GE
Digital Energy

C90Plus

Automation Logic Controller



Instruction manual

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C90^{Plus} Controller Instruction Manual for product revision 1.9x.

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C90Plus Controller

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C90Plus Controller

Chapter 1: Getting started

This section outlines the symbols used in the document, what is in the box, and general approach to set up the C90Plus Automation Logic Controller™.

Important procedures

Review the following sections before placing the C90Plus in service.

Safety words 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.

Unpacking and inspection checklist

Use this procedure to unpack and inspect the C90Plus.

1. Inspect the packaging for physical damage.
2. Open it and inspect the C90Plus for physical damage.
3. Check that the following items have been delivered:
   - C90Plus Automation Logic Controller
   - GE EnerVista™ CD (software and documentation)

- Instruction Manual (soft copy on the CD; hard copy if ordered)
- Communications Guide (soft copy on the CD; hard copy if ordered)
- Certificate of Calibration
- Test Report
- EC Declaration of Conformity

4. View the rear nameplate of the product and verify that the correct model has been delivered.
5. For product information, instruction manual updates, and software updates, visit the GE Digital Energy website at http://GEDigitalEnergy.com/Multilin.
6. If any of the contents listed are missing or there is physical damage to the product, contact GE Digital Energy.

This Instruction Manual contains information on wiring, programming, connecting, and testing the C90^{Plus} Automation Logic Controller. The Communications Guide contains detailed information on the Modbus, DNP, IEC 61850, and IEC 61870-5-104 communications protocols used in the C90^{Plus}.

Introduction to the UR^{Plus}-series

The C90^{Plus} is the advanced automation controller for the UR^{Plus}-series platform and is organized into six major functions.

Hardware architecture

The unit is a microprocessor-based device. It has a modular design, its chassis containing discrete modules that interface over a common bus. Each module has a specific purpose. Several modules are required for basic operation of the device, while others are optional.

The power supply module receives AC or DC power from an external supply and produces conditioned 12 V DC power for all of the modules in the chassis. The power supply also generates 48 V DC power for external contact wetting. The output contact indicating a critical failure of the unit also resides on this module.

The AC module measures AC currents and voltages derived from CTs and VTs. These signals are sampled and digitized and sent over the device's bus to the CPU module for further processing. A version is available that accepts nominal 5 A current and another that accepts nominal 1 A current.

Input and output modules monitor digital (on and off) signals from external devices (field contacts or other IEDs), control external devices such as breakers, and send digital signals to other devices. Input and output modules are subdivided into protection inputs and outputs and automation inputs and outputs, with several flavors of each type.

The CPU module contains the firmware for the C90^{Plus}. The firmware contains the algorithms required for the various functions provided by the device. The CPU receives analog and digital data from the AC and input/output modules. The data is processed by the CPU and resulting control actions are sent back to the input-output modules. The CPU has one rear Ethernet port that is used for configuration and record retrieval and one rear RS485 port supporting the Modbus and DNP protocols. The CPU also contains the IRIG-B port required for clock synchronization.

The communications module is required for communicating with external devices over Ethernet using the trivial file transfer protocol (TFTP), HTTP, Parallel Redundancy Protocol (PTP), IEC 61850, DNP 3.0, or IEC60870-5-104 protocol. This module is also required for peer-to-peer GSSE/GOOSE messaging. This module contains its own microprocessor which is dedicated to handling communications tasks. It also contains two redundant Ethernet

ports. Each port supports 100Base-FX over multi-mode fiber and 10/100Base-TX over twisted pair, with auto-negotiation. These ports may additionally be configured for single IP or dual IP redundancy.

NOTE

The C90^{Plus} requires one power supply module, one CPU module, one AC module, and at least one protection input/output module. Communications modules are optional.

The front panel interface consists of an annunciator display, a main display, and an EnerVista USB port. The annunciator display collects alarm indications from the C90^{Plus} internal functions and presents them using a standard annunciator format. Alarms and their corresponding messages are entirely user-configurable. The main display allows the user to view metering data collected by the C90^{Plus}. It also provides access to the control functions via dedicated control pushbuttons. The USB port allows the user to interface with the C90^{Plus} using the EnerVista software running on a portable PC. The C90^{Plus} operates independently from the front panel interface.

Figure 1: C90^{Plus} block diagram

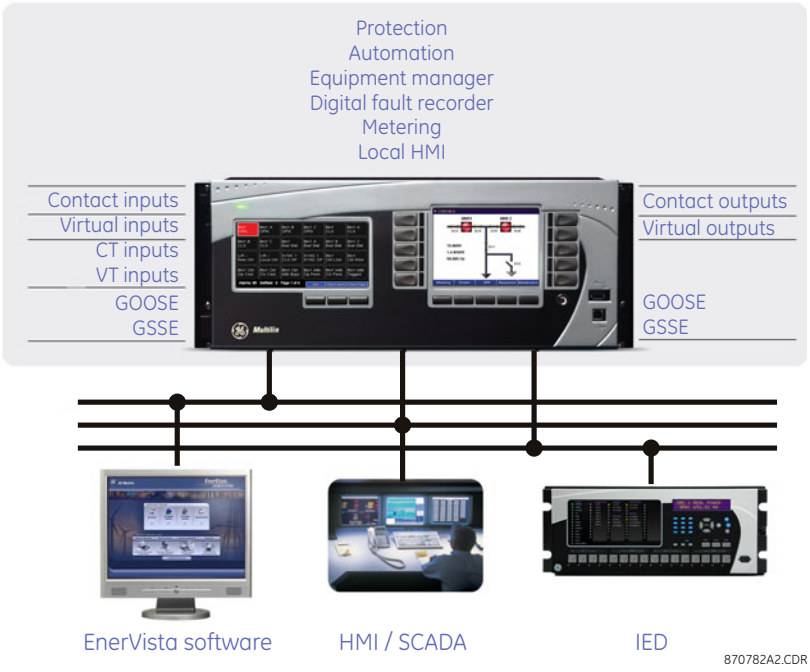
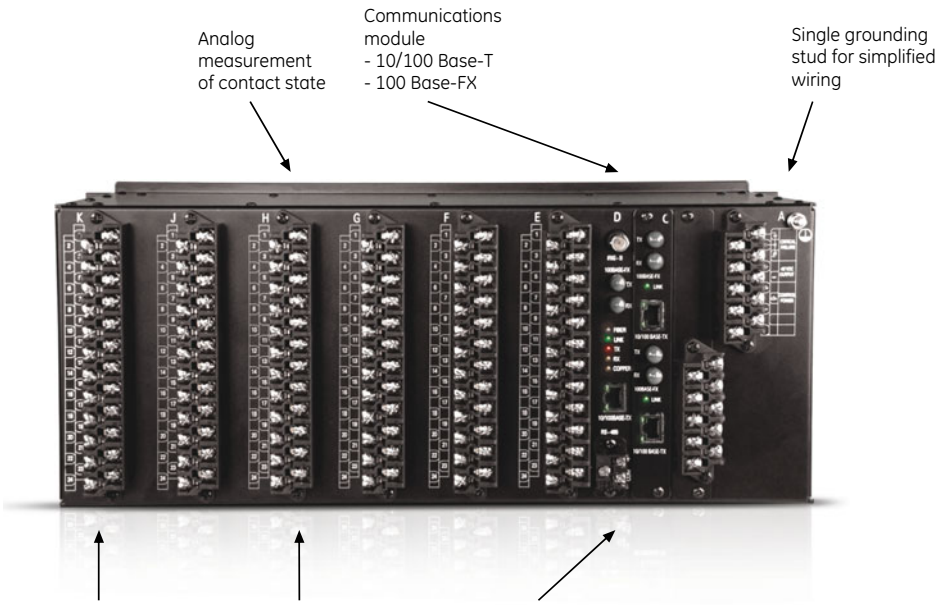


Figure 2: C90^Plus hardware overview



An option of the D90^Plus is support for the Parallel Redundancy Protocol (PRP) of IEC 62439-3 (clause 4, 2012). The PRP allows high availability in substation automation networks. It applies to networks based on Ethernet technology (ISO/IEC 8802-3).

Firmware architecture

The C90^Plus is organized into six major functions.

- Protection
- Automation
- Metering
- Digital fault recorder (DFR)
- Equipment manager
- Front panel interface (HMI)

These functions operate autonomously from one another. Each function has its own configuration parameters and each generates it own output signals. All functions share the hardware and the communications facilities within the device.

The protection function contains the necessary elements required to detect faults in the power system and send tripping signals to isolate the fault. This will be the primary sub-system for many users. The protection function also has its own dedicated FlexLogic™ engine which runs at the same scan rate as the protection (16 times per power system cycle). Protection FlexLogic is used to create custom logic schemes for protection purposes.

Automation is divided into two major sub-groupings: control schemes and automation logic. Control schemes are hard-coded general purpose schemes responsible for automatic control within the substation. These include breaker and disconnect switch control, interlocking, and synchrocheck. Automation logic is intended for development of custom or advanced automatic schemes in the case the user requires a level of

functionality beyond that found in the hard-coded schemes. Automation logic generally requires a lower execution rate than protection logic but has greatly expanded functionality and lines of logic.

The metering function generates a wide range of real-time power system measurements including voltage, current, frequency, complex power, and energy. It also incorporates a data logger that provides historical recording of selected metering quantities and includes statistical (maximum, minimum, and average) and alarming capabilities. The metering function also provides synchrophasor capabilities in accordance with IEEE C37.118-2005.

The digital fault recorder incorporates transient recorder, disturbance recorder and fault report capabilities. The transient recorder is intended to capture short events such as a fault at a high sampling rate (up to 256 samples per cycle). The disturbance recorder captures longer events such as a power swing at a lower sampling rate. The channel assignments and triggering of these features can be independently configured. The fault report facility provides a comprehensive record of the key measurements associated with an event including fault type, fault location, pre-fault and post-fault quantities, and clearing time.

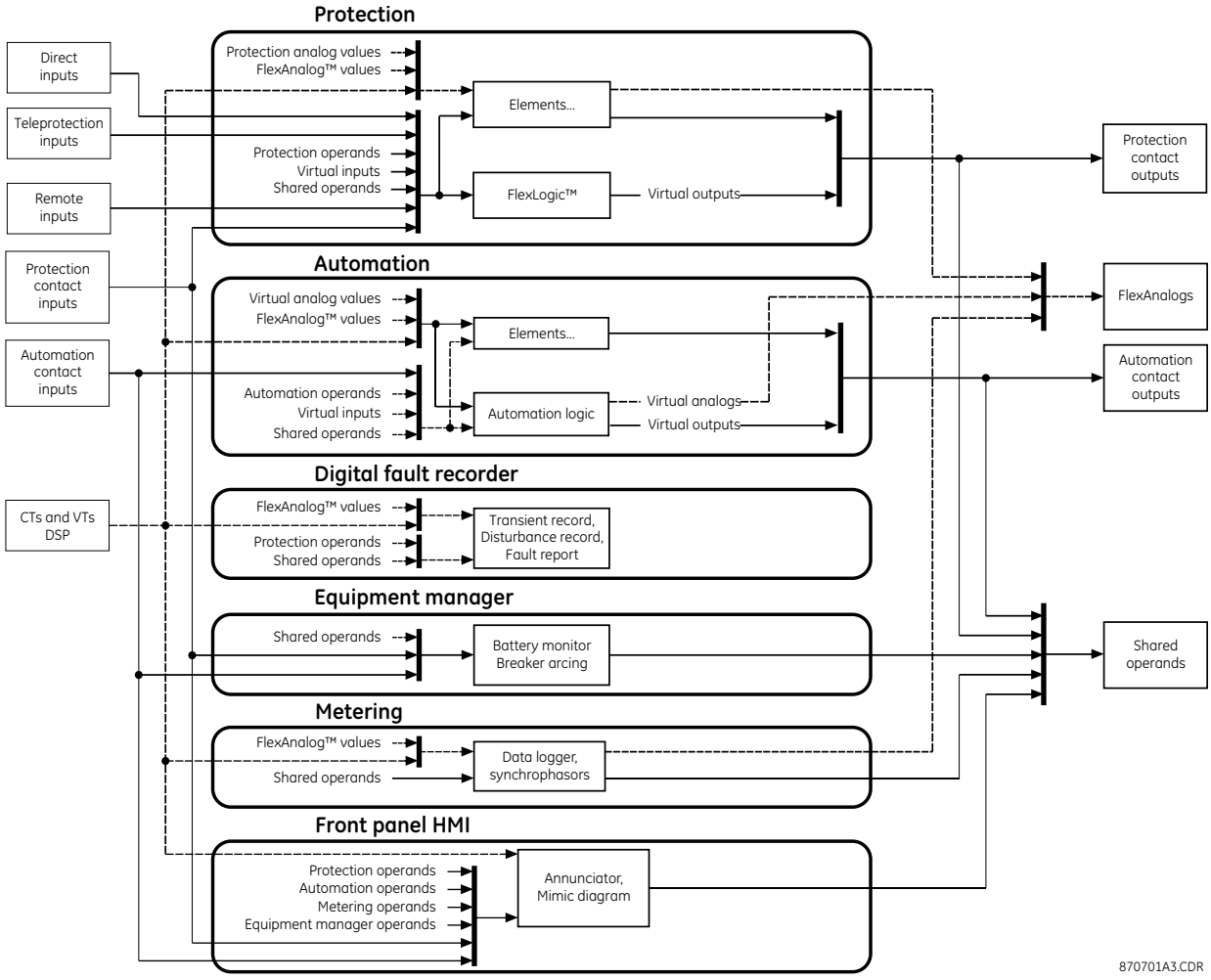
The equipment manager function monitors important parameters of the station battery under normal operation and can be used to detect incipient failures.

Despite their logic separation, signals can be exchanged between these functions. For instance, it is useful for the digital fault recorder to record the output of protection functions. Consequently a fixed, pre-determined set of signals is available as inputs to each function. These are illustrated in the following figure.

The C90^{Plus} also includes shared operand functionality. Output signals from the various functions can be assigned as shared operands available to all functions. These signals can then be assigned as inputs within other functions.

For example, assume that the PHASE TOC1 OP protection FlexLogic operand is required as a signal within the automation function. This signal would be assigned as a shared operand. As such, the PHASE TOC1 OP operand would subsequently become available to the automation function by appearing in the list of available operands.

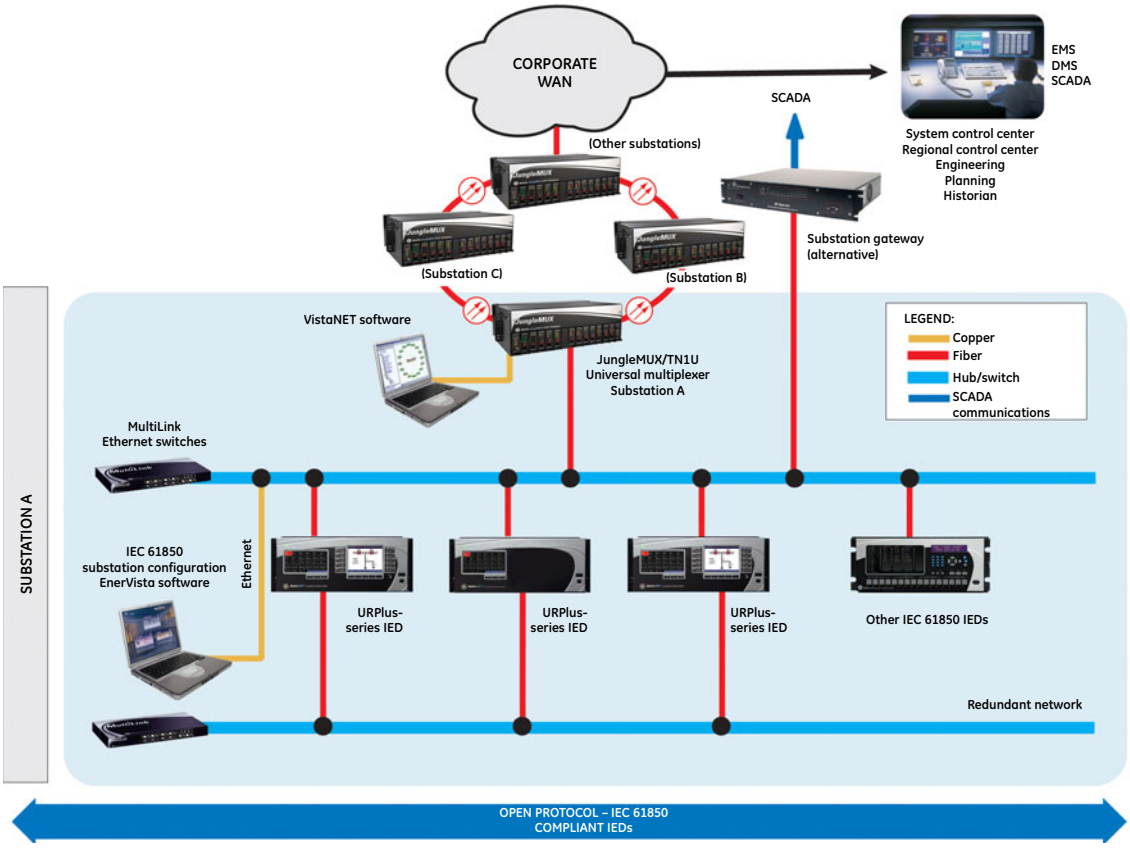
Figure 3: Functional architecture



Communications overview

The EnerVista UR^Plus Setup software can communicate with the relay through three ports: the front panel USB port, the rear Ethernet port, and the rear RS485 port. Both rear ports are located in slot D.

Figure 4: Communications overview



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To communicate through the C90^{Plus} rear RS485 port from a computer's RS232 port, the GE Multilin RS232/RS485 converter box is required. This device (catalog number F485) connects to the computer using a straight-through serial cable. A shielded twisted-pair (20, 22, or 24 AWG) connects the F485 converter to the C90^{Plus} rear communications port. The converter terminals (+, –, GND) are connected to the C90^{Plus} communication module (+, –, COM) terminals. The line should be terminated with a 120 Ω, 1 nF R-C network.

Communications via Ethernet requires a connection to an Ethernet network using a standard copper or fiber cable. The Ethernet port can also connect directly to a PC using a cross-over cable.

To communicate via the faceplate USB port, a standard USB serial cable is used.

For additional information, refer to:

Main processor module on page 44.

EnerVista software

The EnerVista software suite is an industry-leading set of programs that simplifies every aspect of the C90^{Plus}. The EnerVista suite provides tools to monitor the status of your protected asset, maintain the device, and integrate information measured by the C90^{Plus} into DCS or SCADA monitoring systems. Convenient COMTRADE and sequence of events viewers are an integral part of the EnerVista UR^{Plus} Setup software included with every C90^{Plus}. This allows the user to carry out post-mortem event analysis to ensure proper protection system operation.

Software requirements

The EnerVista UR^{Plus} Setup software interface is used to communicate with the C90^{Plus}. It is the preferred method to edit settings and view actual values because the computer monitor can display more information in a simple comprehensible format.

The following minimum requirements must be met for the EnerVista UR^{Plus} Setup software to properly operate on a computer:

- Pentium class or higher processor (Pentium II 300 MHz or higher recommended)
- Windows XP, Vista, 7 (64-bit), and Server 2008 (64-bit)
- Internet Explorer 4.0 or higher
- 128 MB of RAM (256 MB recommended)
- 200 MB of available space on system drive and 200 MB of available space on installation drive
- Video capable of displaying 800 × 600 or higher in high-color mode (16-bit color)
- USB 2.0 or Ethernet port for communications to the IED

The software and unit are backwards-compatible with UR^{Plus}-series devices having any previous firmware version.

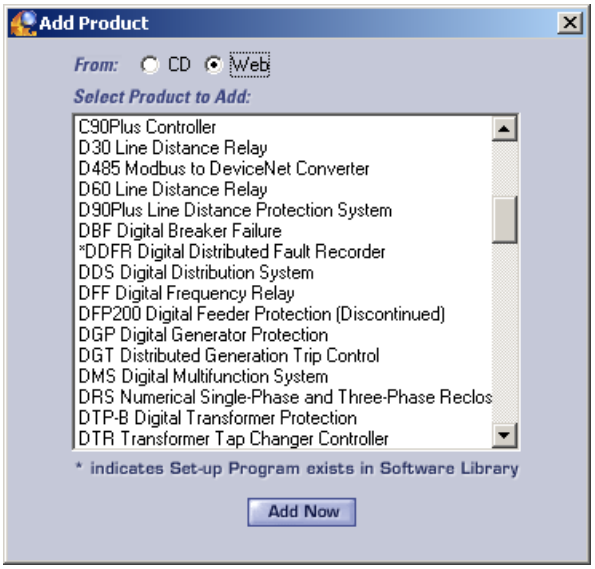
Installing the software

After ensuring the minimum requirements for using EnerVista UR^{Plus} Setup software (see previous section), use the following procedure to install the EnerVista UR^{Plus} Setup from the enclosed GE EnerVista CD.

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



5. In the EnerVista Launch Pad window, click the **Add Product** button and select the "C90^{Plus} Automation Logic Controller" from the Install Software window as shown below. Select the "Web" option to ensure the most recent software release, or select "CD" if you do not have a web connection, then click the **Add Now** button to list software items for the C90^{Plus}.



EnerVista Launchpad obtains the software from the Web or CD and automatically starts the installation program.

6. Select the complete path, including the new directory name, where the EnerVista UR^{Plus} Setup is to be installed.
7. Click on **Next** to begin the installation. The files are installed in the directory indicated and the installation program automatically creates icons and adds EnerVista UR^{Plus} Setup to the Windows start menu.
8. Click **Finish** to end the installation. The UR^{Plus}-series device is added to the list of installed IEDs in the EnerVista Launchpad window, shown as follows.

Figure 5: Example list of installed devices showing UR^{Plus}-series device



Software access

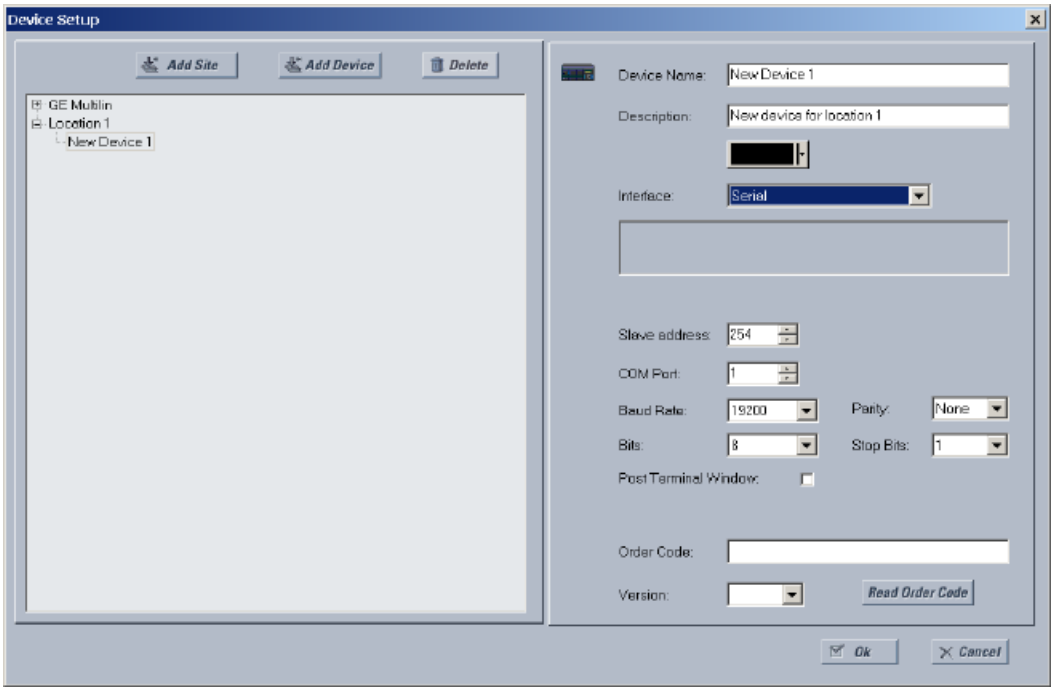
The user can connect remotely to the C90^{Plus} through the rear Ethernet port with a computer running the EnerVista UR^{Plus} Setup software. The C90^{Plus} can also be accessed locally with a computer through the front panel USB port or the rear Ethernet port using the Quick Connect feature. See the following sections for details.

Configuring serial communications

Before starting, verify that the serial cable is properly connected to the RS485 terminals on the back of the device. The faceplate USB port is intended for local use and is not described in this section; refer to the Using the Quick Connect Feature section for details on configuring the USB port.

1. Verify that the latest version of the EnerVista UR^{Plus} Setup software is installed (available from the GE EnerVista CD or online from http://GEDigitalEnergy.com/Multilin). See the Software Installation section for installation details.
2. Select the "C90^{Plus}" device from the EnerVista Launchpad to start EnerVista UR^{Plus} Setup.
3. Click the **Device Setup** button to open the Device Setup window and click the **Add Site** button to define a new site.
4. Enter the desired site name in the "Site Name" field. If desired, a short description of site can also be entered along with the display order of devices defined for the site. In this example, we will use "Location 1" as the site name. Click the **OK** button when complete.

5. The new site will appear in the upper-left list in the EnerVista UR^{Plus} Setup window. Click the **Device Setup** button then select the new site to re-open the Device Setup window.
6. Click the **Add Device** button to define the new device.
7. Enter the desired name in the "Device Name" field and a description (optional) of the site.
8. Select "Serial" from the **Interface** drop-down list. This will display a number of interface parameters that must be entered for proper serial communications.



9. Enter the relay slave address, COM port, baud rate, and parity settings from the **Settings > Communications > Serial Ports** tree item in their respective fields.
10. Click the **Read Order Code** button to connect to the UR^{Plus} device and upload the order code. If the software is unable to upload the order code due to a communications error, ensure that the EnerVista UR^{Plus} Setup serial communications values entered in the previous step correspond to the relay setting values.
11. Click **OK** when the relay order code has been received. The new device is added to the Site List window (or Online window) located in the top left corner of the main EnerVista UR^{Plus} Setup window.

The site device has now been configured for serial communications. Proceed to the Connecting to the C90^{Plus} section to begin communications.

Configuring Ethernet communications

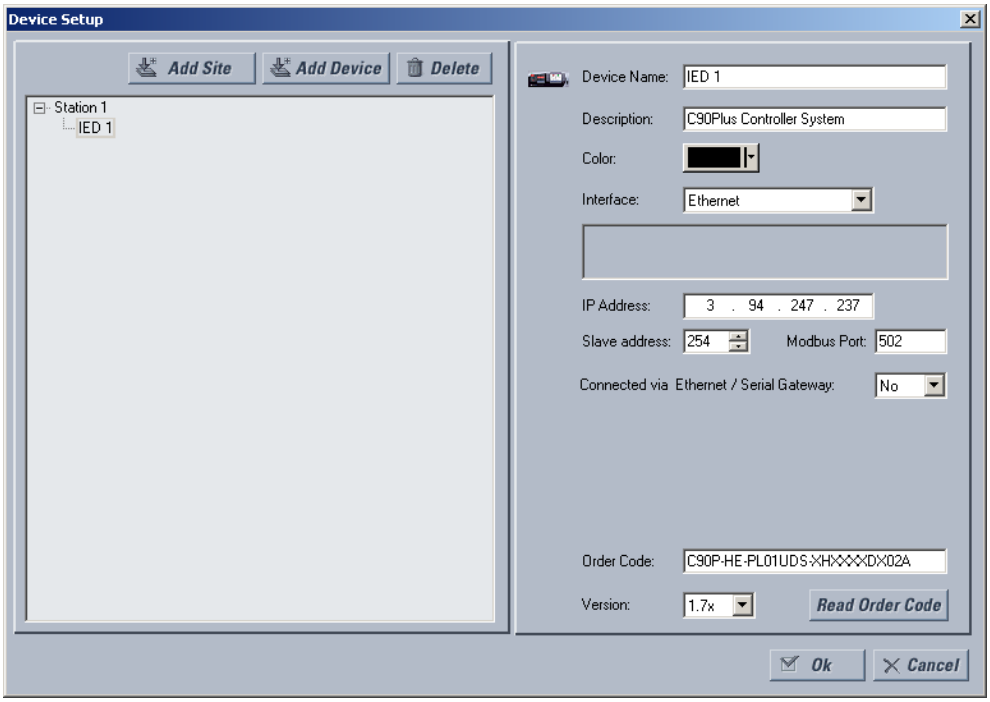
Before starting, verify that the Ethernet network cable is properly connected to the Ethernet port on the back of the device. To setup the device for Ethernet communications, it will be necessary to define a site, then add the C90^{Plus} as a device at that site.

1. Verify that the latest version of the EnerVista UR^{Plus} Setup software is installed (available from the GE EnerVista CD or online from http://www.gedigitalenergy.com/multilin).
2. Select the "UR^{Plus}" device from the EnerVista Launchpad to start EnerVista UR^{Plus} Setup.

3. Click the **Device Setup** button to open the Device Setup window, then click the **Add Site** button to define a new site.
4. Enter the desired site name in the "Site Name" field.

   If desired, a short description of site can also be entered along with the display order of devices defined for the site. In this example, we will use "Location 2" as the site name.
5. Click the **OK** button when complete.

   The new site will appear in the upper-left list in the EnerVista UR^{Plus} Setup window.
6. Click the **Device Setup** button then select the new site to re-open the Device Setup window.
7. Click the **Add Device** button to define the new device.
8. Enter the desired name in the "Device Name" field and a description (optional) of the site.
9. Select "Ethernet" from the **Interface** drop-down list.



   This will display a number of interface parameters that must be entered for proper Ethernet functionality.
10. Enter the device IP address specified in the **Settings > Communications > Network > Addressing** menu in the "IP Address" field.
11. Enter the relay slave address and Modbus port address values from the respective settings in the **Settings > Communications > Modbus > Protocol** menu.
12. Click the **Read Order Code** button to connect to the C90^{Plus} device and upload the order code. If an communications error occurs, ensure that the three EnerVista UR^{Plus} Setup values entered in the previous steps correspond to the relay setting values.
13. Click **OK** when the relay order code has been received. The new device will be added to the Site List window (or Online window) located in the top left corner of the main EnerVista UR^{Plus} Setup window.

The site device has now been configured for Ethernet communications. Proceed to the Connecting to the C90^{Plus} section to begin communications.

Establishing communications for the first time

The most convenient way to establish communication to the C90^{Plus} for the first time using the EnerVista UR^{Plus} Setup software is to use the USB interface located on the front of the relay. Once communications has been established the settings for the RS485 and Ethernet port can then be configured as described in the following procedure. This procedure assumes the latest version of EnerVista UR^{Plus} Setup software has been loaded into the computer as described in the previous section of this manual.

1. Ensure that the USB cable is not connected to the C90^{Plus}.
2. Start EnerVista UR^{Plus} Setup software.
3. Once the software has launched, connect the USB cable between the computer and the front panel of the C90^{Plus}.



870823A2.CDR

4. The first time that the computer is connected, a hardware configuration wizard opens. Complete the wizard. For the driver location, browse to the EnerVista Setup software location and located the **USB Driver** folder that contains the SerialUSB.inf driver file. The path is typically **C:/Program Files/GE Power Management/C90^{Plus}/USB Driver**, or for Windows 7 64-bit **C:/Program Files/GE Power Management/C90^{Plus}/USB Driver 64-bit**.

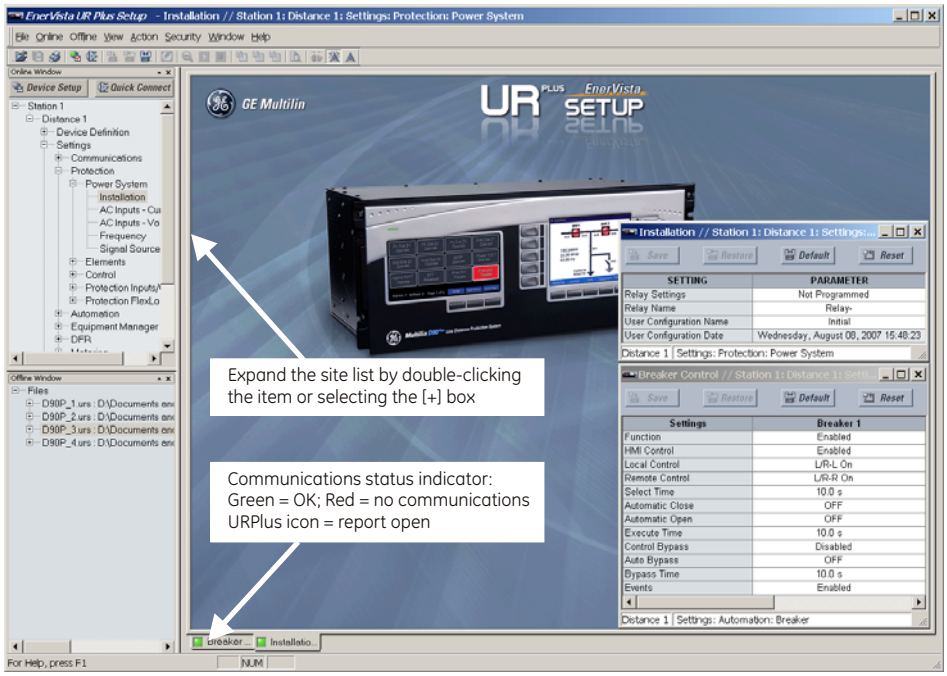
   If an error message displays and the wizard does not complete, the Multilin Relay USB Serial Emulation driver software is being blocked. The following fix uses Windows XP Service Pack 3 as an example. Access the **Control Panel** application in Windows, then click **System**, click the **Hardware** tab, then click the **Driver Signing** button. Change the setting to **Warn** or **Ignore**. Then restart the hardware wizard in the Control Panel by clicking **Administrative Tools**, then **Computer Management**, then **Device Manager**, and search for the **GE Protective Relay** entry. Reinstall the driver.
5. Launch the EnerVista software, and click the **Quick Connect** icon to open the Quick Connect window.
6. The EnerVista UR^{Plus} Setup software will create a site named "Quick Connect" with a corresponding device also named "Quick Connect" and display them on the upper-left corner of the screen. Expand the sections to view data directly from the C90^{Plus} device.

Each time the EnerVista UR^{Plus} Setup software is initialized, click the **Quick Connect** button to establish direct communications to the C90^{Plus}. This ensures that configuration of the EnerVista UR^{Plus} Setup software matches the C90^{Plus} model number.

Connecting to the C90Plus

This example shows how to connect to the C90Plus and configure the breaker settings.

1. Open the Breakers window through the site list tree.



   The breaker configuration window opens and a status indicator displays on the lower left of the EnerVista URPlus Setup 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 device and that the C90Plus has been properly setup for communications.

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

3. The breaker settings can now be edited, printed, or changed according to user specifications.

See the software chapter or the EnerVista URPlus Setup help file for more information about the using the software interface.

C90Plus Controller

Chapter 2: Product description

This section provides an overview and technical specifications of the C90Plus.

C90Plus overview

The C90Plus is a powerful logic controller specifically designed for use in substation environments and for the unique automation requirements of industrial and utility power systems. The C90Plus provides unmatched logic processing ability combined with a powerful math engine with deterministic execution of logic equations regardless of the configuration of the number of lines of logic.

The C90Plus provides the tools and functionality necessary for creating customized automation and control schemes that include:

- Advanced bay control and interlocking.
- Breaker monitoring and control.
- Automatic bus transfer schemes.
- Load shedding and load restoration schemes.

Additional key benefits of the C90Plus are listed below.

- Deterministic execution of logic regardless of the number of configured equations.
- Substation hardened controller that surpasses the transient, ESD, and RFI immunity of a standard PLC.
- Local front panel interface provides real time control and annunciation of station events.
- Configurable alarm annunciator eliminates the need for separate annunciator panel.
- Intuitive and easy-to-use large front panel color display with pre-configured information on metering, fault records, event records, and separate control screen for bay control.
- High-end fault and disturbance recording, including internal relay operating signals, eliminating the need for redundant recording devices.
- Reduced installation space requirements through compact design.
- True convergence of protection, metering, automation, control functions, multiple input and output options, and extensive communications capability.

Front panel interface

An intuitive and easy-to-use color graphical display is provided in the C90Plus front panel. The display provides easy access and visualization of device information, ranging from the large display of metered values such as voltage, current, demand, energy, and sequence components, to a comprehensive display of fault reports, sequence of events, and transient recorded waveforms. The front panel interface also displays device health information with critical and non-critical alarm status.

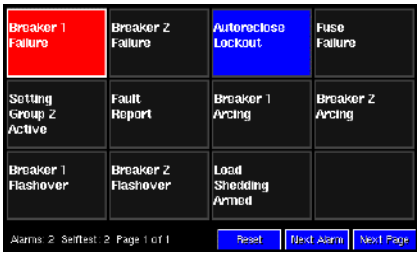
This advanced functionality allows the user to access comprehensive information without having to navigate through conventional displays and keypads. Information is displayed through two dedicated display panels. One serves as a digital annunciator and the other reflects display and control functions.

Annunciator

The C90Plus provides an embedded, configurable color LCD annunciator on the front panel of the device, eliminating the need for LEDs and separate annunciators in the panel.

Any contact, direct input, remote input, or internally generated operand can be assigned to the annunciator. Up to 288 targets can be assigned. The display can be configured for 12, 24, or 48 alarms per page to a maximum of 24 pages. A separate self-test message page displays easy-to-understand error messages about device health. This page also provides a graphical representation of the error messages, which assists in identifying and correcting problems.

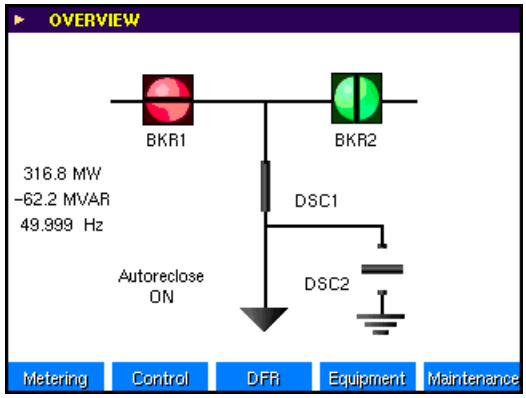
Figure 1: Typical annunciator display



Control functions

The front panel interface contains a mimic diagram that provides status and control for 6 breakers and up to 30 disconnect switches. Many different bay configurations can be realized through the setting of the device. Tagging of a device and substitution of device status can also be carried out through front panel. Status and control of the autoreclose function is also available through the mimic diagram.

Figure 2: Front panel control example



USB port

The front panel provides a USB 2.0 port for local connection to a computer.

Figure 3: Front panel USB connection



Protection features

The C90Plus is designed for superior performance and ease-of-use, providing a single platform solution for automation logic control. The scalable platform consists of protection, control, automation, monitoring, communication, digital fault recorder (DFR) and security functionality. The incrementally scalable concept allows customization in building the device to suit specific user requirements. The truly convergent platform integrates multiple devices eliminating external devices and reduces the footprint of relay panels resulting in reduced wiring, commissioning and capital costs.

Overvoltage and undervoltage protection

Long lines under lightly loaded conditions or no-load may experience voltages exceeding the rated per unit voltage level of the line. The C90Plus also provides additional voltage functions including neutral overvoltage, negative-sequence overvoltage, and phase undervoltage.

Overcurrent functions

The C90Plus provides overcurrent functions for phase, neutral, and ground that can run parallel with distance protection or can be programmed to provide primary protection under conditions when distance elements are blocked during fuse-failure conditions.

- Instantaneous and timed overcurrent elements for phase, neutral, ground, and negative-sequence protection
- Directional supervision is available for phase, neutral, and negative-sequence elements
- Time overcurrent elements can individually be set to use IEEE, IEC, or custom FlexCurves

For additional information, refer to:

Current elements on page 175

Autoreclose

The C90Plus provides multi-shot autoreclosing for single-pole or three-pole autoreclose on all types of faults with independently programmable dead times for each shot. Autoreclosing also can be dynamically blocked by user programmable logic. Four different autoreclose modes are available enabling the users to select the reclosing mode of their practice.

For additional information, refer to:

Autoreclose on page 248

Breaker failure

The C90Plus can be used to carry out fully independent breaker failure protection over the breakers associated to the line when connected to a substation with a breaker-and-a-half or ring bus arrangement. The C90Plus provides the required current source inputs, digital inputs and outputs, and elements to perform two independent breaker failure functions.

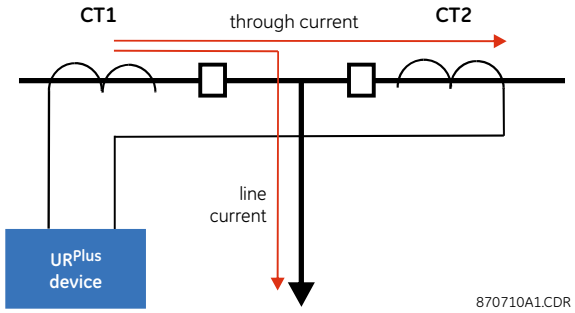
For additional information, refer to:

Breaker failure on page 226

Multi-breaker configurations

The C90Plus supports multi-breaker busbar configurations such as breaker-and-a-half or ring bus arrangements, providing dual breaker autoreclose, dual synchrocheck elements, and dual independent breaker failure elements.

Figure 4: Breaker-and-a-half configuration example



Small signal oscillation detection

The small signal oscillation detection (SSOD) element detects small oscillations of real power and frequency values (selectable) on interconnections between neighboring power systems. The SSOD element operates on local measurements only or a combination of local and remote measurements (taken at the same instance) sampled at predetermined rate of 100 ms. These values are summed and processed using a single-cycle Fourier filter. The low frequency signal magnitude (for example, 0.1 to 0.2 Hz) is compared with a user-programmable threshold, and after a specified time delay, a trip or alarm action is issued by the C90Plus.

For additional information, refer to:

Small signal oscillation detection on page 242

Automation features

A separate automation engine with powerful Boolean and math functions allows the user to easily engineer complex custom automation schemes. This includes advanced interlocking schemes, remedial action schemes, and advanced load shedding schemes.

Execution of the automation logic is independent of protection elements and protection logic. The automation capability is segmented into seven independent modules to simplify implementation and testing of complex schemes in which each module is independently editable and password protected. While building and compiling these modules, intelligent error detection automatically notifies the users of errors such as overflows, type mismatch, division by zero, and square root of a negative number, allowing the user to achieve maximum optimization. The programming interface complies with the global standard IEC 61131 for industrial control programming and also allows for embedded comments. Easy to use on-line and off-line debugging and simulation tools provide extensive testing capabilities of complex schemes. This includes forcing of input variables, simulation of analog values and visualization of live logic states and live analog values.

Synchrocheck and breaker control, disconnect switch control, and local/remote breaker control are available as hard-coded schemes as part of the C90Plus automation capabilities.

For additional information, refer to:

Automation specifications on page 30
Automation on page 331

Synchronism check

The synchrocheck elements are typically used at locations where the two parts of the system are interconnected through at least one other point in the system, which are to be joined by the closure of one or more circuit breakers. The C90Plus provides the required voltage source inputs, digital inputs and outputs, and elements to monitor differences in voltage magnitudes, phase angles, and frequencies to perform synchronism check across two breakers. The C90Plus can be used to carry out full independent control over the breakers associated to the line when connected to a substation with a breaker-and-a-half or ring bus arrangement.

For additional information, refer to:

Synchrocheck on page 352

Fast load shedding

The fast load shedding (FLS) element rapidly sheds load in a large industrial campus in response to loss of one or more infeeds in order to avoid complete system collapse while maintain supply to as much of the process as practical. Unlike undervoltage, underfrequency, or rate of frequency decay load shedding schemes, the fast load shedding element can initiate load shedding before the system frequency/voltage declines, which in many cases is essential for maintaining system stability. The fast load shed element uses IEC 61850 GOOSE communications to collect load and infeed power information from a very large number of end units at very high speed. This information is processed in one protection pass and shed requests issued according to configurable priority or pattern again using GOOSE messaging.

For additional information, refer to:

Fast load shedding on page 369

Scalable hardware

The C90Plus is available with a multitude of input and output configurations to suit the most demanding application needs. The expandable modular design allows for easy configuration and future upgrades. Types of digital outputs include trip-rated form-A and solid-state (SSR) relays available with optional circuit continuity monitoring and current detection to verify continuity and health of the associated circuitry.

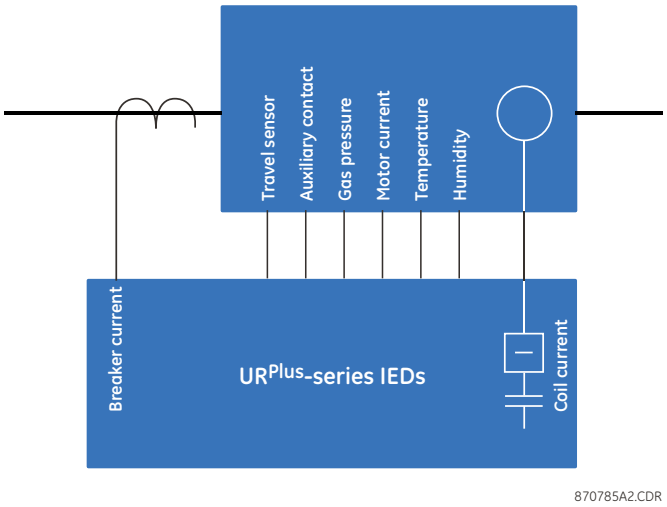
Equipment manager features

Critical assets, such as circuit breakers and the station battery, are monitored with the powerful C90Plus condition monitoring and diagnostic features. The C90Plus processes the interrupted current of the breaker, the auxiliary contact status of the breakers, spring compressor operating time and frequency, compressor motor current, SF6 pressure stages and the circuit breaker trip and close coil monitoring to alert the operator an impending circuit breaker problem. Up to two breakers, associated trip, close coils and station battery can be monitored in real time. These features are available through the front panel interface in real time allowing the operating personnel to detect any abnormality and take corrective actions. A comprehensive equipment-monitoring feature of C90Plus reduces the downtime of your assets and improves the availability of the power system.

