MARKLAND STREET
MARKHAM, ONTARIO
CANADA L6C 0M1
ATTN: SERVICE DEPT.

RMA# : _____

Customers are responsible for shipping costs to the factory, regardless of whether the unit is under warranty.

- Fax a copy of the shipping information to the GE Grid Solutions service department in Canada at +1 905 927 5098.

Use the detailed return procedure outlined at

https://www.gegridsolutions.com/multilin/support/ret_proc.htm

The current warranty and return information are outlined at

<https://www.gegridsolutions.com/multilin/warranty.htm>

10.9 Storage

Store the unit indoors in a cool, dry place. If possible, store in the original packaging. Follow the storage temperature range outlined in the Specifications.

NOTICE

To avoid deterioration of electrolytic capacitors, power up units that are stored in a de-energized state once per year, for one hour continuously.

10.10 Disposal

Other than the battery, there are no special requirements for disposal of the unit at the end its service life. For customers located in the European Union, dispose of the battery as outlined earlier. To prevent non-intended use of the unit, remove the modules as outlined earlier, dismantle the unit, and recycle the metal when possible.

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Appendix A: FlexAnalog operands

This appendix outlines FlexAnalog parameters.

A.1 FlexAnalog items

A FlexAnalog parameter is an analog parameter.

FlexAnalog items are also viewable in a web browser. Enter the IP address of the UR, access the **Device Information Menu** option, then the **FlexAnalog Parameter Listing** option. Entries displayed online depend on order code.



The following addresses are given for the maximum number of physical channels. For example, if there are 7 CT channels in the CT/VT module, that address 28437 corresponds to the "L1 Current Mag" value.

Table A-1: FlexAnalog data items

Decimal address	FlexAnalog name	Units	Description
8656	Bus 1 Diff Mag	Amps	B90 bus zone DMag
8660	Bus 1 Diff Angle	Degrees	B90 bus zone diff angle
8661	Bus 1 Rest Mag	Amps	B90 bus zone restraint RMag
8663	Bus 1 Rest Angle	Degrees	B90 bus zone rest angle
8664	Bus 1 Max CT	Amps	B90 bus max CT
9493	Bus Max CT Primary	Amps	Bus maximum CT primary
12306	Oscill Num Triggers	---	Oscillography number of triggers
14189	PTP-IRIG-B Delta	ns	PTP time minus IRIG-B time
24432	Communications Group	---	Groups communications group
24447	Active Setting Group	---	Current setting group
28416	F1 Curr Mag	Amps	Terminal 1 current magnitude
28418	F1 Curr Ang	Degrees	Terminal 1 current angle
28419	F2 Curr Mag	Amps	Terminal 2 current magnitude
28421	F2 Curr Ang	Degrees	Terminal 2 current angle
28422	F3 Curr Mag	Amps	Terminal 3 current magnitude
28424	F3 Curr Ang	Degrees	Terminal 3 current angle

A

Decimal address	FlexAnalog name	Units	Description
28425	F4 Curr Mag	Amps	Terminal 4 current magnitude
28427	F4 Curr Ang	Degrees	Terminal 4 current angle
28428	F5 Curr Mag	Amps	Terminal 5 current magnitude
28430	F5 Curr Ang	Degrees	Terminal 5 current angle
28431	F6 Curr Mag	Amps	Terminal 6 current magnitude
28433	F6 Curr Ang	Degrees	Terminal 6 current angle
28434	F7 Curr Mag	Amps	Terminal 7 current magnitude
28436	F7 Curr Ang	Degrees	Terminal 7 current angle
28437	F8 Curr Mag	Amps	Terminal 8 current magnitude
28439	F8 Curr Ang	Degrees	Terminal 8 current angle
28440	L1 Curr Mag	Amps	Terminal 9 current magnitude
28442	L1 Curr Ang	Degrees	Terminal 9 current angle
28443	L2 Curr Mag	Amps	Terminal 10 current magnitude
28445	L2 Curr Ang	Degrees	Terminal 10 current angle
28446	L3 Curr Mag	Amps	Terminal 11 current magnitude
28448	L3 Curr Ang	Degrees	Terminal 11 current angle
28449	L4 Curr Mag	Amps	Terminal 12 current magnitude
28451	L4 Curr Ang	Degrees	Terminal 12 current angle
28452	L5 Curr Mag	Amps	Terminal 13 current magnitude
28454	L5 Curr Ang	Degrees	Terminal 13 current angle
28455	L6 Curr Mag	Amps	Terminal 14 current magnitude
28457	L6 Curr Ang	Degrees	Terminal 14 current angle
28458	L7 Curr Mag	Amps	Terminal 15 current magnitude
28460	L7 Curr Ang	Degrees	Terminal 15 current angle
28461	L8 Curr Mag	Amps	Terminal 16 current magnitude
28463	L8 Curr Ang	Degrees	Terminal 16 current angle
28464	S1 Curr Mag	Amps	Terminal 17 current magnitude
28466	S1 Curr Ang	Degrees	Terminal 17 current angle
28467	S2 Curr Mag	Amps	Terminal 18 current magnitude
28469	S2 Curr Ang	Degrees	Terminal 18 current angle
28470	S3 Curr Mag	Amps	Terminal 19 current magnitude
28472	S3 Curr Ang	Degrees	Terminal 19 current angle
28473	S4 Curr Mag	Amps	Terminal 20 current magnitude
28475	S4 Curr Ang	Degrees	Terminal 20 current angle
28476	S5 Curr Mag	Amps	Terminal 21 current magnitude
28478	S5 Curr Ang	Degrees	Terminal 21 current angle
28479	S6 Curr Mag	Amps	Terminal 22 current magnitude
28481	S6 Curr Ang	Degrees	Terminal 22 current angle
28482	S7 Curr Mag	Amps	Terminal 23 current magnitude
28484	S7 Curr Ang	Degrees	Terminal 23 current angle
28485	S8 Curr Mag	Amps	Terminal 24 current magnitude
28487	S8 Curr Ang	Degrees	Terminal 24 current angle
28488	F1 Volt Mag	Volts	Terminal 1 voltage magnitude
28490	F1 Volt Ang	Degrees	Terminal 1 voltage angle
28491	F2 Volt Mag	Volts	Terminal 2 voltage magnitude
28493	F2 Volt Ang	Degrees	Terminal 2 voltage angle