NOTE

Only the battery monitor and breaker arcing current features are supported in the current version of the C90Plus.

Figure 5: Circuit breaker monitoring example



For additional information, refer to:

Equipment manager on page 421

Metering and monitoring features

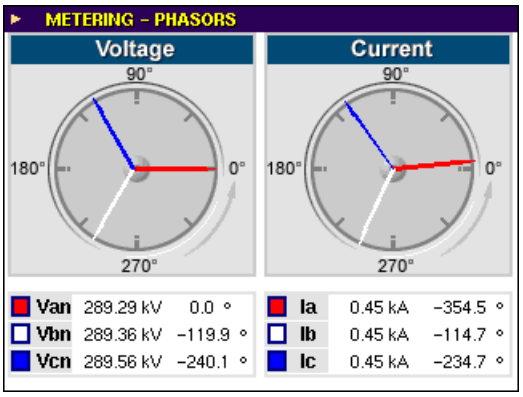
Voltage, current, and power metering are built into the protection platform as a standard feature. Current parameters are available as total waveform RMS magnitude, or as fundamental frequency only RMS magnitude and angle (phasor).

Measured values include

- Voltage phasors
- Voltage symmetrical components
- Current phasors
- Current symmetrical components
- Current true one-cycle RMS values
- Active, reactive, and apparent power
- Power factor (all power values per phase and total)
- Four-quadrant energy
- Frequency
- Synchrophasors
- Data logger

The measured signals are available for larger local display in the color LCD, accessible remotely using communications.

Figure 6: Phasors display example



Energy metering

The metered values for real, reactive, and apparent power, as well as power factor, are displayed via the front panel interface or through the EnerVista UR^{Plus} Setup software.

Phasors

The metered values and phasor representations for phase current, ground current, phase voltage, and auxiliary voltage are displayed via the front panel interface or through the EnerVista UR^{Plus} Setup software.

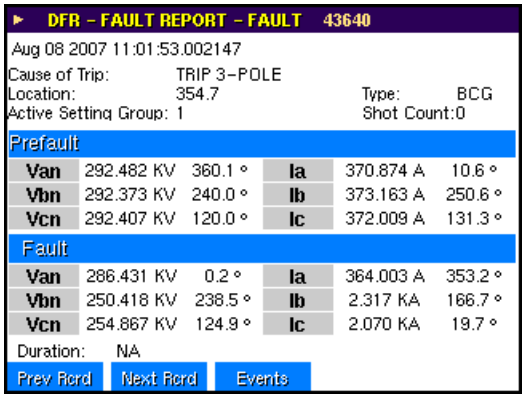
Sequence components metering

The metered values and phasor representations for negative-sequence current and voltage, positive-sequence current and voltage, and zero-sequence current and voltage are displayed via the front panel interface or through the EnerVista UR^{Plus} Setup software.

Digital fault recorder features

The powerful data acquisition and computing platform of the C90^{Plus} provides high-resolution recording of power system parameters replacing the need for an expensive stand-alone digital fault recorder (DFR), resulting in capital costs savings for the end user. The digital fault recorder features a high-resolution transient recorder (fast scan), a long-term disturbance recorder (slow scan), and a longer sequence of events with up to 8000 events. The internal clock used for time-tagging events can be synchronized with an IRIG-B signal or via the SNTP protocol over the Ethernet port. This precise time stamping allows the sequence of events to be determined throughout the system.

Figure 7: Typical front panel fault report display



Sequence of events recorder

The C90^{Plus} contains an advanced sequence of events recorder with the capability to record up to 8000 events.

Event information can be accessed either through the front panel interface or through the EnerVista Launchpad software. The very high sampling rate and large amount of storage capacity available for data recording in the C90^{Plus} can eliminate the need for installing costly standalone event recording equipment.

Fault reports and fault locator

The C90^{Plus} supports a fault report and associated fault location data. The fault report stores data pertinent to an event that is triggered and provides the distance to the fault location. A maximum of 15 records are stored in the nonvolatile memory providing a comprehensive summary of events associated with a fault.

Transient recorder

The transient recorder captures critical system data during a transient event. It is tailored to capture shorter duration events such as faults at a high resolution. The transient recorder can be programmed to sample at 256 samples per cycle. The C90^{Plus} can store up to 64 records in nonvolatile memory with up to one minute of storage capacity for all 16 analog channels and 128 digital channels. The transient recorder incorporates integrated triggering. Any monitored channel may be configured to trigger the recorder.

Disturbance recorder

Longer-term events are monitored by disturbance recorders, which include voltage sag, swell, and overloading. Any computed analog channel or digital channel can trigger the disturbance recorder. The C90^{Plus} can store up to 64 records in nonvolatile memory with up to five minutes of storage capacity.

Communications features

The C90^{Plus} incorporates powerful communications capabilities required for the demanding applications anticipated in future substations. The communications module is dedicated to processing the IEC 61850, DNP 3.0, and IEC 60870-5-104 protocols. This module provides redundant Ethernet ports each with 10/100Base-TX and 100Base-FX connectors.

Modbus RTU and DNP3.0 are also available as default protocols through the RS485 port or the CPU Ethernet ports (slot D).

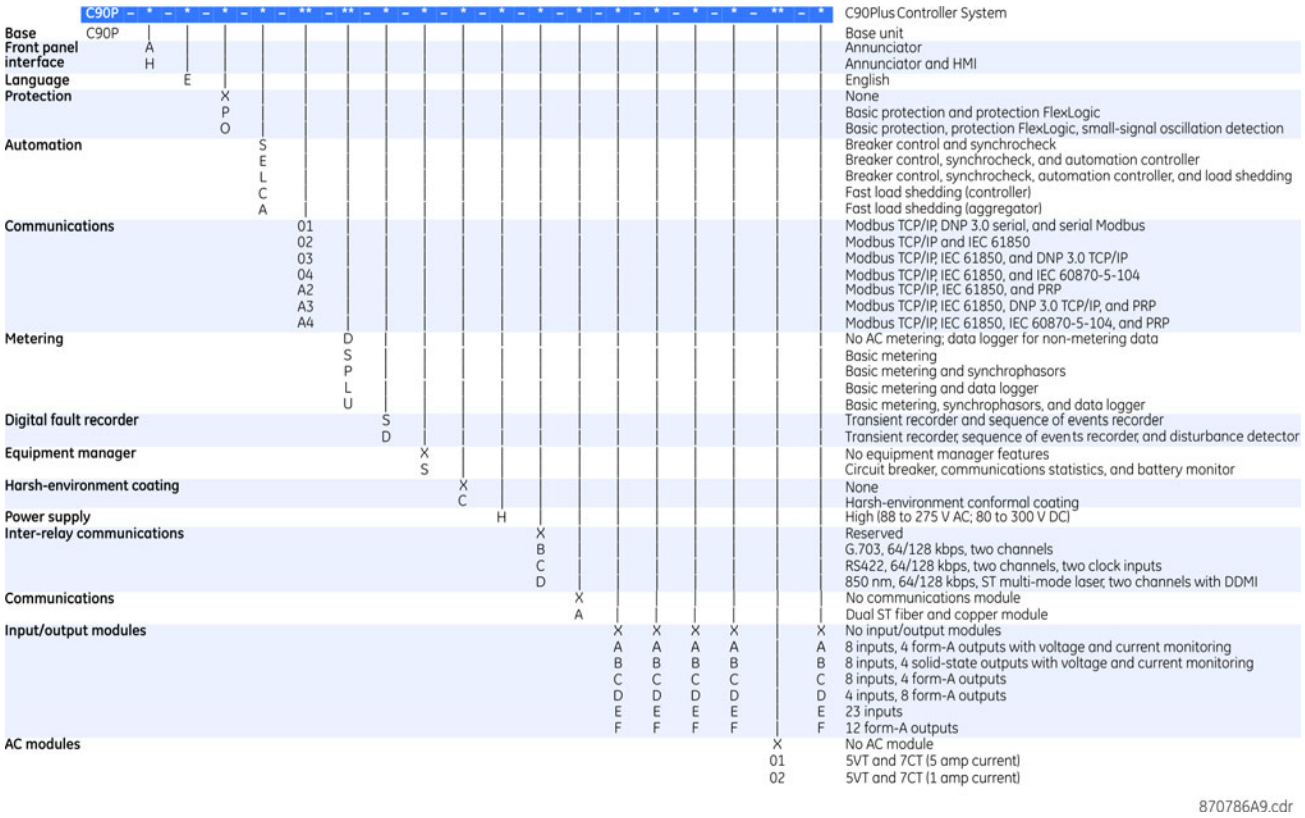
Order codes

The C90^{Plus} is available as a 19-inch rack horizontal mount and consists of a number of optional and required modules. 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 system is provided in the following table.

NOTE

Order codes are subject to change without notice. See the ordering page at http://www.gedigitalenergy.com/multilin/order.htm for the latest ordering options.

Figure 8: Order codes



NOTE

The C90^{Plus} has a dynamic order code. As such, selecting certain protection and automation options can limit the options available in other fields. See the ordering page at http://www.gedigitalenergy.com/multilin/order.htm or the software for details.

Specifications

NOTE

Specifications are subject to change without notice.

Protection specifications

AUTORECLOSURE

Applications:.....two breakers
Tripping schemes:.....single-pole and three-pole
Reclose attempts:.....up to 4 before lockout
Reclosing mode:.....selectable
Breaker sequence:.....selectable

AUXILIARY OVERVOLTAGE

Pickup level: 0.000 to 1.100 pu in steps of 0.001
Dropout level: <98% of pickup
Level accuracy: ±0.5% of reading from 10 to 208 V
Pickup delay: 0.00 to 600.00 seconds in steps of 0.01
Reset delay: 0.00 to 600.00 seconds in steps of 0.01
Timing accuracy: ±3% of operate time or ±4 ms (whichever is greater)
Operate time: <2 cycles at 1.10 × pickup at 60 Hz

AUXILIARY UNDERVOLTAGE

Pickup level: 0.000 to 1.100 pu in steps of 0.001
Dropout level: >102% of pickup
Level accuracy: ±0.5% of reading from 10 to 208 V
Curve shapes: GE IAV inverse, definite time
Curve multiplier: 0.00 to 600.00 in steps of 0.01
Timing accuracy: ±3% of operate time or ±4 ms (whichever is greater)

BREAKER FAILURE

Mode: single-pole, three-pole
Current supervision: phase current, neutral current
Supervision pickup: 0.001 to 30.000 pu in steps of 0.001
Supervision dropout: <98% of pickup
Supervision accuracy at 0.1 to 2.0 × CT: ±2% of rated
Supervision accuracy at >2.0 × CT: ±2.5% of reading
Time accuracy: ±3% or 4 ms (whichever is greater)

BREAKER FLASHOVER

Operating quantity: phase current, voltage, and voltage difference
Pickup level voltage: 0.000 to 1.500 pu in steps of 0.001
Dropout level voltage: 97 to 98% of pickup
Pickup level current: 0.000 to 1.500 pu in steps of 0.001
Dropout level current: 97 to 98% of pickup
Level accuracy: ±0.5% or ±0.1% of rated (whichever is greater)
Pickup delay: 0.000 to 65.535 seconds in steps of 0.001
Time accuracy: ±3% or ±42 ms (whichever is greater)
Operate time: <42 ms at 1.10 × pickup at 60 Hz

CONTACT INPUTS

Input rating: 300 V DC maximum
On threshold: 70% of nominal voltage setting or 20 V (whichever is greater)
Off threshold: 30% of nominal voltage setting or 15 V (whichever is greater)
Bounce threshold: 50% of nominal voltage setting or 20 V (whichever is greater)
AZ threshold: 80% of nominal voltage setting
Overvoltage threshold: 130% of nominal voltage setting or 285 V maximum
Maximum current: 10 mA during turn on, 0.5 mA steady-state
Nominal voltage: 24 to 250 V
Input impedance: active
Recognition time: <1 ms
Debounce timer: 1.50 to 16.00 ms in steps of 0.25
Chatter detection timer: 1 to 100 seconds
Chatter state changes: 10 to 100

DISTURBANCE DETECTOR (50DD)

Type: sensitive current disturbance detector
Range: 0.004 to 0.04 pu (twice the current cut-off level threshold)

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

FLEXELEMENTS™

Elements: 16
Operating signal: any analog actual value, or two values in differential mode
Operating signal mode: signed or absolute value
Operating mode: level, delta
Comparator detection: over, under
Pickup level: –90.000 to 90.000 pu in steps of 0.001
Hysteresis: 0.1 to 50.0% in steps of 0.1
Delta *dt*: 20 ms to 60 days
Pickup delay: 0.000 to 65.535 seconds in steps of 0.001
Dropout delay: 0.000 to 65.535 seconds in steps of 0.001

FLEXMATRIX

Principle: aggregates and conditions signals for tripping and auxiliary functions
Timing accuracy: ±1 ms

FLEX STATES

Number: up to 256 logical variables grouped under 16 Modbus addresses
Programmability: any logical variable, contact, or virtual input

GROUND INSTANTANEOUS OVERCURRENT

Pickup level: 0.000 to 30.000 pu in steps of 0.001
Dropout level: <98% of pickup
Level accuracy at 0.1 to 2.0 × CT: ±0.5% of reading or ±1% of rated (whichever is greater)
Level accuracy at >2.0 × CT: ±1.5% of reading
Overreach: <2%
Pickup delay: 0.00 to 600.00 seconds in steps of 0.01
Reset delay: 0.00 to 600.00 seconds in steps of 0.01
Operate time: <16 ms at 3 × pickup at 60 Hz
Timing accuracy for operation at 1.5 × pickup: ±3% or ±4 ms (whichever is greater)

GROUND TIME OVERCURRENT

Current: phasor or RMS
Pickup level: 0.000 to 30.000 pu in steps of 0.001
Dropout level: <98% of pickup
Level accuracy at 0.1 to 2.0 × CT: ±0.5% of reading or ±1% of rated (whichever is greater)
Level accuracy at >2.0 × CT: ±1.5% of reading
Curve shapes: IEEE Moderately Inverse, IEEE Very Inverse, IEEE Extremely Inverse, IEC (BS) A, IEC (BS) B, IEC (BS) C, IEC Short Inverse, IAC Inverse, IAC Short Inverse, IAC Very Inverse, IAC Extremely Inverse, I^2t, FlexCurves™ (programmable), definite time (0.01 second base curve)
Curve multiplier: 0.01 to 600.00 in steps of 0.01
Reset type: instantaneous/timed (per IEEE)
Timing accuracy for 1.03 to 20 × pickup: ±3.5% of operating time or ±1 cycle (whichever is greater)

NEGATIVE-SEQUENCE DIRECTIONAL OVERCURRENT

Directionality: co-existing forward and reverse
Polarizing: voltage
Polarizing voltage: V_2
Operating current: I_2
Level sensing (zero-sequence): |I_0| – *K* × |I_1|
Level sensing (negative-sequence): |I_2| – *K* × |I_1|
Restraint, *K*: 0.000 to 0.500 in steps of 0.001
Characteristic angle: 0 to 90° in steps of 1
Limit angle: 40 to 90° in steps of 1, independent for forward and reverse
Angle accuracy: ±2°
Offset impedance: 0.00 to 250.00 ohms in steps of 0.01
Pickup level: 0.05 to 30.00 pu in steps of 0.01
Dropout level: <98%
Operation time: <16 ms at 3 × pickup at 60 Hz

NEGATIVE-SEQUENCE INSTANTANEOUS OVERCURRENT

Pickup level: 0.000 to 30.000 pu in steps of 0.001
Dropout level: <98% of pickup
Level accuracy at 0.1 to 2.0 × CT: ±0.5% of reading or ±1% of rated (whichever is greater)
Level accuracy at >2.0 × CT: ±1.5% of reading
Overreach: <2%
Pickup delay: 0.00 to 600.00 seconds in steps of 0.01
Reset delay: 0.00 to 600.00 seconds in steps of 0.01
Operate time: <20 ms at 3 × pickup at 60 Hz
Timing accuracy for operation at 1.5 × pickup: ±3% or ±4 ms (whichever is greater)

NEGATIVE-SEQUENCE OVERVOLTAGE

Pickup level: 0.000 to 1.250 pu in steps of 0.001
Dropout level: <98% of pickup
Level accuracy: ±0.5% of reading from 10 to 208 V
Pickup delay: 0.00 to 600.00 seconds in steps of 0.01
Reset delay: 0.00 to 600.00 seconds in steps of 0.01
Timing accuracy: ±3% or ±20 ms (whichever is greater)
Operate time: < 30 ms at 1.10 × pickup at 60 Hz

NEGATIVE-SEQUENCE TIME OVERCURRENT

Pickup level: 0.000 to 30.000 pu in steps of 0.001
Dropout level: <98% of pickup
Level accuracy at 0.1 to 2.0 × CT: ±0.5% of reading or ±1% of rated (whichever is greater)
Level accuracy at >2.0 × CT: ±1.5% of reading
Curve shapes: IEEE Moderately Inverse, IEEE Very Inverse, IEEE Extremely Inverse, IEC (BS) A, IEC (BS) B, IEC (BS) C, IEC Short Inverse, IAC Inverse, IAC Short Inverse, IAC Very Inverse, IAC Extremely Inverse, I^2t, FlexCurves™ (programmable), definite time (0.01 second base curve)
Curve multiplier: 0.01 to 600.00 in steps of 0.01
Reset type: instantaneous/timed (per IEEE) and linear
Timing accuracy for 1.03 to 20 × pickup: ±3.5% of operating time or ±1 cycle (whichever is greater)

NEUTRAL DIRECTIONAL OVERCURRENT

Directionality: co-existing forward and reverse
Polarizing: voltage, current, dual
Polarizing voltage: V_0 or VX
Polarizing current: IG
Operating current: I_0
Level sensing: 3 × (|I_0| – *K* × |I_1|), IG; independent for forward and reverse
Restraint (*K*): 0.000 to 0.500 in steps of 0.001
Characteristic angle: –90 to 90° in steps of 1
Limit angle: 40 to 90° in steps of 1, independent for forward and reverse
Angle accuracy: ±2°
Offset impedance: 0.00 to 250.00 ohms in steps of 0.01
Pickup level: 0.002 to 30.000 pu in steps of 0.01
Dropout level: <98%
Operation time: <16 ms at 3 × pickup at 60 Hz

NEUTRAL INSTANTANEOUS OVERCURRENT

Pickup level: 0.000 to 30.000 pu in steps of 0.001
Dropout level: <98% of pickup
Level accuracy at 0.1 to 2.0 × CT: ±0.5% of reading or ±1% of rated (whichever is greater)
Level accuracy at >2.0 × CT: ±1.5% of reading
Overreach: <2%
Pickup delay: 0.00 to 600.00 seconds in steps of 0.01
Reset delay: 0.00 to 600.00 seconds in steps of 0.01
Operate time: <20 ms at 3 × pickup at 60 Hz
Timing accuracy for operation at 1.5 × pickup: ±3% or ±4 ms (whichever is greater)

NEUTRAL OVERVOLTAGE

Pickup level: 0.000 to 1.250 pu in steps of 0.001
Dropout level: <98% of pickup
Level accuracy: ±0.5% of reading from 10 to 208 V
Pickup delay: 0.00 to 600.00 seconds in steps of 0.01 (definite time) or user-defined curve
Reset delay: 0.00 to 600.00 seconds in steps of 0.01
Timing accuracy: ±3% or ±20 ms (whichever is greater)
Operate time: <3 cycles at 1.10 × pickup

NEUTRAL TIME OVERCURRENT

Current: phasor or RMS
Pickup level: 0.000 to 30.000 pu in steps of 0.001
Dropout level: <98% of pickup
Level accuracy at 0.1 to 2.0 × CT: ±0.5% of reading or ±1% of rated (whichever is greater)
Level accuracy at >2.0 × CT: ±1.5% of reading
Curve shapes: IEEE Moderately Inverse, IEEE Very Inverse, IEEE Extremely Inverse, IEC (BS) A, IEC (BS) B, IEC (BS) C, IEC Short Inverse, IAC Inverse, IAC Short Inverse, IAC Very Inverse, IAC Extremely Inverse, I^2t, FlexCurves™ (programmable), definite time (0.01 second base curve)
Curve multiplier: 0.01 to 600.00 in steps of 0.01
Reset type: instantaneous/timed (per IEEE)
Timing accuracy at 1.03 to 20 × pickup: ±3.5% of operating time or ±1 cycle (whichever is greater)

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™

PHASE DIRECTIONAL OVERCURRENT

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

PHASE INSTANTANEOUS OVERCURRENT

Pickup level: 0.000 to 30.000 pu in steps of 0.001
Dropout level: <98% of pickup
Level accuracy at 0.1 to 2.0 × CT: ±0.5% of reading or ±1% of rated (whichever is greater)
Level accuracy at >2.0 × CT: ±1.5% of reading
Overreach: <2%
Pickup delay: 0.00 to 600.00 seconds in steps of 0.01
Reset delay: 0.00 to 600.00 seconds in steps of 0.01
Operate time: <16 ms at 3 × pickup at 60 Hz
Timing accuracy for operation at 1.5 × pickup: ±3% or ±4 ms (whichever is greater)

PHASE OVERVOLTAGE

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

PHASE TIME OVERCURRENT

Current: phasor or RMS
Pickup level: 0.000 to 30.000 pu in steps of 0.001
Dropout level: <98% of pickup
Level accuracy at 0.1 to 2.0 × CT: ±0.5% of reading or ±1% of rated (whichever is greater)
Level accuracy at >2.0 × CT: ±1.5% of reading
Curve shapes: IEEE Moderately Inverse, IEEE Very Inverse, IEEE Extremely Inverse, IEC (BS) A, IEC (BS) B, IEC (BS) C, IEC Short Inverse, IAC Inverse, IAC Short Inverse, IAC Very Inverse, IAC Extremely Inverse, I^2t, FlexCurves™ (programmable), definite time (0.01 second base curve)
Curve multiplier: 0.01 to 600.00 in steps of 0.01
Reset type: instantaneous/timed (per IEEE)
Timing accuracy at 1.03 to 20 × pickup: ±3.5% of operating time or ±1 cycle (whichever is greater)

PHASE UNDERVOLTAGE

Pickup level: 0.000 to 1.100 pu in steps of 0.001
Dropout level: >102% of pickup
Level accuracy: ±0.5% of reading from 10 to 208 V
Curve shapes: GE IAV Inverse; Definite Time (0.1 second base curve)
Curve multiplier: 0.00 to 600.00 in steps of 0.01
Timing accuracy for operation at <0.90 × pickup: ±3.5% of operate time or ±4 ms (whichever is greater)

PROTECTION FLEXLOGIC™

Programming: 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, seconds, or minutes) in steps of 1
Dropout delay: 0 to 60000 (ms, seconds, or minutes) in steps of 1

PROTECTION VIRTUAL INPUTS

Input points: 64
Programmability: self-reset or latched

PROTECTION VIRTUAL OUTPUTS

Output points: 96
Programmability: output of a protection FlexLogic™ equation or input to a protection FlexLogic™ equation

REMOTE INPUTS (IEC 61850 GSSE/GOOSE)

Input points: 64
Remote devices: 32
Default states on loss of communications: on, off, latest/off, latest/on
Remote double-points status inputs: 16

REMOTE OUTPUTS (IEC 61850 GSSE/GOOSE)

Standard output points: 32
User output points: 32

SENSITIVE DIRECTIONAL POWER

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

SMALL SIGNAL OSCILLATION DETECTOR

Measured value: any analog value
Elements: 2
Inputs: 6
Minimum pickup: 0.02 to 10.00 pu in steps of 0.01 for alarm; 0.05 to 10.00 pu in steps of 0.01 for trip
Pickup level accuracy: ±5% or ±0.1 pu (whichever is greater)
Pickup delay: definite time, 0.00 to 600.00 seconds in steps of 0.01
Time accuracy: ±3% or ± 20 ms (whichever is greater)
Operate time: 3 / (4 × f_S) to 1 / f_S, where f_S is the signal frequency

VT FUSE FAILURE SUPERVISION

Elements: 1 per source
Monitored parameters: V_2, V_1, I_1

Automation specifications

AUTOMATION LOGIC

Number of lines of logic: 4096
Number of blocks: 1
Edit and view capability: yes
Logic type: cyclic
Programming language: proprietary
Execution rate: 50 ms
Variable types: Boolean, IEEE floating point
Boolean operations: NOT, XOR, OR, AND, NOR, NAND, any contact input, any direct input, any teleprotection input, any remote input, any virtual input, any automation logic operand
Arithmetic operations: add, subtract, multiply, divide, negation, absolute value, square root, exponent, logarithm, sine, cosine, tangent, arcsine, arccosine, arctangent, natural logarithm, base 10 logarithm, modulo, ceiling, floor
Control operations: latch, timer, comparator, absolute timer functions
Boolean inputs: any contact input, direct input, teleprotection input, remote input, virtual input, or automation logic operand
Analog inputs: any FlexAnalog™ quantity
Virtual inputs: 128
Virtual outputs: 255
Remote inputs: 64
Remote outputs: 64
Remote devices: 32

AUTOMATION VIRTUAL INPUTS

Input points: 128
Programmability: self-reset or latched

AUTOMATION VIRTUAL OUTPUTS

Output points: 255
Programmability: output of an automation logic equation or input to an automation logic equation

BREAKER CONTROL

Mode: single-pole, three-pole
Control: open/close, local/SCADA
Control seal-in: 0 to 2000 ms in steps of 1

BREAKER INTERLOCKING

Interlocking inputs: 6

DISCONNECT CONTROL

Mode: single-pole, three-pole
Control: open/close, local/SCADA
Control seal-in: 0 to 2000 ms in steps of 1

DISCONNECT INTERLOCKING

Interlocking inputs: 3

FAST LOAD SHEDDING (FLS)

Elements: 1
Algorithm: ..... adaptive (using priorities) or static (using trip masks)
Static mode scenarios: ..... up to 32
Adaptive mode priorities: ..... up to 128
Total of infeeds, loads, and aggregators monitored per C90^{Plus}: ..... up to 64 via communications plus 6 local infeeds or loads
Infeeds: ..... up to 32
Loads per end device: ..... up to 6 per GOOSE data message
Loads per C90^{Plus}: ..... up to 70 (up to 64 from end device, plus up to 6 from local contact input/output cards)
Load groups: ..... up to 32
Operate time: ..... ⅛ power system cycle (exclusive of communications and end device delays)
Power measurement updating: ..... 250 ms

FREQUENCY RATE OF CHANGE LOAD SHEDDING

Elements: 4
Minimum voltage: ..... 0.10 to 1.25 pu in steps of 0.01
Pickup level: ..... 0.10 to 15.00 Hz/s in steps of 0.01
Dropout level: ..... pickup – 0.02 Hz/s
Pickup delay: ..... 0.00 to 99.99 seconds in steps of 0.001
Dropout delay: ..... 0.00 to 99.99 seconds in steps of 0.001
Level accuracy: ..... 30 mHz/s or 3.5% (whichever is greater)
Time accuracy: ..... ±3% or ±4 ms (whichever is greater)
95% settling time for df/dt: ..... <24 cycles
Operate time (typical): ..... 6 cycles at 2 × pickup; 5 cycles at 3 × pickup; 4 cycles at 5 × pickup

LOAD SHEDDING SOURCE

Minimum voltage pickup: ..... 0.00 to 1.25 pu in steps of 0.01
Minimum voltage dropout: ..... pickup + 0.20 pu
Maximum negative-sequence voltage pickup: ..... 0.00 to 1.25 pu in steps of 0.01
Maximum negative-sequence voltage dropout: ..... pickup – 0.20 pu

SELECTOR SWITCH

Upper position limit: ..... 1 to 7 in steps of 1
Selecting mode: ..... time-out or acknowledge
Time-out timer: ..... 3.0 to 60.0 seconds in steps of 0.1
Control inputs: ..... step-up and three-bit
Power-up mode: ..... restore from non-volatile memory or synchronize to a three-bit control input or synchronize/restore mode

SYNCHROCHECK

Elements: 2
Maximum voltage difference: ..... 0 to 100000 volts in steps of 1
Maximum angle difference: ..... 0 to 100° in steps of 1
Maximum frequency difference: ..... 0.00 to 2.00 Hz in steps of 0.01
Hysteresis for maximum frequency difference: ..... 0.00 to 0.10 Hz in steps of 0.01
Dead source function:: ..... none, LV1 & DV2, DV1 & LV2, DV1 or DV2, DV1 xor DV2, DV1 & DV2 (L = live, D = dead)

UNDERFREQUENCY LOAD SHEDDING

Elements: 10
Pickup level: 45.00 to 65.00 Hz in steps of 0.01
Dropout level: pickup level + 0.03 Hz
Pickup delay: 0.00 to 99.99 seconds in steps of 0.01
Dropout delay: 0.00 to 99.99 seconds in steps of 0.01
Level accuracy: ±0.01 Hz
Time accuracy: ±3% or 4 ms (whichever is greater)
Operate time (typical): 4 cycles at –0.1 Hz/s change; 3.5 cycles at –0.3 Hz/s change; 3 cycles at –0.5 Hz/s change

UNDERVOLTAGE LOAD SHEDDING

Elements: 6
Pickup level: 0.10 to 1.25 pu in steps of 0.01
Dropout level: pickup level + 0.20 pu
Pickup delay: 0.00 to 99.99 seconds in steps of 0.01
Dropout delay: 0.00 to 99.99 seconds in steps of 0.01
Level accuracy: ±0.5% of reading from 10 to 208 volts
Time accuracy: ±3% or 4 ms (whichever is greater)
Operate time (typical): 2 cycles at 0.90 × pickup

Equipment manager

BATTERY MONITOR

Principle: monitors battery voltage and auxiliary alarms
Hysteresis: 5%
Timing accuracy: 1 cycle

BREAKER ARCING CURRENT

Elements: 1 per breaker (to a maximum of 2)
Principle: accumulates contact wear ($I_x t$), measures fault magnitude and duration
Auxiliary contact compensation: 0 to 50 ms in steps of 1
Alarm threshold: 0 to 50000 kA^2-cycle in steps of 1
Fault duration accuracy: 0.25 of power cycle

Metering specifications

CURRENT METERING

Type: phase and ground RMS current
Accuracy at 0.1 to 2.0 × CT: ±0.25% of reading or ±0.1% of rated (whichever is greater) at 50/60 Hz nominal frequency
Accuracy at >2.0 × CT: ±1.0% of reading, at 50/60 Hz nominal frequency

DATA LOGGER

Channels: 1 to 16
Parameters: any FlexAnalog value
Statistics: maximum and time of maximum, minimum and time of minimum, average
Alarms: high, high-high, low, low-low

ENERGY METERING

Type: positive and negative watt-hours and var-hours
Accuracy: ±2.0% of reading
Range: -2.0×10^9 to 2.0×10^9 MWh/Mvarh
Parameters: three-phase only
Update rate: 50 ms

FREQUENCY METERING

Accuracy at *V* = 0.8 to 1.2 pu: ±0.001 Hz (when voltage signal is used for frequency measurement)
Accuracy at *I* = 0.1 to 0.25 pu: ±0.05 Hz (when current signal is used for frequency measurement)
Accuracy at *I* > 0.25 pu: ±0.001 Hz (when current signal is used for frequency measurement)

PHASOR MEASUREMENT UNIT

Output format: per IEEE C37.118 standard
Channels: 14 synchrophasors, 8 analogs, 16 digitals
TVE (total vector error): <1%
Triggering: frequency, voltage, current, power, rate of change of frequency, user-defined
Reporting rate: 1, 2, 5, 10, 12, 15, 20, 25, 30, 50, or 60 times per second
Number of clients: One over TCP/IP port, two over UDP/IP ports
AC ranges: as indicated in appropriate specifications sections
Network reporting format: 16-bit integer or 32-bit IEEE floating point numbers
Network reporting style: rectangular (real and imaginary) or polar (magnitude and angle) coordinates
Post-filtering: none, 3-point, 5-point, 7-point
Calibration: ±5°

POWER METERING

Real power accuracy: ±1.0% of reading at $-1.0 \le PF < 0.8$ and $0.8 < PF \le 1.0$
Reactive power accuracy: ±1.0% of reading at $-0.2 \le PF \le 0.2$
Apparent power accuracy: ±1.0% of reading

VOLTAGE METERING

Type: RMS voltage
Accuracy: ±0.5% of reading from 30 to 208 volts at 50/60 Hz nominal frequency

Digital fault recorder specifications

DISTURBANCE RECORDER

Storage capacity: one record with all available channels at 60 samples per second for 40 seconds
Maximum records: 64
Sampling rate: 1 sample per cycle
Sampling accuracy: <1 ms per second of recording
Analog channels: 64
Analog channel data: any FlexAnalog™ quantity
Digital channels: 32
Digital channel data: any contact input, direct input, remote input, virtual input, automation logic operand, or FlexLogic™ operand
Triggers: any digital change of state (user-programmable), undervoltage, overvoltage, undercurrent, overcurrent, underfrequency, overfrequency, rate of change of frequency, 1 user-programmable trigger, 1 block
Storage modes: automatic overwrite, protected
Triggering modes: time window from rising edge of trigger, continuous recording as long as trigger is active
Pre-trigger window: 0 to 100%
Data storage: non-volatile memory

EVENT RECORDER

Storage capacity: 8192 events
Time tag: to 1 ms
Triggers: any contact input, direct input, remote input, virtual input, logic operand, or self-test event
Data storage: non-volatile memory

FAULT REPORT

Records: 15
Data: station and circuit ID, date and time of trip, fault type, active setting group at time of trigger, pre-fault current and voltage phasors (2 cycles before 50DD associated with fault report source), fault current and voltage phasors (1 cycle after trigger), protection elements operated at time of trigger, firmware revision
Triggers: user-selected operand
Data storage: non-volatile memory

FAULT LOCATOR

Method: single-ended
Accuracy: 2% of line length
Units: miles or kilometers
Trigger: from fault report
Data storage: non-volatile memory

FAST LOAD SHED REPORT

Records: 16
Data: FLSC relay name, firmware revision, contingency date/time and duration, steady-state power flows, infeeds lost, scenarios encountered, load groups shed, settings last change date
Triggers: any FLS contingency
Data storage: non-volatile memory

TRANSIENT RECORDER

Storage capacity: one record with all available channels at 32 samples per cycle for 1 minute
Number of records: 1 to 64
Sampling rate: 16 to 256 samples per power cycle
Timestamp accuracy: <10 µs per second of recording
Analog channels: up to twelve 16-bit, unprocessed, AC input channels
Analog channel data: any FlexAnalog quantity
Digital channels: up to 128
Digital channel data: any contact input, direct input, remote input, virtual input, automation logic operand, or FlexLogic™ operand
Sampled channels: up to 24
Sampled channel data: 16-bit, unprocessed sampled channels
Triggers: any digital channel change of state, undervoltage, overvoltage, undercurrent, overcurrent, underfrequency, overfrequency, rate of change of frequency, one user-programmable, one block
Storage modes: automatic overwrite, protected
Triggering modes: time window from rising edge of trigger, continuous recording as long as trigger is active
Pre-trigger window: 0 to 100%
Data storage: non-volatile memory

Front panel interface

ANNUNCIATOR

Inputs: 288
Windows per page: 12 to 48
Pages: up to 24
Sequence: manual reset, locking
Off indication: alarm inactive and reset
Flashing indication: alarm active and not acknowledged, alarm inactive and not acknowledged
On indication: alarm active and acknowledged, alarm inactive and not reset
Priority: by active window and page number
Data storage: non-volatile memory

CONTROL DISPLAY

Devices: status and control of up to 8 power system devices
Pushbuttons: 30 dedicated user-programmable pushbuttons
Functionality: supports select-before-operate functionality

DIGITAL FAULT RECORDER DISPLAY

Sequence of events: displays the stored sequence of events record
Fault reports: display and retrieval of the critical metrics of a stored fault report
Transient records: retrieval of a stored transient record
Disturbance records: retrieval of a stored disturbance record
Fast load shedding (FLS) records: retrieval of a stored FLS record

EQUIPMENT MANAGER DISPLAY

Battery monitoring: displays the current battery voltage and alarm states

METERING DISPLAY

Summary: displays present values of voltage, current, real power, reactive power, power factor, and frequency on a per-phase and total basis
Phasors: digital and graphical display of present voltage and current magnitudes and angles
Sequence components: displays present magnitudes and angles of current and voltage sequence components
Energy: four-quadrant display of accumulated energy
Demand: present and peak demand values for current and real, reactive, and apparent power

MAINTENANCE DISPLAY

Input and output status: displays the current status of all contact inputs and outputs

Hardware specifications

AC CURRENT

CT rated primary: 1 to 50000 A
CT rated secondary: 1 A or 5 A
Nominal frequency: 50 or 60 Hz
Relay burden: <0.2 VA secondary
Conversion range: 0.02 to 46 × CT rating RMS symmetrical
Current withstand: 20 ms at 250 × rated, 1 second at 100 × rated, continuous at 3 × rated

AC VOLTAGE

VT rated secondary: 50.0 to 240.0 V
VT ratio: 1.00 to 24000.0
Nominal frequency: 50 or 60 Hz
Relay burden: <0.25 VA at 120 V
Conversion range: 1 to 275 V
Voltage withstand: continuous at 260 V to neutral, 1 minute per hour at 420 V neutral

CONTACT INPUTS

Input rating: 300 V DC maximum
Selectable thresholds: 24 to 250 V
Maximum current: 10 mA during turn on, 0.5 mA steady-state
Recognition time: <1 ms
Debounce timer: 1.50 to 16.00 ms in steps of 0.25

CONTACT OUTPUTS: CRITICAL FAILURE RELAY

Make and carry for 0.2 s: 10 A
Continuous carry: 6 A
Break at L/R of 40 ms: 0.250 A at 125 V DC; 0.125 A at 250 V DC
Operate time: <8 ms
Contact material: silver alloy

CONTACT OUTPUTS: FORM-A RELAY

Make and carry for 0.2 s: 30 A as per ANSI C37.90
Continuous carry: 6 A
Break at L/R of 40 ms: 0.250 A at 125 V DC; 0.125 A at 250 V DC
Operate time: <4 ms
Contact material: silver alloy

CONTACT OUTPUTS: SOLID-STATE RELAY

Make and carry for 0.2 s: 30 A as per ANSI C37.90
Continuous carry: 6 A
Break at L/R of 40 ms: 10 A at 250 V DC
Operate time: <100 µs
Contact material: silver alloy

CONTROL POWER EXTERNAL OUTPUT

Capacity: 100 mA DC at 48 V DC
Isolation: 2 kV

CRITICAL FAILURE RELAY

Make and carry for 0.2 s: 30 A as per ANSI C37.90
Carry continuous: 6 A
Break at L/R of 40 ms: 0.250 A DC at 125 V DC; 0.125 A DC at 250 V DC; 0.10 A DC maximum at 125 V
Operate time: <8 ms
Contact material: silver alloy

ETHERNET PORTS

Standard: 1 port supporting Modbus TCP
Optional: 2 ports supporting TFTP, HTTP, SNTP, PRP, DNP 3.0, IEC 60870-5-104, and IEC 61850 located on communications module
100Base-FX media type: 1300 nm, multi-mode, half/full-duplex, fiber optic with ST connector
10/100Base-TX media type: RJ45 connector
Power budget: 10 dB
Maximum optical input power: –14 dBm
Receiver sensitivity: –30 dBm
Typical distance: 2.0 km
SNTP clock synchronization: <10 ms typical

FORM-A RELAY

Make and carry for 0.2 s: 30 A per ANSI C37.90
Carry continuous: 6 A
Break at L/R of 40 ms: 0.250 A DC at 125 V DC; 0.125 A DC at 250 V DC
Operate time: <4 ms
Contact material: silver alloy

IRIG-B INPUT

Amplitude modulation: 1 to 10 V pk-pk
DC shift: TTL
Input impedance: 50 kΩ
Isolation: 2 kV

POWER SUPPLY

Nominal DC voltage: 125 to 250 V
Minimum DC voltage: 80 V
Maximum DC voltage: 300 V
Nominal AC voltage: 100 to 240 V at 50/60 Hz
Minimum AC voltage: 80 V at 48 to 62 Hz
Maximum AC voltage: 275 V at 48 to 62 Hz
Voltage withstand: 2 × highest nominal voltage for 10 ms
Voltage loss hold-up: 200 ms duration at nominal
Power consumption: 30 VA typical, 65 VA maximum

RS485 PORT

Baud rates: 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200
Protocol: Modbus RTU and DNP 3.0
Distance: 1200 m
Isolation: 2 kV

SOLID-STATE RELAY

Make and carry for 0.2 s: 30 A as per ANSI C37.90
Carry continuous: 6 A
Break at L/R of 40 ms: 10.0 A DC at 250 V DC
Operate time: < 100 µs

USB PORT

Standard: type B USB connector for EnerVista software

Communications specifications

DIRECT INPUTS

Input points: 96 per channel
Remote devices: 16
Default states on loss of communications: On, Off, Latest/On, Latest/Off
Ring configuration: yes, no
Data rate: 64 or 128 kbps
CRC: 32-bit
CRC alarm: responding to rate of messages failing the CRC
CRC alarm monitoring message count: 10 to 10000 in steps of 1
CRC alarm threshold: 1 to 1000 in steps of 1
Unreturned messages alarm: responding to rate of unreturned messages in the ring
Unreturned messages alarm monitoring message count: 10 to 10000 in steps of 1
Unreturned messages alarm threshold: 1 to 1000 in steps of 1

DIRECT OUTPUTS

Output points: 96 per channel

FAST LOAD SHEDDING (FLS) END DEVICE DATA UNITS (IEC 61850 GOOSE)
Number: 64

MODBUS USER MAP
Number: up to 256 Modbus addresses
Programmability: any setting or actual value in decimal

REMOTE INPUTS (IEC 61850 GSSE/GOOSE)
Input points: 64
Remote devices: 32
Default states on loss of communications: On, Off, Latest/Off, Latest/On
Remote double-point status inputs: 16

REMOTE OUTPUTS (IEC 61850 GSSE/GOOSE)
Standard output points: 32
User output points: 32

TELEPROTECTION
Input points: 16 per channel
Remote devices: 3
Default states on loss of communications: On, Off, Latest/On, Latest/Off
Ring configuration: No
Data rate: 64 or 128 kbps
CRC: 32-bit

PARALLEL REDUNDANCY PROTOCOL (PRP) (IEC 62439-3 CLAUSE 4, 2012)
Ports used: 2 and 3
Networks used: 10/100 MB Ethernet

Inter-relay communications specifications

TYPICAL DISTANCE
RS422 interface: 1200 m (based on transmitter power; does not take into consideration the clock source provided by the user)
G.703 interface: 100 m
850 nm laser (multimode) interface: 2.0 km (50/125 µm cable with ST connector); 2.9 km (62.5/125 µm cable with ST connector)

NOTE

The typical distances shown are based on the assumptions for system loss shown below. As actual losses vary from one installation to another, the distance covered by your system may vary.

LINK LOSSES (850 NM LASER, MULTIMODE MODULE)
ST connector losses: 2 dB (total of both ends)
50/125 µm fiber loss: 2.5 dB/km
62.5/125 µm fiber loss: 3.0 dB/km
Splice loss: one splice every 2 km, at 0.05 dB loss per splice
System margin: 3 dB of additional loss was added to calculations to compensate for all other losses, including age and temperature

LINK POWER BUDGET (850 NM LASER, MULTIMODE MODULE)
Maximum optical input power: –9 dBm
Minimum transmit power: –22 dBm (into 50 µm fiber), –18 dBm (into 62.5 µm fiber)
Maximum receiver sensitivity: –32 dBm
Power budget: 10 dBm (for 50 µm fiber), 14 dBm (for 62.5 µm fiber)

NOTE

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

Test specifications

PRODUCTION TESTS

Thermal: products go through a 12 hour burn-in process at 60°C

TYPE TESTS

Vibration: IEC 60255-21-1, 1G (class Bm)
Shock / bump: IEC 60255-21-2, 10G (class Bm)
Seismic (single axis): IEC60255-21-3, 1G / 3.5 mm (class 1)
Make and carry (30 A): IEEE C37.90
Conducted immunity: IEC 61000-4-6 / IEC60255-22-6, class 3 (10 V RMS)
Surge: IEC 61000-4-5 or IEC 60225-22-5, 1.2/50 test up to level 4 (4 kV)
Burst disturbance (1 MHz oscillatory): IEC60255-22-1 up to 2.5 kV at 1 MHz damped
Fast transients: ANSI/IEEE C37.90.1, EC61000-4-4 class 4, (2 kV, 5 kHz / 4 kV, 2.5 kHz, 2 kV on data control ports and inputs/outputs), IEC 60255-22-4
Radiated immunity: IEC 61000-4-3 / IEC 60255-22-3 class 3 (10 V/m) or IEEE C37.90.2 radiated RFI (35 V/m)
Power frequency disturbance: IEC 61000-4-8 (30 A/m) class 4
Radiated/conducted emissions: IEC 60255-25 / CISPR 11/22 class A
Insulation resistance: IEC 60255-5
Dielectric strength: IEC 60255-5, ANSI/IEEE C37.90
Dielectric across relay contacts: IEEE C37.90 (1.6 kV)
Electrostatic discharge: EN 61000-4-2, IEC60255-22-2 8 kV C, 15 kV A, L4
Voltage dips/interruptions/variations: IEC 61000-4-11 (30% 1 cycle), IEC 60255-11
AC ripple: IEC 61000-4-17 (standard)
Interruptions on DC power: IEC61000-4-29
Damped magnetic immunity: IEC61000-4-10 (level 5, 100A/m)
Impulse voltage withstand: EN/IEC60255-5 (5 kV)
Humidity cyclic: IEC60068-2-30, 6 days 55°C, 95%RH (variant 1)

Environmental specifications

OPERATING TEMPERATURE

Cold: IEC 60068-2-1, 16 hours at –40°C
Dry heat: IEC 60068-2-2, 16 hours at 80°C

OTHER ENVIRONMENTAL SPECIFICATIONS

Altitude: up to 2000 m
Installation category: II
IP rating: IP30 for front, IP10 for back

Approvals and certification

APPROVALS

UL508 17th edition and C22.2 No.14-05: UL listed for the USA and Canada

CERTIFICATION

CE LVD 2006/95/EC: EN/IEC 61010-1:2001 / EN60255-5:2000
CE EMC 89/336/EEC: EN 60255-26:2004-08

C90Plus Controller

Chapter 3: Installation

This section describes the physical installation of the C90Plus.

Physical installation

The C90Plus is designed as a 19-inch rack horizontal mount unit. The modular design allows the relay to be easily upgraded or repaired by a qualified service person. The faceplate is hinged to allow easy access to the removable modules.

WARNING

To minimize risk of electrical shock from contact with the power terminals, install the unit in an electrical closet/enclosure whereby the terminal connections are not readily accessible.

Dimensions

The case dimensions are shown here, along with 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.

Mount the C90Plus such that the faceplate sits semi-flush with the panel or switchgear door, allowing the operator access to the front panel keys and USB communications port. Secure the C90Plus to the panel with the use of four screws supplied with the relay.

Leave a1U (1 rack-unit) space below the chassis when mounting for ventilation and to allow the front panel to swing open without obstruction.

Figure 1: Panel cutout dimensions

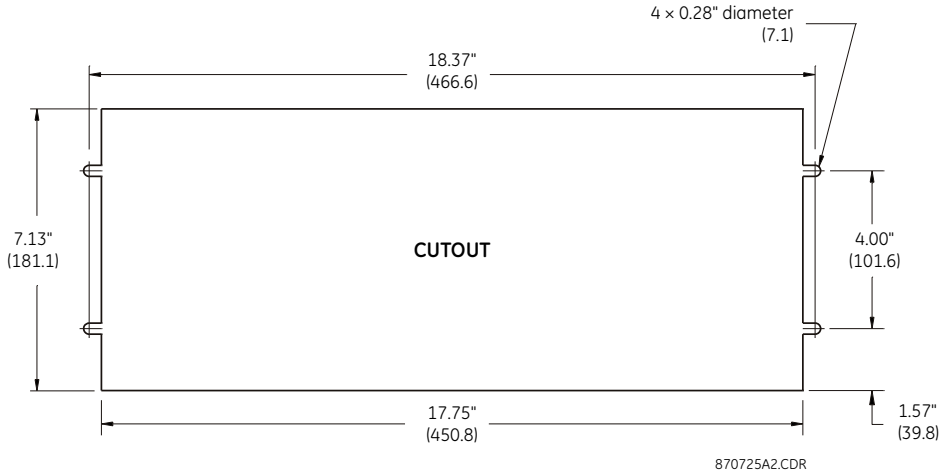
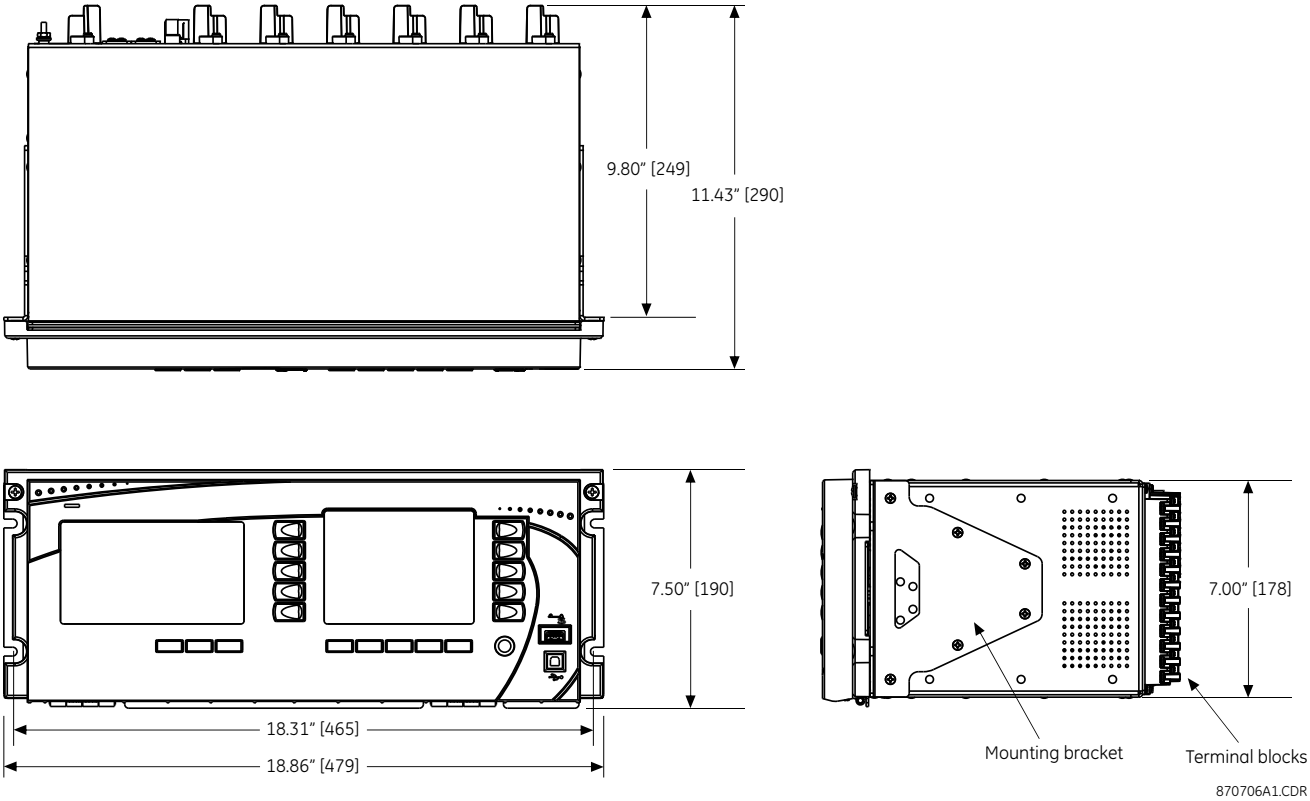


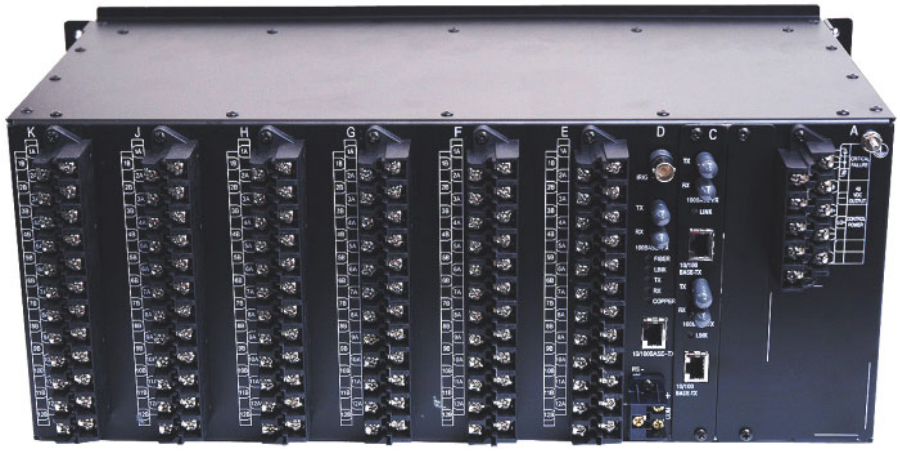
Figure 2: C90Plus dimensions



Rear terminal layout

Terminal number assignments in the C90Plus are represented by three characters, assigned in order by module slot position, row number, and column letter. The figure provides an example of rear terminal assignments.

Figure 3: Rear terminal view



870824A1.CDR

Slot A houses the power supply module.
Slot C houses the communications module.
Slot D houses the main processing card.

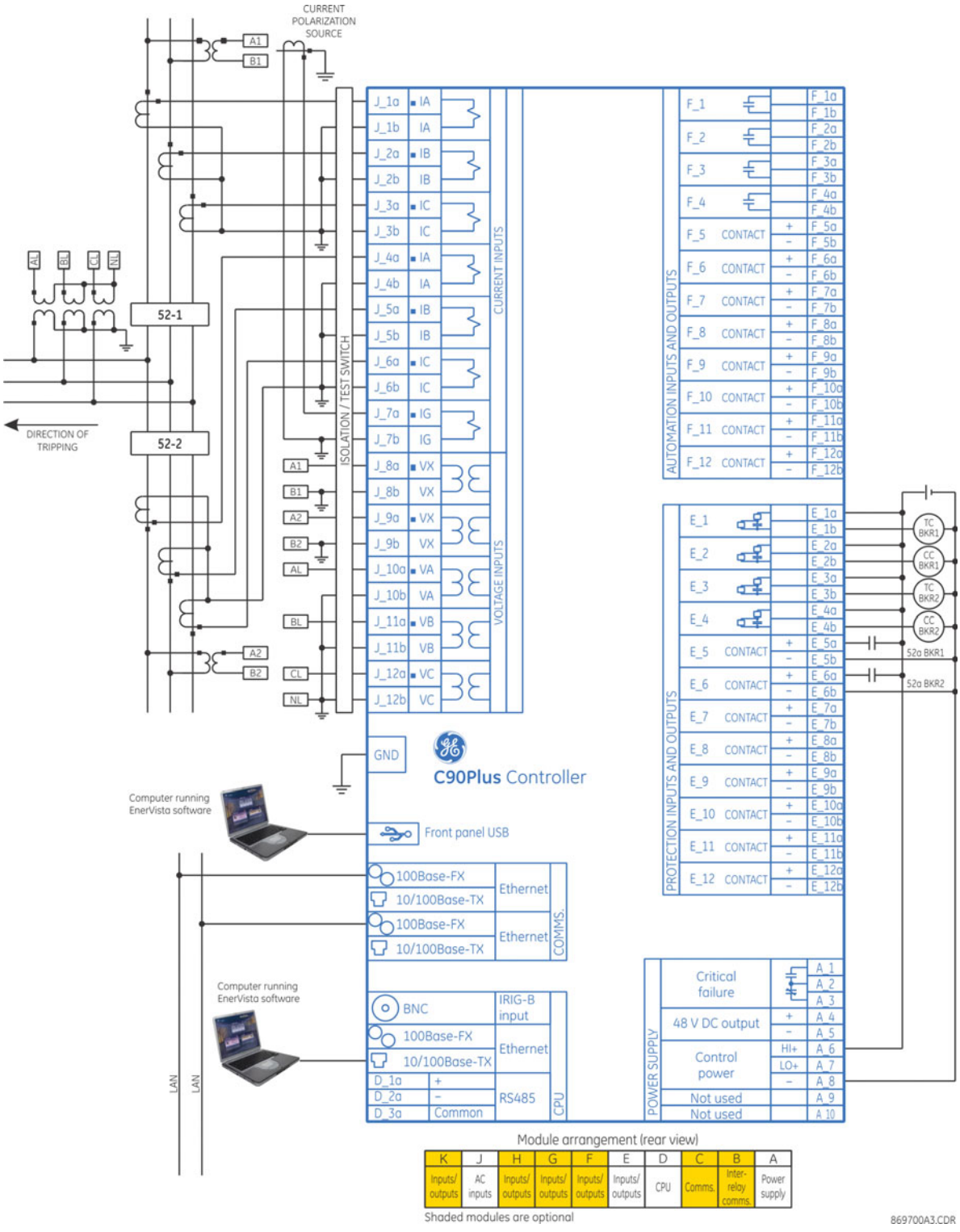
Electrical installation

This section outlines the electrical installation of the C90^{Plus}.

Typical wiring

The figure provides an example of how to wire the C90^{Plus}. Actual wiring varies with application.

Figure 4: Typical wiring diagram



Main processor module

The main processor module in slot D contains ports for Ethernet communications, serial RS485 communications, and IRIG-B connection.

Ethernet port

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 multi-mode.

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

⚠CAUTION

Observing any fiber transmitter output can injure the eye.

NOTE

Ensure the dust covers are installed when the fiber is not in use. Dirty or scratched connectors can lead to high losses on a fiber link.

RS485 port

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

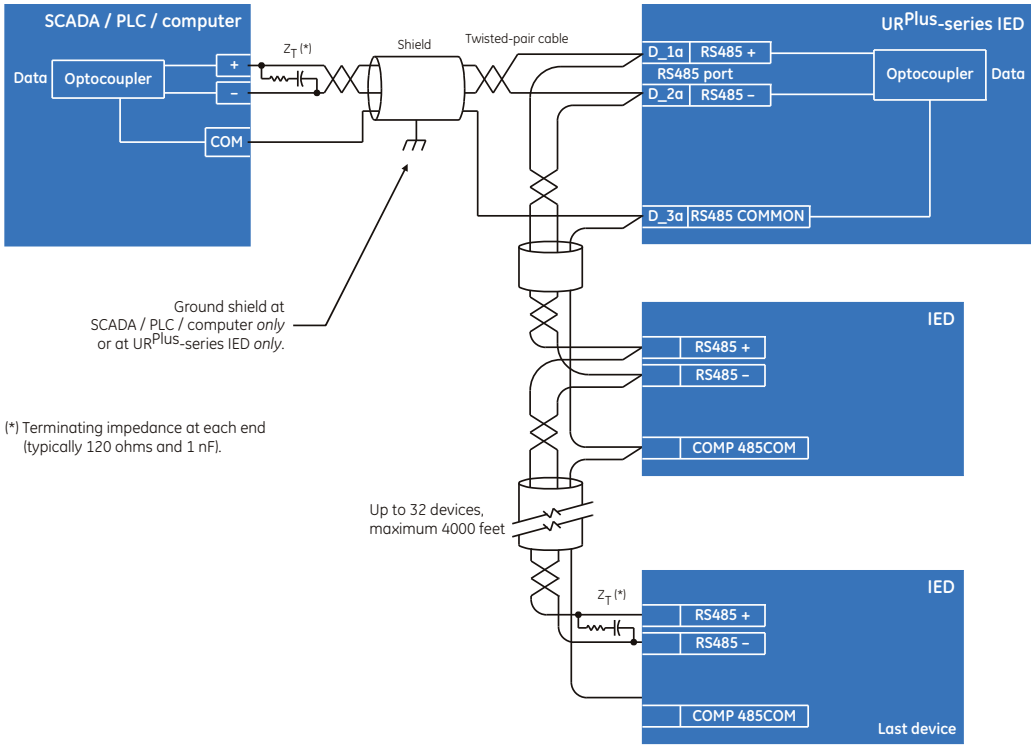
To minimize errors from noise, the use of shielded twisted pair wire is recommended. Correct polarity must also be observed. For instance, the relays must be connected with all RS485 "+" terminals connected together, and all RS485 "–" terminals connected together. Though data is transmitted over a two-wire 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 C90^{Plus} COM terminal (3a); others function correctly only if the common wire is connected to the C90^{Plus} COM terminal but insulated from the shield.

To avoid loop currents, the shield should be grounded at one point only. 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 UR^{Plus}-series device should also be daisy-chained to the next one in the link. A maximum of 32 devices can be connected in this manner without exceeding driver capability. For larger systems, additional serial channels must be added. It is also possible to use commercially available repeaters to increase the number of devices on a single channel to more than 32. Star or stub connections should be avoided entirely.

Lightning strikes and ground surge currents can cause large momentary voltage differences between remote ends of the communication link. For this reason, surge protection devices are internally provided at both communication ports. An isolated power supply with an optocoupled data interface also acts to reduce noise coupling. To ensure maximum reliability, all equipment should have similar transient protection devices installed.

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

Figure 5: RS485 serial connection

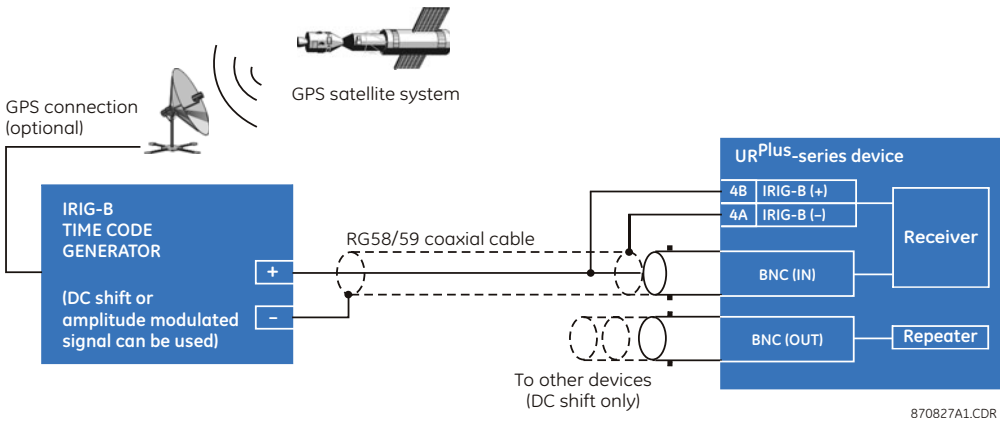


IRIG-B port

IRIG-B is a standard time code format that allows stamping of events to be synchronized among connected devices within one millisecond. The IRIG time code formats are serial, pulse width-modulated codes that can be either DC level shifted or amplitude modulated (AM).

Third party equipment is available for generating the IRIG-B signal. This equipment can use a GPS satellite system to obtain the time reference so that devices at different geographic locations can also be synchronized.

Figure 6: IRIG-B connection



For additional information, refer to:

Real time clock on page 137

Communications module

The communications module in slot C contains two ports for Ethernet communications, designated as port 2 and port 3. These are fully independent from each other and from port 1 on the main processor module. The communication module ports support redundancy and several protocols not supported by port 1.

The fiber optic communication ports allow for fast and efficient communications between devices at 100 Mbps. Optical fiber can be connected to the C90^{Plus} supporting a wavelength of 1310 nm in multi-mode.

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

⚠CAUTION **Observing any fiber transmitter output can injure the eye.**

NOTE Ensure the dust covers are installed when the fiber is not in use. Dirty or scratched connectors can lead to high losses on a fiber link.

Power supply module

The power supply module in slot A provides power to the relay and supplies power for dry contact input connections. It can be connected to any of the following standard power sources.

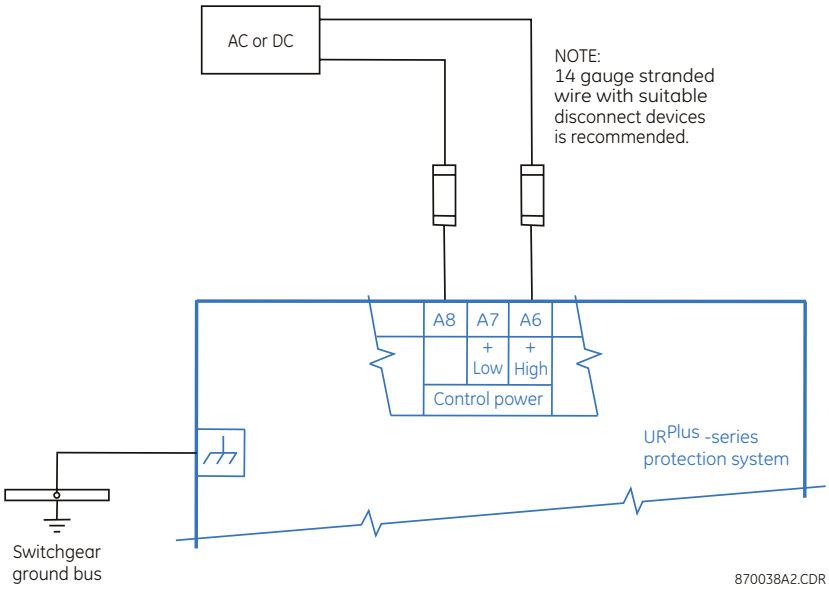
- DC power: 110 V DC, 125 V DC, 220 V DC, or 250 V DC.
- AC power: 115 V AC or 230 V AC.

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

NOTICE The C90^{Plus} system, like almost all electronic relays, contains electrolytic capacitors. These capacitors are well known to be subject to deterioration over time if voltage is not applied periodically. Deterioration can be avoided by powering the relays up once a year.

The power supply module provides 48 V DC power for dry contact input connections and a critical failure relay. The critical failure relay is a form-C 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 or control power is lost, the relay de-energizes.

Figure 7: Control power connection



AC modules

An AC module has voltage inputs on channels 8 through 12 inclusive. Channel 10 is intended for connection to a source that represents phase A voltage of the power system (produced by a VT or CVT). Likewise, channel 11 is intended for connection to phase B, and channel 12 is intended for connection to phase C. The phase voltage channels are used for most metering and protection purposes.

Channels 8 and 9 are intended for connection to single-phase sources. In the C90^{Plus}, each of these inputs are typically used to measure the voltage on the side of the breaker opposite to the line terminal. Each of these channels is labeled as an auxiliary voltage (VX). The auxiliary voltage channels are used as inputs for synchrocheck, but can also be used for auxiliary undervoltage or overvoltage elements.

An AC module has current inputs on channels 1 through 7 inclusive. In a single breaker application, channel 1 is intended for connection to a source representing the phase A current of the power system (produced by a CT). Likewise, channel 2 is intended for connection to phase B, and channel 3 is intended for connection to phase C. In a breaker-and-a-half application, channels 1 through 3 are connected to the phase A, B, and C currents from one breaker, while channels 4 through 6 are connected to the phase A, B, and C currents from the second breaker. The phase current channels are used for most metering and protection purposes.

Channel 7 can be used for either of two purposes. First, it can be connected to a CT that is directly measuring system ground current. It can also be connected to the CT residual circuit of a parallel line.

⚠CAUTION

Verify that the connection made to the relay nominal current of 1 A or 5 A matches the secondary rating of the connected CTs. Unmatched CTs can result in equipment damage or inadequate protection.

⚠CAUTION

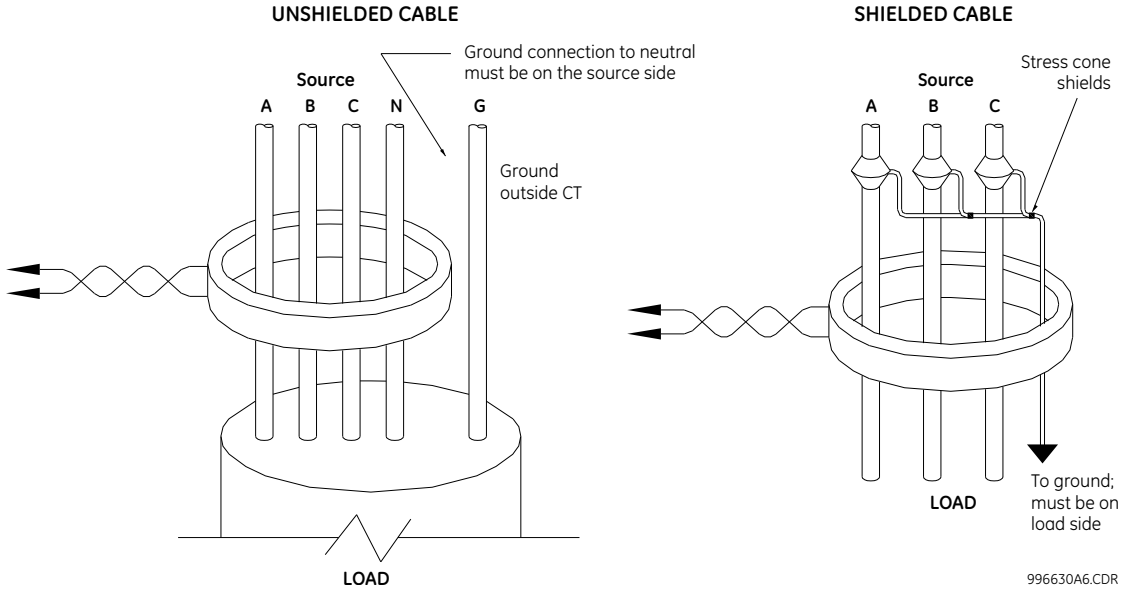
The CT secondaries should be connected to the AC terminals of the C90^{Plus} through a shorting-type test switch or shorting-type terminal blocks in order to facilitate safe withdrawal of the AC module.

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 can be used.

CT connections for both ABC and ACB phase rotations are identical as shown in the typical wiring diagram.

The exact placement of a zero-sequence core balance CT to detect ground fault current is shown below. Twisted-pair cabling on the zero-sequence CT is recommended.

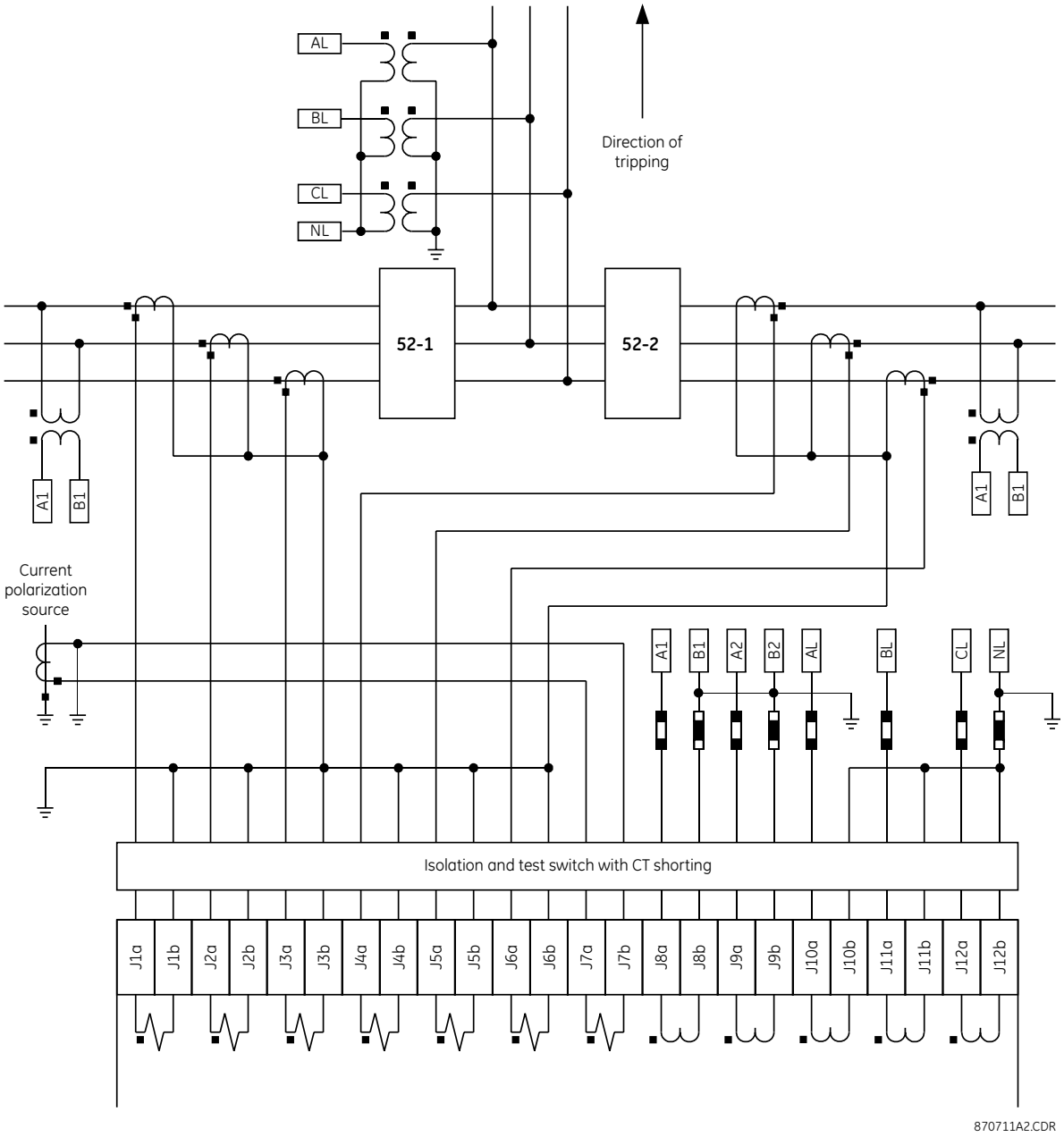
Figure 8: Zero-sequence core-balance CT installation



The phase voltage channels are used for most metering and protection purposes. The auxiliary voltage channel is used as an input for features such as synchrocheck, volts per hertz, and auxiliary undervoltage.

A typical AC module wiring diagram is shown as follows. Substitute the tilde "~" symbol with the slot position of the AC module.

Figure 9: Typical AC module wiring



Contact input and output modules

Each input/output module has 24 terminal connections. They are arranged in two terminals per row, with twelve rows in total. A given row of two terminals can be used for the outputs of one relay. There are options of using current or voltage detection for feature supervision, depending on the module ordered.

All inputs and outputs are isolated from one another with each input and output having two dedicated terminals. Since an entire module row is used for a single contact input or output, the name is assigned using the module slot position and row number.

Form-A and solid-state relay output contacts

Some form-A and solid-state relay (SSR) outputs include circuits to monitor the DC voltage across the output contact when it is open, and the DC current through the output contact when it is closed. Each of the monitors contains a level detector whose output is set to logic 1 (on) when the current in the circuit is above the threshold setting. 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.

Figure 10: Form-A relay contact input functions

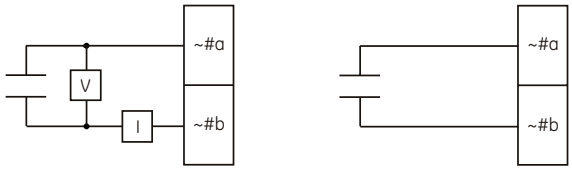
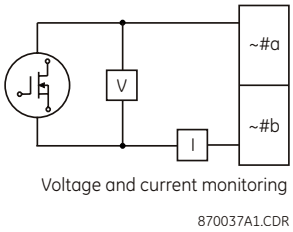


Figure 11: Solid-state relay contact input functions



The operation of voltage and current monitors is reflected with the corresponding FlexLogic operands (Cont Op ### Von, Cont Op ### Voff, Cont Op ### Ion, and Cont Op ### Ioff) 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.

DANGER

Relay contacts are unsafe to touch when the unit is energized. If the relay contacts need to be used for low voltage accessible applications, it is the customer's responsibility to ensure proper insulation levels.

NOTE

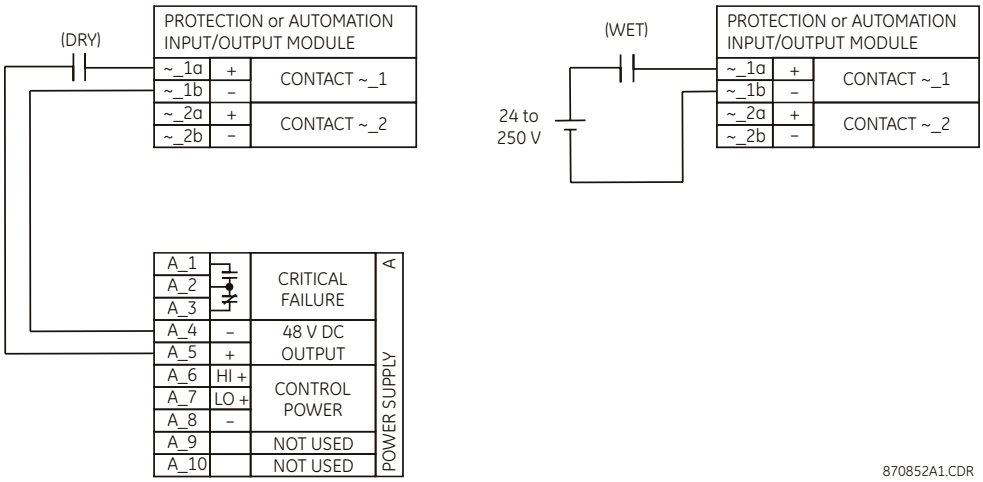
When current monitoring is used to seal-in the form-A and solid-state relay contact outputs, give the FlexLogic operand driving the contact output a reset delay of 10 ms to prevent damage of the output contact (in situations when the element initiating the contact output is bouncing, at values in the region of the pickup value).

Contact inputs wiring

Contact inputs are not polarity sensitive. A dry contact has one side connected to terminal A_5. 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 either of the contact input terminals. The other contact input terminal is connected to the DC negative terminal (A_4) of the power supply module. When a dry contact closes, a 10 mA current initially flows through the associated circuit. Once the relay has validated the state change of the contact, the input current is reduced to 1 mA.

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 one of the contact input terminals. In addition, the negative side of the external source must be connected to the other contact input terminal. The maximum external source voltage for this arrangement is 300 V DC. The voltage threshold at which each group of four contact inputs will detect a closed contact input is programmable as from 24 to 250 V DC.

Figure 12: Dry and wet contact input connections



NOTE

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

Contact outputs wiring

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

NOTE

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

Contact input/output module configuration

There are six types of contact input and output modules available for the C90^{Plus}.

- Type A — Eight contact inputs, four form-A contact outputs with voltage and current monitoring
- Type B — Eight contact inputs, four solid-state (SSR) contact outputs with voltage and current monitoring
- Type C — Eight contact inputs, four form-A contact outputs
- Type D — Four contact inputs, eight form-A contact outputs
- Type E — 23 contact inputs
- Type F — 12 form-A contact outputs

The following figure and table show the terminal block pin assignments for all module types.

Figure 13: Terminal block pin view

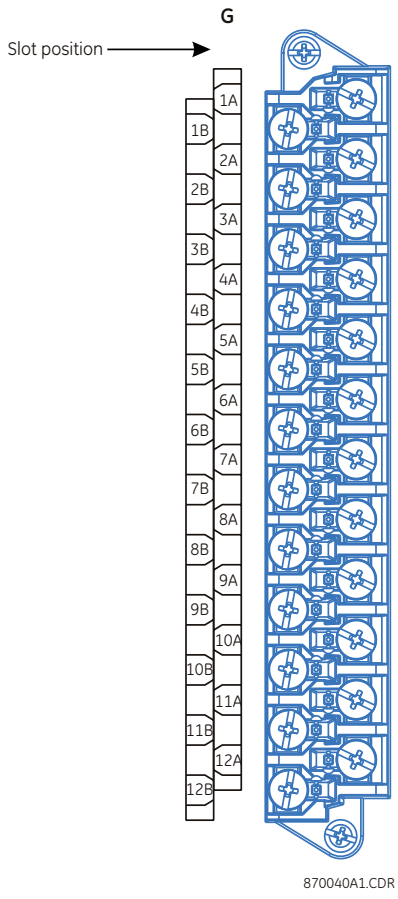


Table 1: Module configuration

Pin	Contact input/output module					
	Type A	Type B	Type C	Type D	Type E	Type F
1A	Form-A output 1 +	SSR output 1 +	Form-A output 1 +	Form-A output 1 +	Contact input 1 +	Form-A output 1 +
1B	Form-A output 1 –	SSR output 1–	Form-A output 1 –	Form-A output 1 –	Contact input 2 +	Form-A output 1 –
2A	Form-A output 2 +	SSR output 2 +	Form-A output 2 +	Form-A output 2 +	Contact input 3 +	Form-A output 2 +
2B	Form-A output 2 –	SSR output 2–	Form-A output 2 –	Form-A output 2 –	Contact input 4 +	Form-A output 2 –
3A	Form-A output 3 +	SSR output 3 +	Form-A output 3 +	Form-A output 3 +	Contact input 5 +	Form-A output 3 +
3B	Form-A output 3 –	SSR output 3–	Form-A output 3 –	Form-A output 3 –	Contact input 6 +	Form-A output 3 –
4A	Form-A output 4 +	SSR output 4 +	Form-A output 4 +	Form-A output 4 +	Contact input 7 +	Form-A output 4 +
4B	Form-A output 4 –	SSR output 4–	Form-A output 4 –	Form-A output 4 –	Contact input 8 +	Form-A output 4 –
5A	Contact input 1 +	Contact input 1 +	Contact input 1 +	Form-A output 5 +	Contact input 9 +	Form-A output 5 +
5B	Contact input 1 –	Contact input 1 –	Contact input 1 –	Form-A output 5 –	Contact input 10 +	Form-A output 5 –
6A	Contact input 2 +	Contact input 2 +	Contact input 2 +	Form-A output 6 +	Contact input 11 +	Form-A output 6 +
6B	Contact input 2 –	Contact input 2 –	Contact input 2 –	Form-A output 6 –	Contact input 12 +	Form-A output 6 –
7A	Contact input 3 +	Contact input 3 +	Contact input 3 +	Form-A output 7 +	Contact input 13 +	Form-A output 7 +
7B	Contact input 3 –	Contact input 3 –	Contact input 3 –	Form-A output 7 –	Contact input 14 +	Form-A output 7 –
8A	Contact input 4 +	Contact input 4 +	Contact input 4 +	Form-A output 8 +	Contact input 15 +	Form-A output 8 +
8B	Contact input 4 –	Contact input 4 –	Contact input 4 –	Form-A output 8 –	Contact input 16 +	Form-A output 8 –
9A	Contact input 5 +	Contact input 5 +	Contact input 5 +	Contact input 1 +	Contact input 17 +	Form-A output 9 +
9B	Contact input 5 –	Contact input 5 –	Contact input 5 –	Contact input 1 –	Contact input 18 +	Form-A output 9 –
10A	Contact input 6 +	Contact input 6 +	Contact input 6 +	Contact input 2 +	Contact input 19 +	Form-A output 10 +
10B	Contact input 6 –	Contact input 6 –	Contact input 6 –	Contact input 2 –	Contact input 20 +	Form-A output 10 –
11A	Contact input 7 +	Contact input 7 +	Contact input 7 +	Contact input 3 +	Contact input 21 +	Form-A output 11 +
11B	Contact input 7 –	Contact input 7 –	Contact input 7 –	Contact input 3 –	Contact input 22+	Form-A output 11 –
12A	Contact input 8 +	Contact input 8 +	Contact input 8 +	Contact input 4 +	Contact input 23 +	Form-A output 12 +
12B	Contact input 8 –	Contact input 8 –	Contact input 8 –	Contact input 4 –	Common –	Form-A output 12 –

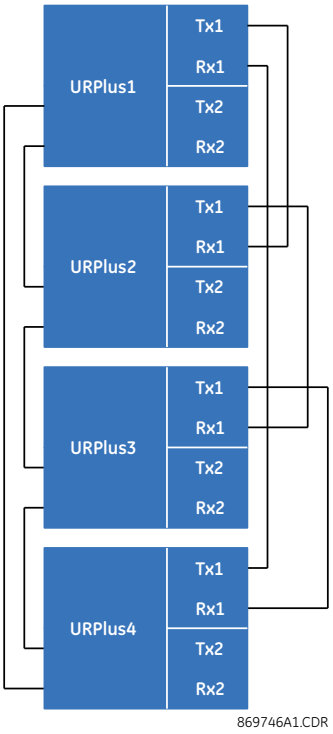
Inter-relay communication modules

The inter-relay communications modules support high speed direct communications between UR^{Plus}-series devices. The direct inputs and outputs feature uses the communications channels provided by these modules to exchange digital state information between devices. This feature is available on all UR^{Plus}-series devices.

The communications channels are normally connected in a ring configuration as shown below. The transmitter of one module is connected to the receiver of the next module. The transmitter of this second module is then connected to the receiver of the next module in the ring. This is continued to form a communications ring.

The interconnection for dual-channel communications modules is shown below. Two channel modules allow for a redundant ring configuration. That is, two rings can be created to provide an additional independent data path. The required connections are: URPlus1-Tx1 to URPlus2-Rx1, URPlus2-Tx1 to URPlus3-Rx1, URPlus3-Tx1 to URPlus4-Rx1, and URPlus4-Tx1 to URPlus1-Rx1 for the first ring; and URPlus1-Tx2 to URPlus4-Rx2, URPlus4-Tx2 to URPlus3-Rx2, URPlus3-Tx2 to URPlus2-Rx2, and URPlus2-Tx2 to URPlus1-Rx2 for the second ring.

Figure 14: Direct input and output dual channel connection



The interconnection requirements are described in further detail in this section for each specific variation of inter-relay communications module. These modules are listed in the following table. All fiber modules use ST type connectors.

Table 2: Channel communication options

Module	Specification
B	G.703, 64/128 kbps, two channels
C	RS422, 64/128 kbps, two channels, two clock inputs
D	850 nm, 64/128 kbps, ST multi-mode laser, two channels with DDMI

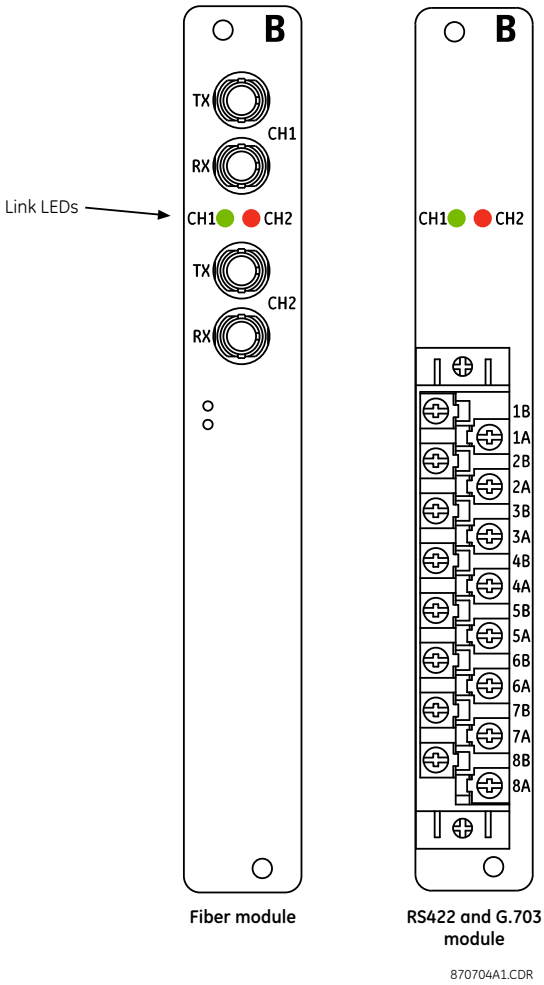
DANGER

The 850 nm module uses a class 1 VCSEL laser that is harmful to the eye. Observing any fiber transmitter output can cause serious injury to the eye.

Direct input and output link LEDs

The link LEDs for channels 1 and 2 are located on the rear of the inter-relay communications card.

Figure 15: Link LEDs for fiber, RS422, and G.703 modules



The table describes the operation of the link LEDs.

Table 3: Link LED operation

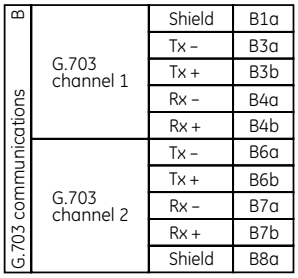
Protocol	LED indications			
	Red, solid	**Green, solid**	**Green, blinking**	**Yellow, blinking**
IEEE C37.94	Loss of signal	Signal detected, but not receiving valid data	Signal detected and receiving valid data; yellow bit alarm not set	Signal detected, receiving valid data and the received yellow bit alarm is set; the yellow bit indicates that remote unit is not receiving valid data
Direct fiber	Loss of signal	Signal detected, but not receiving valid data	Signal detected and receiving valid data	Not used
G.703	Loss of signal	Signal detected, but not receiving valid data	Signal detected and receiving valid data	Not used
RS422	Loss of clock	Clock detected, but not receiving valid data	Clock detected and receiving valid data	Not used

G.703 communication interface

AWG 24 twisted shielded pair is recommended for external connections, with the shield grounded only at one end. Connecting the shield to pin B1a or B8a grounds the shield since these pins are internally connected to ground. Thus, if pin B1a or B8a is used, do not ground at the other end. The G.703 module chassis is protected by surge suppression devices.

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

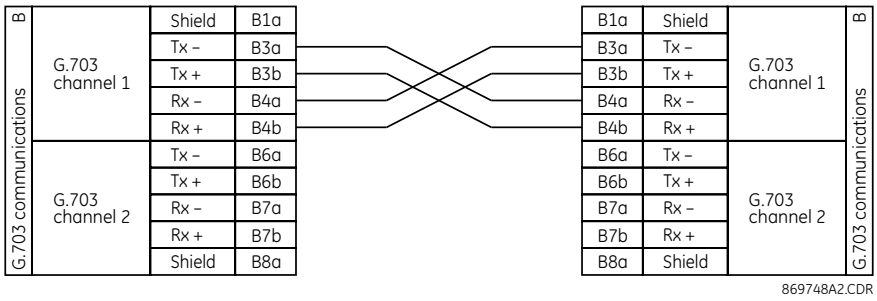
Figure 16: G.703 module connections



The G.703 octet timing and timing mode are set using the **Protocol Encoding** setting.

The following figure shows the typical pin interconnection between two G.703 interfaces. All pin interconnections are to be maintained for a connection to a multiplexer.

Figure 17: Typical pin interconnection between two G.703 interfaces



NOTE

Pin nomenclature can differ 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 "–".

RS422 communication interface

The RS422 inter-relay communications module is a dual-channel dual-clock RS422 interface. The module can be configured to run at 64 or 128 kbps. AWG 24 twisted shielded pair cable is recommended for external connections. The module is protected by an optically-isolated surge suppression device.

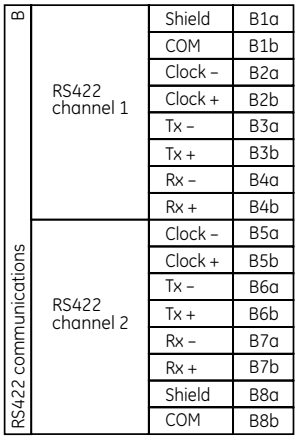
The two-channel two-clock RS422 interface is intended for use with two independent channel banks with two independent clocks. It is intended for situations where a single clock for both channels is not acceptable.

The shield pins (B1a and B8a) are internally connected to chassis ground. Proper shield termination is as follows:

- Site 1 — Terminate shield to pins B1a
- Site 2 — Connect COM pin B1b to site 1 COM pin B1b. Note that pins B1b and B8b are internally connected.