Decimal address	FlexAnalog name	Units	Description
28494	F3 Volt Mag	Volts	Terminal 3 voltage magnitude
28496	F3 Volt Ang	Degrees	Terminal 3 voltage angle
28497	F4 Volt Mag	Volts	Terminal 4 voltage magnitude
28499	F4 Volt Ang	Degrees	Terminal 4 voltage angle
28500	L1 Volt Mag	Volts	Terminal 5 voltage magnitude
28502	L1 Volt Ang	Degrees	Terminal 5 voltage angle
28503	L2 Volt Mag	Volts	Terminal 6 voltage magnitude
28505	L2 Volt Ang	Degrees	Terminal 6 voltage angle
28506	L3 Volt Mag	Volts	Terminal 7 voltage magnitude
28508	L3 Volt Ang	Degrees	Terminal 7 voltage angle
28509	L4 Volt Mag	Volts	Terminal 8 voltage magnitude
28511	L4 Volt Ang	Degrees	Terminal 8 voltage angle
28512	S1 Volt Mag	Volts	Terminal 9 voltage magnitude
28514	S1 Volt Ang	Degrees	Terminal 9 voltage angle
28515	S2 Volt Mag	Volts	Terminal 10 voltage magnitude
28517	S2 Volt Ang	Degrees	Terminal 10 voltage angle
28518	S3 Volt Mag	Volts	Terminal 11 voltage magnitude
28520	S3 Volt Ang	Degrees	Terminal 11 voltage angle
28521	S4 Volt Mag	Volts	Terminal 12 voltage magnitude
28523	S4 Volt Ang	Degrees	Terminal 12 voltage angle
28624	System Frequency	Hz	Terminal frequency
28625	Tracking Frequency	Hz	Terminal tracking frequency
32768	Tracking Frequency	Hz	Tracking frequency
45584	RxGOOSE Analog1	---	RxGOOSE analog input 1
45586	RxGOOSE Analog2	---	RxGOOSE analog input 2
45588	RxGOOSE Analog3	---	RxGOOSE analog input 3
45590	RxGOOSE Analog4	---	RxGOOSE analog input 4
45592	RxGOOSE Analog5	---	RxGOOSE analog input 5
45594	RxGOOSE Analog6	---	RxGOOSE analog input 6
45596	RxGOOSE Analog7	---	RxGOOSE analog input 7
45598	RxGOOSE Analog8	---	RxGOOSE analog input 8
45600	RxGOOSE Analog9	---	RxGOOSE analog input 9
45602	RxGOOSE Analog10	---	RxGOOSE analog input 10
45604	RxGOOSE Analog11	---	RxGOOSE analog input 11
45606	RxGOOSE Analog12	---	RxGOOSE analog input 12
45608	RxGOOSE Analog13	---	RxGOOSE analog input 13
45610	RxGOOSE Analog14	---	RxGOOSE analog input 14
45612	RxGOOSE Analog15	---	RxGOOSE analog input 15
45614	RxGOOSE Analog16	---	RxGOOSE analog input 16
45616	RxGOOSE Analog17	---	RxGOOSE analog input 17
45618	RxGOOSE Analog18	---	RxGOOSE analog input 18
45620	RxGOOSE Analog19	---	RxGOOSE analog input 19
45622	RxGOOSE Analog20	---	RxGOOSE analog input 20
45624	RxGOOSE Analog21	---	RxGOOSE analog input 21
45626	RxGOOSE Analog22	---	RxGOOSE analog input 22
45628	RxGOOSE Analog23	---	RxGOOSE analog input 23

A

Decimal address	FlexAnalog name	Units	Description
45630	RxGOOSE Analog24	---	RxGOOSE analog input 24
45632	RxGOOSE Analog25	---	RxGOOSE analog input 25
45634	RxGOOSE Analog26	---	RxGOOSE analog input 26
45636	RxGOOSE Analog27	---	RxGOOSE analog input 27
45638	RxGOOSE Analog28	---	RxGOOSE analog input 28
45640	RxGOOSE Analog29	---	RxGOOSE analog input 29
45642	RxGOOSE Analog30	---	RxGOOSE analog input 30
45644	RxGOOSE Analog31	---	RxGOOSE analog input 31
45646	RxGOOSE Analog32	---	RxGOOSE analog input 32
63634	Bus 1 M_Id	---	B90 Bus M_Id
63636	Bus 1 M_Ir	---	B90 Bus M_Ir
63638	Bus 1 d_Ir	---	B90 Bus d_Ir

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Appendix B: RADIUS server configuration

B.1 RADIUS server configuration

The following procedure is an example of how to set up a simple RADIUS server. You install the RADIUS server software on a separate computer. In this example, we use FreeRADIUS third-party software.

1. Download and install FreeRADIUS from www.freeradius.org as the RADIUS server. This is a Windows 32-bit installation that is known to work. If you try another third-party tool and it does not work, use the FreeRADIUS software from freeradius.net.
2. Open the `radiusd.conf` file in the `<Path_to_Radius>\etc\raddb` folder, locate the "bind_address" field, and enter your RADIUS server IP address. An example is

```
bind_address = 10.14.61.122
```

Text editor software that supports direct editing and saving of UNIX text encodings and line breaks, such as EditPad Lite, is needed for this editing.

3. In the `users.conf` file in the `<Path_to_Radius>\etc\raddb` folder, add the following text to configure a user "Tester" with an Administrator role.

```
Tester          User-Password == "TesterPw1#"
                GE-UR-Role = Administrator
```

4. In the `clients.conf` file in the `<Path_to_Radius>\etc\raddb` folder, add the following text to define the UR as a RADIUS client, where in this example the client IP address is 10.14.61.132, the shared secret specified here is also configured on the UR device for successful authentication, and the shortname is a short, optional alias that can be used in place of the IP address.

```
client 10.14.61.132 {
    secret = Testing!123
    shortname = ur1-test
}
```

Alternatively, you may specify one secret for a network of clients, where in the example below the clients are all within the 10.14.61.0/24 subnet and the shared secret specified here is also configured on all the UR devices in the subnet for successful authentication.

```
client 10.14.61.0/24 {
    secret = Testing!123
    shortname = net1-test
}
```

5. In the `<Path_to_Radius>\etc\raddb` folder, create a file called `dictionary.ge` and add the following content.

```

#####
# GE VSAS
#####

VENDOR                                GE                                2910

# Management authorization
BEGIN-VENDOR                          GE

# Role ID
ATTRIBUTE                             GE-UR-Role                    1                integer

# GE-UR-ROLE values
VALUE GE-UR-Role                      Administrator                1
VALUE GE-UR-Role                      Supervisor                 2
VALUE GE-UR-Role                      Engineer                   3
VALUE GE-UR-Role                      Operator                   4
VALUE GE-UR-Role                      Observer                   5

END-VENDOR                            GE
#####

```

6. In the dictionary file in the <Path_to_Radius>\etc\raddb folder, add the following line.

```
$INCLUDE dictionary.ge
```

For example, the file can look like the following:

```
$INCLUDE ../share/freeradius/dictionary
$INCLUDE dictionary.ge
```

7. For the first start, run the RADIUS server in debug mode to ensure that there are no compiling errors.
- ```
<Path_to_Radius>/start_radiusd_debug.bat
```
8. Set up the RADIUS parameters on the UR as follows.
- 8.1. If logging in, select **Device** for the **Authentication Type**, and use Administrator for the **User Name**. The default password is "ChangeMe1#".
  - 8.2. Access **Settings > Product Setup > Security**. Configure the IP address (10.14.61.122 in this example) and ports (default values in this example) for the RADIUS server. Leave the GE vendor ID field at the default of 2910. Update the RADIUS shared secret (Testing!123 in this example) as specified in the clients.conf file. Restart the relay for the IP address and port changes to take effect.
9. Verify operation. Log in to the UR software as follows. In the login window, select **Server** as the **Authentication Type**, enter the user name entered (for example user name Tester and password "TesterPw1#"). Check that the RADIUS server log file shows the access with an "Access-Accept" entry.
- Recall that if you tried another third-party tool and it did not work, you can use the FreeRADIUS software from freeradius.net.

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## Appendix C: Command line interface

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### C.1 Command line interface

SetupCLI is a command line interface to communicate with the EnerVista UR Setup software. Commands can be sent from a DOS prompt or a Windows batch file.

The interface is installed with the EnerVista software. Its default location is similar to  
C:\Program Files\EnerVista\Tools\SetupCLI

The EnerVista software needs to be installed on a computer to run the command line interface. The command line interface does not provide a remote connection to a computer running the EnerVista software.

Items to note are as follows:

- Works with EnerVista UR Setup version 6.10 and later
- Available in English only
- The graphical user interface of the software is not available concurrently with the command line interface
- It does not support concurrent commands
- It has limited functionality with CyberSentry
- It does not interface with Engineer
- It does not work when EnerVista UR Setup security is enabled, meaning when login is required

Command syntax is as follows:

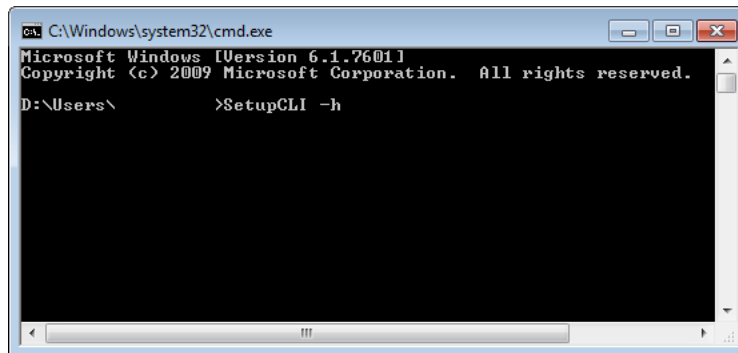
- Options enclosed in [ ] are optional
- Values enclosed in < > are replaced with your own values
- <Application> is replaced with the EnerVista software to receive the command. Use "URPC" for EnerVista UR Setup.
- <device> is the UR device name, as displayed in the **Device Name** field of the Device Setup window and listed in the Online Window. Use quotes with spaces, such as "B30 Belfort".
- "-s" can be used with any command to suppress error messages
- All commands, their return codes, and error description are logged in the All Users > Application Data folder
- When the Supervisor account is enabled, the 'Lock Relay' setting must first be changed to No before the putsettings, inservice, or reboot command can be used. This setting cannot be changed using the command line interface.
- Use quotes (") to enclose any parameter containing a space
- Commands, options, and parameters are case sensitive

- All commands have a return code of 0-255. 0 indicates success and 1-255 indicate different errors
- If SetupCLI is automated (in a batch file), make sure that only a single batch is running at a time. SetupCLI does not support concurrent operations.

To run the command line interface:

1. In Windows, click the **Start** button, enter **cmd**, and press the **Enter** key. After prompting for permission, the Windows command window opens.
2. Enter **SetupCLI** followed by the action to execute. An example of use is to enter "SetupCLI -h" to display help, specifically the commands and explanations outlined here.

Figure C-1: Command line interface run in the command window



### SetupCLI -h

Display help.

It displays the content outline here.

### SetupCLI <Application> start [-c] [-s]

Launch application with name <Application>.