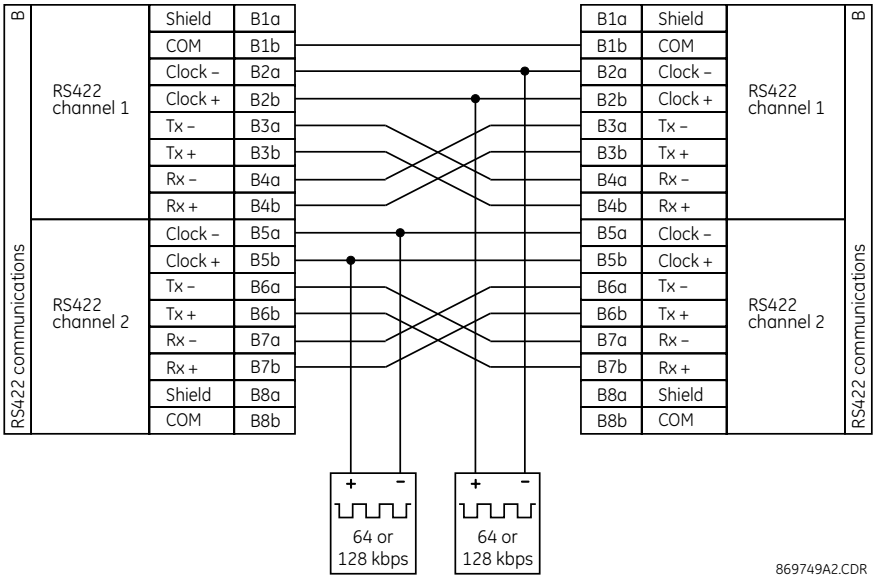
Match the clock terminating impedance with the impedance of the line.

Figure 18: RS422 interface connections



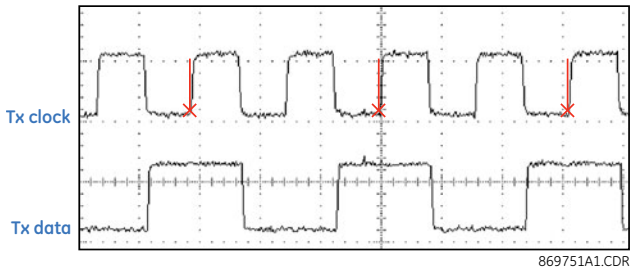
The following figure shows the typical pin interconnection between two dual-channel RS422 interfaces. All pin interconnections are to be maintained for a connection to a multiplexer.

Figure 19: Typical connection between two RS422 interfaces



Each channel of the RS422 interface accepts a 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 20: Clock and data transitions



The RS422 interface utilizes NRZI-MARK modulation code and therefore does not rely on an Rx clock to recapture data. NRZI-MARK is an edge-type, invertible, self-clocking code.

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

Fiber communications interface

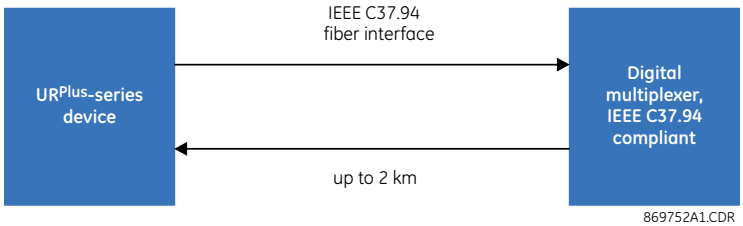
The UR^{Plus}-series communication module is designed to interface with IEEE C37.94 compliant digital multiplexers or an IEEE C37.94 compliant interface converter for use with direct input and output applications when the **Protocol Encoding** setting is "C37.94" or for direct fiber interfaces using the Differential Manchester protocol when the **Protocol Encoding** setting is "Direct Fiber". The IEEE C37.94 standard defines a point-to-point optical link for synchronous data between a multiplexer and a teleprotection device. This data is typically 64 kbps, but the standard provides for speeds up to 64*n* kbps, where *n* = 1, 2,..., 12. The UR^{Plus}-series C37.94 communication modules are either 64 kbps (with *n* fixed at 1) for 128 kbps (with *n* fixed at 2). The frame is a valid International Telecommunications Union (ITU-T) recommended G.704 pattern from the standpoint of framing and data rate. The frame is 256 bits and is repeated at a frame rate of 8000 Hz, with a resultant bit rate of 2048 kbps.

The specifications for the module are as follows:

- IEEE standard — C37.94 for 2 × 64/128 kbps optical fiber interface
- Differential Manchester protocol — 2 × 64/128 kbps optical fiber interface
- Fiber optic cable type — 50 mm or 62.5 mm core diameter optical fiber
- Fiber optic mode — Multi-mode
- Fiber optic cable length — Up to 2 km
- Fiber optic connector — Type ST
- Wavelength — 850 nm VCSEL laser
- Connection — As per all fiber optic connections, a Tx to Rx connection is required

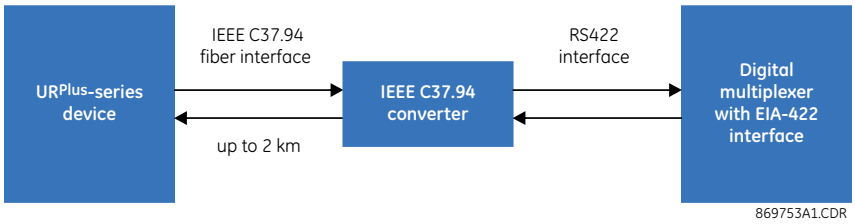
The UR^{Plus}-series C37.94 communication module can be connected directly to any compliant digital multiplexer that supports the IEEE C37.94 standard as shown below.

Figure 21: IEEE C37.94 connection to compliant digital multiplexer



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

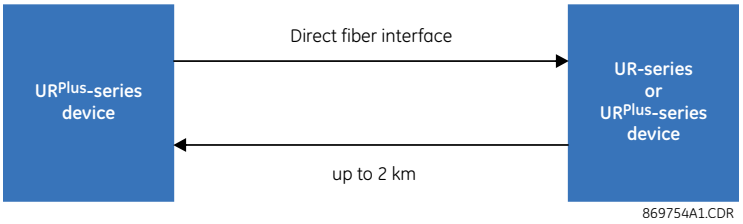
Figure 22: IEEE C37.94 connection to non-compliant digital multiplexer



The **Protocol Encoding** setting is used to set the protocol and clock option for the IEEE C37.94 protocol selection. If the setting is programmed as "C37.94 Internal Clock", then the system clock is generated internally. For an external or loop timing scheme, the system clock is derived from the received line signal. For these cases, the program the setting to "C37.94 External Clock" or "Default" for connection to higher-order systems.

The UR^{Plus}-series direct fiber module can be connected directly to another UR^{Plus}-series or UR-series device with an installed direct fiber module.

Figure 23: Direct fiber to direct fiber connection



C90Plus Controller

Chapter 4: Interfaces

This section describes the methods of interfacing with the C90Plus.

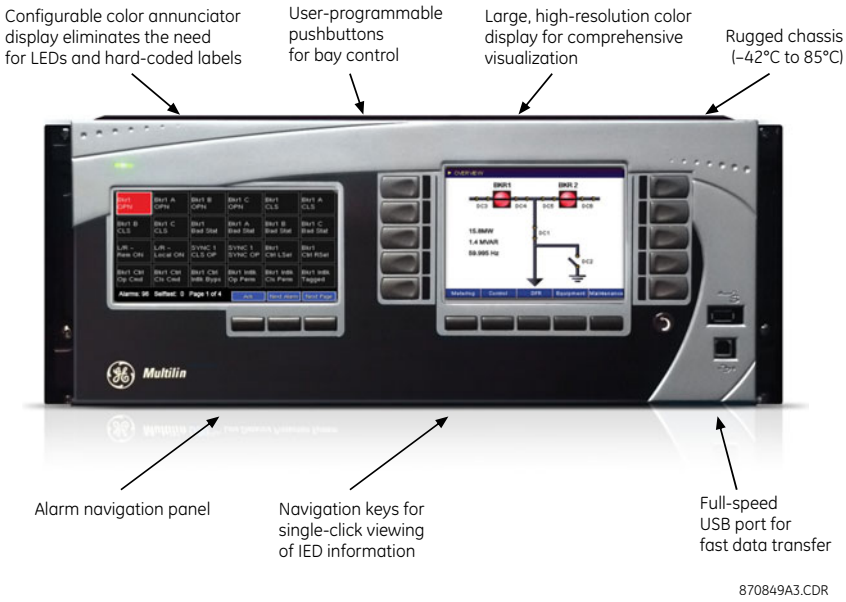
Front panel overview

The front panel provides a convenient means to interface with the C90Plus. It includes a color LCD display (annunciator) and two sets of user-programmable pushbuttons. This interface provides immediate access to all major C90Plus functions.

There are three groupings of pushbuttons. The pushbuttons located at the bottom of the display are for navigation, while the pushbuttons located at both sides of the display are dedicated for control functions.

The annunciator is a color LCD display that provides alarm and trip information. The annunciator also provides indication of any active self-diagnostic messages and includes a product information screen.

Figure 1: Front panel interface



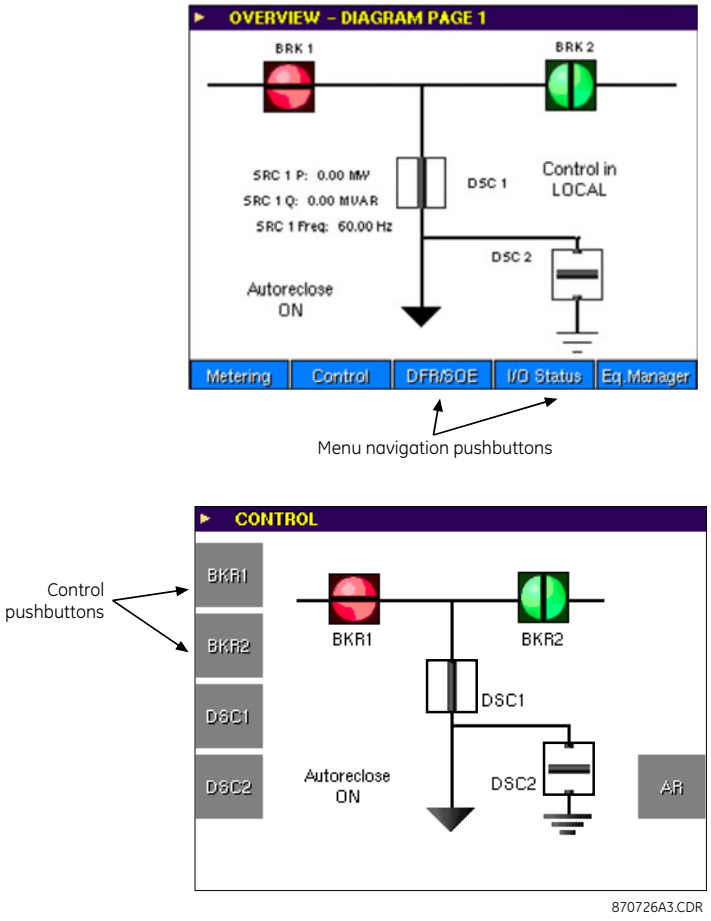
The front panel also contains a USB port for communication with a computer running the EnerVista software.

Front panel interface operation

The front panel interface is a color TFT panel with pushbuttons for menu navigation and dedicated pushbuttons for control functions. This display provides convenient access to operational data generated by the C90^{Plus}. It also enables local control of power system devices that are connected to the IED.

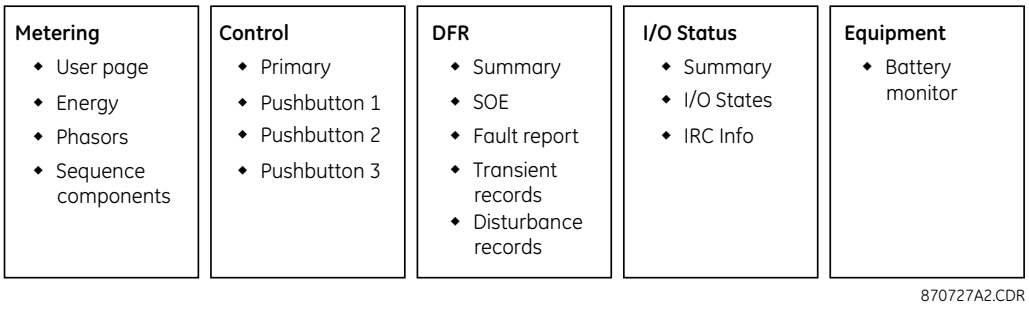
The control pushbuttons are shown only in the control menu. Otherwise, the menu navigation pushbuttons are shown. The number of control pushbuttons is dependent on the number of disconnects and breakers in the selected mimic diagram.

Figure 2: Front panel interface operation



The next figure shows atypical menu structure. The structure for any specific C90^{Plus} varies according to the specified order code.

Figure 3: Menu structure



Metering menu

The system metering quantities are available from the front panel in the metering menu. These values are derived automatically from the metering source. There are four user-configurable metering summary screens and three fixed metering screens available.

There are four user-configurable metering pages. Each location in the metering grid can be either text or an actual value. The EnerVista UR^{Plus} Setup software provides the ability to configure each of the metering display pages.

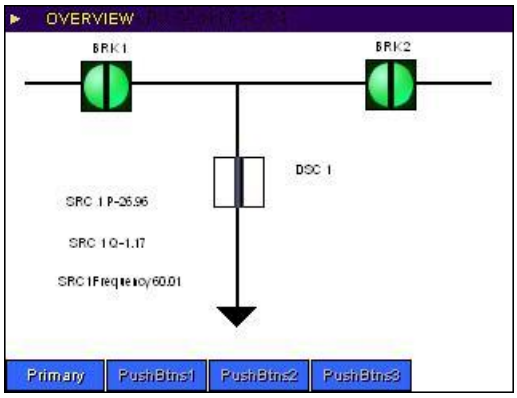
The following three fixed metering screens are also available:

- The energy page displays and allows the user to reset four quadrant energy values
- The phasor screen graphically displays the phasor components of the system voltage (phase-neutral) and current for the selected metering source
- The sequence screen graphically displays the sequence components of the system voltage and currents for the selected metering source

Control menu

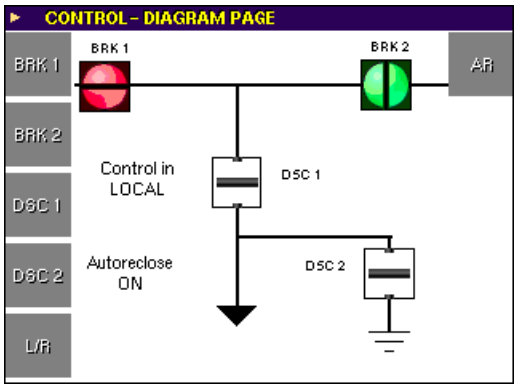
The control menu provides the option to select a control diagram view or select one of the user-programmable pushbutton views. The menu names are user-configurable. The following figure shows the overview window.

Figure 4: Control menu overview display



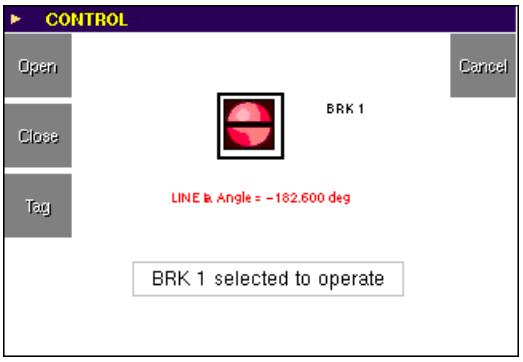
The user can access the mimic diagram and dedicated control pushbuttons through the primary control menu. The mimic page provides status of circuit breakers and disconnect switches. Operation of these devices is also available through the control pushbuttons.

Figure 5: Mimic page - operate example



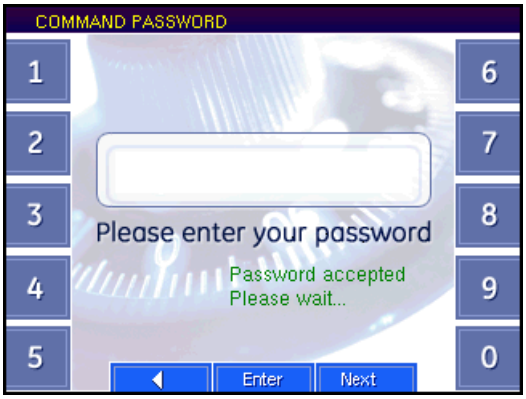
The configurable selected component display allows the user to position the selected control element and display other diagram components like metering values, breakers, disconnect switches, local/remote status, or autoreclose. The following figure shows the selected component display.

Figure 6: Mimic page - Selected breaker with operate actions menu and dynamic display of current phase angle



The front panel control pushbuttons can be placed under password security. When password security is enabled, the front panel requests the command password before performing any actions. Use the **Next** button to access additional alphanumeric characters.

Figure 7: Command password entry screen



Digital fault recorder menu

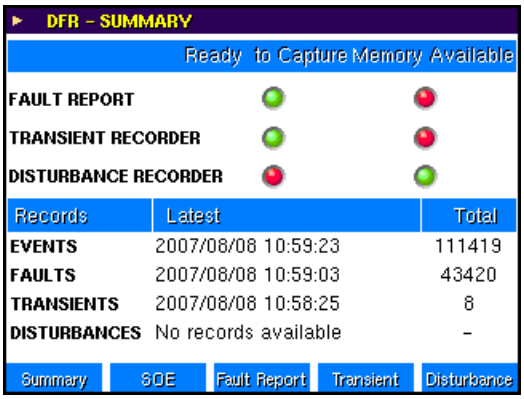
The digital fault recorder menu provides access to various records stored within the C90^{Plus}, including sequence of events, fault report, transient records, and disturbance records. The summary page displays the status of each function, as follows:

- A green indicator indicates that the function is enabled and more than 20% of the memory is available
- A yellow indicator indicates that the available memory is between zero and 20%
- A red indicator indicates that the memory is full

If the function is configured for protected mode then the enabled indicator also switches to red indicating that new records can be captured. If the function is configured for automatic overwrite, then the element overwrites old records and the enabled LED remains green.

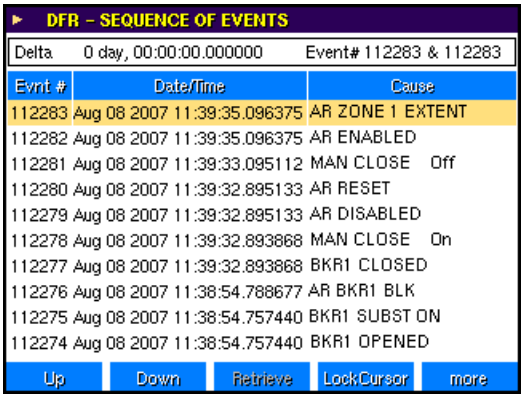
Refer to Digital fault recorder on page 433 for additional details on the indicators for the fault report, transient recorder, and disturbance recorder.

Figure 8: Digital fault recorder - example summary page



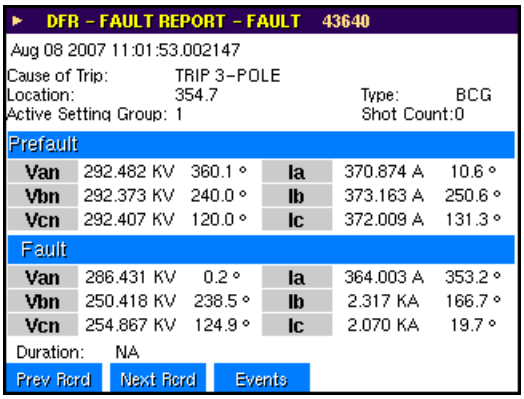
The sequence of events record can be accessed from this page. Using the navigations keys, the user can scroll or page through the events list. Two cursors are provided for measurement of the time difference between events.

Figure 9: Example sequence of events record



Principal fault information measured by C90^{Plus} can also be accessed from the digital fault recorder menu.

Figure 10: Example fault record

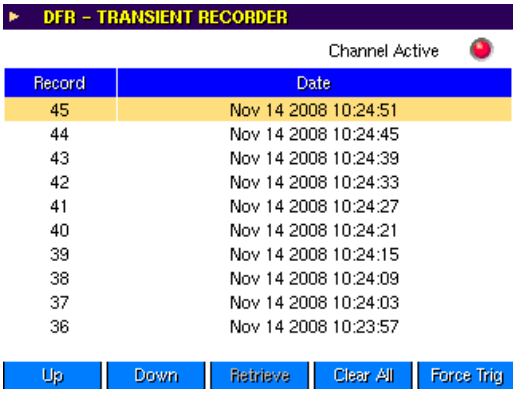


The digital fault recorder menu transient record menu lists all of the records currently stored in the C90^{Plus}. It also indicates the status of the trigger, where:

- Green indicates that the trigger is not active
- Red indicates an active trigger

Records can be retrieved and deleted and triggers can be manually generated from this screen.

Figure 11: Example transient record

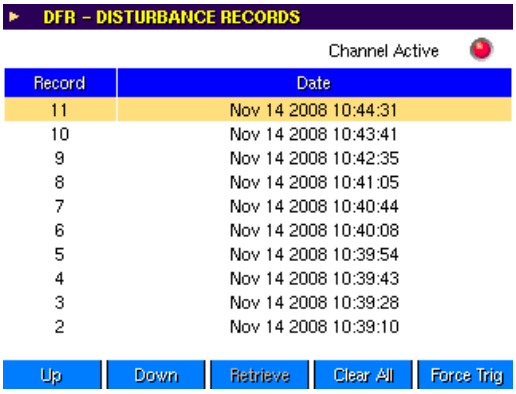


The digital fault recorder menu disturbance record menu lists all disturbance records currently stored in the C90^{Plus}. It also indicates the status of the trigger, where:

- Green indicates that the trigger is not active
- Red indicates an active trigger

Records can be retrieved and deleted and triggers can be manually generated from this screen.

Figure 12: Example disturbance record



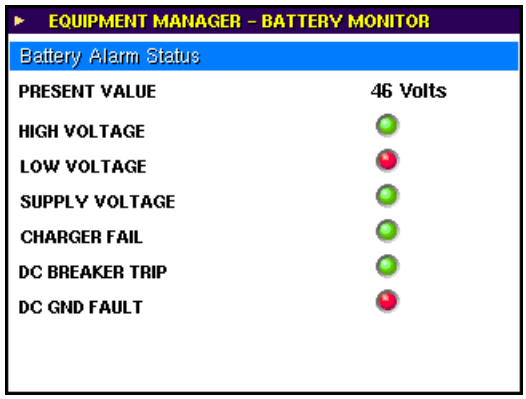
Equipment manager menu

This menu provides access to the equipment manager battery monitor function. There are three status indicators, colored red, yellow, and green.

- A green indication denotes no alarms for the device
- A yellow indication denotes at least one non-critical alarm and no critical alarms
- A red indication denotes at least one critical alarm

The battery monitor page displays the state of all battery monitor alarms for a particular device. Alarms can also be reset from this page.

Figure 13: Equipment manager battery monitor alarms example



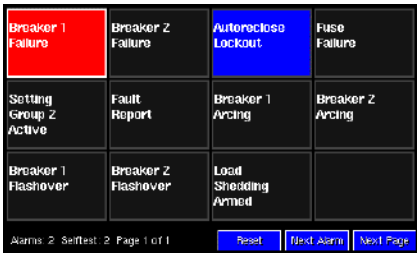
Annunciator

The annunciator is a color panel on the front of the unit.

Annunciator operation

The annunciator supports three types of alarms: self-reset, latched, and acknowledgeable. Each location in an annunciator display page can be configured to be one of the three alarm types and can also display an optional metered value. The value of each self-reset alarm is refreshed approximately once every half second.

Figure 14: Typical annunciator display

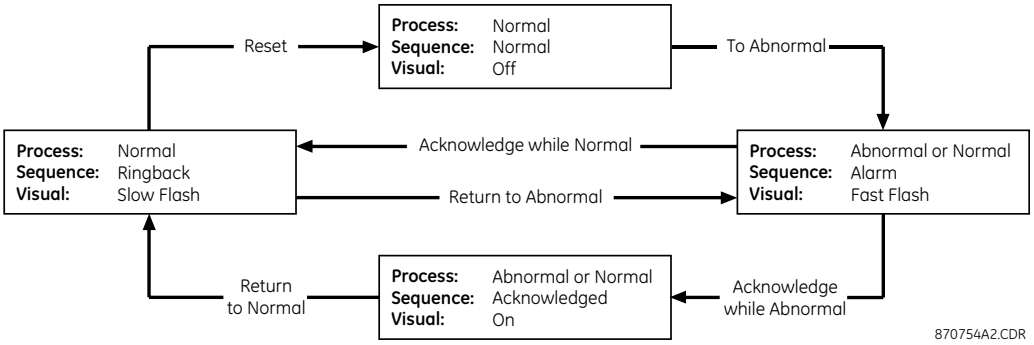


There are three control buttons at the bottom of the display.

- The Next Page button navigates through the configured alarm, self-test and product information pages. It should be noted that pages that contain no configured alarms are not displayed.
- The Next Alarm button navigates horizontally though the current alarms that are active, from left-to-right, starting with the first row of alarms. A border is drawn around the current alarm.
- The Ack/Reset button is used to acknowledge alarms or reset latched and acknowledgeable alarms that are in the ringback state.

The annunciator alarm sequence conforms to ISA 18.1-1979 (R1992) standard, type R.

Figure 15: Annunciator alarm sequence



The annunciator states are described in the following table.

Table 1: Acknowledgeable alarm states

Sequence (initial state)	Process (status)	Pushbutton (input)	Sequence (final state)	Visual indication
Normal	Normal	N/A	N/A	Off
Normal	Abnormal	N/A	Alarm	Fast flash
Alarm	Normal	N/A	Alarm	Fast flash
Alarm	Normal	Acknowledged	Normal	Off
Alarm	Abnormal	Acknowledged	Acknowledged	On
Acknowledged	Abnormal	N/A	Acknowledged	On
Acknowledged	Normal	N/A	Ringback	Slow flash
Ringback	Normal	Reset	Normal	Off
Ringback	Abnormal	N/A	Acknowledged	On

The visual indications display as follows:

- Off — Grey text on a darker grey background
- On — User-configurable
- Fast flash — Alternating between the off state and the on state two times per second
- Slow flash — Alternating between the off state and the on state one time per second

In the event of an alarm, the page containing the alarm will be promoted to active page. If there are multiple pages with alarms, the page with the lowest page number is promoted.

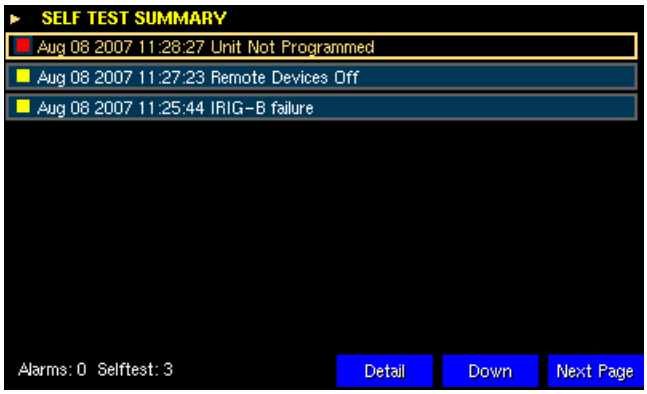
If there are alarms on multiple pages, and alarms on some pages have already been acknowledged (but not cleared) by the user, then the pages with active alarms move ahead of the pages that have acknowledged alarms. The user always has to navigate through the pages of alarms to view them.

Display of alarm pages is prioritized according to active window (unacknowledged or flashing alarm) and page number (for example, if two pages have an unacknowledged alarm, the page with the lowest number is automatically promoted as the displayed page).

Self-test page

The self-test page displays any active self test alarms as well as the time of occurrence and the severity of the alarm (yellow for non-critical and red for critical).

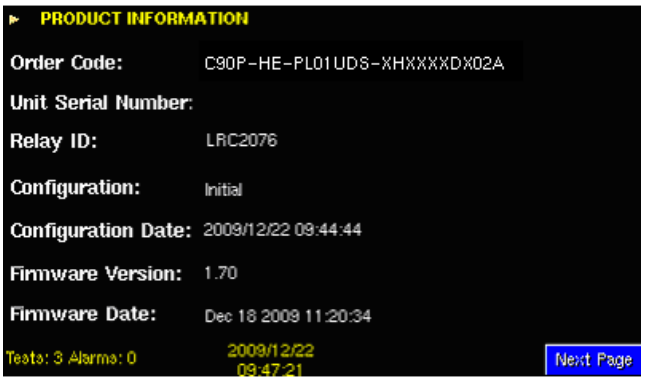
Figure 16: Self-test page example



Product information page

The product information page contains all of the constituent data describing the makeup of the IED, including the order code and serial number of the IED, in addition to the device identification name, the setting configuration name, the time of last change, the firmware version, and the firmware release date.

Figure 17: Example product information page

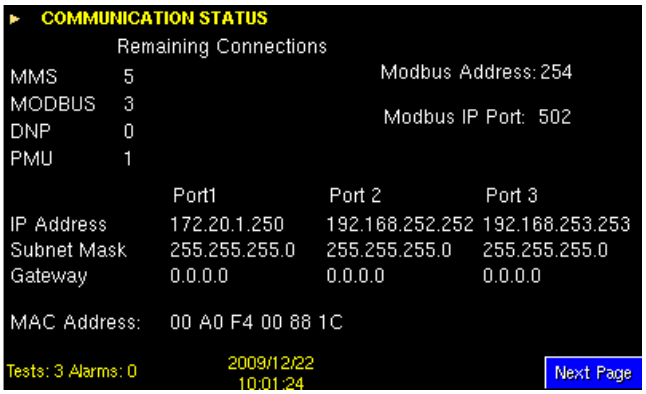


The Relay ID value reflects the string entered as the Relay Name in the in the **Settings > Protection > Power System > Installation** menu. The Configuration value reflects the string entered as the User Configuration Name in the **Settings > Protection > Power System > Installation** menu. The setup program automatically updates the Configuration Date after each setting change. The current C90^{Plus} date and time display on all annunciator pages, as does the total number of active self-tests and alarms.

Communication status page

The communication status page provides a summary of the currently available TCP/IP connections for the supported IED protocols. The C90^{Plus} supports up to five MMS connections, four Modbus connections, two Distributed Network Protocol (DNP) connections, and one PMU connection. The DNP connections are only shown as available if the protocol has been enabled and the C90^{Plus} restarted. The configured IP protocol values display for each of the available Ethernet ports. Ethernet port 1 is the port on the main CPU card in slot D, while port 2 is located at the top of the slot C communications processor and port 3 at the bottom. The displayed MAC address is for Ethernet port 1. The MAC address of Ethernet port 2 is the MAC address of Ethernet port 1 incremented by 1. The MAC address of Ethernet port 3 is the MAC address of Ethernet port 1 incremented by 2.

Figure 18: Communication status page



C90Plus Controller

Chapter 5: EnerVista software suite

The EnerVista software suite is an industry-leading set of programs that simplifies every aspect of the C90Plus. The EnerVista suite provides tools to monitor the status of your protected asset, maintain the relay, and integrate information measured by the C90Plus into DCS or SCADA monitoring systems. Convenient COMTRADE and sequence of events viewers are an integral part of the EnerVista software included with every C90Plus. This allows the user to carry out post-mortem event analysis to ensure proper protection system operation.

Introduction to EnerVista URPlus Setup

The EnerVista URPlus Setup software provides a graphical user interface (GUI) that allows users to configure, monitor, maintain and troubleshoot the operation of URPlus-series devices connected locally to a computer or over local or wide area communications networks. The EnerVista URPlus Setup software interface can be initiated in either offline (not communicating) or online (communicating) modes with a URPlus-series device. In offline mode, a device settings file can be created or configured for eventual downloading to that device. In online mode, the settings and actual values of a URPlus-series device can be configured or monitored utilizing real-time communications.

Extended software features

The EnerVista URPlus Setup software contains extended features that compliment the information monitored from URPlus-series devices. These features are not part of the standard C90Plus built-in features. The following sections explain how to use the EnerVista URPlus Setup software to accomplish various advanced monitoring and control.

Setting templates

Setting file templates simplify the configuration and commissioning of multiple devices that protect similar assets. An example is a substation that has 10 similar feeders protected by 10 URPlus-series relays.

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

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

The settings template mode allows the user to define the settings that 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. When in template mode, only settings that are available for editing are saved to the device or setting file during the read/write process.

Settings file conversion from any previous firmware version is supported.

Enabling the settings template in offline mode

The settings file template feature is disabled by default. The following procedure outlines how to enable the settings template for UR^{Plus}-series settings files in offline mode.

1. Select a settings file from the offline window of the EnerVista UR^{Plus} Setup main screen.
2. Right-click the selected settings file and select the **Settings File Template > Create Template** option.

The settings file template is now enabled and the file tree displayed in light blue. The settings file is now in template editing mode.

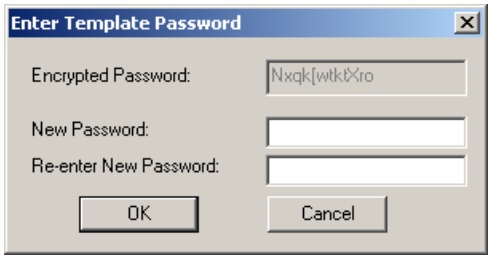
Enabling the settings template in online mode

The settings file template feature is disabled by default. The following procedure outlines how to enable the settings template to online UR^{Plus}-series settings.

1. Select an installed device from the online window of the EnerVista UR^{Plus} Setup main screen.
2. Right-click the selected 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 1: Entering a setting 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.

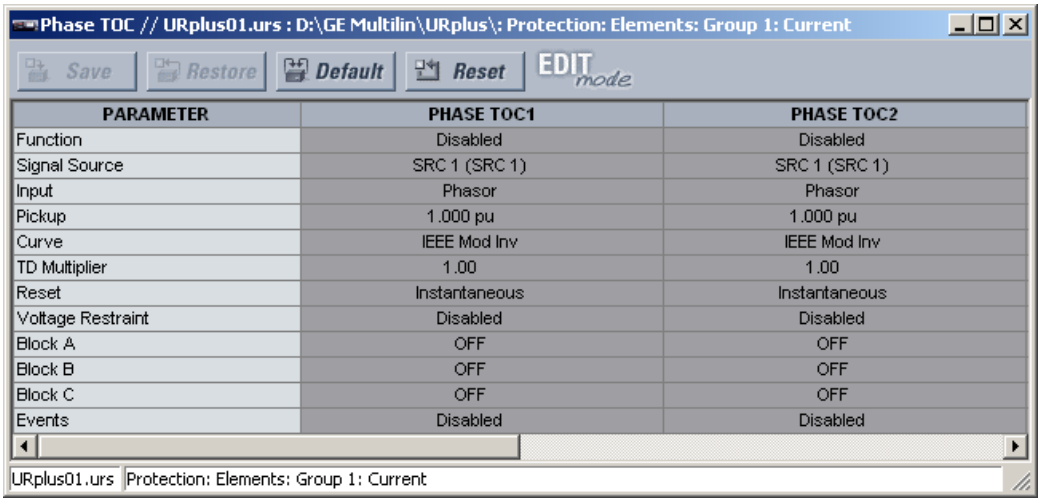
Editing a settings template

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

1. Select an installed device or a settings file from the tree menu on the left of the EnerVista UR^{Plus} Setup main screen.

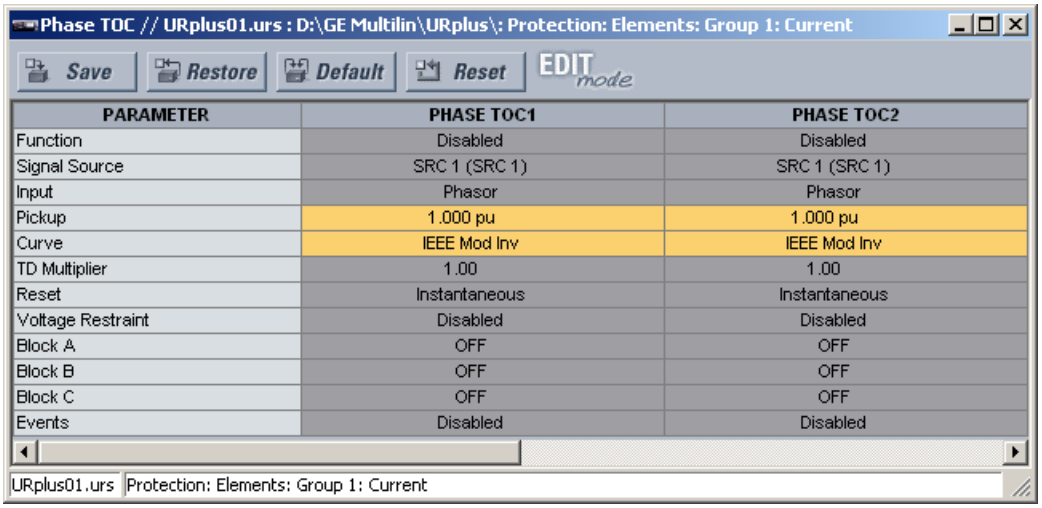
2. Select the **Template Mode > Edit Template** option (online mode) or the **Settings File Template > Edit Template** option (offline mode) to place the device or settings file in template editing mode.
3. Enter the template password (if required) then click **OK**.
4. Open the relevant settings windows that contain settings to be specified as viewable.

   By default, all settings are specified as locked and displayed against a grey background. The icon on the upper right of the settings window will also indicate that EnerVista UR^{Plus} Setup is in edit mode. The following example shows the phase time overcurrent settings window in edit mode.



5. Specify which settings to make viewable by clicking on them.

   The settings selected as available to view will be displayed against a yellow background as shown below.



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

   Only the settings that are available for editing are saved to the device or setting file.
7. Proceed through the settings tree to specify all viewable settings.

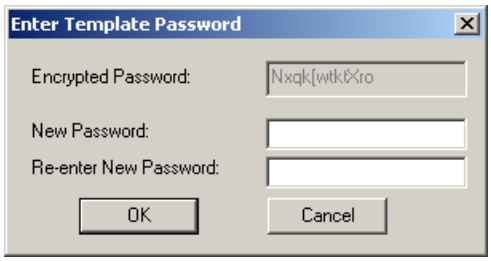
Adding password protection to a template

It is highly recommended that templates be saved with password protection to maximize security. The following procedure outlines how to add password protection to a settings file template.

1. Select a settings file from the offline window on the left of the EnerVista UR^{Plus} Setup main screen.
2. Select the **Settings File Template > Password Protect Template** option.

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

Figure 2: Template password entry window



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

The settings file template is now secured with password protection.

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.

Viewing a settings template

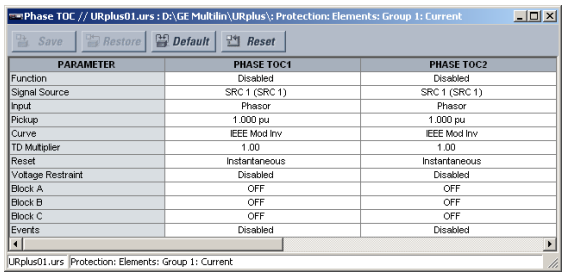
Once all necessary settings are specified for viewing, users are able to view the settings template on the online device or settings file.

Use the following procedure to display only the settings available for editing.

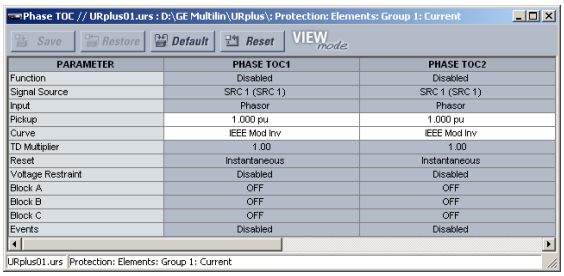
1. Select an installed device or a settings file from the tree menu on the left of the EnerVista UR^{Plus} Setup main screen.
2. Select the **Template Mode > View in Template Mode** option (online) or the **Settings File Template > View in Template Mode** option (offline).
3. Enter the template password then click **OK** to apply the template.

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

Figure 3: Setting window view via the View in Template Mode command



Phase time overcurrent settings window without template applied.

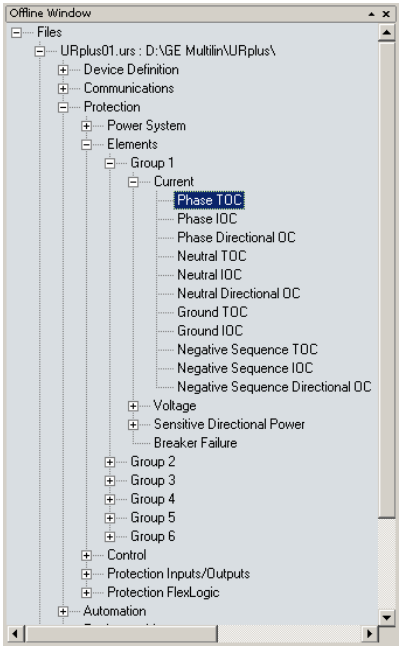


Phase time overcurrent window with template applied via the **View In Template Mode** command. The template specifies that only the Pickup and Curve settings be available.

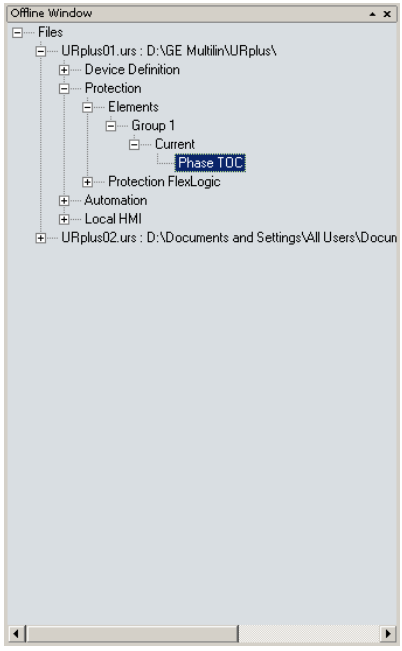
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Viewing in template mode also modifies the settings tree, showing only the settings categories that contain editable settings. The following figures show the effect of applying the template to a typical settings tree view.

Figure 4: Setting tree view via the View in Template Mode command



Typical settings tree view without template applied.



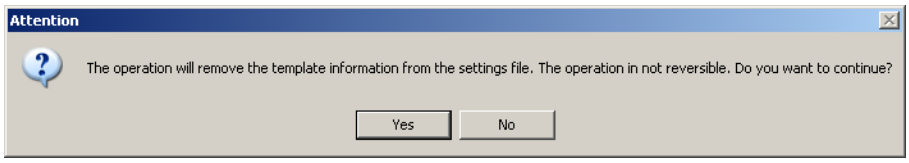
Typical settings tree view with template applied via the **View In Template Mode** command.

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Removing a settings template

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

1. Select an installed device or settings file from the tree menu on the left of the EnerVista UR^{Plus} Setup main screen.
2. Select the **Template Mode > Remove Settings Template** option (online) or the **Settings File Template > Remove Settings Template** option (offline).
3. Enter the template password and click **OK** to continue.
4. Confirm that you want to remove the template by clicking **Yes**.



The EnerVista software then removes all template information and all settings become available.

Securing and locking FlexLogic equations

The C90^{Plus} 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^{Plus}-series device.

Locking FlexLogic equation entries

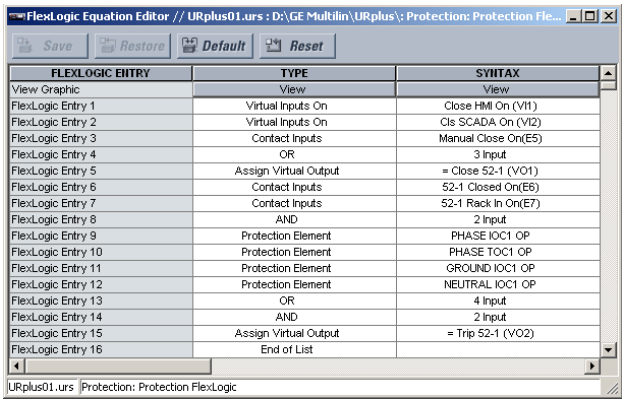
The following procedure describes how to lock individual entries of a FlexLogic equation.

1. Right-click the settings file or online device and select the **Template Mode > Create Template** item to enable the settings template feature.
2. Select the **Protection > Protection FlexLogic > FlexLogic Equation Editor** settings menu item.

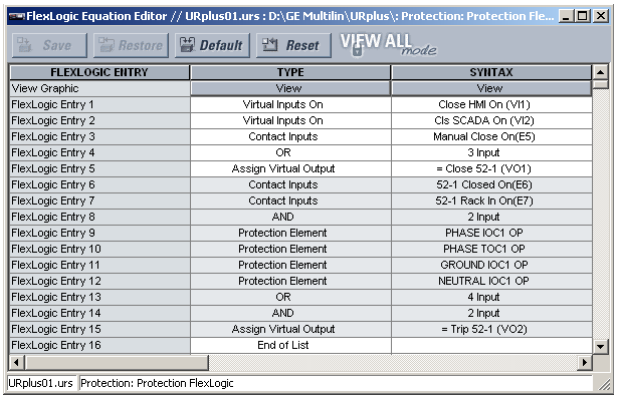
   By default, all FlexLogic entries are specified as viewable and displayed against a yellow background. The icon on the upper right of the window also indicates that EnerVista UR^{Plus} Setup is in edit mode.
3. Specify which entries to lock by clicking them.

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

Figure 5: Locking FlexLogic entries through setting templates



Typical FlexLogic™ entries without template applied.



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

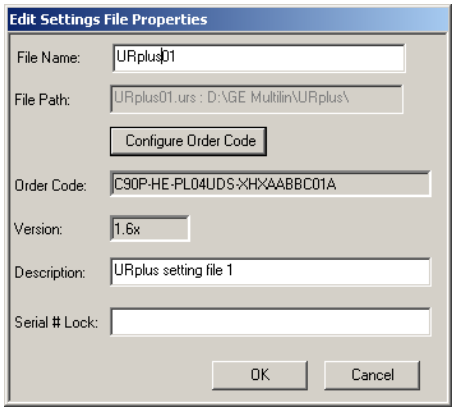
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Locking FlexLogic equations to a serial number

A settings file and associated FlexLogic equations can also be locked to a specific UR serial number. Once the desired FlexLogic entries in a settings file have been secured, use the following procedure to lock the settings file to a specific serial number.

1. Select the settings file in the offline window.
2. Right-click the file and select the **Manage Settings File > Edit Properties** item.

   The following window displays.



3. Enter the serial number of the C90^{Plus} device to lock to the settings file in the **Serial # Lock** field.

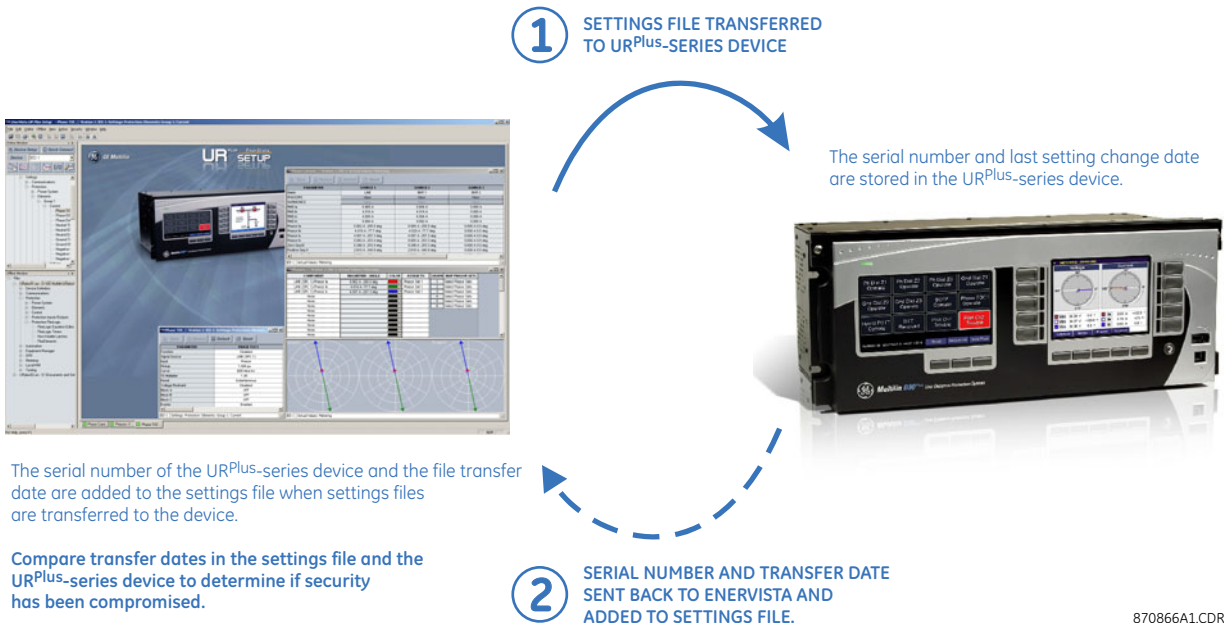
The settings file and corresponding secure FlexLogic equations are now locked to the C90^{Plus} device specified by the serial number.

Settings file traceability

A traceability feature for settings files allows the user to quickly determine if the settings in a C90^{Plus} device have been changed since the time of installation from a settings file. When a settings file is transferred to a C90^{Plus} device, the date, time, and serial number of the C90^{Plus} are sent back to EnerVista UR^{Plus} Setup and added to the settings file on the local computer. This information can be compared with the C90^{Plus} 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 C90^{Plus} device or obtained from the C90^{Plus} device. Any partial settings transfers by way of drag and drop do not add the traceability information to the settings file.

Figure 6: Settings file traceability mechanism



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

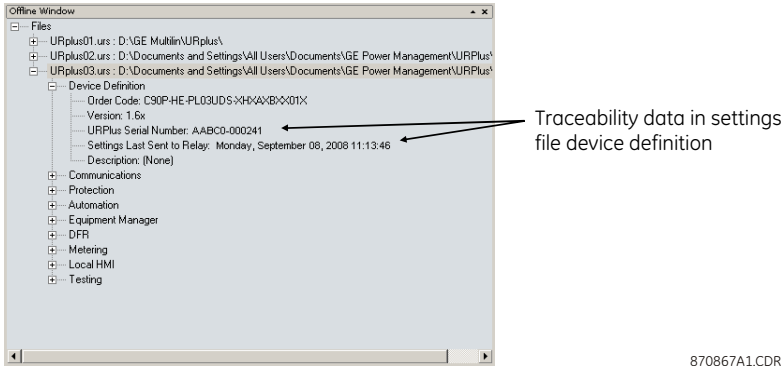
1. The transfer date of a setting file written to a C90^{Plus} is logged in the device and can be viewed via EnerVista UR^{Plus} Setup or the front panel display. Likewise, the transfer date of a setting file saved to a local computer is logged in EnerVista UR^{Plus} Setup.
2. Comparing the dates stored in the device and on the settings file at any time in the future will indicate if any changes have been made to the C90^{Plus} configuration since the settings file was saved.

Settings file traceability information

The serial number and file transfer date are saved in the settings files when sent to the C90^{Plus} device.

The C90^{Plus} serial number and file transfer date are included in the settings file device definition within the EnerVista UR^{Plus} Setup offline window, as shown in the example.

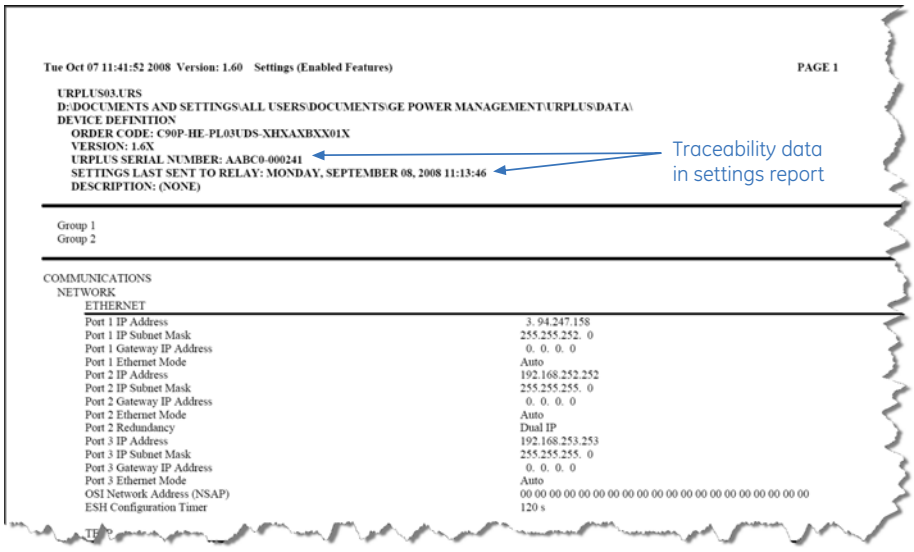
Figure 7: Device definition showing traceability data



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

Figure 8: Settings file report showing traceability data

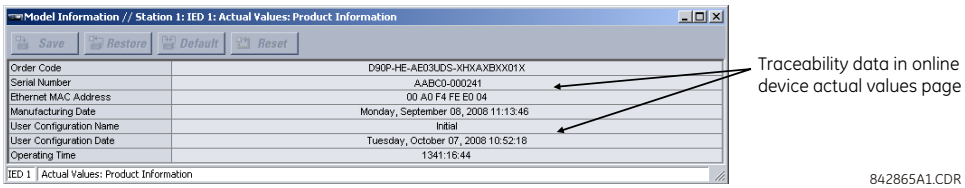


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Online traceability information

The C90^{Plus} serial number and file transfer date are available for an online device through actual values. Select the **Actual Values > Product Information > Model Information** menu item within the EnerVista UR^{Plus} Setup online window, as shown in the example.

Figure 9: Traceability data in actual values window



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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

C90Plus Controller

Chapter 6: Communications

This section describes how to program the C90Plus communications settings.

Communications overview

The C90Plus has one Ethernet port (port 1) on the main CPU module and two additional Ethernet ports (ports 2 and 3) on the communications module. Each port supports 100Base-FX over multi-mode fiber and 10/100Base-TX over twisted-pair, with auto-negotiation. Port 1 is primarily intended for configuration and file retrieval purposes and has a dedicated IP address. Ports 2 and 3 are intended for SCADA and peer-to-peer messaging. Additionally, there is one serial RS485 port.

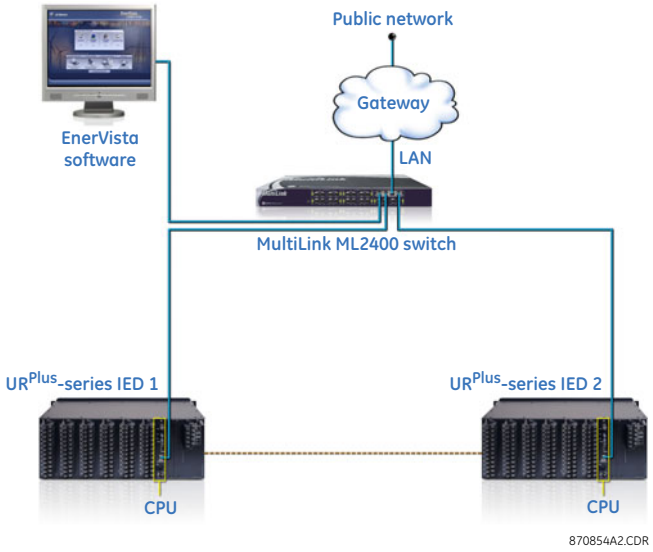
The following protocols are available, depending on the configuration of the unit:

- Ethernet port 1 — Modbus TCP, TFTP, SNTP, HTTP
- Ethernet port 2 — Modbus TCP, DNP 3.0, IEC 60870-5-104, IEC 61850, SNTP, TFTP, HTTP, PRP
- Ethernet port 3 — Modbus TCP, DNP 3.0, IEC 60870-5-104, IEC 61850, SNTP, TFTP, HTTP, PRP
- RS485 port — Modbus serial

Ethernet network topology

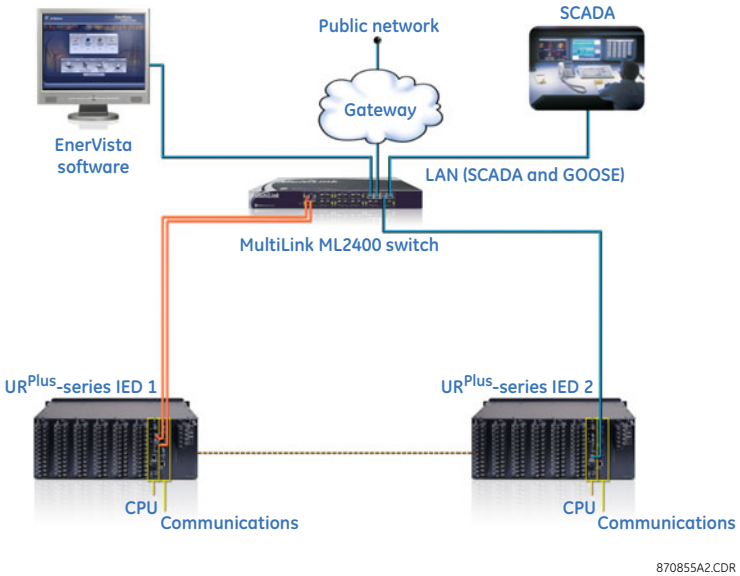
The topology shown here allows several C90Plus devices to communicate with a computer running EnerVista software or with a gateway for remote access. This allows device configuration, monitoring, and file transfers (transient records, sequence of events, and so on) to be carried out over Ethernet. Communications processor cards are not required and no redundancy is provided.

Figure 1: Simple network topology without communications cards



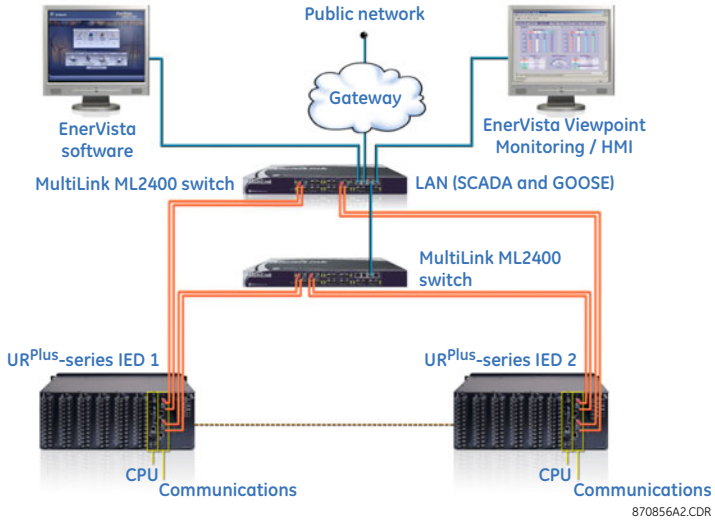
The topology shown as follows allows SCADA, GOOSE, configuration, and monitoring functions to share a single network. No redundancy is provided in this configuration. A communications processor is required in each C90^{Plus} device to facilitate SCADA and GOOSE messaging. Ports 2 and 3 can be configured for single or dual IP redundancy. This network topology is backwards-compatible with UR-series devices that are configured with a single Ethernet port.

Figure 2: Simple single network topology with no redundancy



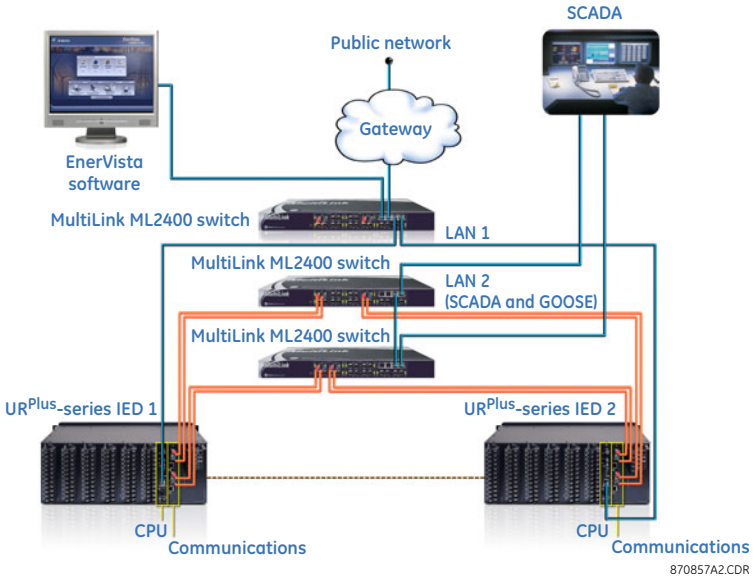
The following topology illustrates a single network for SCADA, GOOSE, configuration, and monitoring functions. This configuration provides redundant hardware and media redundancy. All communications are handled by port 2 under normal circumstances. Failure of a fiber or Ethernet switch causes the communications to be re-routed to port 3. Ports 2 and 3 are configured for single IP redundancy in this case. This network topology is backwardly compatible with UR-series devices that are configured with dual Ethernet ports.

Figure 3: Simple single network topology with redundancy



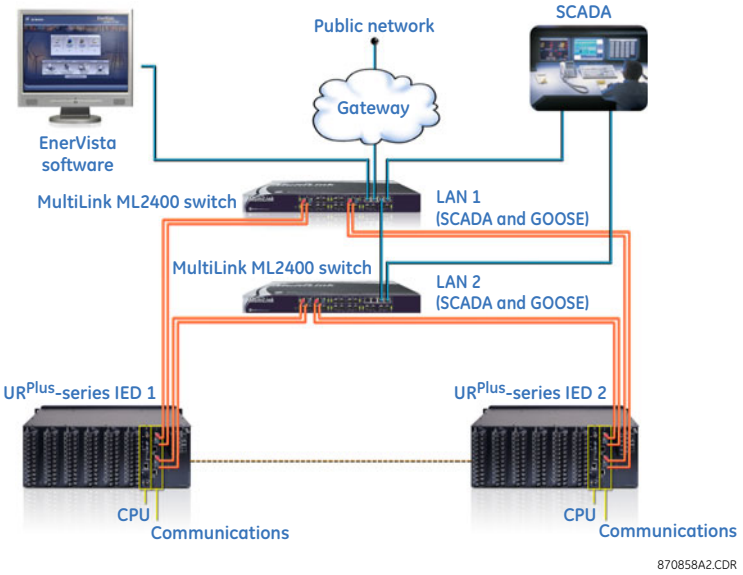
The following topology illustrates a dual LAN network. Configuration, and monitoring functions are provided on LAN 1 with no redundancy. LAN 2 is dedicated to SCADA and GOOSE communications and includes redundant hardware and media. Ports 2 and 3 are configured for single IP redundancy.

Figure 4: Simple dual network topology



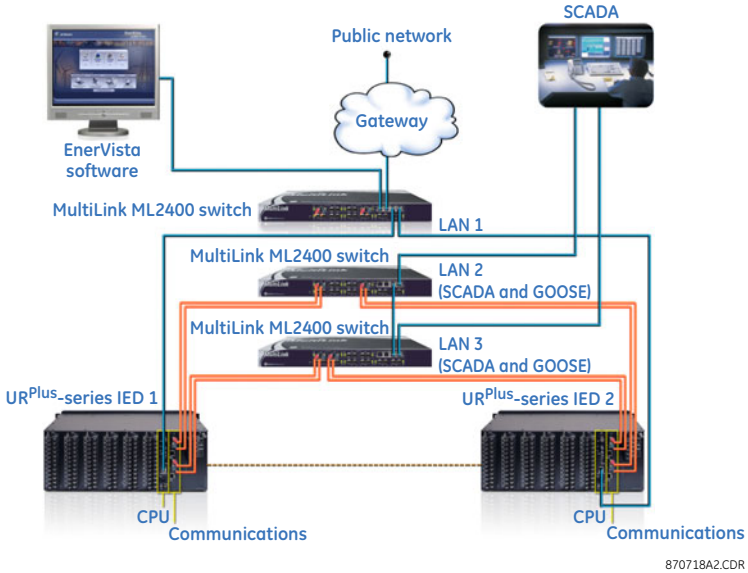
The following topology illustrates a dual redundant LAN network. Ports 2 and 3 are always active. Each C90^{Plus} device serves clients on either network as required. GOOSE messages are transmitted and received on both LANs simultaneously. Ports 2 and 3 are configured for dual IP redundancy. In dual IP redundancy, both ports operate independently. Loss of communication on one port does not result in connections being closed or connections being transferred to the other port. With dual IP redundancy, both GOOSE and GSSE messages are sent and received on both ports (there is no main or alternate designation), but have a source MAC address of the sending port.

Figure 5: Simple dual redundant network topology



The following topology illustrates a dedicated LAN for configuration and monitoring functions and dual redundant LANs for SCADA and GOOSE traffic. Each C90^{Plus} device services clients on either network as required. GOOSE messages are transmitted and received on both LANs simultaneously. Ports 2 and 3 are configured for dual IP redundancy.

Figure 6: Simple three network topology



Network settings

Settings are available to configure for Ethernet, as well as the TFTP and SNTP protocols.

Ethernet ports

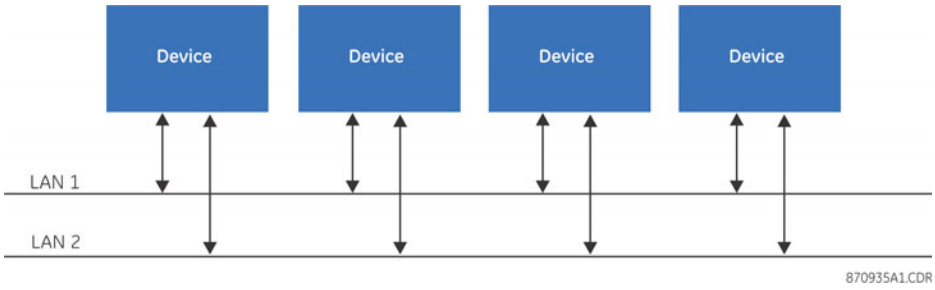
The Ethernet ports can be configured for single IP, dual IP, or redundancy using the Parallel Redundancy Protocol (PRP).

The single IP redundancy configuration provides compatibility with UR-series relays and other devices with single-IP redundancy. In this configuration, the port 2 IP address, subnet mask, and gateway address are used and the port 3 settings are ignored. All communications traffic is normally routed on port 2. If a failure occurs (determined at the hardware layer upon detecting loss of link signal on the active channel), then the traffic is re-routed to port 3. Switchover to port 3 takes place in less than 10 ms from the moment that the physical layer detects a failure. The device reverts from port 3 to port 2 as soon as port 2 becomes available, regardless of the state of port 3. Switchover to port 2 takes place in less than 500 ms. A link pulse is maintained in the transmit direction on both ports regardless of which port is in use. This ensures that communications are established with minimal delays. An Ethernet broadcast message is transmitted immediately upon switching ports, thereby forcing all Ethernet switches in the network to immediately update their routing tables.

In the dual IP redundancy configuration, each port has a unique IP address, subnet mask, and gateway address. Multiple client-server connections can be opened on each port simultaneously. Under normal conditions, GOOSE messages are sent on both ports.

If the PRP option was purchased, the C90^{Plus} supports PRP as per IEC 62439-3 (Clause 4, 2012). PRP provides seamless recovery in case of a single failure in the network, by using a combination of local area network (LAN) duplication and frame duplication. Identical frames are sent on two independent networks that connect source and destination. Under normal circumstances, both frames reach the destination and one of them is used while the second frame is discarded. If an error occurs in one of the networks and traffic is prevented from flowing on that path, connectivity is still provided over the other network. When designing the two LANS, take care that no single point of failure (such as a common power supply) is encountered, because it can bring down both LANs simultaneously. Similar to single and dual-IP configuration, ports 2 and 3 are used on the C90^{Plus} communications card for PRP. The following figure shows an example of a PRP redundant network.

Figure 7: Sample PRP redundant network



To configure the Ethernet ports, select the **Settings > Communications > Network > Ethernet** menu item to open the Ethernet configuration window. A selection of settings, commands, and actual values is available. Options visible depend on whether PRP was purchased with the C90^{Plus}.

The IP addresses are used with the DNP, Modbus/TCP, IEC 61580, IEC 60870-5-104,TFTP, and PRP protocols.

NOTE

When the NSAP address or any user map setting (when used with DNP) is changed, it becomes active when power to the relay has been cycled (off-to-on).

The following settings are available for each Ethernet port, except for **OSI Network Address (NSAP)** and **ESH Configuration Time**, which are not port-specific, and the **Port 2 Redundancy**, which applies only to Ethernet port 2.

Port 1 IP Address, Port 2 IP Address, Port 3 IP Address

Range: standard IP address range

Default: 192.168.251.251 (port 1), 192.168.252.252 (port 2), 192.168.253.253 (port 3)

These settings specify the dedicated IP address for each Ethernet port. When using multiple Ethernet ports, each port must be configured for a different subnet.

This setting is valid on port 3 when **Port 2 Redundancy** is set to "Dual IP".

Port 1 IP Subnet Mask, Port 2 IP Subnet Mask, Port 3 IP Subnet Mask

Range: standard IP address range

Default: 255.255.255.0

These settings specify the dedicated subnet mask for each Ethernet port.

The subnet mask settings for ports 2 and 3 are available when the C90^{Plus} contains a communications card. The subnet mask setting for port 3 is not available when the **Port 2 Redundancy** setting is "Single IP".

This setting is valid on port 3 when **Port 2 Redundancy** is set to "Dual IP".

Port 1 Gateway IP Address, Port 2 Gateway IP Address, Port 3 Gateway IP Address

Range: standard IP address range

Default: 0.0.0.0

These settings specify the dedicated gateway address for the selected Ethernet port.

The gateway IP address settings for ports 2 and 3 are available when the C90^{Plus} contains a communications card. The gateway IP address setting for port 3 is not available when the **Port 2 Redundancy** setting is "Single IP".

This setting is valid on port 3 when **Port 2 Redundancy** is set to "Dual IP".

Port 1 Ethernet Mode, Port 2 Ethernet Mode, Port 3 Ethernet Mode

Range: Auto, 10/100 Base-TX, 100 Base-TX

Default: Auto

These settings select the Ethernet connection hardware type, either 10/100Base-TX (twisted-pair) or 100Base-FX (fiber optic). The "Auto" selection is used to automatically detect the Ethernet hardware type.

The Ethernet mode settings for ports 2 and 3 are available when the C90^{Plus} contains a communications card. The Ethernet mode setting for port 3 is not available when the **Port 2 Redundancy** setting is "Single IP".

Port 2 Redundancy

Range: Single IP, Dual IP, RRP

Default: Dual IP

This setting is available when the C90^{Plus} contains a communications card. It selects single-IP, dual-IP, or PRP operation for Ethernet ports 2 and 3.

In single-IP mode, the link status of both ports is continuously monitored but only one port is active at a time. Each port uses the same source MAC address and IP parameters specified for Ethernet port 2.

In dual-IP mode, Ethernet ports 2 and 3 operate independently with their own MAC addresses and IP parameters.

When set to either Single IP or PRP, ports 2 and 3 operate in redundant mode. The differences between the two settings are explained as follows.

If set to Single IP, ports 2 and 3 operate as follows:

- Ports 2 and 3 use the port 2 MAC address, IP address, mask, and gateway
- The configuration fields for IP address, mask and gateway on port 3 are hidden
- Port 3 is in a standby mode in that it 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 port 2 and the switch is good, communications automatically switch back to port 2 and port 3 goes back to standby mode.

If set to PRP, ports 2 and 3 operate as follows:

- Ports 2 and 3 use the port 2 MAC address, IP address, mask, and gateway
- The configuration fields for IP address, mask, and gateway on port 3 are hidden
- Port 2 PRP Multicast Address field is visible so that it can be configured; configure it

Port 2 PRP Multicast Address

Range: 01-15-4E-00-01-00 to 01-15-4E-00-01-FF
Default: 01-15-4E-00-01-00

This setting allows the user to change the multicast address used by the PRP supervision frames. This setting is available when the communications card is installed and **Redundancy** is set to "PRP".

OSI Network Address (NSAP)

Range: 20 alphanumeric characters
Default: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 49 00 00 00

This setting specifies the NSAP address used with the IEC 61850 protocol over the OSI (CLNP/TP4) stack.

ESH Configuration Timer

Range: 0 to 32767 seconds in steps of 1
Default: 120 seconds

The End System to Intermediate System Routing Exchange protocol used with ISO 8473 mandates that the end system construct and transmit an End System Hello (ESH) signal for each NSAP it serves, based on an internal timer. This setting specifies the transmission time for the ESH signal. This setting takes affect when the C90^{Plus} is started.

The following command is also available from this window.

Configure IP Network

This command validates the IP address, subnet mask, and gateway IP address settings for all ports. If the validation is successful, then the **Configure IP Network Status** value will be "OK" and the new settings take effect immediately. If the validation fails, then the **Configure IP Network Status** value indicates the reason for failure and the network settings are restored to their previous values.

The following actual values are also available from this window.

Configure IP Network Status

Range: OK, PORT 1 NETMASK ERROR, PORT 2 NETMASK ERROR, PORT 3 NETMASK ERROR, PORT 1 IP ADDR RSVD, PORT 2 IP ADDR RSVD, PORT 3 IP ADDR RSVD, PORT 1 IP ADDR LPBK, PORT 2 IP ADDR LPBK, PORT 3 IP ADDR LPBK, PORT 1 IP ADDR NETWK, PORT 2 IP ADDR NETWK, PORT 3 IP ADDR NETWK, PRT 1-2 SUBNET OVRLP, PRT 1-3 SUBNET OVRLP, PRT 2-3 SUBNET OVRLP, >1 GATEWAY DEFINED

This actual value displays the status of the **Configure IP Network** command. The following status values are indicated.

- "OK": All supplied user IP parameters are valid and have been applied to the network stack.
- "PORT 1 NETMASK ERROR", "PORT 2 NETMASK ERROR", "PORT 3 NETMASK ERROR": An invalid network mask value was entered for Ethernet port 1, 2, or 3, respectively.
- "PORT 1 IP ADDR RSVD", "PORT 2 IP ADDR RSVD", "PORT 3 IP ADDR RSVD": A reserved IP address was entered for Ethernet port 1, 2, or 3, respectively. Reserved IP addresses include 0.---.---.--- (for self-identification), 224.---.---.--- through

239.---.---.--- (multicast), and 240.---.---.--- through 255.---.---.--- (reserved by IANA).

- "PORT 1 IP ADDR LPBK", "PORT 2 IP ADDR LPBK", "PORT 3 IP ADDR LPBK": A loopback IP address was entered for Ethernet port 1, 2, or 3, respectively.
- "PORT 1 IP ADDR NETWK", "PORT 2 IP ADDR NETWK", "PORT 3 IP ADDR NETWK": The entered IP address is the network address for Ethernet port 1, 2, or 3, respectively.
- "PRT 1-2 SUBNET OVRLP": The entered network parameters for Ethernet port 1 overlap the network parameters for Ethernet port 2.
- "PRT 1-3 SUBNET OVRLP": The entered network parameters for Ethernet port 1 overlap the network parameters for Ethernet port 3.
- "PRT 2-3 SUBNET OVRLP": The entered network parameters for Ethernet port 2 overlap the network parameters for Ethernet port 3.
- ">1 GATEWAY DEFINED": The user has entered more than one default gateway.

Active Port 1 IP Address, Active Port 2 IP Address, Active Port 3 IP Address

Range: standard IP address range

These actual values display the configured IP address for each Ethernet port.

The active port IP address actual values for ports 2 and 3 are available when the C90^{Plus} contains a communications card. The active port IP address actual value for port 3 is not available when the **Port 2 Redundancy** setting is "Dual IP".

Active Port 1 IP Subnet Mask, Active Port 2 IP Subnet Mask, Active Port 3 IP Subnet Mask

Range: standard IP address range

These actual values display the configured subnet mask for each Ethernet port.

The active port subnet mask actual values for ports 2 and 3 are available when the C90^{Plus} contains a communications card. The active port subnet mask actual value for port 3 is not available when the **Port 2 Redundancy** setting is "Dual IP".

Active Port 1 Gateway IP Address, Active Port 2 Gateway IP Address, Active Port 3 Gateway IP Address

Range: standard IP address range

These actual values display the configured gateway address for the selected Ethernet port.

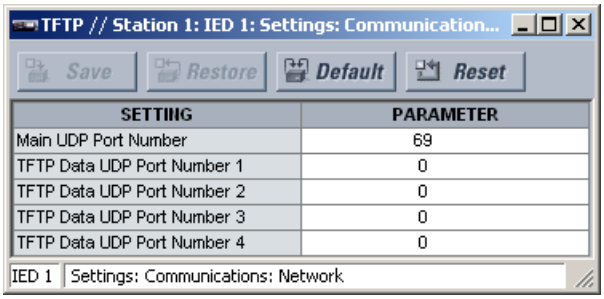
The active port gateway address actual values for ports 2 and 3 are available when the C90^{Plus} contains a communications card. The active port gateway address actual value for port 3 is not available when the **Port 2 Redundancy** setting is "Dual IP".

TFTP protocol

The Trivial File Transfer Protocol (TFTP) can be used to transfer files from the C90^{Plus} over a network. The C90^{Plus} operates as a TFTP server. TFTP client software is available from various sources, including Microsoft Windows XP. The `dir.txt` file obtained from the C90^{Plus} contains a list and description of all available files (for example, event records and oscillography).

Select the **Settings > Communications > Network > TFTP** menu item to open the TFTP configuration window.

Figure 8: TFTP configuration settings



The following settings are available for the TFTP protocol.

Main UDP Port Number

Range: 1 to 65535 in steps of 1
Default: 69

This setting specifies the main UDP port number.

TFTP Data UDP Port Number 1, TFTP Data UDP Port Number 2, TFTP Data UDP Port Number 3, TFTP Data UDP Port Number 4

Range: 0 to 65535 in steps of 1
Default: 0

These settings specify data for UDP port numbers 1 through 4. A TFTP data port value of zero specifies that the C90^{Plus} automatically assigns a port number.

NOTE

Changes to the TFTP protocol settings become active when power to the C90^{Plus} has been cycled (off-to-on).

SNTP protocol

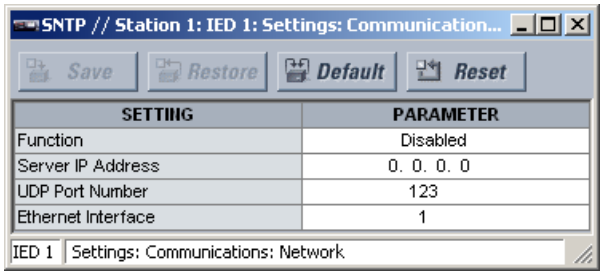
The C90^{Plus} supports the Simple Network Time Protocol (SNTP) specified in RFC-2030. With SNTP, the C90^{Plus} can obtain clock time over an Ethernet network. The C90^{Plus} acts as an SNTP client to receive time values from an SNTP/NTP server, usually a dedicated product using a GPS receiver to provide an accurate time.

Unicast and broadcast SNTP are supported. The UR^{Plus}-series relays do not support multicast or anycast SNTP functionality.

If SNTP functionality is enabled at the same time as IRIG-B, the IRIG-B signal provides the time value to the C90^{Plus} clock for as long as a valid signal is present. If the IRIG-B signal is removed, the time obtained from the SNTP server is used. If either SNTP or IRIG-B is enabled, the C90^{Plus} clock value cannot be changed using the EnerVista UR^{Plus} Setup software.

Select the **Settings > Communications > Network > SNTP** menu item to open the SNTP protocol configuration window.

Figure 9: SNTP protocol configuration settings



The following settings are available to configure the SNTP protocol.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the SNTP protocol.

Server IP Address

Range: standard IP address
Default: 0.0.0.0

This setting specifies the SNTP/NTP server IP address.

To use SNTP in unicast mode, this setting must be programmed to the SNTP/NTP server IP address. Once this address is set, the C90^{Plus} 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 C90^{Plus} clock is closely synchronized with the SNTP/NTP server. It can take up to two minutes for the C90^{Plus} to signal an SNTP self-test error if the server is offline.

To use SNTP in broadcast mode, program this setting to "0.0.0.0". The C90^{Plus} then listens to SNTP messages sent to the *all ones* broadcast address for the subnet. The C90^{Plus} waits up to eighteen minutes (1024 seconds) without receiving an SNTP broadcast message before signaling an SNTP self-test error.

UDP Port Number

Range: 0 to 65535 in steps of 1
Default: 123

This setting specifies the UDP port number for use with the SNTP protocol.

Ethernet Interface

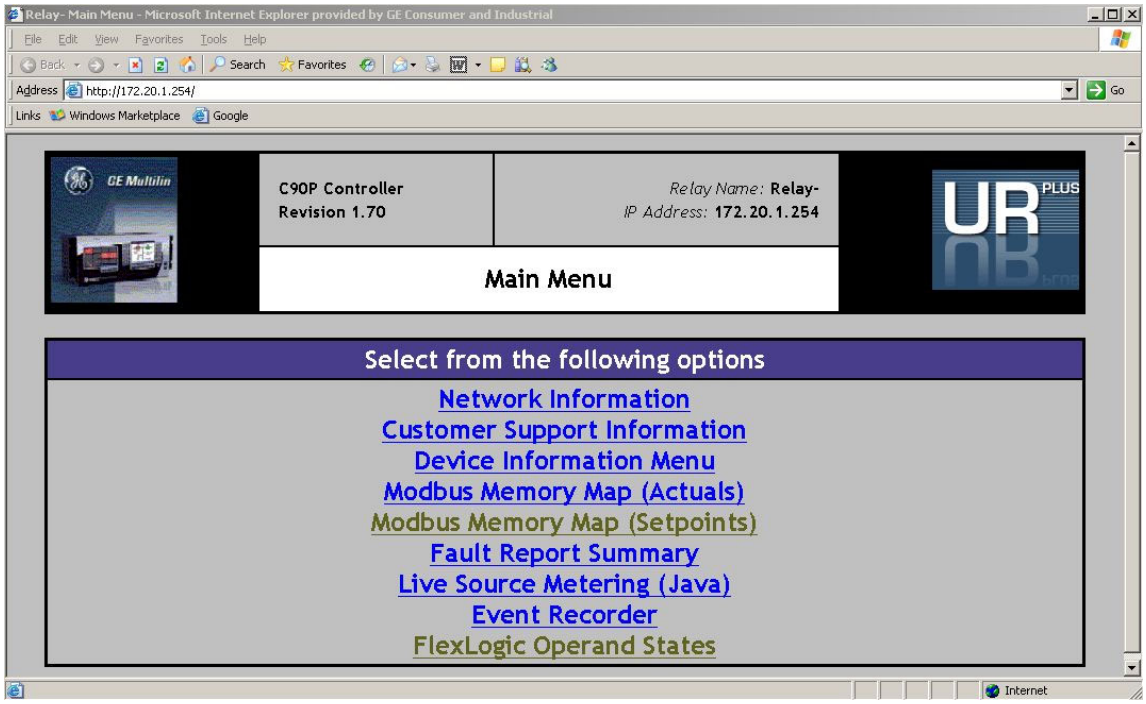
Range: 1, 2, or 3
Default: 1

This setting selects the Ethernet port to use for SNTP communications.

HTTP protocol

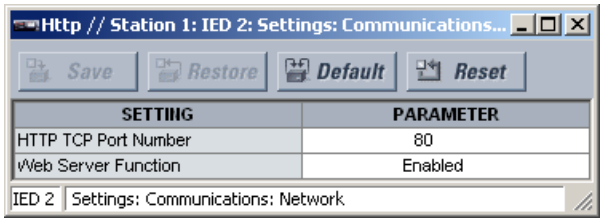
The C90^{Plus} contains an embedded web server and is capable of transferring web pages to a web browser such as Microsoft Internet Explorer or Mozilla Firefox. The web pages are organized as a series of menus that can be accessed starting at the C90^{Plus} main menu. Web pages are read-only and are available showing DNP and IEC 60870-5-104 points lists, Modbus registers, event records, fault reports, etc. Enable the feature, then to view the main menu in the web browser, enter the IP address of the C90^{Plus} in the address field of the web browser.

Figure 10: Sample web access page



Select the **Settings > Communications > Network > HTTP** menu item to open the HTTP configuration window.

Figure 11: HTTP configuration settings



The following settings are available.

HTTP TCP Port Number

Range: 1 to 65535 in steps of 1
Default: 80

This setting specifies the TCP port number for the embedded web server. This setting takes effect upon restart of the C90^{Plus}.

Web Server Function

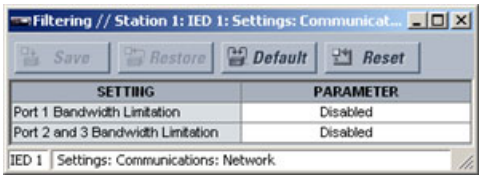
Range: Disabled, Enabled
Default: Disabled

This setting enables and disabled the web server feature.

Network filtering

Select the **Settings > Communications > Network > Filtering** menu item to open the network filtering configuration window.

Figure 12: Network filtering configuration settings



The following settings are available.

Port 1 Bandwidth Limitation

Range: Disabled, Enabled

Default: Disabled

This setting is used to enable IP protocol bandwidth limiting on Ethernet port 1. The COMM HIGH TRAFFIC self-test message is issued when the C90^{Plus} is actively limiting IP bandwidth usage. This is a minor self-test error that does not interfere with protection functionality.

Port 2 and 3 Bandwidth Limitation

Range: Disabled, Enabled

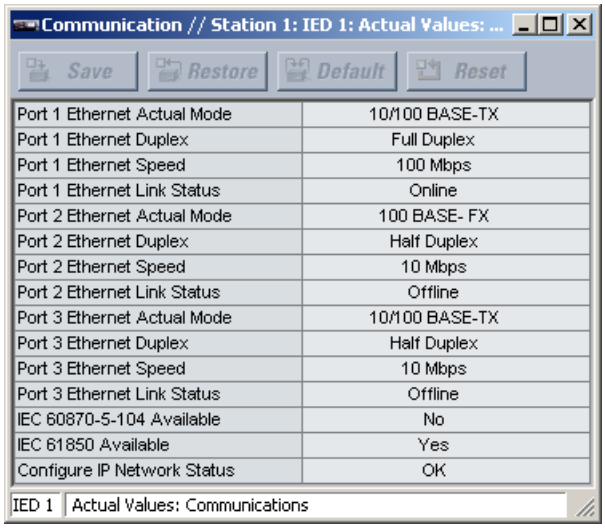
Default: Disabled

This setting is used to enable IP protocol bandwidth limiting on Ethernet ports 2 and 3. The COMM HIGH TRAFFIC self-test message is issued when the C90^{Plus} is actively limiting IP bandwidth usage. This is a minor self-test error that does not interfere with protection functionality. IP bandwidth limiting of Ethernet ports 2 and 3 does not affect GOOSE messaging.

Ethernet actual values

Select the **Actual Values > Communications > Communication** menu item to open the communications actual values window.

Figure 13: Ethernet actual values



The following actual values are related to the Ethernet communications feature.

Port 1 Ethernet Actual Mode, Port 2 Ethernet Actual Mode, Port 3 Ethernet Actual Mode

Range: 10/100 BASE-TX, 10/100 BASE-FX

This actual value indicates the Ethernet hardware type on each of the three ports.

Port 1 Ethernet Duplex, Port 2 Ethernet Duplex, Port 3 Ethernet Duplex

Range: Full Duplex, Half Duplex

This actual value indicates the Ethernet duplex mode on each of the three ports.

Port 1 Ethernet Speed, Port 2 Ethernet Speed, Port 3 Ethernet Speed

Range: 10 Mbps, 100 Mbps

This actual value indicates the network speed on each of the three Ethernet ports.

Port 1 Ethernet Link Status, Port 2 Ethernet Link Status, Port 3 Ethernet Link Status

Range: Online, Offline

This actual value indicates the connection status on each of the three Ethernet ports.

IEC 60870-5-104 Available

Range: No, Yes

This actual value indicates if the IEC 60870-5-104 protocol is enabled on the Ethernet ports.

IEC 61850 Available

Range: No, Yes

This actual value indicates if the IEC 61850 protocol in enabled on the Ethernet ports.

Configure IP Network Status

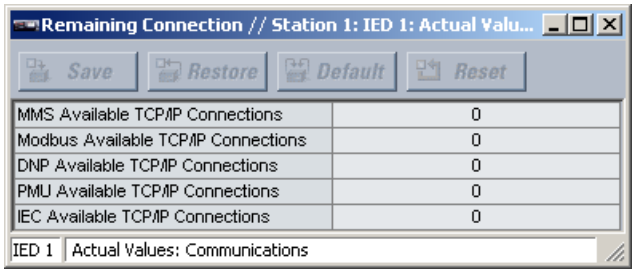
Range: OK, PORT 1 NETMASK ERROR, PORT 2 NETMASK ERROR, PORT 3 NETMASK ERROR, PORT 1 IP ADDR RSVD, PORT 2 IP ADDR RSVD, PORT 3 IP ADDR RSVD, PORT 1 IP ADDR LPBK, PORT 2 IP ADDR LPBK, PORT 3 IP ADDR LPBK, PORT 1 IP ADDR NETWK, PORT 2 IP ADDR NETWK, PORT 3 IP ADDR NETWK, PRT 1-2 SUBNET OVRLP, PRT 1-3 SUBNET OVRLP, PRT 2-3 SUBNET OVRLP, > 1 GATEWAY DEFINED

This actual value indicates the validity of the IP parameters applied to the network stack. Refer to Ethernet ports on page 87for details on the status values. The Ethernet parameters for ports 2 and 3 exist only when the C90^{Plus} contains a communications card.

Remaining TCP/IP connections actual values

Select the **Actual Values > Communications > Remaining Connection** menu item to open the remaining TCP/IP connections actual values window.

Figure 14: Remaining TCP/IP connections actual values



The following actual values are available to display the remaining TCP/IP connections.

MMS Available TCP/IP Connections

Range: 0, 1, 2, 3, 4, 5

This actual value indicates the number of connections available for IEC 61850 MMS communications.

Modbus Available TCP/IP Connections

Range: 0, 1, 2, 3, 4

This actual value indicates the number of connections available for Modbus communications.

DNP Available TCP/IP Connections

Range: 0, 1, 2

This actual value indicates the number of connections available for DNP communications. The number of DNP connections is zero unless the "Network - TCP" value has been selected for both the **DNP Channel 1 Port** and **DNP Channel 2 Port** settings.

PMU Available TCP/IP Connections

Range: 0, 1

This actual value indicates the number of connections available for the phasor measurement unit.

IEC Available TCP/IP Connections

Range: 0, 1, 2

This actual value indicates the number of connections available for IEC 60870-5-104 communications.

PRP actual values

Select the **Actual Values > Communications > PRP** menu to open the window.

Figure 15: PRP actual values

PARAMETER	VALUE
Total Received Port A	0
Total Received Port B	0
Total Errors	0
Total Mismatches Port A	0
Total Mismatches Port B	0

The following actual values display.

Total Received Port

Range: 0 to 4G, blank if PRP disabled

This is a counter of total messages received on a port.

Total Errors

Range: 0 to 4G, blank if PRP disabled

This is a counter of total messages received with an error (bad port code, frame length too short).