To start in client mode, which is the graphical user interface, include option '-c'. Before use, the software must be idle without any windows open. Any activity or open windows can cause unexpected behavior. When in client mode, do not use Launchpad's Site Management feature.

To suppress errors, include option -s.

Example: SetupCLI URPC start -c

### SetupCLI <Application> exit [-s]

Exit application with name <Application>.

Example: SetupCLI URPC exit

### SetupCLI <Application> login -d <device> [-A <authentication type>] [-a <account>] -w <password> [-s]

Authenticate with device <device> using password <password>.

**For non-CyberSentry devices** — Set <authentication type> to "traditional". Note that <authentication type> defaults to "traditional" if not specified. Set <account> to "COMMANDS" or "SETTINGS". If not specified, the SETTINGS account is used.

Example: SetupCLI URPC login -d "C30 Melbourne" -A traditional -a SETTINGS -w 1password1

Example of a batch file that checks for an error (this batch file uses standard batch file operations to check the return code (ERRORLEVEL) and jump to an error handler):

SetupCLI URPC start

```

SetupCLI URPC login -d demoDevice -a SETTINGS -w WrongPassword -A traditional
IF NOT ERRORLEVEL 0 GOTO FAILED
SetupCLI URPC putsettings -d demoDevice -f "example file.urs"
SetupCLI URPC inservice -d demoDevice
SetupCLI URPC reboot -d demoDevice
SetupCLI URPC exit
exit

:FAILED
echo Please try again
exit

```

**For CyberSentry devices with local authentication** — Set <authentication type> to "local". Set <account> to "Supervisor", "Administrator", "Engineer", "Operator", or "Observer".

**For CyberArmor devices with RADIUS authentication** — Set <authentication type> to "radius". Set <account> to the user's account on the radius server.

### SetupCLI <Application> logout -d <device> [-s]

Log out of device <device>.  
 Example: SetupCLI URPC logout -d C30

### SetupCLI <Application> getsettings -d <device> -f <File> [-s]

Read settings from device <device> and save them to the .urs file <File>. The <File> must not already exist. The default path to the output file is C:\Users\Public\Public Documents\GE Power Management\URPC\Data

Example: SetupCLI URPC getsettings -d C30 -f "C30 Markham.urs"

Example of a batch file to retrieve a settings file:

```

SetupCLI URPC start
SetupCLI URPC getsettings -d demoDevice -f C:\example.urs
SetupCLI URPC exit

```

Example of a batch file to retrieve a settings file from a relay that requires RADIUS authentication:

```

SetupCLI URPC start
SetupCLI URPC login -d demoDevice -a %1 -w %2 -A radius
SetupCLI URPC getsettings -d demoDevice -f "example file.urs"
SetupCLI URPC logout -d demoDevice
SetupCLI URPC exit

```

Although a user name and password could have been entered in this batch file, it would have created a security risk. Batch files allow you to pass in runtime parameters and refer to them in your script as %1, %2, and so on. For example, if this file is called example.bat, one calls it as follows: "example.bat MyUserName MyPassword"

### SetupCLI <Application> putsettings -d <device> -f <File> [-s]

Write the settings file <File> to the device <device>.

For CyberSentry devices, putsettings is only supported for users with the "Administrator" role.

Example: SetupCLI URPC putsettings -d C30 -f "C30 Markham.urs"

### SetupCLI <Application> compare -f <File1> -r <File2> -o <OutputFile> [-s]

Compare settings files <File1> and <File2>, and save output to <OutputFile>.

Example: SetupCLI URPC compare -f may.urs -r september.urs -o compared.txt

Batch file example that retrieves a settings file, compares it with an existing settings file, and opens the resulting comparison file:

SetupCLI URPC start

SetupCLI URPC getsettings -d demoDevice -f devicefile.urs

SetupCLI URPC compare -f existingfile.urs -r devicefile.urs -o output.txt

The output is similar to the following:

Comparing settings file aaa.urs : C:\Users\Public\Public Documents\GE Power Management\URPC\Data\ with bbb.urs : C:\Users\Public\Public Documents\GE Power Management\URPC\Data\

| #   | Setting Name            | (Group,Module,Item) Value |
|-----|-------------------------|---------------------------|
| 1 + | Default Message Timeout | (1,1,1) = 299 s           |
| 2 - | Default Message Timeout | (1,1,1) = 300 s           |
| 3 + | Flash Message Time      | (1,1,1) = 0.9 s           |
| 4 - | Flash Message Time      | (1,1,1) = 1.0 s           |

### SetupCLI <Application> inservice -d <device> [-n] [-s]

Put the device in service. Include option -n to take the device out of service.

Example: SetupCLI URPC inservice -d C30

### SetupCLI <Application> reboot -d <device> [-s]

Reboot the relay <device>. This is necessary after changing IEC 61850 settings and aggregator source settings.

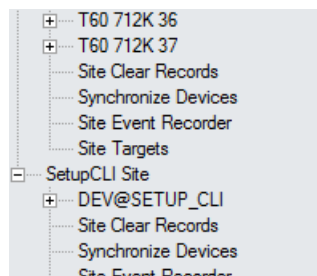
Example: SetupCLI URPC reboot -d "C30\_Instanbul"

### SetupCLI <Application> adddevice -I <IP Address> -S <Slave Address> -P <Modbus Port>

Connect to a device using its IP address, slave address, and Modbus port. Show the device in the EnerVista interface under the SetupCLI Site as DEV@SETUP\_CLI.

EnerVista UR Setup 7.30 or higher supports this command.

Figure C-2: Device added using IP address



The device is named as DEV@SETUP\_CLI, which is used as the device name required by the <device> parameter of other SetupCLI commands.

The device name DEV@SETUP\_CLI is always assigned to the device that is connected most recently by performing 'adddevice' command. It means that the Application only keeps up to one device named as DEV@SETUP\_CLI, the 'adddevice' command disconnects/deletes the device DEV@SETUP\_CLI that was connected previously by performing 'adddevice' command.

The device name DEV@SETUP\_CLI is never used to configure/connect to a device through the graphical user interface.

Example of a batch file using a device IP address to retrieve its settings file:

```
SetupCLI URPC start
SetupCLI URPC adddevice -I 192.168.140.113 -S 113 -P 502
SetupCLI URPC getsettings -d DEV@SETUP_CLI -f C:\example.urs
SetupCLI URPC exit
```

After connecting the device using IP address, the device name DEV@SETUP\_CLI is used to identify this device in 'getsettings' command.

Example of a batch file using a device IP address to retrieve a settings file when RADIUS authentication is required:

```
SetupCLI URPC start
SetupCLI URPC adddevice -I 192.168.140.113 -S 113 -P 502
SetupCLI URPC login -d DEV@SETUP_CLI -a %1 -w %2 -A radius
SetupCLI URPC getsettings -d DEV@SETUP_CLI -f "example file.urs"
SetupCLI URPC logout -d DEV@SETUP_CLI
SetupCLI URPC exit
```

DEV@SETUP\_CLI has to be used as the device name in the commands followed by the 'adddevice' command.

C



# B90 Low Impedance Bus Differential System

## Appendix D: Miscellaneous

This chapter provides the warranty and revision history.

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### D.1 Warranty

For products shipped as of 1 October 2013, GE Grid Solutions warrants most of its GE manufactured products for 10 years. For warranty details including any limitations and disclaimers, see the Terms and Conditions at

<https://www.gegridsolutions.com/multilin/warranty.htm>

For products shipped before 1 October 2013, the standard 24-month warranty applies.

---

### D.2 Revision history

The tables outline the releases and revision history of this document.

**Table D-1: Revision history (English)**

| Manual P/N   | B90 revision | Release date     | ECO     |
|--------------|--------------|------------------|---------|
| 1601-0115-C1 | 3.0x         | 02 July 2002     | URB-006 |
| 1601-0115-C2 | 3.0x         | 18 November 2002 | URB-011 |
| 1601-0115-C3 | 3.0x         | 30 August 2003   | URB-009 |
| 1601-0115-G1 | 4.0x         | 23 March 2004    | URX-123 |
| 1601-0115-G2 | 4.0x         | 17 May 2004      | URX-136 |
| 1601-0115-K1 | 4.6x         | 15 February 2005 | URX-176 |
| 1601-0115-M1 | 4.9x         | 15 December 2005 | URX-208 |
| 1601-0115-M2 | 4.9x         | 27 February 2006 | URX-214 |
| 1601-0115-P1 | 5.2x         | 28 February 2007 | URX-236 |
| 1601-0115-P2 | 5.2x         | 01 March 2007    | URX-236 |
| 1601-0115-R1 | 5.4x         | 26 June 2007     | URX-242 |
| 1601-0115-R2 | 5.4x         | 31 August 2007   | URX-246 |
| 1601-0115-R3 | 5.4x         | 17 October 2007  | URX-251 |
| 1601-0115-S1 | 5.5x         | 7 December 2007  | URX-253 |
| 1601-0115-S2 | 5.5x         | 22 February 2008 | URX-258 |

| Manual P/N    | B90 revision | Release date      | ECO     |
|---------------|--------------|-------------------|---------|
| 1601-0115-S3  | 5.5x         | 12 March 2008     | URX-260 |
| 1601-0115-T1  | 5.6x         | 27 June 2008      | 08-0390 |
| 1601-0115-U1  | 5.7x         | 29 May 2009       | 09-0938 |
| 1601-0115-U2  | 5.7x         | 30 September 2009 | 09-1165 |
| 1601-0115-V1  | 5.8x         | 29 May 2010       | 09-1457 |
| 1601-0115-V2  | 5.8x         | 04 January 2011   | 11-2237 |
| 1601-0115-W1  | 5.9x         | 12 January 2011   | 11-2227 |
| 1601-0115-X1  | 6.0x         | 21 December 2011  | 11-2840 |
| 1601-0115-X2  | 6.0x         | 5 April 2012      | 12-3254 |
| 1601-0115-Y1  | 7.0x         | 30 September 2012 | 12-3529 |
| 1601-0115-Y2  | 7.0x         | 11 November 2012  | 12-3601 |
| 1601-0115-Z1  | 7.1x         | 30 March 2013     | 13-0126 |
| 1601-0115-AA1 | 7.2x         | 1 August 2013     | 13-0401 |
| 1601-0115-AB1 | 7.3x         | 7 November 2014   | 14-1408 |
| 1601-0115-AB2 | 7.3x         | 1 September 2015  | 15-2215 |
| 1601-0115-AB3 | 7.3x         | 1 March 2021      | 21-6255 |

Table D-2: Major changes for B90 manual version AB3 (English)

| Page | Description                                                                                                                                                                                                                                                                                                                                              |
|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ---  | Updated document throughout, including branding from GE Digital Energy to GE Grid Solutions                                                                                                                                                                                                                                                              |
| ---  | Deleted EAC logo from title page and deleted EAC certification from Approvals specifications because document not translated into Russian                                                                                                                                                                                                                |
| 2-   | Updated Dropout Level specification for several elements, changing percent range to a number                                                                                                                                                                                                                                                             |
| 2-   | Deleted end-of-manufacturing modules 2G, 74, 75, 7E, 7L from order code tables                                                                                                                                                                                                                                                                           |
| 2-8  | Updated order codes from SH / SL to RH / RL for the redundant power supply for the UR. The power supply modules were upgraded in 2014 to SH and SL, but the order codes when purchasing a UR remain as RH and RL so that customers do not need to change order codes. The order codes for the power supply replacement modules are correct as SH and SL. |
| 2-8  | Added order codes for Inter-relay communication modules in U column for horizontal unit                                                                                                                                                                                                                                                                  |
| 2-15 | Updated Bus Differential specification for Characteristic Accuracy                                                                                                                                                                                                                                                                                       |
| 3-   | Updated Typical Wiring Diagram at CPU module, CPU Module Communications Wiring figure, and Options for IRIG-B Connection figure                                                                                                                                                                                                                          |
| 3-34 | Updated RS422 and Fiber Interface Connection figure for the clock channels (from 7a and 7b to 1a and 1b)                                                                                                                                                                                                                                                 |
| B-   | Updated RADIUS chapter                                                                                                                                                                                                                                                                                                                                   |
| C-   | Added Command Line Interface appendix                                                                                                                                                                                                                                                                                                                    |