Total Mismatches

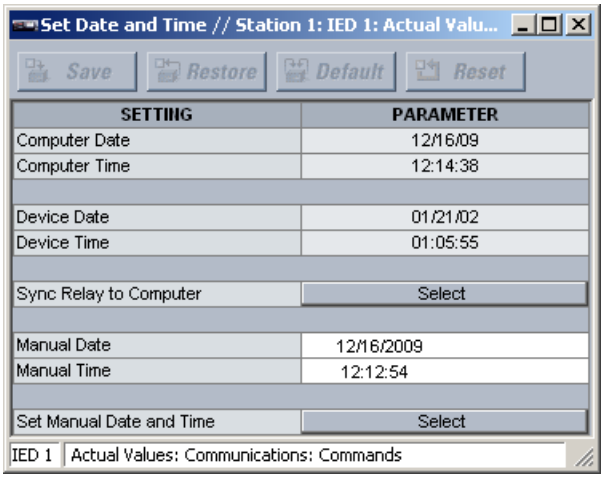
Range: 0 to 4G, blank if PRP disabled

This is a counter of total messages received with an error on a port (PRP frame, but port received through and LAN ID in the frame do not match).

Date and time actual values and commands

Select the **Actual Values > Communications > Commands > Set Date and Time** menu item to open the date and time commands window.

Figure 16: Date and time actual values and commands



The following date and time actual values are displayed.

Computer Date

Range: date in MM/DD/YY format

This actual value displays the date specified by the computer running the EnerVista UR^{Plus} Setup software.

Computer Time

Range: time in HH:MM:SS format

This actual value displays the time specified by the computer running the EnerVista UR^{Plus} Setup software.

Device Date

Range: date in MM/DD/YY format

This actual value displays the date programmed in the C90^{Plus}.

Device Time

Range: time in HH:MM:SS format

This actual value displays the time programmed in the C90^{Plus}.

The following date and time commands are available.

Sync Relay to Computer

This command sets the C90^{Plus} date and time values to the date and time of the computer running the EnerVista UR^{Plus} Setup software.

Set Manual Date and Time

This command sets the C90^{Plus} date and time values to the date and time values specified by the **Manual Date** and **Manual Time** entries.

Modbus communications

The Modbus protocol is supported by the C90^{Plus}. Modbus is available via the RS485 serial link (Modbus RTU) or Ethernet (Modbus/TCP). The C90^{Plus} supports Modbus RTU.

The C90^{Plus} always acts as a slave device, meaning that it never initiates communications; it listens and responds to requests issued by a master device.

See the C90Plus Communications Guide (publication GEK-113467) for information on developing communication drivers and for the Modbus memory map. The rest of this section outlines Modbus configuration settings.

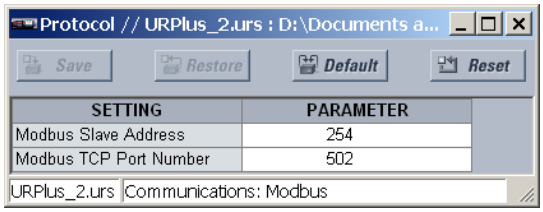
Modbus protocol

The Modbus server can simultaneously support one client over serial RS485 and four clients over Ethernet. The server is capable of reporting any indication or measurement and operating any output present in the device. A user-configurable input and output map is also implemented.

The C90Plus operates as a Modbus slave device only.

Select the **Settings > Communications > Modbus > Protocol** menu item to open the Modbus protocol configuration window.

Figure 17: Modbus protocol configuration settings



The following Modbus protocol settings are available.

Modbus Slave Address

Range: 1 to 254 in steps of 1

Default: 254

This setting specifies the Modbus slave address for the C90Plus. Each device must have a unique address from 1 to 254. Address 0 is the broadcast address to which all Modbus slave devices listen. Addresses do not have to be sequential, but no two devices can have the same address or conflicts resulting in errors occur. Generally, each device added to the link should use the next higher address starting at 1.

Modbus TCP Port Number

Range: 1 to 65535 in steps of 1

Default: 502

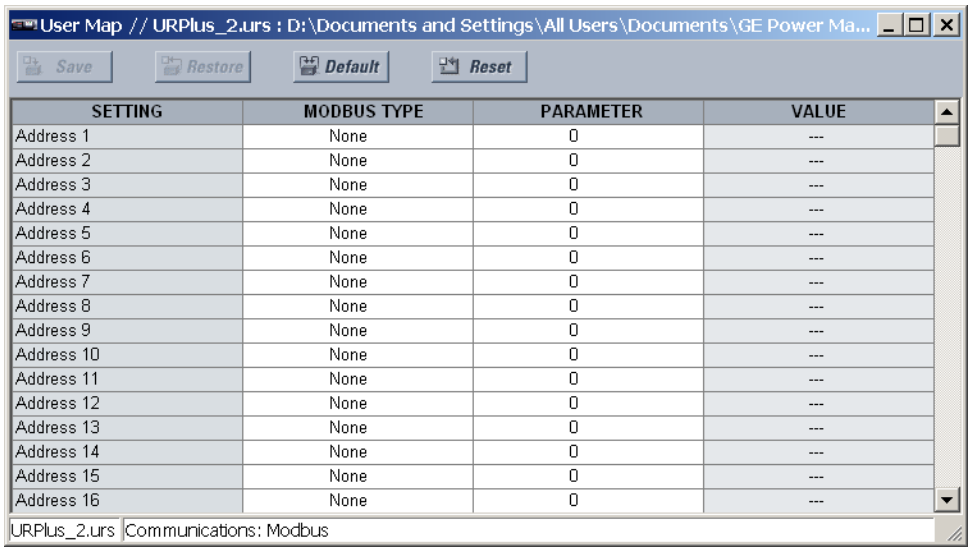
This setting specifies the Modbus TCP port number for Ethernet communications. Power to the C90Plus must be cycled for changes to this setting to take effect.

Modbus user map

The Modbus user map provides read-only access for up to 256 registers. To obtain a memory map value, enter the required address in the **Parameter** field (this value must be converted from hexadecimal to decimal format). The corresponding value (if programmed) is displayed in the value field. 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" displays for all registers. Different address values can be entered as required in any of the register positions.

Select the **Settings > Communications > Modbus > User Map** menu item to open the Modbus user map configuration window.

Figure 18: Modbus user map configuration settings



SETTING	MODBUS TYPE	PARAMETER	VALUE
Address 1	None	0	---
Address 2	None	0	---
Address 3	None	0	---
Address 4	None	0	---
Address 5	None	0	---
Address 6	None	0	---
Address 7	None	0	---
Address 8	None	0	---
Address 9	None	0	---
Address 10	None	0	---
Address 11	None	0	---
Address 12	None	0	---
Address 13	None	0	---
Address 14	None	0	---
Address 15	None	0	---
Address 16	None	0	---

The following Modbus user map settings are available for each of the 256 registers.

Modbus Type

Range: None, Settings, Actuals

Default: None

This setting indicates if the Modbus user map address represents a setting or an actual value.

Parameter

Range: Modbus memory map address in decimal representation

Default: 0

This setting represents the value of the programmed Modbus memory map address.

DNP communications

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.

See the C90^{Plus} Communications Guide (publication GEK-113467) for details on the DNP.

DNP protocol

The DNP server can simultaneously support one client over serial RS485 and one client over Ethernet or two clients over Ethernet. Level 3 is supported for parsing requests and generating responses. It is capable of reporting any indication or measurement and operating any output present in the device. Both direct-operate and select-before-operate modes of control are supported. Two user-configurable input and output maps are implemented.

Select the **Settings > Communications > DNP > Protocol** menu item to open the DNP protocol configuration window.

Figure 19: DNP protocol configuration settings

Protocol // Station 1: IED 2: Settings: Communications: DNP

Save | Restore | Default | Reset

SETTING	PARAMETER
DNP Channel 1 Port	NONE
DNP Channel 2 Port	NONE
DNP Channel Address	1
DNP Client Address 1	0. 0. 0. 0
DNP Client Address 2	0. 0. 0. 0
DNP Client Address 3	0. 0. 0. 0
DNP Client Address 4	0. 0. 0. 0
DNP Client Address 5	0. 0. 0. 0
DNP TCP/UDP Port Number	20000
DNP Unsolicited Response Function	Disabled
DNP Unsolicited Response Timeout	5 s
DNP Unsolicited Response Maximum Re-Tries	10
DNP Unsolicited Response Destination Address	1
DNP Current Scale Factor	1
DNP Voltage Scale Factor	1
DNP Power Scale Factor	1
DNP Other Scale Factor	1
DNP Power Factor Scale Factor	1
DNP Current Default Deadband	30000
DNP Voltage Default Deadband	30000
DNP Power Default Deadband	30000
DNP Other Default Deadband	30000
DNP Power Factor Default Deadband	30000
DNP Time Sync IIN Period	1440 min
DNP Message Fragment Size	240
DNP Object 1 Default Variation	2
DNP Object 2 Default Variation	2
DNP Object 20 Default Variation	1
DNP Object 21 Default Variation	1
DNP Object 22 Default Variation	1
DNP Object 23 Default Variation	1
DNP Object 30 Default Variation	1
DNP Object 32 Default Variation	1
DNP Number of Paired Controls	0
DNP TCP Connection Timeout	120

IED 2 | Settings: Communications: DNP

The following settings are available for DNP protocol communications.

DNP Channel 1 Port, DNP Channel 2 Port

Range: None, COM1-RS485, Network-TCP, Network-UDP
Default: None

These settings specify the communications port assigned to the DNP protocol for each channel. Once DNP is assigned to a serial port, the Modbus protocol is disabled on that port. When this setting is set to "Network-TCP", the DNP protocol can be used over TCP/IP on channels 1 or 2. When this value is set to "Network - UDP", the DNP protocol can be used over UDP/IP on channel 1 only.

Changes to the these settings take effect after power has been cycled to the relay.

DNP Channel Address

Range: 0 to 65519 in steps of 1
Default: 1

This setting specifies the DNP slave address. This number identifies the C90^{Plus} on a DNP communications link. Assign a unique address to each DNP slave.

DNP Client Address 1, DNP Client Address 2,..., DNP Client Address 5

Range: any standard IP address
Default: 0.0.0.0

These settings force the C90^{Plus} to respond to a maximum of five specific DNP masters.

DNP TCP/UDP Port Number

Range: 1 to 65535 in steps of 1
Default: 20000

This setting specifies the TCP/UDP port used for DNP communications.

DNP Unsolicited Response Function

Range: Enabled, Disabled
Default: Disabled

Program this setting to "Disabled" for RS485 applications, since there is no collision avoidance mechanism.

DNP Unsolicited Response Timeout

Range: 0 to 60 seconds in steps of 1
Default: 5 seconds

This setting specifies how long the C90^{Plus} waits for a DNP master to confirm an unsolicited response.

DNP Unsolicited Response Maximum Re-Tries

Range: 1 to 255 in steps of 1
Default: 10

This setting specifies the number of times the C90^{Plus} retransmits an unsolicited response without receiving confirmation from the master. A value of "255" allows infinite re-tries.

DNP Unsolicited Response Destination Address

Range: 0 to 65519 in steps of 1
Default: 1

This setting specifies the DNP address to which all unsolicited responses are sent. The IP address to which unsolicited responses are sent is determined by the C90^{Plus} from the current TCP connection or the most recent UDP message.

DNP Current Scale Factor, DNP Voltage Scale Factor, DNP Power Scale Factor, DNP Power Factor Scale Factor, DNP Other Scale Factor

Range: 0.001, 0.01. 0.1, 1, 10, 100, 1000, 10000, 100000
Default: 1

These settings scale the analog input current values. For example, if the **DNP Current Scale Factor** is "10", all DNP analog input points that represent currents are returned with values 10 times smaller (for example, a value of 700 amps on the C90^{Plus} is returned as 70). Likewise, if the **DNP Voltage Scale Factor** is "0.01", all DNP analog input points that represent voltages are returned with values 100 times larger (for example, a value of 17 volts on the C90^{Plus}is returned as 1700).

These settings are useful when analog input values must be adjusted to fit within certain ranges in DNP masters.

DNP Current Default Deadband, DNP Voltage Default Deadband, DNP Power Default Deadband, DNP Power Factor Default Deadband, DNP Other Default Deadband

Range: 0 to 100000000 in steps of 1

Default: 30000

These settings determine when to trigger unsolicited responses containing analog Input data. These settings group the C90Plus analog input data into types: current, voltage, power, energy, and other. Each setting represents the default deadband value for all analog input points of that type. For example, to trigger unsolicited responses from the C90Plus when any current values change by 15 amps, the **DNP Current Default Deadband** setting should be set to "15".

These settings are the deadband default values. DNP object 34 points can be used to change deadband values from the default for each individual DNP analog input point. Whenever power is removed and re-applied to the C90Plus, the default deadbands are in effect.

DNP Time Sync IIN Period

Range: 1 to 10080 minutes in steps of 1

Default: 1440 minutes

This setting determines how often the Need Time Internal Indication (IIN) bit is set by the C90Plus. Changing this time allows the DNP master to send time synchronization commands more or less often, as required.

DNP Message Fragment Size

Range: 30 to 2048 in steps of 1

Default: 240

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

DNP Object 1 Variation, DNP Object 2 Variation, DNP Object 20 Variation, DNP Object 21 Variation, DNP Object 22 Variation, DNP Object 23 Variation, DNP Object 30 Variation, DNP Object 32 Variation

Range: 1, 2 (object 1); 1, 2, 3 (object 2), 1, 2, 5, 6 (objects 20, 22, and 23); 1, 2, 9, 10 (object 21); 1, 2, 3, 4, 5 (object 30); 1, 2, 3, 4, 5, 7 (object 32)

Default 1 (objects 20, 21, 22, 23, 30, and 32); 2 (objects 1 and 2)

These settings allow the user to select the DNP default variation number for object types 1, 2, 20, 21, 22, 23, 30, and 32. The default variation refers to the variation response when variation 0 is requested or in class 0, 1, 2, or 3 scans.

DNP Number of Paired Controls

Range: 0 to 32 in steps of 1

Default: 0

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 C90Plus, DNP binary outputs are mapped to protection and/or automation 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 and close (for circuit breakers) or raise and 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 C90Plus can be configured to support paired control points, with each paired control point operating two virtual inputs (protection or automation). This setting allows configuration of from 0 to 32 binary output paired controls. Points not configured as paired operate on a one-to-one basis.

DNP TCP Connection Timeout

Range: 10 to 300 seconds in steps of 1

Default: 120 seconds

This 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 C90^{Plus}. This frees the connection to be re-used by a client.

NOTE

Power to the C90^{Plus} must be cycled off and on after changing this setting for the changes to take effect.

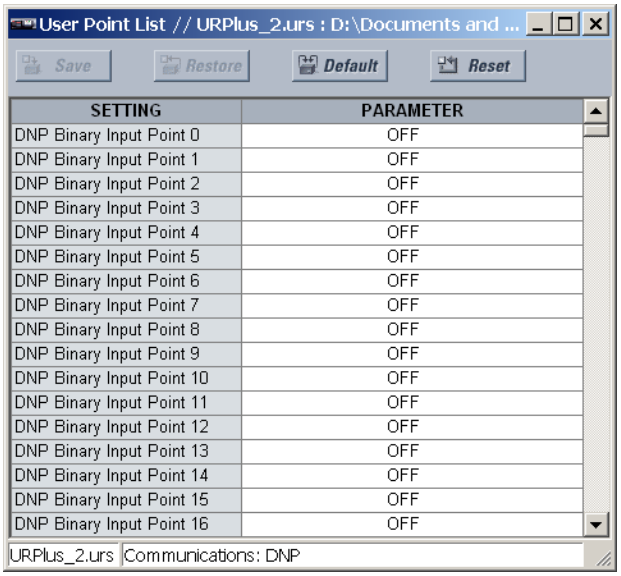
DNP user point list

The binary and analog inputs points for the DNP protocol can configured to a maximum of 256 points. The value for each point is user-programmable and can be configured by assigning FlexLogic operands for binary inputs or FlexAnalog parameters for analog inputs.

The DNP point lists always begin with point 0 and end at the first "Off" value. Since DNP point lists must be in one continuous block, any points assigned after the first "Off" point are ignored. Changes to the DNP point lists take effect when the C90^{Plus} is restarted.

Select the **Settings > Communications > DNP > User Point List** menu item to open the DNP user point list configuration window.

Figure 20: DNP user point list configuration settings



The following settings are available for points 0 through 255.

DNP Binary Input Point 0, DNP Binary Input Point 1,..., DNP Binary Input Point 255

Range: any FlexLogic operand

Default: Off

These settings represent DNP binary input points and are configured by assigning an appropriate FlexAnalog operand to each. Up to 256 binary input points can be configured for the DNP protocol.

DNP Analog Input Point 0, DNP Analog Input Point 2,..., DNP Analog Input Point 255

Range: any FlexAnalog parameter

Default: Off

These settings represent DNP analog input points and are configured by assigning an appropriate FlexAnalog parameter. Up to 256 analog input points can be configured for the DNP protocol.

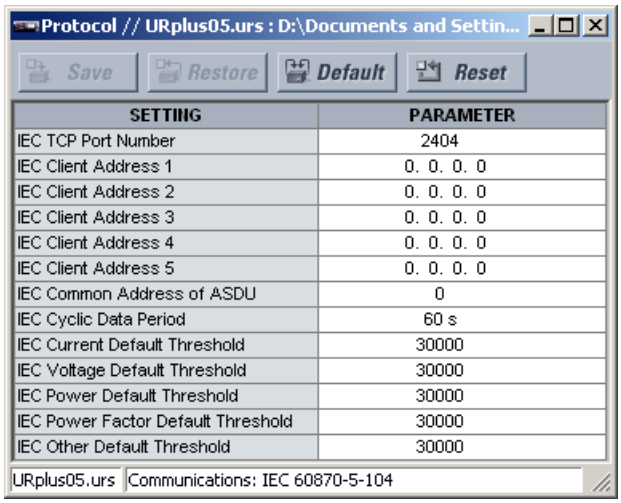
IEC 60870-5-104 communications

The IEC 60870-5-104 server can support two clients simultaneously. It is capable of reporting any indication or measurement and operating any output present in the device. These point lists are shared with the DNP protocol.

IEC 60870-5-104 protocol settings

Select the **Settings > Communications > IEC 60870-5-104 > Protocol** menu item to open the IEC 60870-5-104 protocol configuration window.

Figure 21: IEC 60870-5-104 protocol configuration settings



The following settings are available for the IEC 60870-5-104 protocol.

IEC TCP Port Number

Range: 0 to 65535 in steps of 1

Default: 2404

This setting specifies the TCP port number to use for IEC 60870-5-104 communications.

IEC Client Address 1, IEC Client Address 2,..., IEC Client Address 5

Range: standard IP address format

Default: 0.0.0.0

These settings specify the IP addresses for five IEC 60870-5-104 clients.

IEC Common Address of ASDU

Range: 0 to 65535 in steps of 1

Default: 0

This setting specifies the local address of the C90Plus for IEC 60870-5-104 transactions. The address is common to all data in a single ASDU (Application Service Data Unit). The combination of ASDU common address and IOA (Information Object Address) uniquely identifies each data item in a system.

IEC Cyclic Data Period

Range: 1 to 65535 seconds in steps of 1

Default: 60 seconds

This setting specifies the rate at which the C90Plus sends updated point data regardless of whether or not a status change has occurred. This data includes binary inputs, binary outputs, and analog inputs.

IEC Current Default Threshold, IEC Voltage Default Threshold, IEC Power Default Threshold, IEC Other Default Threshold

Range: 0 to 100000000 in steps of 1

Default: 30000

These settings are used to determine when to trigger spontaneous responses containing M_ME_NC_1 analog data. These settings group the C90Plus 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 C90Plus when any current values change by 15 amps, the **IEC Current Default Threshold** setting should be set to "15". Note that these settings are the default values of the deadbands. P_ME_NC_1 (parameter of measured value, short floating point value) points can be used to change threshold values, from the default, for each individual M_ME_NC_1 analog point. Whenever power is removed and re-applied to the C90Plus, the default thresholds are in effect.

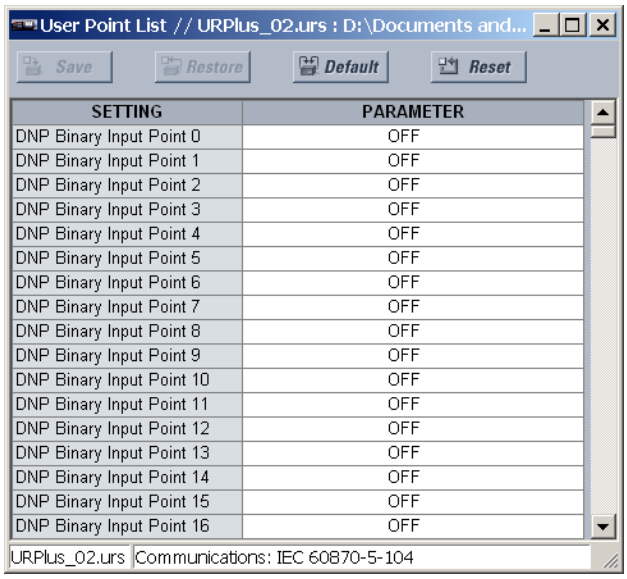
IEC 60870-5-104 point lists

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

The IEC 60870-5-104 point lists always begin with point 0 and end at the first "Off" value. Since IEC 60870-5-104 point lists must be in one continuous block, any points assigned after the first "Off" point are ignored. Changes to the IEC 60870-5-104 point lists take effect when the C90Plus is restarted.

Select the **Settings > Communications > IEC 60870-5-104 > User Point List** menu item to open the IEC 60870-5-104 user point list configuration window.

Figure 22: IEC 60870-5-104 user point list configuration settings



The following settings are available.

Binary Input Point 0, Binary Input Point 1,..., Binary Input Point 255

Range: any FlexLogic operand
Default: Off

These settings represent the IEC 60870-5-104 binary MSP points and are configured by assigning an appropriate FlexLogic operand. Up to 256 MSP points can be configured for the IEC 60870-5-104 protocol.

Analog Input Point 0, Analog Input Point 1,..., Analog Input Point 255

Range: any FlexAnalog parameter
Default: Off

These settings represent the IEC 60870-5-104 analog MME points and are configured by assigning an appropriate FlexAnalog parameter. Up to 256 MME points can be configured for the IEC 60870-5-104 protocol.

IEC 61850 communications

The C90^{Plus} supports the Manufacturing Message Specification (MMS) protocol as specified by IEC 61850. MMS is supported over the TCP/IP over Ethernet protocol stack. Polling, unbuffered reporting, and buffered reporting are supported. Direct operate and select-before-operate are also supported.

GSSE/GOOSE configuration

IEC 61850 provides two fast mechanisms to exchange information between peers in a substation. One is used for transferring status information only, and is called Generic Substation Status Event (GSSE). The other includes support for a variety of in-formation types including measured values. It is called the Generic Object Oriented Substation Event (GOOSE) mechanism.

GOOSE or GSSE messages are multicast repeatedly across a substation LAN. All devices on the LAN can receive these messages, but only those devices that require the data are configured to act on them. Because there is no handshaking between devices, GOOSE and

GSSE messages can transfer changes very rapidly, making them suitable for performing interlocking and other time-critical substation functions. The IEC 61850 server supports both GOOSE and GSSE protocols in publisher and subscriber roles. In dual-IP redundant configurations, the IED transmits and listens on both ports simultaneously.

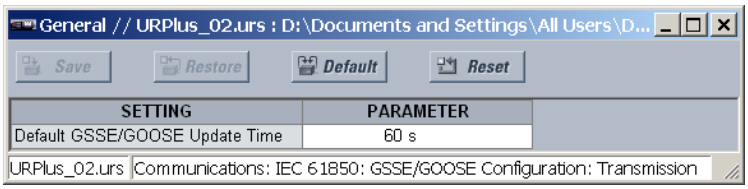
NOTE

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

General transmission configuration

Select the **Settings > Communications > IEC 61850 > GSSE/GOOSE Configuration > Transmission > General** menu item to open the GSSE/GOOSE general transmission configuration window.

Figure 23: General transmission configuration settings



The following setting is available for GSSE/GOOSE general transmission configuration.

Default GSSE/GOOSE Update Time

Range: 1 to 60 seconds
Default: 60 seconds

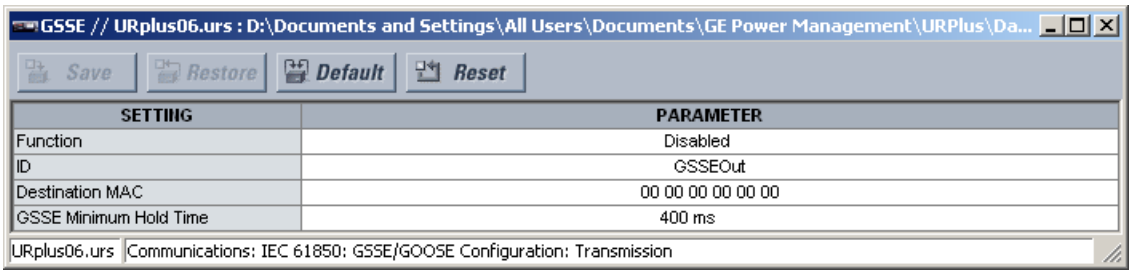
This setting specifies the time between GSSE or GOOSE messages when there are no remote output state changes to be sent. When remote output data changes, GSSE or GOOSE messages are sent immediately. This setting controls the steady-state *heartbeat* time interval.

This setting is applicable to GSSE, fixed C90^{Plus} GOOSE, and configurable GOOSE.

GSSE transmission configuration

Select the **Settings > Communications > IEC 61850 > GSSE/GOOSE Configuration > Transmission > GSSE** menu item to open the GSSE transmission configuration window.

Figure 24: GSSE transmission configuration settings



The following settings are available for GSSE transmission configuration.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the GSSE transmission functionality.

ID

Range: up to 65 ASCII characters

Default: GSSEOut

This setting represents the IEC 61850 GSSE application ID name string sent as part of each GSSE message. This name string identifies the GSSE message to the receiving device.

Destination MAC

Range: standard MAC address format

Default: 00 00 00 00 00 00

This setting specifies the destination Ethernet MAC address for the GSSE transmission. This address must be a multicast address and the least significant bit of the first byte must be set.

If this setting is specified as "00 00 00 00 00 00" (the default value), then a multicast MAC address is formed based on the MAC address of Ethernet ports 2 and 3. The MAC address of Ethernet port 2 is the MAC address of Ethernet port 1 incremented by 1. Likewise, the MAC address of Ethernet port 3 is the MAC address of Ethernet port 1 incremented by 2.

GSSE Minimum Hold Time

Range: 50 to 4000 ms in steps of 1

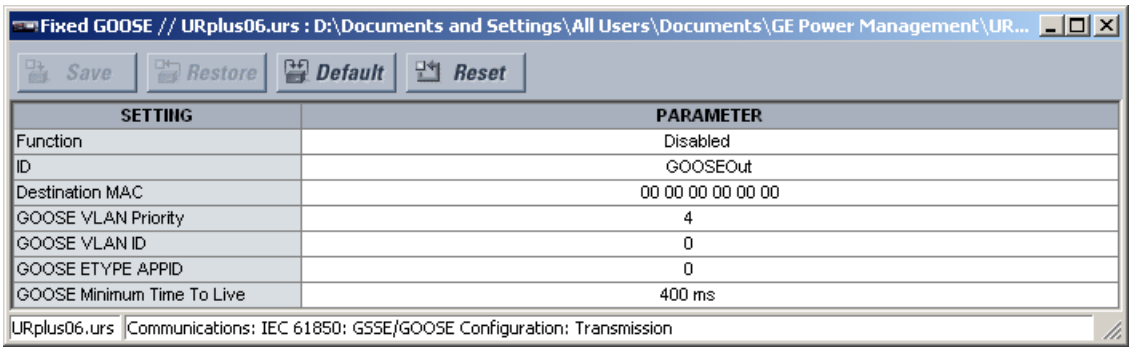
Default: 400 ms

This setting specifies the minimum hold time for GSSE transmission.

Fixed GOOSE transmission configuration

Select the **Settings > Communications > IEC 61850 > GSSE/GOOSE Configuration > Transmission > Fixed GOOSE** menu item to open the fixed GOOSE transmission configuration window.

Figure 25: Fixed GOOSE transmission configuration settings



The following settings are available for fixed GOOSE transmission configuration.

Function

Range: Enabled, Disabled

Default: Disabled

This setting enables and disabled the fixed GOOSE transmission functionality.

ID

Range: up to 65 ASCII characters

Default: GOOSEOut

This setting represents the IEC 61850 GOOSE application ID (GoID) name string sent as part of each GOOSE message. This name string identifies the GOOSE message to the receiving device.

Destination MAC

Range: standard MAC address format

Default: 00 00 00 00 00 00

This setting specifies the destination Ethernet MAC address for the fixed GOOSE transmission. This address must be a multicast address and the least significant bit of the first byte must be set.

If this setting is specified as "00 00 00 00 00 00" (the default value), then a multicast MAC address is formed based on the MAC address of Ethernet ports 2 and 3. The MAC address of Ethernet port 2 is the MAC address of Ethernet port 1 incremented by 1. Likewise, the MAC address of Ethernet port 3 is the MAC address of Ethernet port 1 incremented by 2.

GOOSE VLAN Priority

Range: 0 to 7 in steps of 1

Default: 4

This setting indicates the Ethernet priority of GOOSE messages. This allows GOOSE messages to have higher priority than other Ethernet data. This setting is required by IEC 61850.

GOOSE VLAN ID

Range: 0 to 4096 in steps of 1

Default: 0

This setting allows the selection of a specific VLAN ID for each GOOSE sending device. This value can be left at its default if the feature is not required.

GOOSE ETYPE APPID

Range: 0 to 16383 in steps of 1

Default: 0

This setting allows the selection of a specific application ID for each GOOSE sending device. This value can be left at its default if the feature is not required. This setting is required by IEC 61850.

GOOSE Minimum Time to Live

Range: 50 to 4000 ms in steps of 1

Default: 400 ms

This setting specifies the minimum time to live for the GOOSE transmission data set.

Configurable GOOSE transmission

The configurable GOOSE settings allow the C90^{Plus} to be configured to transmit a number of different datasets within IEC 61850 GOOSE messages. Up to eight (8) different configurable datasets can be configured and transmitted, allowing for the optimization of data transfer between devices. This is useful for intercommunication between C90^{Plus} IEDs and devices from other manufacturers that support IEC 61850.

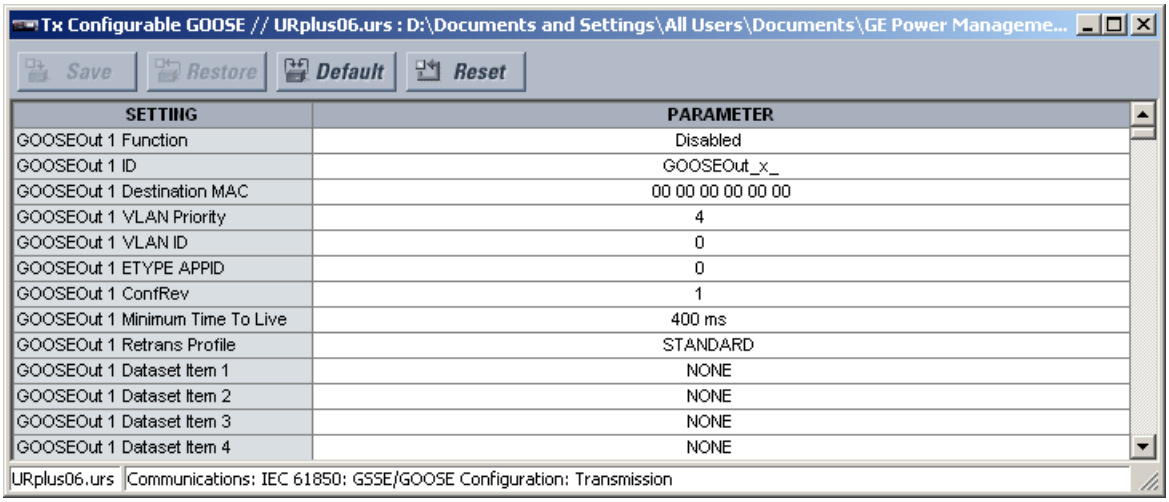
Items programmed for datasets 1 through 8 will have changes in their status transmitted once per protection pass for digital data and every 250 ms for analog data.

The integrity GOOSE message is sent at the pre-configured rate for all datasets, even if no changes in the data items are detected.

The configurable GOOSE feature is recommended for applications that require GOOSE data transfer between UR^{Plus}-series IEDs and devices from other manufacturers. Fixed GOOSE is recommended for applications that require GSSE data transfer between UR^{Plus}-series IEDs. IEC 61850 GOOSE messaging contains a number of configurable parameters, all of which must be correct for successful data transfer. It is critical that the configured datasets at the transmission and reception devices are an exact match in terms of data structure, and that the GOOSE addresses and name strings match exactly. Manual configuration is possible, but third-party substation configuration software may be used to automate the process. The UR^{Plus}-series software can produce IEC 61850 ICD files and import IEC 61850 SCD files produced by a substation configurator.

Select the **Settings > Communications > IEC 61850 > GSSE/GOOSE Configuration > Transmission > Tx Configurable GOOSE** menu item to open the configurable GOOSE transmission configuration window.

Figure 26: Configurable GOOSE transmission configuration settings



The following settings are available for each dataset for configurable GOOSE transmission.

Function

Range: Enabled, Disabled

Default: Disabled

This setting enables and disabled the configurable GOOSE transmission functionality.

ID

Range: up to 65 ASCII characters

Default: GOOSEOut_1

This setting represents the IEC 61850 GOOSE application ID (GoID) name string sent as part of each GOOSE message. This name string identifies the GOOSE message to the receiving device.

Destination MAC

Range: standard MAC address format

Default: 00 00 00 00 00 00

This setting specifies the destination Ethernet MAC address for the configurable GOOSE transmission. This address must be a multicast address and the least significant bit of the first byte must be set.

If this setting is specified as "00 00 00 00 00 00" (the default value), then a multicast MAC address is formed based on the MAC address of Ethernet ports 2 and 3. The MAC address of Ethernet port 2 is the MAC address of Ethernet port 1 incremented by 1. Likewise, the MAC address of Ethernet port 3 is the MAC address of Ethernet port 1 incremented by 2.

VLAN Priority

Range: 0 to 7 in steps of 1

Default: 4

This setting indicates the Ethernet priority of GOOSE messages. This allows GOOSE messages to have higher priority than other Ethernet data. This setting is required by IEC 61850.

VLAN ID

Range: 0 to 4096 in steps of 1
Default: 0

This setting allows the selection of a specific VLAN ID for each GOOSE sending device. This value can be left at its default if the feature is not required.

ETYPE APPID

Range: 0 to 16383 in steps of 1
Default: 0

This setting allows the selection of a specific application ID for each GOOSE sending device. This value can be left at its default if the feature is not required. This setting is required by IEC 61850.

ConfRev

Range: 1 to 16383 in steps of 1
Default: 1

This value changes automatically as described in IEC 61850 part 7-2.

Minimum Time to Live

Range: 50 to 4000 ms in steps of 1
Default: 400 ms

This setting specifies the minimum time to live for the GOOSE transmission data set.

Retransmission Profile

Range: None, Aggressive, Standard, Relaxed
Default: Standard

The C90^{Plus} supports four retransmission schemes: aggressive, standard, relaxed, and none. In general, the "Aggressive" profile is selected for trip schemes, the "Standard" profile for remedial action schemes, the "Relaxed" profile for analogue data sets, and "None" for schemes that incorporate a separate confirmation scheme.

The following retransmission times are specified under these profiles.

- "Aggressive": 4, 8, 16, 32, and 64 ms.
- "Standard": 16, 32, 64, 128, and 256 ms (default).
- "Relaxed": 100, 200, 400, 800, and 1000 ms.
- "None": no retransmission.

These selections are available on a transmit dataset-by-dataset basis. For GSSE and fixed GOOSE, the profile is fixed at "Aggressive" and there is no associated setting.

Dataset Item 1, Dataset Item 2, Dataset Item 3,..., Dataset Item 64

Range: all valid MMS data item references for transmitted data
Default: 0

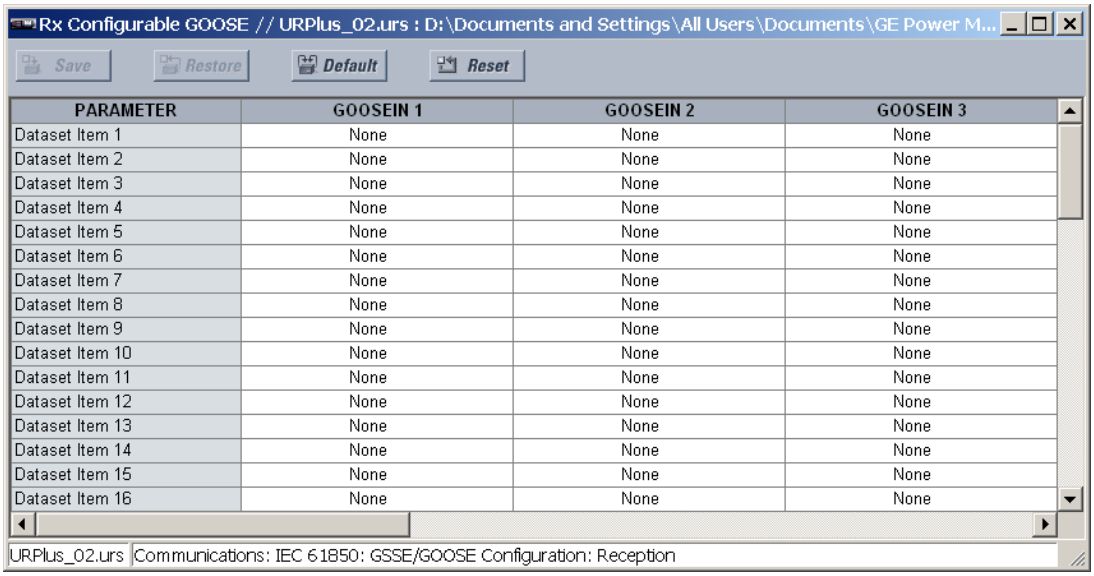
These settings are used to select an MMS data item for each configurable GOOSE dataset item.

To create a configurable GOOSE dataset that contains an IEC 61850 Single Point Status indication and its associated quality flags, the following dataset items can be selected: "GGIO1.ST.Ind1.stVal" and "GGIO1.ST.Ind1.q". The C90^{Plus} then creates a dataset containing these two data items. The status value for GGIO1.ST.Ind1.stVal is determined by the operand assigned to GGIO1 indication 1. Changes to this operand result in the transmission of GOOSE messages containing the defined dataset.

Configurable GOOSE reception

Select the **Settings > Communications > IEC 61850 > GSSE/GOOSE Configuration > Reception > Rx Configurable GOOSE** menu item to open the configurable GOOSE reception configuration window.

Figure 27: Configurable GOOSE reception configuration settings



The following settings are available for each dataset for configurable GOOSE reception.

Dataset Item 1, Dataset Item 2, Dataset Item 3,..., Dataset Item 64

Range: all valid MMS data item references for transmitted data
Default: 0

These settings are used to select an MMS data item for each configurable GOOSE dataset item.

Remote devices

Remote inputs and outputs provide a means of exchanging digital state information between Ethernet-connected devices. The IEC 61850 GSSE (Generic Substation State Event) and GOOSE (Generic Object Oriented Substation Event) standards are used for this purpose.

The sharing of digital point state information between GSSE/GOOSE equipped relays is essentially an extension to FlexLogic, allowing for distributed FlexLogic by making operands available to and from devices on a common communications network. In addition to digital point states, GSSE/GOOSE messages identify the originator of the message and provide other information required by the communication specification. All devices listen to network messages and capture data only from messages that have originated in selected devices.

IEC 61850 GSSE messages are compatible with UCA GOOSE messages and contain a fixed set of digital points. IEC 61850 GOOSE messages can, in general, contain any configurable data items. When used by the remote inputs and outputs feature, IEC 61850 GOOSE messages contain the same data as GSSE messages.

Both GSSE and GOOSE messages are designed to be short, reliable, and have high priority. GOOSE messages have additional advantages over GSSE messages due to their support of VLAN (virtual LAN) and Ethernet priority tagging functionality. The GSSE message structure contains space for 128 bit pairs representing digital point state information. The IEC 61850 specification provides 32 DNA bit pairs that represent the state of two pre-defined events and 30 user-defined events. All remaining bit pairs are UserSt bit pairs, which are status bits representing user-definable events. The C90^{Plus} implementation provides 32 of the 96 available UserSt bit pairs.

The IEC 61850 specification includes features that are used to cope with the loss of communication between transmitting and receiving devices. Each transmitting device will send a GSSE/GOOSE message upon a successful power-up, when the state of any included

point changes, or after a specified interval (the default update time) if a change-of-state has not occurred. The transmitting device also sends a hold time which is the GSSE equivalent of "time to live" in IEC GOOSE messages.

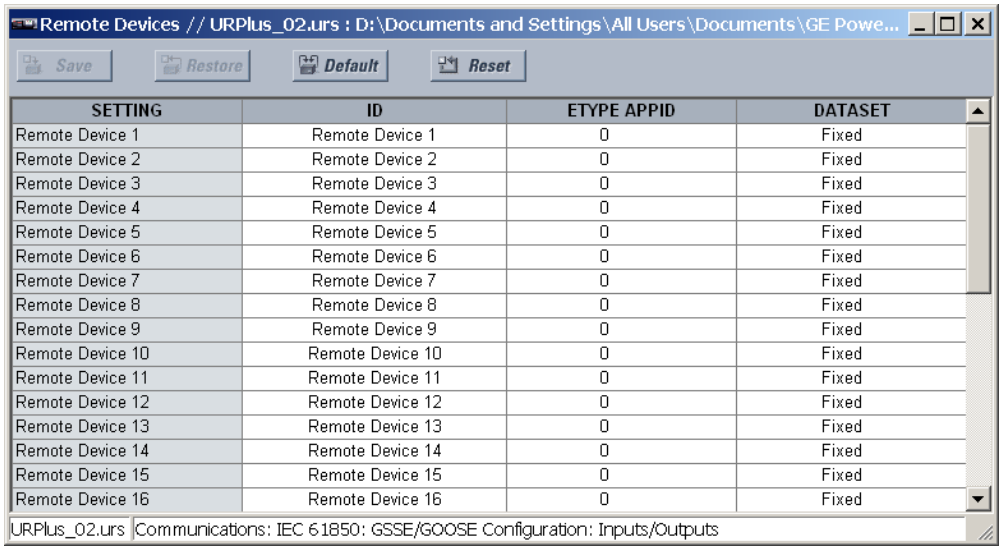
Receiving devices are constantly monitoring the communications network for messages they require, as recognized by the identification of the originating device carried in the message. Messages received from remote devices include the message time allowed to live. The receiving relay sets a timer assigned to the originating device to this time interval, and if it has not received another message from this device at time-out, the remote device is declared to be non-communicating, so it will use the programmed default state for all points from that specific remote device. If a message is received from a remote device before the time allowed to live expires, all points for that device are updated to the states contained in the message and the hold timer is restarted. The status of a remote device, where "Offline" indicates non-communicating, can be displayed.

The C90^{Plus} provides for 64 remote inputs and 64 remote outputs.

In a UR^{Plus}-series IED, the device ID that identifies the originator of the message is programmed in the **IED Name** setting.

Select the **Settings > Communications > IEC 61850 > GSSE/GOOSE Configuration > Inputs/Outputs > Remote Devices** menu item to open the remote devices configuration window.

Figure 28: Remote devices configuration settings



SETTING	ID	ETYPE APPID	DATASET
Remote Device 1	Remote Device 1	0	Fixed
Remote Device 2	Remote Device 2	0	Fixed
Remote Device 3	Remote Device 3	0	Fixed
Remote Device 4	Remote Device 4	0	Fixed
Remote Device 5	Remote Device 5	0	Fixed
Remote Device 6	Remote Device 6	0	Fixed
Remote Device 7	Remote Device 7	0	Fixed
Remote Device 8	Remote Device 8	0	Fixed
Remote Device 9	Remote Device 9	0	Fixed
Remote Device 10	Remote Device 10	0	Fixed
Remote Device 11	Remote Device 11	0	Fixed
Remote Device 12	Remote Device 12	0	Fixed
Remote Device 13	Remote Device 13	0	Fixed
Remote Device 14	Remote Device 14	0	Fixed
Remote Device 15	Remote Device 15	0	Fixed
Remote Device 16	Remote Device 16	0	Fixed

The following settings are available for each of the 32 remote devices.

ID

Range: up to 65 alphanumeric characters

Default: Remote Device 1

Up to 32 remote devices can be selected for setting purposes. A receiving relay must be programmed to capture messages from only those originating remote devices of interest. This setting is used to select specific remote devices by entering an exact identification (ID) assigned to those devices.

ETYPE APPID

Range: 0 to 16383 in steps of 1

Default: 0

This setting is only used with GOOSE messages; it is not applicable to GSSE messages. This setting identifies the application identification in the GOOSE message. It should match the corresponding settings on the sending device.

DATASET

Range: Fixed, GOOSE 1 through GOOSE 8

Default: Fixed

This setting provides for the choice of the UR^{Plus}-series fixed (DNA/UserSt) dataset (that is, containing DNA and UserSt bit pairs), or one of the configurable datasets.

The dataset for the received data items must be made up of existing items in an existing logical node. For this reason, logical node GGIO3 is instantiated to hold the incoming data items. GGIO3 is not necessary to make use of the received data. The remote input data item mapping takes care of the mapping of the inputs to remote input FlexLogic operands. However, GGIO3 data can be read by IEC 61850 clients.

Remote inputs

Remote inputs create FlexLogic operands at the receiving relay and are extracted from GSSE/GOOSE messages originating in remote devices. The C90^{Plus} provides 64 remote inputs, each of which can be selected from a list consisting of 64 selections: DNA-1 through DNA-32 and UserSt-1 through UserSt-32. The function of DNA inputs is defined in the IEC 61850 specification and is presented in the table below. The function of UserSt inputs is defined by the user selection of the FlexLogic operand whose state is represented in the GSSE/GOOSE message. A user must program a DNA point from the appropriate FlexLogic operand.