Table D-3: Major changes for B90 manual version AB2 (English)

| Page | Description                                                                                                                                                                                              |
|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ---  | Updated document throughout, including numbers of elements and FlexLogic operands table                                                                                                                  |
| ---  | Added EAC compliance information throughout, including logo on title page, rear panel, added specifications, added life expectancy and decommissioning, added sections on Repairs, Storage, and Disposal |
| ---  | Updated several figures for consistency                                                                                                                                                                  |
| 2-13 | Added UR Signal Processing section                                                                                                                                                                       |
| 5-   | Updated IEC 61850 content                                                                                                                                                                                |
| A-   | Updated FlexAnalog table                                                                                                                                                                                 |

**Table D-4: Major changes for B90 manual version AB1 (English)**

| Page | Description                                                                                                                                                                                          |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ---  | Updated document throughout and put into new template. Major revision.                                                                                                                               |
| ---  | Updated references to digital inputs/outputs to contact inputs/outputs for consistency                                                                                                               |
| ---  | Updated bus differential zones from four to six throughout document, for example specifications, interface, settings, actual values. Also updated CT trouble zones from four to six for same reason. |
| ---  | Added content for advanced IEC 61850, for example in the Settings and Actual Values chapters                                                                                                         |
| 2-   | Updated Order Codes and Specifications                                                                                                                                                               |
| 5-25 | Added RS232 Baud Rate setting to Serial Ports section. Baud rate is now configurable, with two options.                                                                                              |
| 5-27 | Added Far-End Fault Indication (FEFI) section                                                                                                                                                        |
| 9-2  | Added Software Upgrade section to the Maintenance chapter                                                                                                                                            |
| ---  | Moved communications appendices B through F to new UR Series Communications Guide for UR 7.3x AB1                                                                                                    |
| C-1  | Updated product warranty from 24 months to 10 years                                                                                                                                                  |



# B90 Low Impedance Bus Differential System

## Abbreviations

|        |                                             |           |                                             |
|--------|---------------------------------------------|-----------|---------------------------------------------|
| A      | Ampere                                      | CRT, CRNT | Current                                     |
| AC     | Alternating Current                         | CSA       | Canadian Standards Association              |
| A/D    | Analog to Digital                           | CT        | Current Transformer                         |
| AE     | Accidental Energization, Application Entity | CVT       | Capacitive Voltage Transformer              |
| AMP    | Ampere                                      |           |                                             |
| ANG    | Angle                                       | D/A       | Digital to Analog                           |
| ANSI   | American National Standards Institute       | DC (dc)   | Direct Current                              |
| AR     | Automatic Reclosure                         | DCE       | Data Communications Equipment               |
| ASDU   | Application-layer Service Data Unit         | DCS       | Distributed Control System                  |
| ASYM   | Asymmetry                                   | DD        | Disturbance Detector                        |
| AUTO   | Automatic                                   | DFLT      | Default                                     |
| AUX    | Auxiliary                                   | DGNST     | Diagnostics                                 |
| AVG    | Average                                     | DIFF      | Differential                                |
| AWG    | American Wire Gauge                         | DIR       | Directional                                 |
|        |                                             | DISCREP   | Discrepancy                                 |
| BCS    | Best Clock Selector                         | DIST      | Distance                                    |
| BER    | Bit Error Rate                              | DMD       | Demand                                      |
| BF     | Breaker Fail                                | DNP       | Distributed Network Protocol                |
| BFI    | Breaker Failure Initiate                    | DPO       | Dropout                                     |
| BKR    | Breaker                                     | DPS       | Double-Point Status                         |
| BLK    | Block                                       | DSP       | Digital Signal Processor                    |
| BLKG   | Blocking                                    | DST       | Daylight Savings Time                       |
| BNC    | Bayonet Neill-Concelman                     | dt        | Rate of Change                              |
| BPNT   | Breakpoint of a characteristic              | DTT       | Direct Transfer Trip                        |
| BRKR   | Breaker                                     | DUTT      | Direct Under-reaching Transfer Trip         |
|        |                                             |           |                                             |
| CAP    | Capacitor                                   | EGD       | Ethernet Global Data                        |
| CC     | Coupling Capacitor                          | ENCRMNT   | Encroachment                                |
| CCVT   | Coupling Capacitor Voltage Transformer      | EPRI      | Electric Power Research Institute           |
| CFG    | Configure / Configurable                    | .EVT      | Filename extension for event recorder files |
| .CFG   | Filename extension for oscillography files  | EXT       | Extension, External                         |
| CHK    | Check                                       |           |                                             |
| CHNL   | Channel                                     | F         | Field                                       |
| CID    | Configured IED Description                  | FAIL      | Failure                                     |
| CLS    | Close                                       | FD        | Fault Detector                              |
| CLSD   | Closed                                      | FDH       | Fault Detector high-set                     |
| CMND   | Command                                     | FDL       | Fault Detector low-set                      |
| CMPRSN | Comparison                                  | FLA       | Full Load Current                           |
| CO     | Contact Output                              | FO        | Fiber Optic                                 |
| COM    | Communication                               | FREQ      | Frequency                                   |
| COMM   | Communications                              | FSK       | Frequency-Shift Keying                      |
| COMP   | Compensated, Comparison                     | FTP       | File Transfer Protocol                      |
| CONN   | Connection                                  | FxE       | FlexElement™                                |
| CONT   | Continuous, Contact                         | FWD       | Forward                                     |
| CO-ORD | Coordination                                |           |                                             |
| CPU    | Central Processing Unit                     | G         | Generator                                   |
| CRC    | Cyclic Redundancy Code/Check                | GE        | General Electric                            |
|        |                                             | GND       | Ground                                      |

|         |                                                  |          |                                                 |
|---------|--------------------------------------------------|----------|-------------------------------------------------|
| GNTR    | Generator                                        | MVA_C    | MegaVolt-Ampere (phase C)                       |
| GOOSE   | General Object Oriented Substation Event         | MVAR     | MegaVar (total 3-phase)                         |
| GPS     | Global Positioning System                        | MVAR_A   | MegaVar (phase A)                               |
| GSU     | Generator Step-Up                                | MVAR_B   | MegaVar (phase B)                               |
|         |                                                  | MVAR_C   | MegaVar (phase C)                               |
| HARM    | Harmonic / Harmonics                             | MVARH    | MegaVar-Hour                                    |
| HCT     | High Current Time                                | MW       | MegaWatt (total 3-phase)                        |
| HGF     | High-Impedance Ground Fault (CT)                 | MW_A     | MegaWatt (phase A)                              |
| HIZ     | High-Impedance and Arcing Ground                 | MW_B     | MegaWatt (phase B)                              |
| HMI     | Human-Machine Interface                          | MW_C     | MegaWatt (phase C)                              |
| HTTP    | Hyper Text Transfer Protocol                     | MWH      | MegaWatt-Hour                                   |
| HV      | High Voltage                                     |          |                                                 |
| HYB     | Hybrid                                           | N        | Neutral                                         |
| Hz      | Hertz                                            | N/A, n/a | Not Applicable                                  |
|         |                                                  | NEG      | Negative                                        |
| I       | Instantaneous                                    | NMPLT    | Nameplate                                       |
| I_0     | Zero Sequence current                            | NOM      | Nominal                                         |
| I_1     | Positive Sequence current                        | NTR      | Neutral                                         |
| I_2     | Negative Sequence current                        |          |                                                 |
| IA      | Phase A current                                  | O        | Over                                            |
| IAB     | Phase A minus B current                          | OC, O/C  | Overcurrent                                     |
| IB      | Phase B current                                  | O/P, Op  | Output                                          |
| IBC     | Phase B minus C current                          | OP       | Operate                                         |
| IC      | Phase C current                                  | OPER     | Operate                                         |
| ICA     | Phase C minus A current                          | OPERATG  | Operating                                       |
| ID      | Identification                                   | O/S      | Operating System                                |
| IED     | Intelligent Electronic Device                    | OSI      | Open Systems Interconnect                       |
| IEC     | International Electrotechnical Commission        | OSB      | Out-of-Step Blocking                            |
| IEEE    | Institute of Electrical and Electronic Engineers | OUT      | Output                                          |
| IG      | Ground (not residual) current                    | OV       | Overvoltage                                     |
| Igd     | Differential Ground current                      | OVERFREQ | Overfrequency                                   |
| IN      | CT Residual Current (3I0) or Input               | OVLD     | Overload                                        |
| INC SEQ | Incomplete Sequence                              |          |                                                 |
| INIT    | Initiate                                         | P        | Phase                                           |
| INST    | Instantaneous                                    | PC       | Phase Comparison, Personal Computer             |
| INV     | Inverse                                          | PCNT     | Percent                                         |
| I/O     | Input/Output                                     | PF       | Power Factor (total 3-phase)                    |
| IOC     | Instantaneous Overcurrent                        | PF_A     | Power Factor (phase A)                          |
| IOV     | Instantaneous Overvoltage                        | PF_B     | Power Factor (phase B)                          |
| IRIG    | Inter-Range Instrumentation Group                | PF_C     | Power Factor (phase C)                          |
| ISO     | International Standards Organization             | PFLL     | Phase and Frequency Lock Loop                   |
| IUV     | Instantaneous Undervoltage                       | PHS      | Phase                                           |
|         |                                                  | PICS     | Protocol Implementation & Conformance Statement |
| K0      | Zero Sequence Current Compensation               | PKP      | Pickup                                          |
| kA      | kiloAmpere                                       | PLC      | Power Line Carrier                              |
| kV      | kiloVolt                                         | POS      | Positive                                        |
|         |                                                  | POTT     | Permissive Over-reaching Transfer Trip          |
| LED     | Light Emitting Diode                             | PP       | Power Profile                                   |
| LEO     | Line End Open                                    | PRESS    | Pressure                                        |
| LFT BLD | Left Blinder                                     | PRI      | Primary                                         |
| LOOP    | Loopback                                         | PRP      | Parallel Redundancy Protocol                    |
| LPU     | Line Pickup                                      | PROT     | Protection                                      |
| LRA     | Locked-Rotor Current                             | PSEL     | Presentation Selector                           |
| LTC     | Load Tap-Changer                                 | pu       | Per Unit                                        |
| LV      | Low Voltage                                      | PUIB     | Pickup Current Block                            |
|         |                                                  | PUIT     | Pickup Current Trip                             |
| M       | Machine                                          | PUSHBTN  | Pushbutton                                      |
| mA      | MilliAmpere                                      | PUTT     | Permissive Under-reaching Transfer Trip         |
| MAG     | Magnitude                                        | PWM      | Pulse Width Modulated                           |
| MAN     | Manual / Manually                                | PWR      | Power                                           |
| MAX     | Maximum                                          |          |                                                 |
| MIC     | Model Implementation Conformance                 | QUAD     | Quadrilateral                                   |
| MIN     | Minimum, Minutes                                 |          |                                                 |
| MMI     | Man Machine Interface                            | R        | Rate, Reverse                                   |
| MMS     | Manufacturing Message Specification              | RCA      | Reach Characteristic Angle                      |
| MRT     | Minimum Response Time                            | REF      | Reference                                       |
| MSG     | Message                                          | REM      | Remote                                          |
| MTA     | Maximum Torque Angle                             | REV      | Reverse                                         |
| MTR     | Motor                                            | RI       | Reclose Initiate                                |
| MVA     | MegaVolt-Ampere (total 3-phase)                  | RIP      | Reclose In Progress                             |
| MVA_A   | MegaVolt-Ampere (phase A)                        | RGT BLD  | Right Blinder                                   |
| MVA_B   | MegaVolt-Ampere (phase B)                        |          |                                                 |