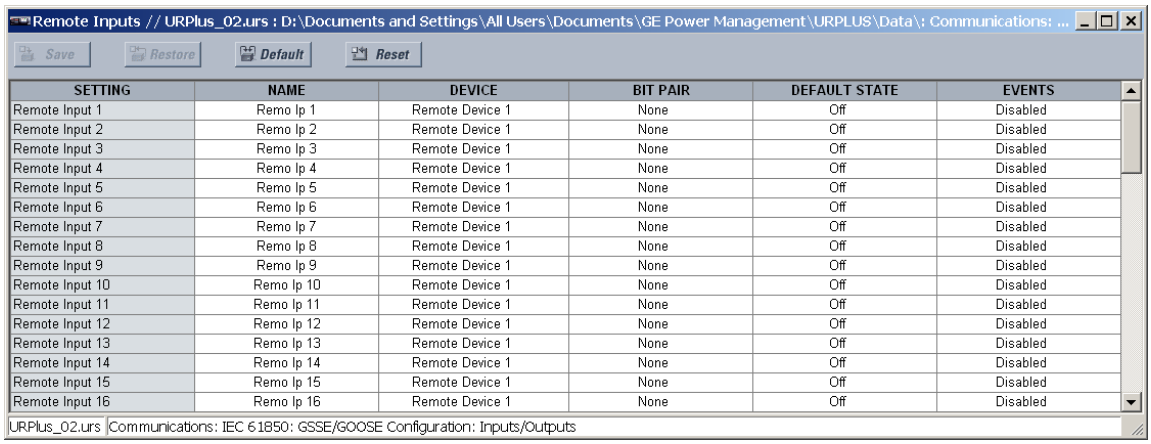
Table 1: IEC 61850 DNA Assignments

DNA	IEC 61850 definition	FlexLogic operand
1	Test	IEC 61850 TEST MODE
2	ConfRev	IEC 61850 CONF REV

Remote input 1 must be programmed to replicate the logic state of a specific signal from a specific remote device for local use. This programming is performed via the three settings indicated below.

Select the **Settings > Communications > IEC 61850 > GSSE/GOOSE Configuration > Inputs/Outputs > Remote Inputs** menu item to open the remote inputs configuration window.

Figure 29: Remote inputs configuration settings



SETTING	NAME	DEVICE	BIT PAIR	DEFAULT STATE	EVENTS
Remote Input 1	Remo Ip 1	Remote Device 1	None	Off	Disabled
Remote Input 2	Remo Ip 2	Remote Device 1	None	Off	Disabled
Remote Input 3	Remo Ip 3	Remote Device 1	None	Off	Disabled
Remote Input 4	Remo Ip 4	Remote Device 1	None	Off	Disabled
Remote Input 5	Remo Ip 5	Remote Device 1	None	Off	Disabled
Remote Input 6	Remo Ip 6	Remote Device 1	None	Off	Disabled
Remote Input 7	Remo Ip 7	Remote Device 1	None	Off	Disabled
Remote Input 8	Remo Ip 8	Remote Device 1	None	Off	Disabled
Remote Input 9	Remo Ip 9	Remote Device 1	None	Off	Disabled
Remote Input 10	Remo Ip 10	Remote Device 1	None	Off	Disabled
Remote Input 11	Remo Ip 11	Remote Device 1	None	Off	Disabled
Remote Input 12	Remo Ip 12	Remote Device 1	None	Off	Disabled
Remote Input 13	Remo Ip 13	Remote Device 1	None	Off	Disabled
Remote Input 14	Remo Ip 14	Remote Device 1	None	Off	Disabled
Remote Input 15	Remo Ip 15	Remote Device 1	None	Off	Disabled
Remote Input 16	Remo Ip 16	Remote Device 1	None	Off	Disabled

The following settings are available for each of the 32 remote inputs.

Name

Range: up to 12 alphanumeric characters

Default: Rem Ip 1

This setting allows the user to assign descriptive text to the remote input.

Device

Range: 1 to 32 inclusive

Default: Remote Device 1

This setting selects the number (1 to 32) of the remote device which originates the required signal, as previously assigned to the remote device via the **Remote Device 1 ID** setting.

Bit Pair

Range: None, DNA-1 to DNA-32, UserSt-1 to UserSt-32, Config Item 1 to Config Item 64

Default: None

This setting selects the specific bits of the GSSE/GOOSE message required.

Default State

Range: On, Off, Latest/On, Latest/Off

Default: Off

This setting selects the logic state for this point if the local relay has just completed startup or the remote device sending the point is declared to be non-communicating. The following choices are available:

- The "On" value defaults the input to logic 1
- The "Off" value defaults the input to logic 0
- The "Latest/On" value freezes the input in case of lost communications. If the latest state is not known, such as after relay power-up but before the first communication exchange, the input will default to logic 1. When communication resumes, the input becomes fully operational.
- The "Latest/Off" value freezes the input in case of lost communications. If the latest state is not known, such as after relay power-up but before the first communication exchange, the input defaults to logic 0. When communication resumes, the input becomes fully operational.

Events

Range: Enabled, Disabled

Default: Disabled

This setting enables and disables the logging of remote input events in the sequence of events recorder.

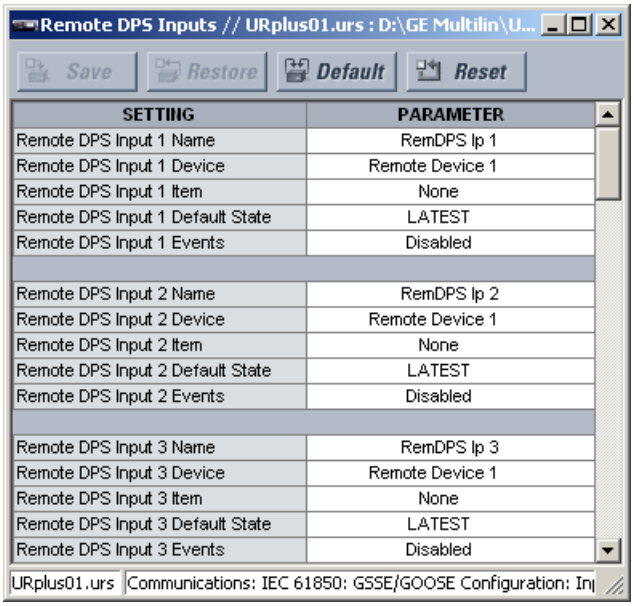
Remote double-point status inputs

Remote double-point status inputs are extracted from GOOSE messages originating in the remote device. The C90^{Plus} provides 16 remote double-point status inputs. Each remote double-point status input must be programmed to replicate the logic state of a specific signal from a specific remote device for local use.

The configurable GOOSE dataset items must be changed to accept a double-point status item from a GOOSE dataset. Dataset items configured to receive any of "GGIO3.ST.IndPos1.stV" to "GGIO3.ST.IndPos16.stV" accept double-point status information that is decoded by the remote double-point status inputs configured to this dataset item.

Select the **Settings > Communications > IEC 61850 > GSSE/GOOSE Configuration > Inputs/Outputs > Remote DPS Inputs** menu item to open the remote double-point status inputs configuration window.

Figure 30: Remote double-point status inputs configuration settings



The following settings are available for each of the 16 remote double-point status inputs.

Name

Range: up to 12 alphanumeric characters
Default: RemDPS Ip 1

This setting specifies specific an exact identification (ID) for each remote double-point status input.

Device

Range: Remote Device 1 through Remote Device 32
Default: Remote Device 1

This setting selects a remote device ID to indicate the origin of a GOOSE message.

Item

Range: None, Dataset Item 1 through Dataset Item 64
Default: None

This setting specifies the required bits of the GOOSE message.

Default State

Range: Intermediate, Off, On, Bad, Latest
Default: Latest

This setting selects the default value for the offline remote double-point status input.

Events

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the logging of remote double-point status input events in the sequence of events recorder.

Remote outputs: DNA bit pairs

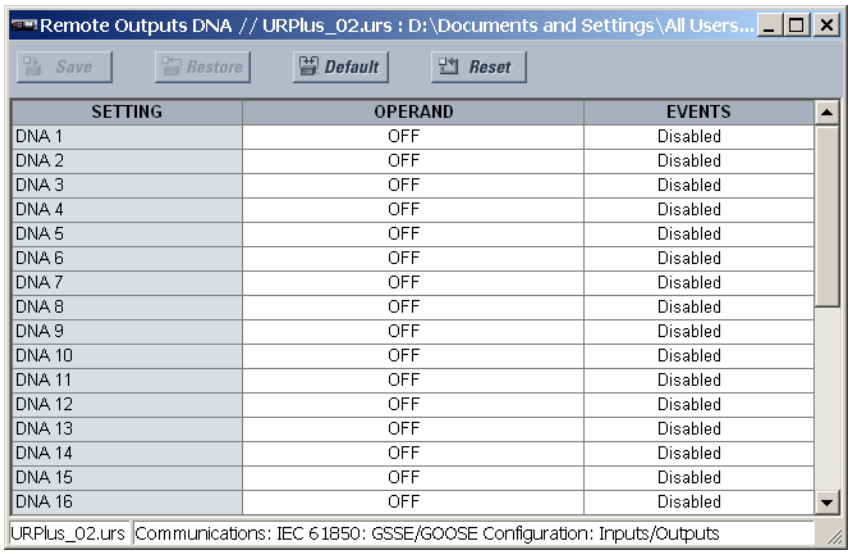
Remote outputs (1 to 32) are FlexLogic operands inserted into GSSE/GOOSE messages that are transmitted to remote devices on a LAN. Each digital point in the message must be programmed to carry the state of a specific FlexLogic operand. The above operand setting represents a specific DNA function (as shown in the following table) to be transmitted.

Table 2: IEC 61850 DNA Assignments

DNA	IEC 61850 definition	FlexLogic operand
1	Test	IEC 61850 TEST MODE
2	ConfRev	IEC 61850 CONF REV

Select the **Settings > Communications > IEC 61850 > GSSE/GOOSE Configuration > Inputs/Outputs > Remote Outputs DNA** menu item to open the remote inputs configuration window.

Figure 31: Remote outputs DNA bit pair configuration settings



The following settings are available for each of the 32 remote outputs.

Operand

Range: any automation logic or FlexLogic operand
Default: Off

This setting specifies the FlexLogic operand assigned to DNA point 1.

Events

Range: Enabled, Disabled
Default: Disabled

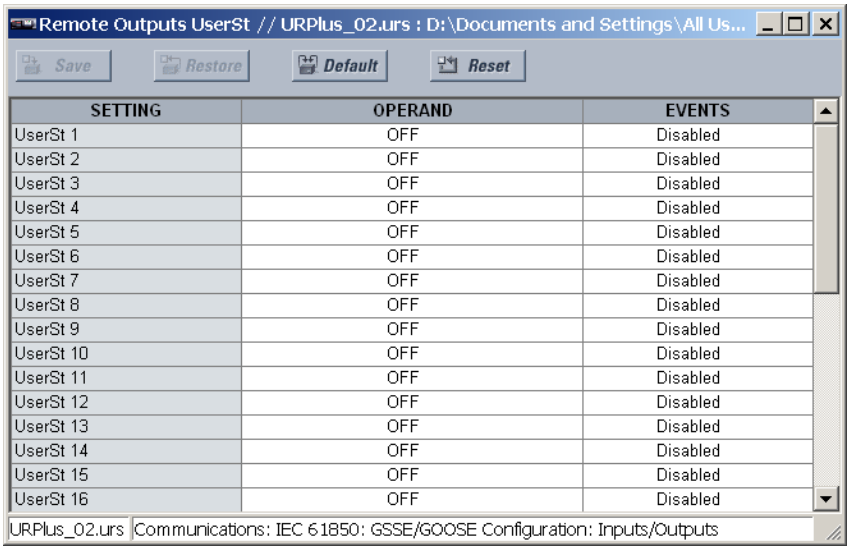
This setting enables and disables the logging of remote output DNA bit pair events in the sequence of events recorder.

Remote outputs: UserSt bit pairs

Remote outputs 1 to 32 originate as GSSE/GOOSE messages to be transmitted to remote devices. Each digital point in the message must be programmed to carry the state of a specific FlexLogic operand. The setting above is used to select the operand which represents a specific UserSt function (as selected by the user) to be transmitted.

Select the **Settings > Communications > IEC 61850 > GSSE/GOOSE Configuration > Inputs/Outputs > Remote Outputs UserSt** menu item to open the remote inputs configuration window.

Figure 32: Remote output UserSt bit pair configuration settings



The following settings are available for each of the 32 bit pairs.

Operand

Range: any FlexLogic operand

Default: Off

This setting specifies the FlexLogic operand assigned to UserSt point 1.

Events

Range: Enabled, Disabled

Default: Disabled

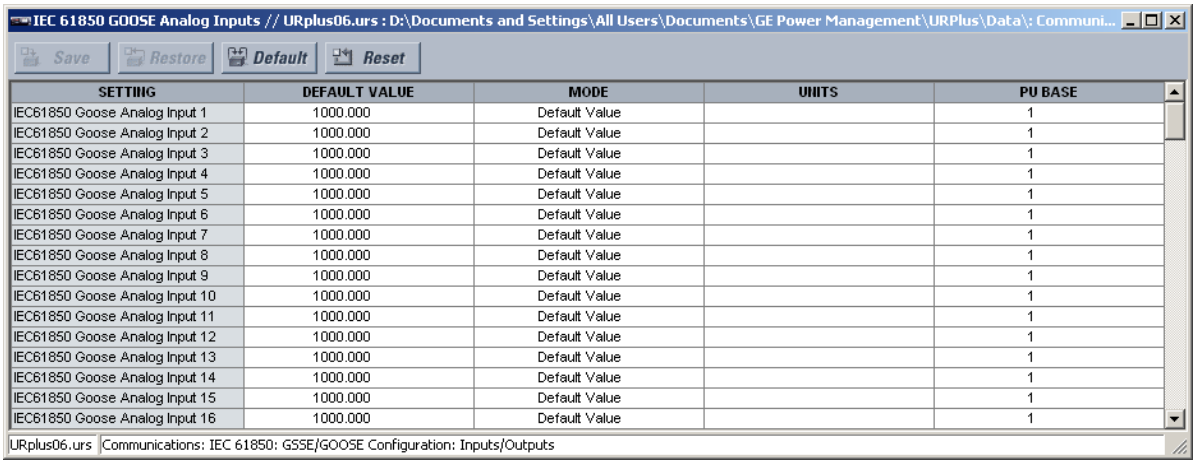
This setting enables and disables the logging of remote output UserSt bit pair events in the sequence of events recorder.

IEC 61850 GOOSE analog inputs

The IEC 61850 GOOSE analog inputs feature allows the transmission of analog values between any two UR^{Plus}-series devices.

Select the **Settings > Communications > IEC 61850 > GSSE/GOOSE Configuration > Inputs/Outputs > IEC 61850 GOOSE Analog Inputs** menu item to open the IEC 61850 GOOSE analog inputs configuration window.

Figure 33: IEC 61850 GOOSE analog inputs configuration settings



The following settings are available for each of the 128 IEC 61850 GOOSE analog inputs.

Default Value

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 sending device is offline and the **Default Mode** setting is set to "Default Value". 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.

Mode

Range: Default Value, Last Known

Default: Default Value

When the sending device is offline and this setting is "Last Known", the value of the GOOSE analog input remains at the last received value. When the sending device is offline and this setting value is "Default Value", then the value of the GOOSE analog input is defined by the **Default Value** setting.

Units

Range: up to 4 alphanumeric characters

Default: ---

This setting specifies a four-character alphanumeric string that is used in the actual values display of the corresponding GOOSE analog input value.

PU Base

Range: 0 to 1000000000 in steps of 1

Default: 1

This setting specifies the per-unit base factor when using the GOOSE analog input FlexAnalog values in other C90^{Plus} features, such as protection FlexElements. The base factor is applied to the GOOSE analog input FlexAnalog quantity to normalize it to a per-unit quantity. The base units are described in the following table.

Table 3: Per-unit base units

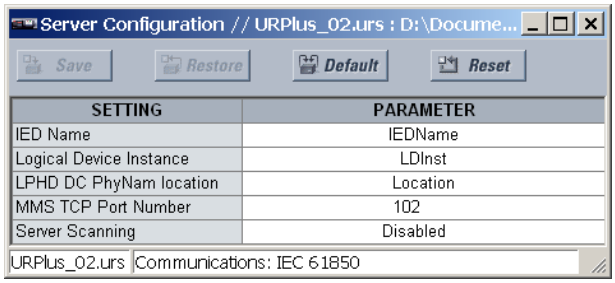
Element	Base unit
Frequency	1 Hz
Phase angles	360 degrees
Power factor	1.00
Source current	Maximum nominal primary RMS value of the +IN and –IN inputs
Source power	Maximum value of the product of the voltage and current base values for the +IN and –IN inputs.
Source voltage	Maximum nominal primary RMS value of the +IN and –IN inputs.

The GOOSE analog input FlexAnalog values are available for use in other C90^{Plus} functions that use FlexAnalog values.

IEC 61850 server configuration

Select the **Settings > Communications > IEC 61850 > Server Configuration** menu item to open the IEC 61850 server configuration window.

Figure 34: IEC 61850 server configuration settings



The following settings are available.

IED Name

Range: up to 32 alphanumeric characters
Default: IEDName

This setting represents the MMS domain name where all IEC/MMS logical nodes are located. Changes to this setting and the GOOSE dataset will not take effect until the unit is restarted. The setting value can be composed of up to 32 characters, including upper and lowercase letters, numbers, and the underscore (_) character. The first character in the string must be a letter.

Logical Device Instance

Range: up to 32 alphanumeric characters
Default: LDInst

This setting represents the IEC 61850 logical device where all IEC/MMS logical nodes are located. The setting value can be composed of up to 32 characters, including upper and lowercase letters, numbers, and the underscore (_) character. The first character in the string must be a letter.

LPHD DC PhyNam Location

Range: up to 80 ASCII characters
Default: Location

This setting represents a string that appears within the PhyName of the LPHD node. It can be up to 80 characters, including upper and lowercase letters, numbers, and the underscore (_) character. The first character in the string must be a letter.

MMS TCP Port Number

Range: 1 to 65535 in steps of 1
Default: 102

This setting specifies the TCP port number for MMS connections.

Server Scanning

Range: Disabled, Enabled
Default: Disabled

Set this option to "Disabled" when IEC 61850 client/server functionality is not required. IEC 61850 has two modes of functionality: GOOSE/GSSE inter-device communication and client/server communication. If the GOOSE/GSSE functionality is required without the IEC 61850 client server feature, then server scanning can be disabled to increase CPU resources. When server scanning is disabled, there is no update to the IEC 61850 logical node status values in the C90^{Plus}. Clients are still able to connect to the server (C90^{Plus} device), but most data values are not updated.

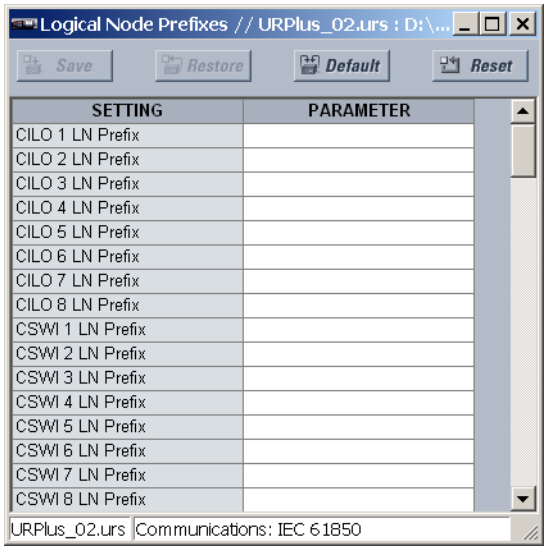
Logical node prefixes

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

Additional details regarding the logical node naming rules are provided in IEC 61850 standard parts 6 and 7-2. GE Digital Energy recommends that a consistent naming convention be used for an entire substation project.

Select the **Settings > Communications > IEC 61850 > Logical Node Prefixes** menu item to open the IEC 61850 logical node prefixes configuration window.

Figure 35: IEC 61850 logical node prefix configuration settings



The following IEC 61850 logical node name prefix settings are available for the C90^{Plus}.

CILO1 LN Prefix through CILO36 LN Prefix

Range: six character ASCII string
Default: empty

These settings specify the prefixes for the interlocking logical nodes 1 through 36.

CSWI1 LN Prefix through CSWI36 LN Prefix

Range: six character ASCII string
Default: empty

These settings specify the prefixes for the switch controller logical nodes 1 through 36.

GGIO1 LN Prefix through GGIO5 LN Prefix

Range: six character ASCII string
Default: empty

These settings specify the prefixes for generic input and output logical nodes 1 through 5.

LPHD1 LN Prefix

Range: six character ASCII string
Default: empty

These settings specify the prefixes for the physical device information logical nodes.

MMXU1 LN Prefix through MMXU4 LN Prefix

Range: six character ASCII string

Default: empty

These settings specify the prefixes for measured quantity logical nodes 1 through 4.

PFRC1 LN Prefix through PFRC4 LN Prefix

Range: six character ASCII string

Default: empty

These settings specify the prefixes for the frequency rate of change logical nodes 1 through 4.

PIOC1 LN Prefix through PIOC14 LN Prefix

Range: six character ASCII string

Default: empty

These settings specify the prefixes for instantaneous overcurrent logical nodes 1 through 14.

PTOC1 LN Prefix through PTOC18 LN Prefix

Range: six character ASCII string

Default: empty

These settings specify the prefixes for time overcurrent logical nodes 1 through 18.

PTOV1 LN Prefix through PTOV8 LN Prefix

Range: six character ASCII string

Default: empty

These settings specify the prefixes for overvoltage logical nodes 1 through 8.

PTRC1 LN Prefix through PTRC6 LN Prefix

Range: six character ASCII string

Default: empty

These settings specify the prefixes for the protection trip conditioning 1 through 6 logical nodes.

PTUF1 LN Prefix through PTUF10 LN Prefix

Range: six character ASCII string

Default: empty

These settings specify the prefixes for underfrequency load shedding logical nodes 1 through 10.

PTUV1 LN Prefix through PTUV10 LN Prefix

Range: six character ASCII string

Default: empty

These settings specify the prefixes for undervoltage logical nodes 1 through 10.

RBRF1 LN Prefix, RBRF2 LN Prefix

Range: six character ASCII string

Default: empty

These settings specify the prefixes for breaker failure logical nodes 1 and 2.

RDIR1 LN Prefix, RDIR2 LN Prefix

Range: six character ASCII string

Default: empty

These settings specify the prefixes for the directional element logical nodes 1 and 2.

RFLO1 LN Prefix

Range: six character ASCII string

Default: empty

This setting specifies the prefix for the fault locator logical node.

RREC1 LN Prefix

Range: six character ASCII string

Default: empty

This setting specifies the prefix for the autoreclose logical node.

RSYN1 LN Prefix, RSYN2 LN Prefix

Range: six character ASCII string

Default: empty

This setting specifies the prefix for the synchrocheck logical nodes 1 and 2.

XCBR1 LN Prefix through XCBR6 LN Prefix

Range: six character ASCII string

Default: empty

These settings specify the prefixes for the circuit breaker 1 through 6 logical nodes.

XSWI1 LN Prefix through XSWI30 LN Prefix

Range: six character ASCII string

Default: empty

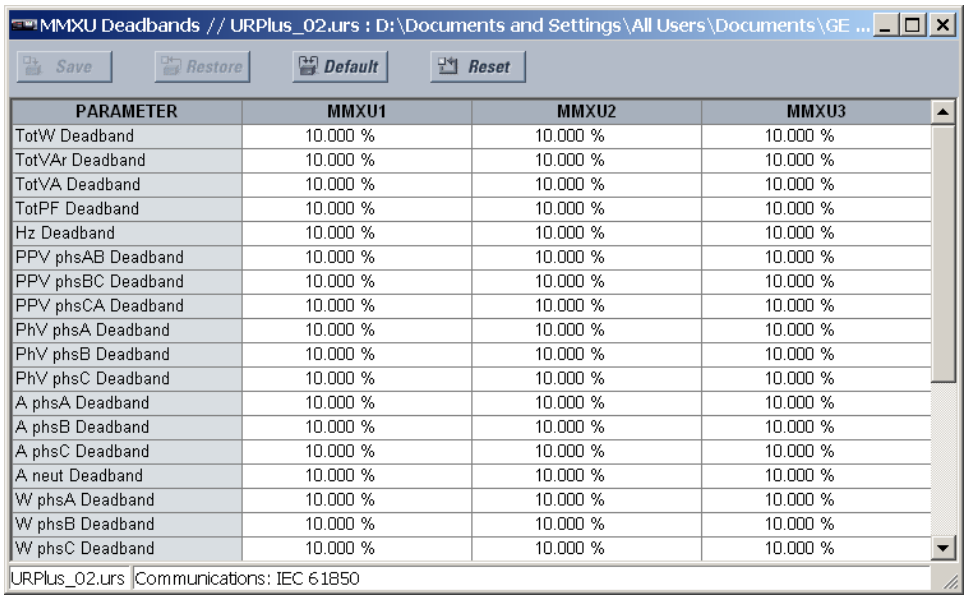
These settings specify the prefixes for the circuit disconnect switch 1 through 30 logical nodes.

MMXU deadbands

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

Select the **Settings > Communications > IEC 61850 > MMXU Deadbands** menu item to open the MMXU deadbands configuration window.

Figure 36: IEC 61850 MMXU deadband configuration settings



PARAMETER	MMXU1	MMXU2	MMXU3
TotW Deadband	10.000 %	10.000 %	10.000 %
TotVAr Deadband	10.000 %	10.000 %	10.000 %
TotVA Deadband	10.000 %	10.000 %	10.000 %
TotPF Deadband	10.000 %	10.000 %	10.000 %
Hz Deadband	10.000 %	10.000 %	10.000 %
PPV phsAB Deadband	10.000 %	10.000 %	10.000 %
PPV phsBC Deadband	10.000 %	10.000 %	10.000 %
PPV phsCA Deadband	10.000 %	10.000 %	10.000 %
PhV phsA Deadband	10.000 %	10.000 %	10.000 %
PhV phsB Deadband	10.000 %	10.000 %	10.000 %
PhV phsC Deadband	10.000 %	10.000 %	10.000 %
A phsA Deadband	10.000 %	10.000 %	10.000 %
A phsB Deadband	10.000 %	10.000 %	10.000 %
A phsC Deadband	10.000 %	10.000 %	10.000 %
A neut Deadband	10.000 %	10.000 %	10.000 %
W phsA Deadband	10.000 %	10.000 %	10.000 %
W phsB Deadband	10.000 %	10.000 %	10.000 %
W phsC Deadband	10.000 %	10.000 %	10.000 %

The following settings are available for each of the four MMXU nodes.

Total Watt Deadband

Range: 0.001 to 100.000% in steps of 0.001
Default: 10.000%

This setting specifies the real power deadband value. The maximum value representing 100% of deadband is 46 × phase CT secondary × phase CT ratio × 275 × VT ratio.

Total Var Deadband

Range: 0.001 to 100.000% in steps of 0.001
Default: 10.000%

This setting specifies the reactive power deadband value. The maximum value representing 100% of deadband is 46 × phase CT secondary × phase CT ratio × 275 × VT ratio.

Total VA Deadband

Range: 0.001 to 100.000% in steps of 0.001
Default: 10.000%

This setting specifies the apparent power deadband value. The 100% deadband value is 46 × phase CT secondary × phase CT ratio × 275 × VT ratio.

Total Power Factor Deadband

Range: 0.001 to 100.000% in steps of 0.001
Default: 10.000%

This setting specifies the power factor deadband value. The 100% deadband value is 2.

Hz Deadband

Range: 0.001 to 100.000% in steps of 0.001
Default: 10.000%

This setting specifies the frequency deadband value. The 100% deadband value is 90 Hz.

PPV Phase AB Deadband, PPV Phase BC Deadband, PPV Phase CA Deadband

Range: 0.001 to 100.000% in steps of 0.001
Default: 10.000%

These settings specify the Vab, Vbc, and Vca per-phase voltage deadband values. The 100% deadband value is 275 × VT ratio.

PhV Phase A Deadband, PhV Phase B Deadband, PhV Phase C Deadband

Range: 0.001 to 100.000% in steps of 0.001

Default: 10.000%

These settings specify the Va, Vb, and Vc phase voltage deadband values. The 100% deadband value is 275 × VT ratio.

Current Phase A Deadband, Current Phase B Deadband, Current Phase C Deadband

Range: 0.001 to 100.000% in steps of 0.001

Default: 10.000%

These settings specify the Ia, Ib, and Ic phase current deadband values. The 100% deadband value is 46 × phase CT secondary × phase CT ratio.

Current Neutral Deadband

Range: 0.001 to 100.00% in steps of 0.001

Default: 10.000%

This setting specifies the neutral current deadband value. The 100% deadband value is 46 × ground CT secondary × ground CT ratio.

Watt Phase A Deadband, Watt Phase B Deadband, Watt Phase C Deadband

Range: 0.001 to 100.000% in steps of 0.001

Default: 10.000%

These settings specify the real per-phase power deadband values. The maximum value representing 100% of deadband is 46 × phase CT secondary × phase CT ratio × 275 × VT ratio.

Var Phase A Deadband, Var Phase B Deadband, Var Phase C Deadband

Range: 0.001 to 100.000% in steps of 0.001

Default: 10.000%

These settings specify the reactive per-phase power deadband values. The maximum value representing 100% of deadband is 46 × phase CT secondary × phase CT ratio × 275 × VT ratio.

VA Phase A Deadband, VA Phase B Deadband, VA Phase C Deadband

Range: 0.001 to 100.000% in steps of 0.001

Default: 10.000%

These settings specify the apparent per-phase power deadband values. The maximum value representing 100% of deadband is 46 × phase CT secondary × phase CT ratio × 275 × VT ratio.

Power Factor Phase A Deadband, Power Factor Phase B Deadband, Power Factor Phase C Deadband

Range: 0.001 to 100.000% in steps of 0.001

Default: 10.000%

These settings specify the per-phase power factor deadband values. The maximum value representing 100% of deadband is 2.

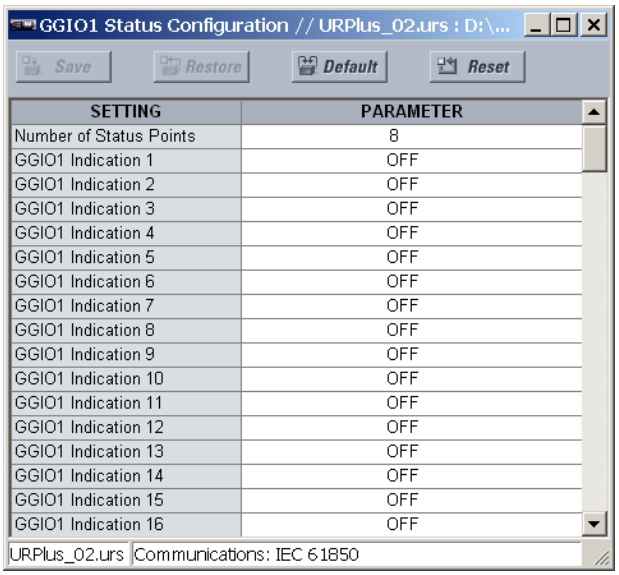
GGIO1 status configuration

The GGIO1 logical node provides access to as many 128 digital status points and associated timestamps and quality flags. It is intended that clients use GGIO1 to access digital status values from the C90^{Plus}. Configuration settings are provided to select the number of digital status indications available in GGIO1 (8 to 128) and select logic operands to drive the status of the GGIO1 status indications. Clients can utilize the IEC 61850 buffered and unbuffered reporting features available from GGIO1 to build sequence of

events (SOE) logs and HMI display screens. Buffered reporting should generally be used for SOE logs since the buffering capability reduces the chances of missing data state changes. Unbuffered reporting should generally be used for local status display.

Select the **Settings > Communications > IEC 61850 > GGIO1 Status Configuration** menu item to open the GGIO1 status configuration window.

Figure 37: IEC 61850 GGIO1 status configuration



The following settings are available.

Number of Status Points

Range: 8 to 128 in steps of 8

Default: 8

This setting specifies the number of "Ind" points (single point status indications) instantiated in the GGIO1 logical node. Changes to this setting take effect when the C90^{Plus} is restarted.

GGIO1 Indication 1, GGIO1 Indication 2,..., GGIO1 Indication 128

Range: any logic operand

Default: OFF

These settings assign logic operands to represent GGIO1 status indications.

GGIO2 control configuration

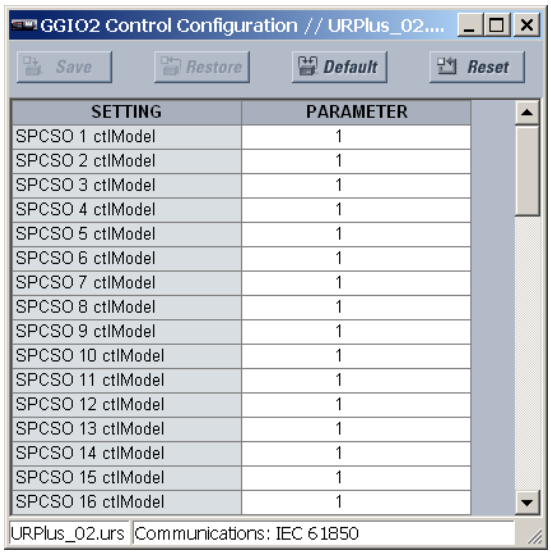
The GGIO2 logical node provides access to the C90^{Plus} protection virtual inputs. Protection virtual inputs are single-point control (binary) values that can be written by clients. They are generally used as control inputs. GGIO2 provides access to protection virtual inputs through the IEC 61850 standard control model (ctlModel) services:

- Status only
- Direct control with normal security
- SBO control with normal security

Configuration settings are available to select the control model for each point. Each protection virtual input used through GGIO2 should be enabled and the corresponding SPSCO ctlModel setting programmed to the appropriate control configuration.

Select the **Settings > Communications > IEC 61850 > GGIO2 Control Configuration** menu item to open the GGIO2 control configuration window.

Figure 38: IEC 61850 GGIO2 control configuration



The following setting is available for each of the 64 GGIO2 control points. Each control point is mapped to a corresponding C90^{Plus} protection virtual input. For example, GGIO2 control point SPCSO 3 is mapped to protection virtual input 3.

SPCSO 1 ctlModel

Range: 0, 1, 2

Default: 1

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

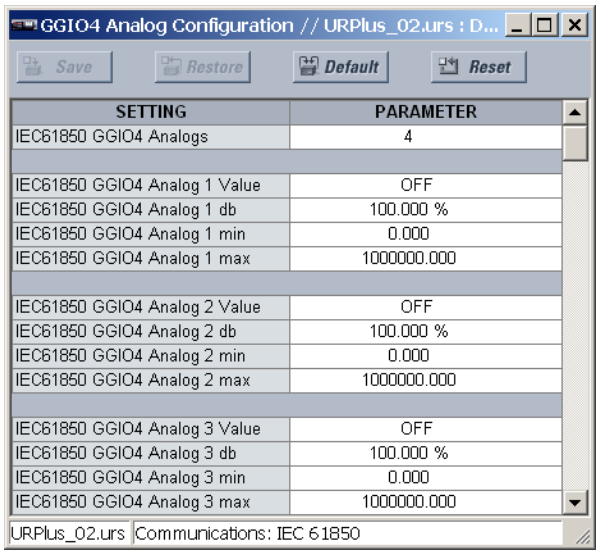
GGIO4 analog configuration

The GGIO4 logical node provides access to as many as 32 analog value points, as well as associated timestamps and quality flags. The data content must be configured before the data can be used. GGIO4 provides analog values for access by clients.

It is intended that clients use GGIO4 to access generic analog values from the C90^{Plus}. Configuration settings select the number of analog values available in GGIO4 (4 to 32) as well as FlexAnalog values that determine the value of the GGIO4 analog inputs. Clients can utilize polling or the IEC 61850 unbuffered reporting feature available from GGIO4 to obtain the analog values provided by GGIO4.

Select the **Settings > Communications > IEC 61850 > GGIO4 Analog Configuration** menu item to open the GGIO4 analog configuration window.

Figure 39: IEC 61850 GGIO4 analog configuration



The following settings are available.

IEC 61850 GGIO4 Analogs

Range: 4 to 32 in steps of 4
Default: 4

This setting specifies how many analog data points exist in GGIO4. When this value is changed, the C90^{Plus} must be restarted to allow the GGIO4 logical node to be re-instantiated and contain the newly configured number of analog points.

IEC 61850 GGIO4 Analog 1 Value

Range: any FlexAnalog value
Default: OFF

These settings select the FlexAnalog value to drive the instantaneous value of each GGIO4 analog status value (GGIO4.MX.AnIn1.instMag.f).

IEC 61850 GGIO4 Analog 1 Deadband

Range: 0.000 to 100.000 in steps of 0.001
Default: 0.000

These settings specify the deadband for each analog value. Refer to IEC 61850-7-1 and IEC 61850- 7-3 for additional details. The deadband is used to determine when to update the deadbanded magnitude from the instantaneous magnitude and is represented as a percentage of the difference between the maximum and minimum values.

IEC 61850 GGIO4 Analog 1 Minimum

Range: –1000000000.000 to 1000000000.000 in steps of 0.001
Default: 0.000

These settings specify the minimum value for each analog value. Refer to IEC 61850-7-1 and IEC 61850-7-3 for additional details. This minimum value is used to determine the deadband. The deadband is used in the determination of the deadbanded magnitude from the instantaneous magnitude.

These settings are stored as IEEE 754 / IEC 60559 floating point numbers. Because of the large range of these settings, not all values can be stored. Some values are rounded to the closest possible floating point number.

IEC 61850 GGIO4 Analog 1 Maximum

Range: –1000000000.000 to 1000000000.000 in steps of 0.001

Default: 0.000

These settings specify the maximum value for each analog value. Refer to IEC 61850-7-1 and IEC 61850-7-3 for additional details. This maximum value is used to determine the deadband. The deadband is used in the determination of the deadbanded magnitude from the instantaneous magnitude.

These settings are stored as IEEE 754 / IEC 60559 floating point numbers. Because of the large range of these settings, not all values can be stored. Some values are rounded to the closest possible floating point number.

GGIO5 control configuration

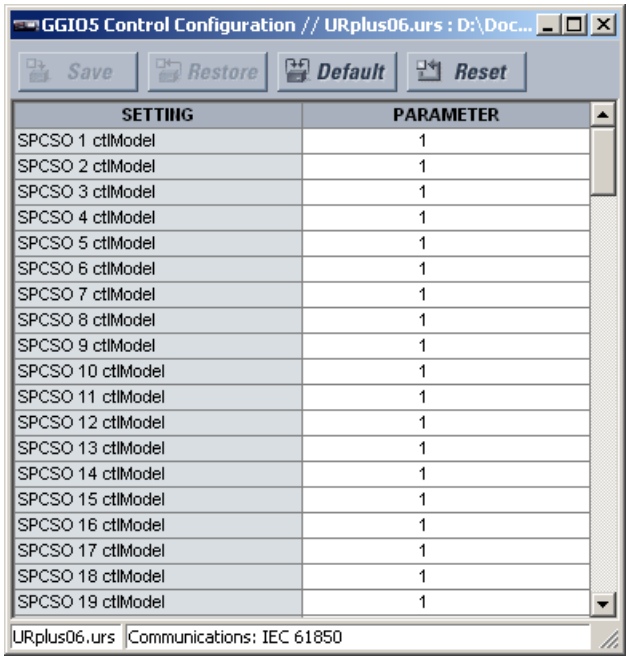
The GGIO5 logical node is available to provide access to the C90^{Plus} automation virtual inputs. Automation virtual inputs are single-point control (binary) values that can be written by clients. They are generally used as control inputs. GGIO5 provides access to automation virtual inputs through the IEC 61850 standard control model (ctlModel) services:

- Status only
- Direct control with normal security
- SBO control with normal security

Configuration settings select the control model for each point. Each automation virtual input used through GGIO5 should be enabled and the corresponding SPSCO ctlModel setting programmed to the appropriate control configuration.

Select the **Settings > Communications > IEC 61850 > GGIO5 Control Configuration** menu item to open the GGIO5 control configuration window.

Figure 40: IEC 61850 GGIO5 control configuration



The following setting is available for each of the 128 GGIO5 control points. Each control point is mapped to a corresponding C90^{Plus} automation virtual input. For example, GGIO5 control point SPCSO 3 is mapped to automation virtual input 3.

SPCSO 1 ctlModel

Range: 0, 1, 2

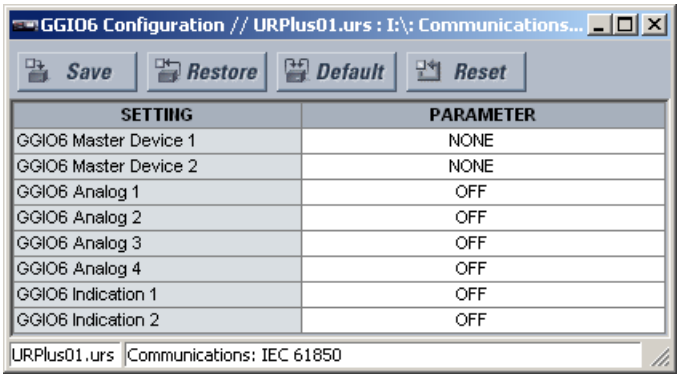
Default: 1

The GGIO5 control configuration settings are used to set the control model for each input. The available choices are "0" (status only), "1" (direct control), and "2" (SBO with normal security).

GGIO6 configuration

The GGIO6 logical node is available to provide access to the C90^{Plus} small signal oscillation detection (SSOD) feature. These settings correspond with SSOD master and slave devices. Select the **Settings > Communications > IEC 61850 > GGIO6 Configuration** menu item to open the GGIO6 control configuration window.

Figure 41: IEC 61850 GGIO6 configuration



The following settings are available for the GGIO6 logical node.

GGIO6 Master Device 1, GGIO6 Master Device 2

Range: None, Remote Device 1, Remote Device 2, Remote Device 3,..., Remote Device 32

Default: None

These setting specify the remote devices to be used as master devices for the GGIO6 logical node.

GGIO6 Analog 1, GGIO6 Analog 2, GGIO6 Analog 3, GGIO6 Analog 4

Range: any FlexAnalog parameter

Default: OFF

These settings select a FlexAnalog parameter (analog operand) to use as an analog quantity for the GGIO6 logical node.

GGIO6 Indication 1, GGIO6 Indication 2

Range: any FlexAnalog operand or shared logic operand

Default: OFF

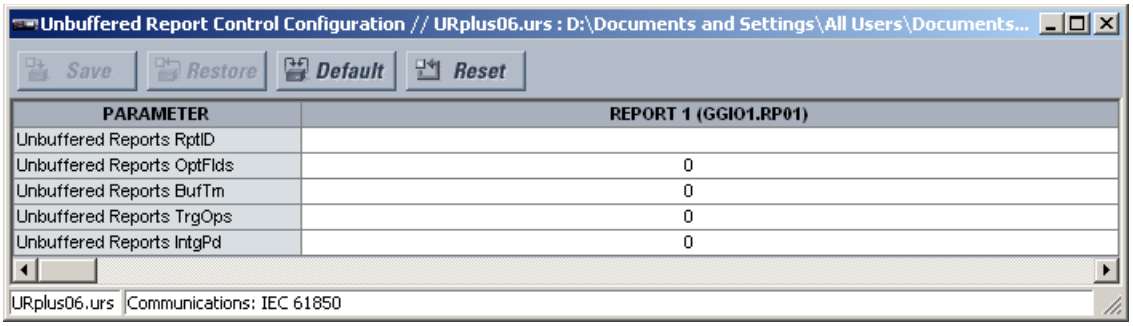
These settings select a FlexAnalog operand (digital operand) to use as a digital indication for the GGIO6 logical node.

Unbuffered report control configuration

IEC 61850 unbuffered reporting is provided in the GGIO1 logical nodes (for binary status values), GGIO4 logical nodes (for analog value points) and MMXU1 to MMXU4 (for analog measured values). Report settings can be configured using the EnerVista UR^{Plus} Setup software, substation configurator software, or via an IEC 61850 client.

Select the **Settings > Communications > IEC 61850 > Unbuffered Report Control Configuration** menu item to open the IEC 61850 unbuffered report configuration window.

Figure 42: IEC 61850 unbuffered report control configuration



The following settings are available for each unbuffered report. Up to 18 unbuffered reports can be configured. Changes to the report configuration take effect when the C90^{Plus} is restarted.

Disconnect any IEC 61850 client connection to the C90^{Plus} prior to making setting changes to the unbuffered report configuration. Disconnecting the rear Ethernet connection from the C90^{Plus} disconnects the IEC 61850 client connection.

Unbuffered Reports RptID

Range: up to 65 alphanumeric characters
Default: empty

This setting specifies the name for the IEC 61850 unbuffered report.

Unbuffered Reports OptFlds

Range: 0 to 65535 in steps of 1
Default: 0

This setting specifies a bitmask that selects the option fields. The following bits are supported by the C90^{Plus}:

- Bit 1 — Sequence-number
- Bit 2 — Report-time-stamp
- Bit 3 — Reason-for-inclusion
- Bit 4 — Data-set-name
- Bit 5 — Data-reference
- Bit 6 — Not supported for unbuffered reports
- Bit 7 — Not supported for unbuffered reports
- Bit 8 — Conf-revision

Unbuffered Reports BufTm

Range: 0 to 4294967295 in steps of 1
Default: 0

This setting specifies the buffer time.