## ABBREVIATIONS

|          |                                                                          |        |                                    |
|----------|--------------------------------------------------------------------------|--------|------------------------------------|
| RMA      | Return Materials Authorization                                           | VARH   | Var-hour voltage                   |
| RMS      | Root Mean Square                                                         | VB     | Phase B voltage                    |
| ROCOF    | Rate of Change of Frequency                                              | VBA    | Phase B to A voltage               |
| ROD      | Remote Open Detector                                                     | VBG    | Phase B to Ground voltage          |
| RST      | Reset                                                                    | VC     | Phase C voltage                    |
| RSTR     | Restrained                                                               | VCA    | Phase C to A voltage               |
| RTD      | Resistance Temperature Detector                                          | VCG    | Phase C to Ground voltage          |
| RTU      | Remote Terminal Unit                                                     | VF     | Variable Frequency                 |
| RX (Rx)  | Receive, Receiver                                                        | VIBR   | Vibration                          |
|          |                                                                          | VT     | Voltage Transformer                |
| s        | second                                                                   | VTFF   | Voltage Transformer Fuse Failure   |
| S        | Sensitive                                                                | VTLOS  | Voltage Transformer Loss Of Signal |
| SA       | Security Association                                                     |        |                                    |
| SAT      | CT Saturation                                                            | WDG    | Winding                            |
| SBO      | Select Before Operate                                                    | WH     | Watt-hour                          |
| SCADA    | Supervisory Control and Data Acquisition                                 | w/ opt | With Option                        |
| SCC      | Serial Communication Controller                                          | WGS    | World Geodetic System              |
| SCL      | Substation Configuration Language                                        | WRT    | With Respect To                    |
| SEC      | Secondary                                                                |        |                                    |
| SEL      | Select / Selector / Selection                                            | X      | Reactance                          |
| SENS     | Sensitive                                                                | XDUCER | Transducer                         |
| SEQ      | Sequence                                                                 | XFMR   | Transformer                        |
| SFTP     | Secure Shell (SSH) File Transfer Protocol, Secure File Transfer Protocol |        |                                    |
|          |                                                                          | Z      | Impedance, Zone                    |
| SIR      | Source Impedance Ratio                                                   |        |                                    |
| SNTP     | Simple Network Time Protocol                                             |        |                                    |
| SRC      | Source                                                                   |        |                                    |
| SSB      | Single Side Band                                                         |        |                                    |
| SSEL     | Session Selector                                                         |        |                                    |
| STATS    | Statistics                                                               |        |                                    |
| SUPN     | Supervision                                                              |        |                                    |
| SUPV     | Supervise / Supervision                                                  |        |                                    |
| SV       | Supervision, Service                                                     |        |                                    |
| SYNC     | Synchrocheck                                                             |        |                                    |
| SYNCHCHK | Synchrocheck                                                             |        |                                    |
|          |                                                                          |        |                                    |
| T        | Time, transformer                                                        |        |                                    |
| TC       | Thermal Capacity                                                         |        |                                    |
| TCP      | Transmission Control Protocol                                            |        |                                    |
| TCU      | Thermal Capacity Used                                                    |        |                                    |
| TD MULT  | Time Dial Multiplier                                                     |        |                                    |
| TEMP     | Temperature                                                              |        |                                    |
| TFTP     | Trivial File Transfer Protocol                                           |        |                                    |
| THD      | Total Harmonic Distortion                                                |        |                                    |
| TMR      | Timer                                                                    |        |                                    |
| TOC      | Time Overcurrent                                                         |        |                                    |
| TOV      | Time Overvoltage                                                         |        |                                    |
| TRANS    | Transient                                                                |        |                                    |
| TRANSF   | Transfer                                                                 |        |                                    |
| TSEL     | Transport Selector                                                       |        |                                    |
| TUC      | Time Undercurrent                                                        |        |                                    |
| TUV      | Time Undervoltage                                                        |        |                                    |
| TX (Tx)  | Transmit, Transmitter                                                    |        |                                    |
|          |                                                                          |        |                                    |
| U        | Under                                                                    |        |                                    |
| UC       | Undercurrent                                                             |        |                                    |
| UCA      | Utility Communications Architecture                                      |        |                                    |
| UDP      | User Datagram Protocol                                                   |        |                                    |
| UL       | Underwriters Laboratories                                                |        |                                    |
| UNBAL    | Unbalance                                                                |        |                                    |
| UR       | Universal Relay                                                          |        |                                    |
| URC      | Universal Recloser Control                                               |        |                                    |
| .URS     | Filename extension for settings files                                    |        |                                    |
| UV       | Undervoltage                                                             |        |                                    |
|          |                                                                          |        |                                    |
| V/Hz     | Volts per hertz                                                          |        |                                    |
| V_0      | Zero Sequence voltage                                                    |        |                                    |
| V_1      | Positive Sequence voltage                                                |        |                                    |
| V_2      | Negative Sequence voltage                                                |        |                                    |
| VA       | Phase A voltage                                                          |        |                                    |
| VAB      | Phase A to B voltage                                                     |        |                                    |
| VAG      | Phase A to Ground voltage                                                |        |                                    |





# B90 Low Impedance Bus Differential System

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