Unbuffered Reports TrgOps

Range: 0 to 65535 in steps of 1
Default: 0

This setting specifies a bitmask that selects the trigger options. The following bits are supported by the C90^{Plus}:

- Bit 1 — Data-change
- Bit 4 — Integrity
- Bit 5 — General interrogation

Unbuffered Reports IntgPd

Range: 0, or 250 to 4294967295 in steps of 1

Default: 0

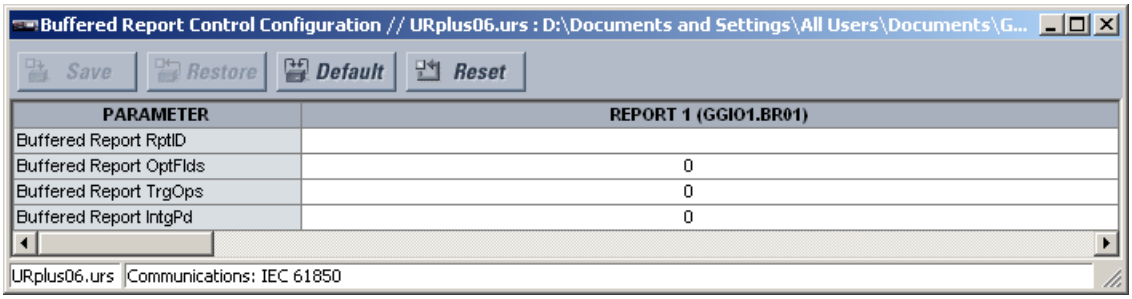
This setting specifies the integrity period for unbuffered reports.

Buffered report control configuration

IEC 61850 buffered reporting is provided in the GGIO1 logical nodes (for binary status values) and MMXU1 to MMXU4 (for analog measured values). Report settings are configured using the EnerVista UR^{Plus} Setup software, substation configurator software, or via an IEC 61850 client.

Select the **Settings > Communications > IEC 61850 > Buffered Report Control Configuration** menu item to open the IEC 61850 buffered report configuration window.

Figure 43: IEC 61850 buffered report control configuration



The following settings are available for each buffered report. Up to six buffered reports can be configured. Changes to the report configuration take effect when the C90^{Plus} is restarted.

Disconnect any IEC 61850 client connection to the C90^{Plus} prior to making setting changes to the buffered report configuration. Disconnecting the rear Ethernet connection from the C90^{Plus} disconnects the IEC 61850 client connection.

Buffered Reports RptID

Range: up to 65 alphanumeric characters

Default: empty

This setting specifies the name for the IEC 61850 buffered report.

Buffered Reports OptFlds

Range: 0 to 65535 in steps of 1

Default: 0

This setting specifies a bitmask that selects the option fields. The following bits are supported by the C90^{Plus}:

- Bit 1 — Sequence-number
- Bit 2 — Report-time-stamp
- Bit 3 — Reason-for-inclusion
- Bit 4 — Data-set-name
- Bit 5 — Data-reference
- Bit 6 — Buffer-overflow
- Bit 7 — EntryID
- Bit 8 — Conf-revision

Buffered Reports TrgOps

Range: 0 to 65535 in steps of 1

Default: 0

This setting specifies a bitmask that selects the trigger options. The following bits are supported by the C90Plus:

- Bit 1 — Data-change
- Bit 4 — Integrity
- Bit 5 — General interrogation

Buffered Reports IntgPd

Range: 0, or 250 to 4294967295 in steps of 1

Default: 0

This setting specifies the integrity period for buffered reports.

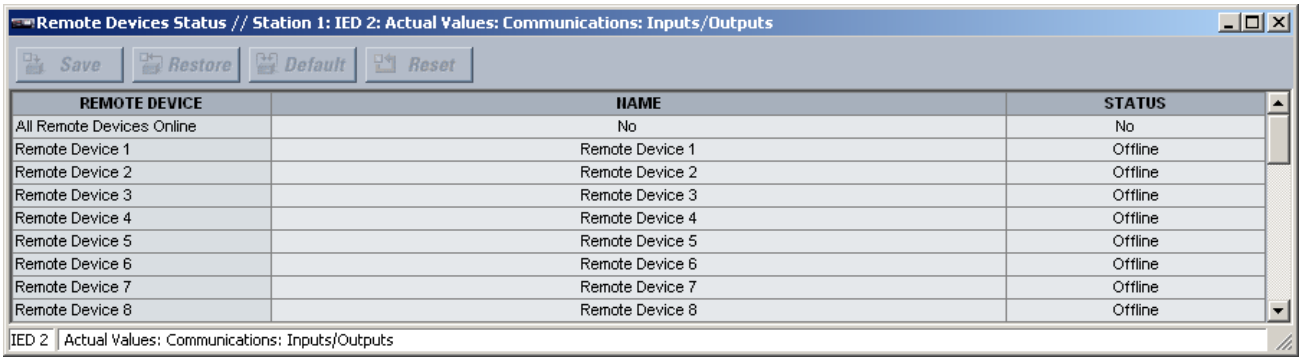
IEC 61850 actual values

Actual values for IEC 61850 are available in two locations. A general IEC 61850 communications actual value is available through the **Actual Values > Communications > Communication** menu. The IEC 61850 GOOSE input and output actual values are available through the **Actual Values > Communications > Inputs/Outputs** menu.

Remote device status values

Select the **Actual Values > Communications > Inputs/Outputs > Remote Devices Status** menu item to open the remote device status values window.

Figure 44: Remote device status values



REMOTE DEVICE	NAME	STATUS
All Remote Devices Online	No	No
Remote Device 1	Remote Device 1	Offline
Remote Device 2	Remote Device 2	Offline
Remote Device 3	Remote Device 3	Offline
Remote Device 4	Remote Device 4	Offline
Remote Device 5	Remote Device 5	Offline
Remote Device 6	Remote Device 6	Offline
Remote Device 7	Remote Device 7	Offline
Remote Device 8	Remote Device 8	Offline

The following status values are available for the IEC 61850 remote devices. The name and status values are available each of the remote devices.

All Remote Devices Online

Range: Yes, No

This value indicates whether or not all programmed remote devices are online. If the corresponding state is "No", then at least one required remote device is offline.

Name

Range: up to 65 alphanumeric characters

This value displays the name programmed for the corresponding remote device.

Status

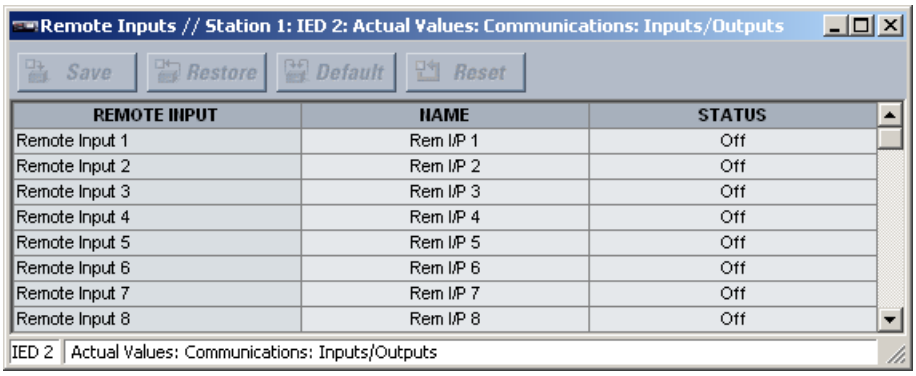
Range: Online, Offline

This value indicates the present state of the corresponding remote device.

Remote input actual values

Select the **Actual Values > Communications > Inputs/Outputs > Remote Inputs** menu item to open the remote input actual values window.

Figure 45: Remote input actual values



The following actual values are available for each of the remote inputs.

Name

Range: up to 12 alphanumeric characters

This value displays the name programmed for the corresponding remote input.

Status

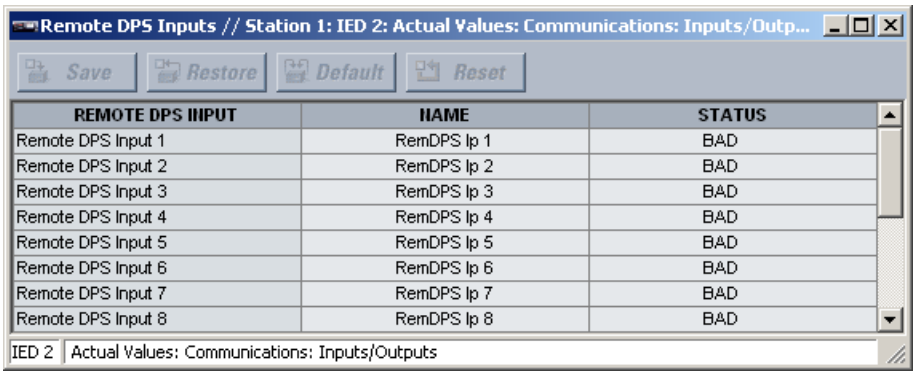
Range: On, Off

This value indicates the present state of the corresponding remote input. The state displayed is that of the remote point unless the remote device has been established to be "Offline", in which case the value shown is the programmed default state for the remote input.

Remote double-point status input actual values

Select the **Actual Values > Communications > Inputs/Outputs > Remote DPS Inputs** menu item to open the remote double-point status input actual values window.

Figure 46: Remote double-point status input actual values



The following actual values are available for each the remote double-point status inputs.

Name

Range: up to 12 alphanumeric characters

This value displays the name programmed for the corresponding remote double-point status input.

Status

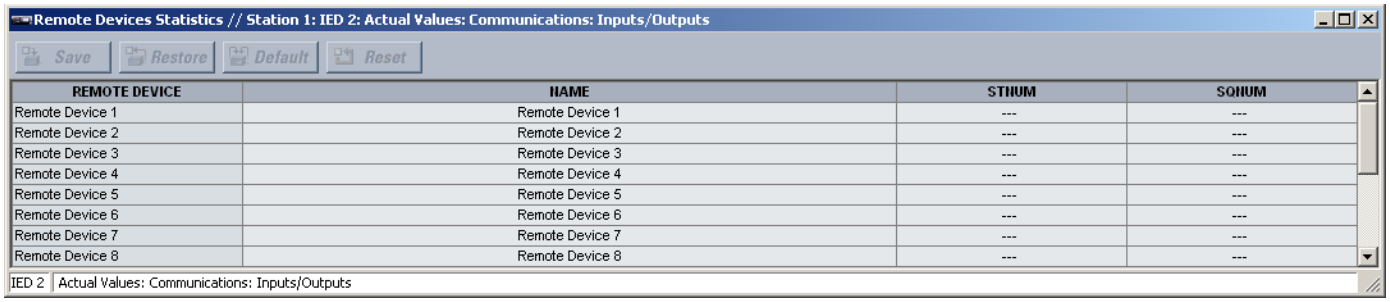
Range: On, Off, Intermediate, Bad

This value indicates if the corresponding remote double-point status input is in the on (close), off (open), intermediate, or bad state.

Remote device statistics

Select the **Actual Values > Communications > Inputs/Outputs > Remote Devices Statistics** menu item to open the remote devices statistics window.

Figure 47: Remote device statistics



The following statistics are available for each remote device.

Name

Range: up to 65 alphanumeric characters

This value displays the name programmed for the corresponding remote device.

StNum

Range: 0 to 4294967295 in steps of 1

This value is obtained from the indicated remote device and is incremented whenever a change of state of at least one DNA or UserSt bit occurs.

SqNum

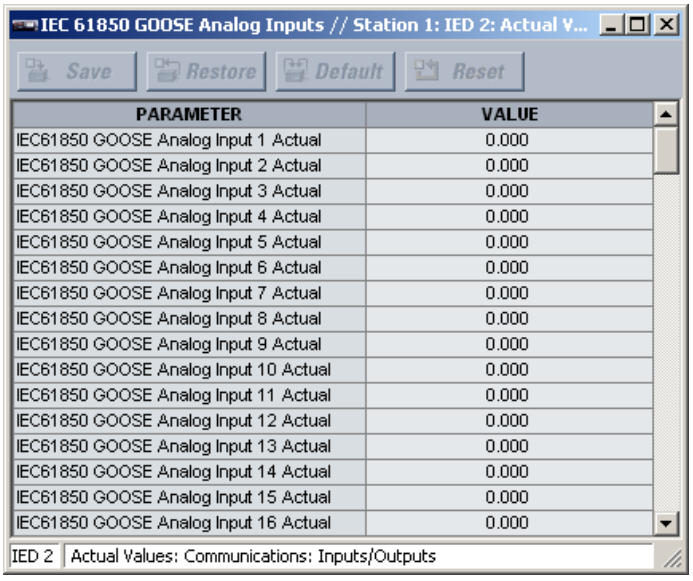
Range: 0 to 4294967295 in steps of 1

This value is obtained from the indicated remote device and is incremented whenever a GSSE message is sent. This number rolls over to zero when a count of 4294967295 is incremented.

IEC 61850 GOOSE analog input actual values

Select the **Actual Values > Communications > Inputs/Outputs > IEC61850 GOOSE Analog Inputs** menu item to open the IEC 61850 GOOSE analog input actual values window.

Figure 48: IEC 61850 GOOSE analog input actual values



The following actual value is available for each of the IEC 61850 GOOSE analog inputs.

IEC 61850 GOOSE Analog Input 1 Actual

Range: Yes, No

This value displays the IEC 61850 GGIO3 analog input data point 1. The GGIO3 analog data values are received via IEC 61850 GOOSE messages sent from other devices.

FlexStates

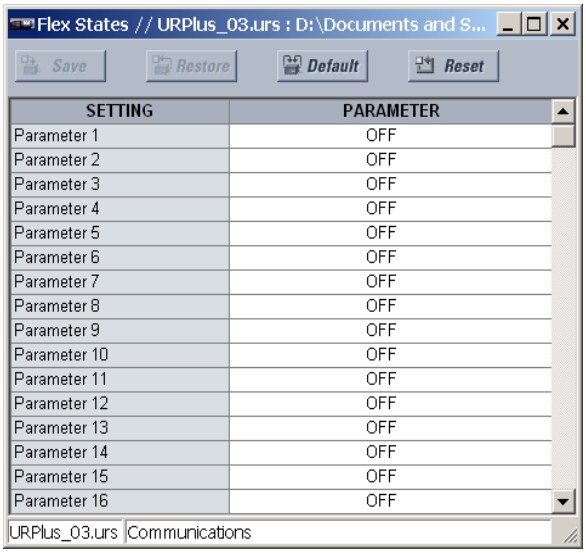
The FlexStates feature provides a mechanism where any of 256 selected FlexLogic operand states can be used for efficient monitoring. The feature allows user-customized access to the FlexLogic operand states in the C90^{Plus}. The state bits are packed so that sixteen (16) states can be read in a single Modbus register. The state bits can be configured so that all of the states which are of interest to the user are available in a minimum number of Modbus registers.

The state bits can be read in the FlexStates register array beginning at Modbus address 0900h. Sixteen states are packed into each register, with the lowest-numbered state in the lowest-order bit. There are sixteen registers in total to accommodate the 256 state bits.

FlexState settings

Select the **Settings > Communications > Flex States** menu item to open the FlexStates configuration window.

Figure 49: Flex States configuration settings



The following settings are available.

Parameter 1 through Parameter 256

Range: any FlexLogic operand

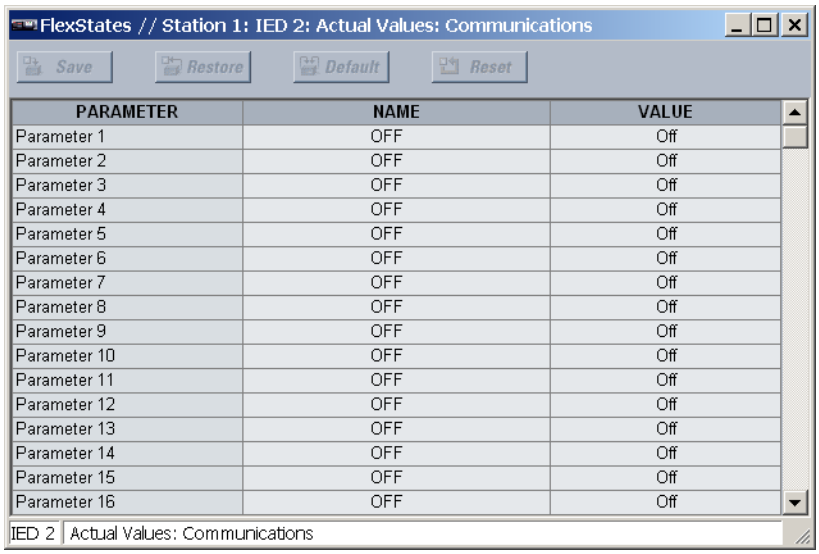
Default: Off

These settings assign FlexLogic parameters to each of the 256 FlexStates. The FlexState register array begins at Modbus address 0900h.

FlexState actual values

Select the **Actual Values > Communications > FlexStates** menu item to open the FlexStates actual values window.

Figure 50: FlexStates actual values



The following actual values are available for each FlexState parameter.

Name

Range: any FlexLogic operand

This actual value indicates the FlexLogic operand assigned to the FlexState parameter

Value

Range: OFF, ON

This actual value indicates the logic state (ON, OFF) of the FlexState parameter.

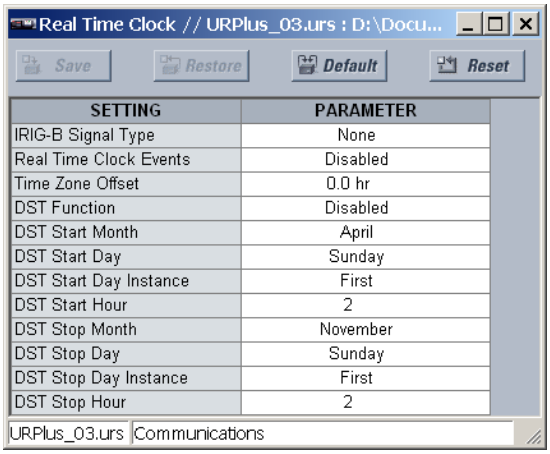
Real time clock

The date and time can be synchronized to a known time base and to other devices using an IRIG-B signal. If an IEEE 1344 compliant IRIG-B generator is connected to the C90^{Plus}, then no additional information is required. Otherwise, only the current year needs to be entered. Use the Set Date and Time command to manually set the relay clock.

The daylight savings time (DST) settings can be used to allow the C90^{Plus} clock to follow the DST rules of the local time zone. Note that when IRIG-B time synchronization is active, the DST settings are ignored. The DST settings are used when the C90^{Plus} is synchronized with SNTP, or when neither SNTP nor IRIG-B is used.

Select the **Settings > Communications > Real Time Clock** menu item to open the real time clock configuration window.

Figure 51: Real time clock configuration settings



The following settings are available to configure the real time clock.

IRIG-B Signal Type

Range: None, DC Shift, Amplitude Modulated
Default: None

This setting selects the type of IRIG-B signal. Select "None" to disable IRIG-B.

Real Time Clock Events

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the logging of real time clock events in the sequence of events recorder.

Time Zone Offset

Range: –24.0 to 24.0 hours in steps of 0.5
Default: 0.0 hours

This setting specifies the local time zone offset from Universal Coordinated Time (Greenwich Mean Time) in hours. This setting has two uses. When the C90^{Plus} is time synchronized with IRIG-B, or has no permanent time synchronization, the offset is used to calculate UTC time for IEC 61850 features. When the C90^{Plus} is time synchronized with SNTP, the offset is used to determine the local time for the C90^{Plus} clock, since SNTP provides UTC time.

DST Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the daylight saving time function.

DST Start Month

Range: January through December (all months of the year)
Default: April

This setting specifies the start month for daylight saving time.

DST Start Day

Range: Sunday through Saturday (all days of the week)
Default: Sunday

This setting specifies the day of the week to start daylight saving time.

DST Start Day Instance

Range: First, Second, Third, Fourth, Last

Default: First

This setting specifies the which instance of the day of the week to start daylight saving time. For example, if daylight saving time begins on the second Monday in April, program this setting to "Second".

DST Start Hour

Range: 0 to 23 in steps of 1

Default: 2

This setting specifies the hour to start daylight saving time. For example, if daylight saving time begins at 2:00 AM, program this setting to "2".

DST Stop Month

Range: January through December (all months of the year)

Default: November

This setting specifies the stop month for daylight saving time.

DST Stop Day

Range: Sunday through Saturday (all days of the week)

Default: Sunday

This setting specifies the day of the week to stop daylight saving time.

DST Stop Day Instance

Range: First, Second, Third, Fourth, Last

Default: First

This setting specifies the which instance of the day of the week to start daylight saving time. For example, if daylight saving time ends on the fourth Monday in November, program this setting to "Fourth".

DST Stop Hour

Range: 0 to 23 in steps of 1

Default: 2

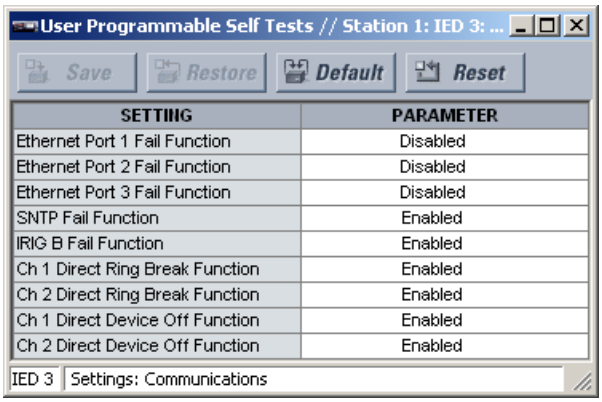
This setting specifies the hour at which daylight saving time ends. For example, if daylight saving time ends at 4:00 AM, program this setting to "4".

User-programmable self-tests

All major self-test alarms are reported automatically with their corresponding FlexLogic operands. And most of the minor alarms can be disabled.

Select the **Settings > Communications > User-Programmable Self-Tests** menu item to open the user-programmable self-test configuration window.

Figure 52: User-programmable self-test configuration settings



The following settings are available to configure the user-programmable self-tests.

Ethernet Port 1 Fail Function

Range: Enabled, Disabled
Default: Enabled

When this setting is "Disabled", the ETHERNET PORT 1 FAILURE alarm does not assert a FlexLogic operand or write to the event recorder. Moreover, it does not trigger the ANY MINOR ALARM or ANY SELF-TEST messages. When this setting is "Enabled", the ETHERNET PORT 1 FAILURE alarm continues to function along with other major and minor alarms. See the *Relay self-tests* section in for additional information on major and minor self-test alarms.

Ethernet Port 2 Fail Function

Range: Enabled, Disabled
Default: Disabled

When this setting is "Disabled", the ETHERNET PORT 2 FAILURE alarm does not assert a FlexLogic operand or write to the event recorder. Moreover, it does not trigger the ANY MINOR ALARM or ANY SELF-TEST messages. When this setting is "Enabled", the ETHERNET PORT 2 FAILURE alarm continues to function along with other major and minor alarms. See the *Relay self-tests* section in for additional information on major and minor self-test alarms.

Ethernet Port 3 Fail Function

Range: Enabled, Disabled
Default: Disabled

When this setting is "Disabled", the ETHERNET PORT 3 FAILURE alarm does not assert a FlexLogic operand or write to the event recorder. Moreover, it does not trigger the ANY MINOR ALARM or ANY SELF-TEST messages. When this setting is "Enabled", the ETHERNET PORT 3 FAILURE alarm continues to function along with other major and minor alarms. See the *Relay self-tests* section in for additional information on major and minor self-test alarms.

SNTP Fail Function

Range: Enabled, Disabled
Default: Enabled

When this setting is "Disabled", the SNTP FAILURE alarm does not assert a FlexLogic operand or write to the event recorder. Moreover, it does not trigger the ANY MINOR ALARM or ANY SELF-TEST messages. When this setting is "Enabled", the SNTP FAILURE alarm continues to function along with other major and minor alarms. See the *Relay self-tests* section in for additional information on major and minor self-test alarms.

IRIG-B Fail Function

Range: Enabled, Disabled

Default: Enabled

When this setting is "Disabled", the IRIG-B FAILURE alarm does not assert a FlexLogic operand or write to the event recorder. Moreover, it does not trigger the ANY MINOR ALARM or ANY SELF-TEST messages. When this setting is "Enabled", the IRIG-B FAILURE alarm continues to function along with other major and minor alarms. See the *Relay self-tests* section in for additional information on major and minor self-test alarms.

Ch 1 Direct Ring Break Function

Range: Enabled, Disabled

Default: Disabled

When this setting is "Enabled", the CH1 DIRECT RING BREAK self-test alarm indicates that direct output messages sent from channel 1 the C90^{Plus} are not being received back by the device.

Ch 2 Direct Ring Break Function

Range: Enabled, Disabled

Default: Disabled

When this setting is "Enabled", the CH2 DIRECT RING BREAK self-test alarm indicates that direct output messages sent from channel 2 the C90^{Plus} are not being received back by the device.

Ch 1 Direct Device Off Function

Range: Enabled, Disabled

Default: Disabled

When this setting is "Enabled", the CH1 DIRECT DEVICE OFF self-test alarm indicates that direct output messages from at least one direct device on channel 1 are not being received.

Ch 2 Direct Device Off Function

Range: Enabled, Disabled

Default: Disabled

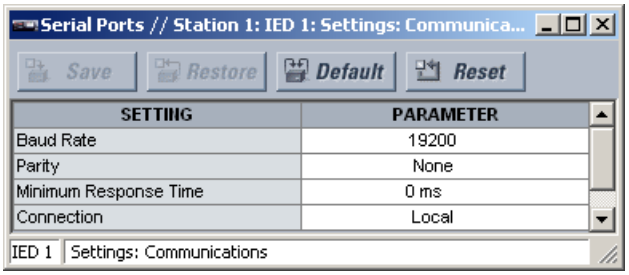
When this setting is "Enabled", the CH2 DIRECT DEVICE OFF self-test alarm indicates that direct output messages from at least one direct device on channel 2 are not being received.

Serial port

The C90^{Plus} is equipped with one serial RS485 communication port. The RS485 port 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. This ports may be connected to a computer running the EnerVista UR^{Plus} Setup software. This software can download and upload setting files, view measured parameters, and upgrade the device firmware. A maximum of 32 C90^{Plus} devices can be daisy-chained and connected to a DCS, PLC, or PC using the RS485 port.

Select the **Settings > Communications > Serial Ports** menu item to open the serial port configuration window.

Figure 53: Serial port configuration settings



The following settings are available to configure the RS485 port.

Baud Rate

Range: 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200
Default: 19200

This setting specifies the baud rate (bits per second) for the RS485 port.

Parity

Range: None, Odd, Even
Default: None

This setting specifies the parity for the RS485 port.

Minimum Response Time

Range: 0 to 1000 ms in steps of 10
Default: 0 ms

The minimum time before the port transmits after receiving data from a host can be set. This allows operation with hosts that hold the RS485 transmitter active for some time after each transmission.

Connection

Range: Local, Remote
Default: Local

This setting selects whether the serial RS485 connection is classified as local access or remote access for security purposes.

Direct inputs and outputs

Direct inputs and outputs are available if an inter-relay communications card is installed. Direct inputs and outputs provide a means of sharing digital point states between a number of UR^{Plus}-series or UR-series IEDs over a dedicated fiber, RS422, or G.703 interface. No additional switching equipment is required as the IEDs are connected directly in a ring or redundant (dual) ring configuration. This feature is optimized for speed and intended for pilot-aided schemes, distributed logic applications, or the extension of the input/output capabilities of a single device.

The C90^{Plus} provides 96 direct inputs and 96 direct outputs per communications channel.

Direct inputs and outputs are intended for exchange of status information (inputs and outputs) between UR^{Plus}-series devices connected directly via inter-relay communications cards. The mechanism is very similar to IEC 61850 GSSE, except that communications takes place over a non-switchable isolated network and is optimized for speed. All inter-relay communication cards support two channels, allowing direct output messages to be sent from both channels simultaneously. This effectively sends direct output messages both ways around a ring configuration. Messages are resent (forwarded) when it is determined that the message did not originate at the receiver.

Direct output message timing is similar to GSSE message timing. Integrity messages (with no state changes) are sent at least every 1000 ms at 64 kbps or 500 ms at 128 kbps. 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:

- CH1 DIR IO RING BREAK and CH2 DIR IO RING BREAK: These operands indicate that direct output messages sent from a UR^{Plus}-series device are not being received back by the device.
- CH1 DIR DEV 1 OFF to CH1 DIR DEV 16 OFF and CH2 DIR DEV 1 OFF to CH2 DIR DEV 16 OFF: These operands indicate that direct output messages from the corresponding 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 Device ID**. 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".

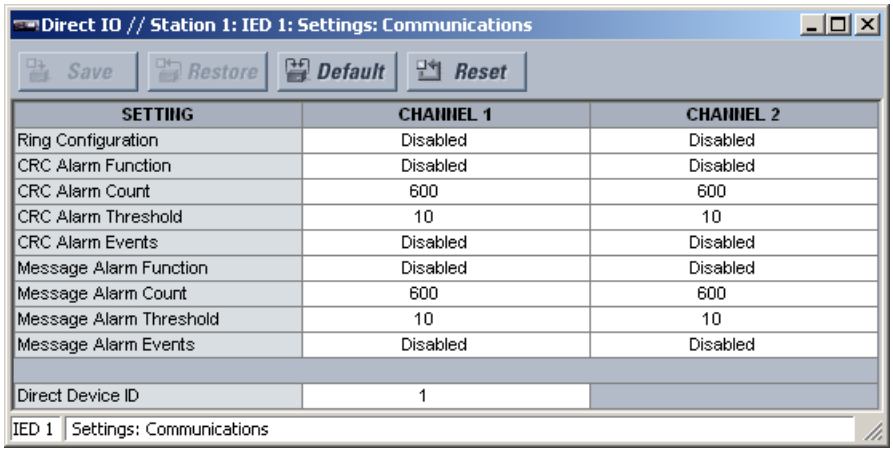
NOTE

Direct inputs and outputs exchange between UR^{Plus}-series IEDs is supported over the inter-relay communication card's G.703, C37.94, direct fiber, and RS422 interfaces. Direct inputs and outputs exchange with UR-series IEDs is supported on the C37.94, direct fiber, and RS422 interfaces.

Direct inputs and outputs configuration

Select the **Settings > Communications > Direct I/O** menu item to open the direct inputs and outputs configuration window.

Figure 54: Direct inputs/outputs configuration settings



The following setting is available and applicable to both channels in all direct inputs and direct outputs.

Direct Device ID

Range: 1 to 16 in steps of 1

Default: 1

This setting identifies the C90^{Plus} in all direct output messages. Assign a unique number to each UR^{Plus}-series IEDs in a ring. Each ID is used to identify the sender of the direct input/output message.

The following settings are available for each channel and are applicable to all direct inputs and direct outputs.

Ring Configuration

Range: Enabled, Disabled

Default: Disabled

These settings configure the direct input/output scheme to operate in a ring. If set to "Enabled", 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 CH1 DIR IO RING BRK and CH2 DIR IO RING BRK FlexLogic operands.

CRC Alarm Function

Range: Enabled, Disabled

Default: Disabled

The C90^{Plus} checks integrity of the incoming direct input/output messages using a 32-bit CRC. The CRC alarm function is available for monitoring the communication medium noise by tracking the rate of messages failing the CRC check. The monitoring function counts all incoming messages, including messages that failed the CRC check. A separate counter adds up messages that failed the CRC check.

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 bit error rate (BER) is not possible. Under certain assumptions an approximation can be made as follows. A direct input/output packet containing 20 bytes results in 160 bits of data being sent and therefore, a transmission of 63 packets is equivalent to 10000 bits. A BER of 10^{-4} implies 1 bit error for every 10000 bits sent/received. Assuming the best case of only 1 bit error in a failed packet, having 1 failed packet for every 63 received is about equal to a BER of 10^{-4}.

The CRC alarm function is available on a per-channel basis. The total number of direct input/output messages that failed the CRC check is available as an actual value.

CRC Alarm Count

Range: 100 to 10000 in steps of 1

Default: 600

When the total message counter reaches the user-defined maximum specified by this setting, both the counters reset and the monitoring process is restarted.

To monitor communications integrity, the C90^{Plus} 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 Count** to "10000" corresponds a time window of about 160 minutes at 64 kbps and 80 minutes at 128 kbps. If the messages are sent faster as a result of direct outputs activity, the monitoring time interval will shorten. This should be taken into account when determining this setting. For example, if the requirement is a maximum monitoring time interval of 10 minutes at 64 kbps, then the setting should be 10 × 60 × 1 = 600.

CRC Alarm Threshold

Range: 1 to 1000 in steps of 1

Default: 10

When the failed CRC counter reaches the user-defined level specified by this setting within the user-defined message count specified by **CRC Alarm Count**, the DIR IO CH1 CRC ALARM or DIR IO CH2 CRC ALARM FlexLogic operand is set. The operand can be configured to drive an output contact, annunciator alarm, or selected communication-based output. Program latching and acknowledging conditions, if required, accordingly in the annunciator settings.

CRC Alarm Events

Range: Enabled, Disabled

Default: Disabled

This setting enables and disables the logging of CRC alarm events in the sequence of events recorder.

Message Alarm Function

Range: Enabled, Disabled

Default: Disabled

The C90^{Plus} checks integrity of the direct input/output communication ring by counting unreturned messages. In the ring configuration, all messages originating at a given device should return within a pre-defined period of time. The unreturned messages alarm function is available for monitoring the integrity of the communication ring by tracking the rate of unreturned messages. This function counts all the outgoing messages and a separate counter adds the messages have failed to return.

The unreturned messages alarm function is available on a per-channel basis and is active only in the ring configuration. The total number of unreturned input/output messages is available as an actual value.

Message Alarm Count

Range: 100 to 10000 in steps of 1

Default: 600

When the total message counter reaches the user-defined maximum specified by this setting, both the counters reset and the monitoring process is restarted.

Message Alarm Threshold

Range: 1 to 1000 in steps of 1

Default: 10

When the unreturned messages counter reaches the user-definable level specified by this setting and within the user-defined message count specified by **Channel 1 Msg Alarm Count**, the DIR IO CH1 UNRET ALM FlexLogic operand is set. The operand shall be configured to drive an output contact, annunciator alarm, or selected communication-based output. Latching and acknowledging conditions, if required, should be programmed accordingly in the annunciator settings.

Message Alarm Events

Range: Enabled, Disabled

Default: Disabled

This setting enables and disables the logging of unreturned message alarm events in the sequence of events recorder.

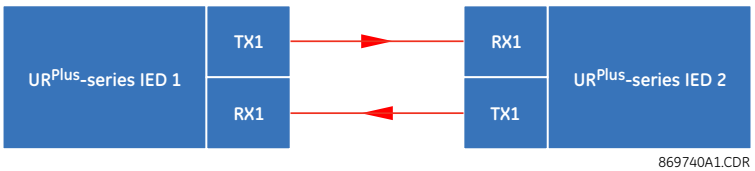
Direct input and output applications

The following application examples illustrate the basic concepts for direct input and output configuration.

Using direct inputs and outputs to extend input/output capabilities

Consider an application that requires additional contact inputs or outputs or lines of programmable logic that exceed the capabilities of a single UR^{Plus}-series device. The problem is solved by adding an extra UR^{Plus}-series IED to satisfy the additional input and output and programmable logic requirements. The two IEDs are connected via single-channel digital communication cards as shown below.

Figure 55: Input and output extension via direct inputs and outputs



The following settings should be applied to implement this application. For both IEDs, set the inter-relay baud rate for channel 1 to 128 kbps in the **Settings > Communications > Inter-Relay** menu.

For UR^{Plus}-series IED 1:

Figure 56: Inter-relay communications settings for IED 1

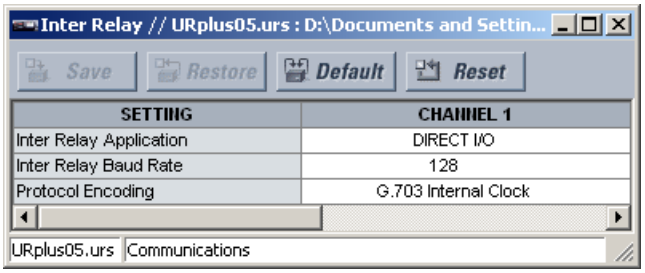
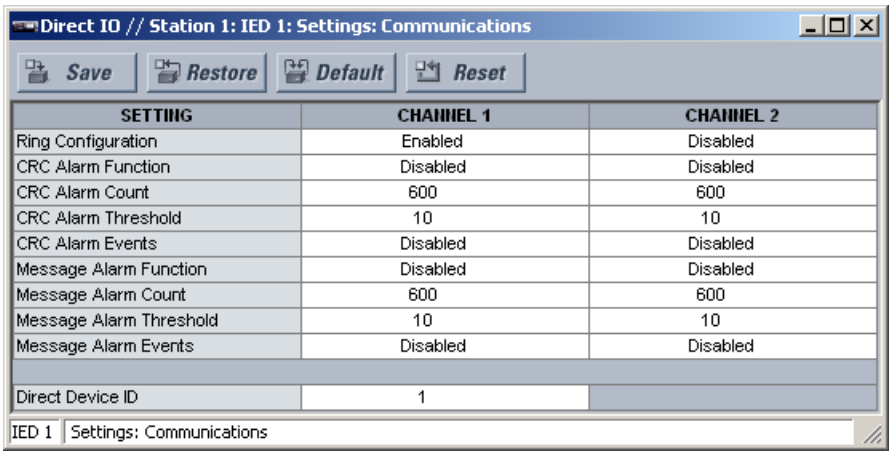


Figure 57: Direct input and output settings for IED 1



For UR^{Plus}-series IED 2:

Figure 58: Inter-relay communications settings for IED 2

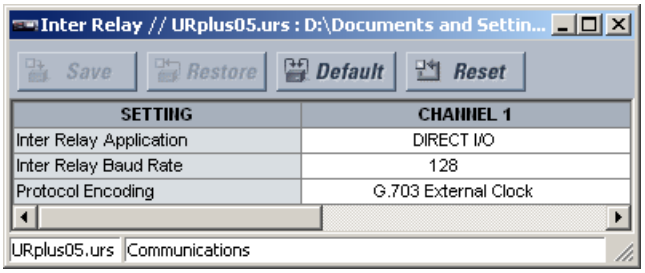
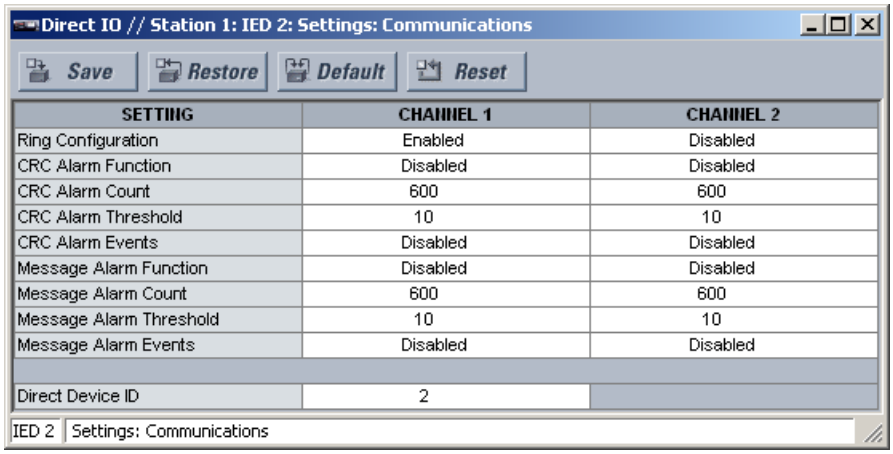


Figure 59: Direct input and output settings for IED 2

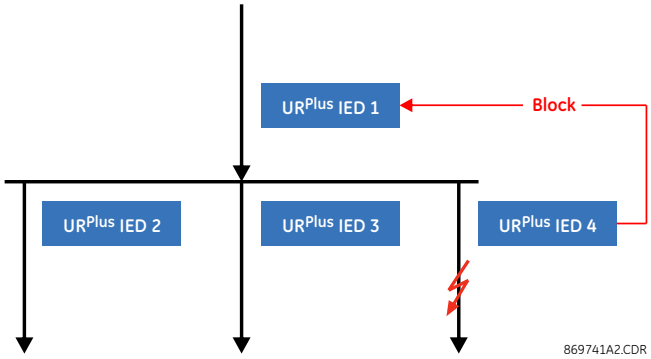


The message delivery time is about 0.2 of power cycle in both ways (at 128 kbps); that is, from device 1 to device 2, and from device 2 to device 1. Different communications cards can be selected by the user for this back-to-back connection (for example: fiber, G.703, or RS422).

Using direct inputs and outputs for interlocking busbar protection

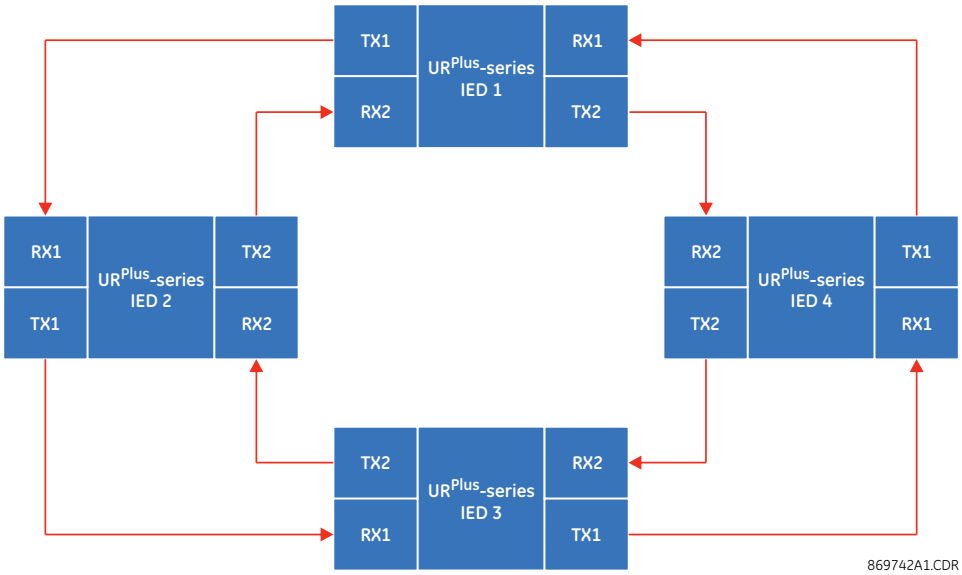
A simple interlocking busbar protection scheme can be accomplished by sending a blocking signal from downstream devices, say 2, 3, and 4, to the upstream device that monitors a single incomer of the busbar, as shown.

Figure 60: Example interlocking busbar protection scheme



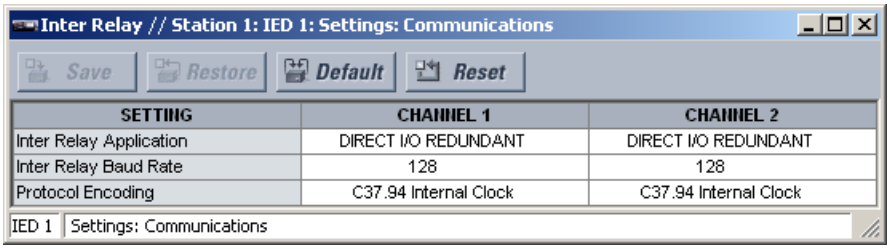
For increased reliability, a dual-ring configuration is recommended for this application, shown as follows.

Figure 61: Interlocking busbar protection scheme via direct inputs and outputs



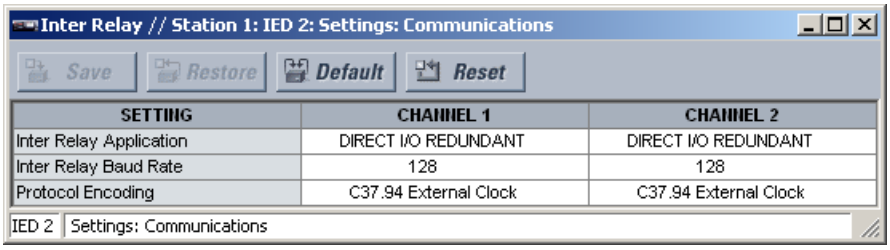
The following settings should be applied to implement this application. For IED 1, set the inter-relay application for both channels as follows in the **Settings > Communications > Inter-Relay** menu. If there are more than two IEDs in a ring configuration, then one device (for example, IED 1) must have it's protocol encoding set as an internal clock and the remaining devices have their protocol encoding set as external clock if no multiplexer is used.

Figure 62: Inter-relay communications settings for IED 1



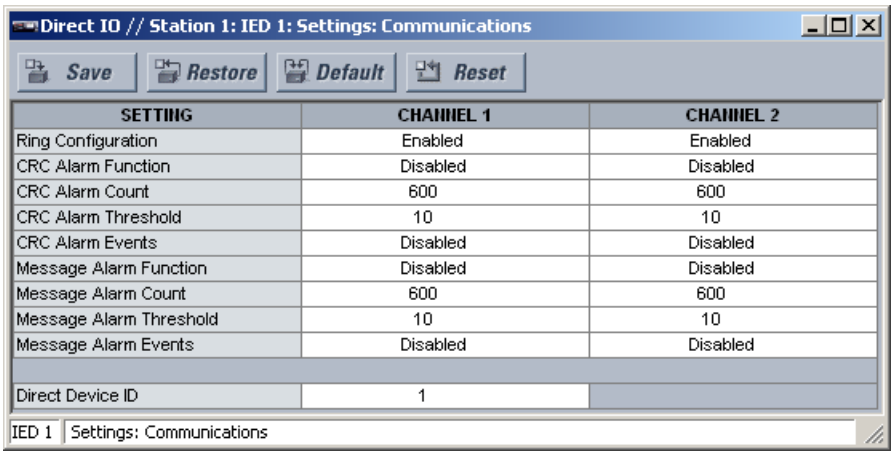
For IEDs 2 through 4, set the inter-relay application for both channels as follows in the **Settings > Communications > Inter-Relay** menu.

Figure 63: Inter-relay communications settings for IEDs 2 through 4



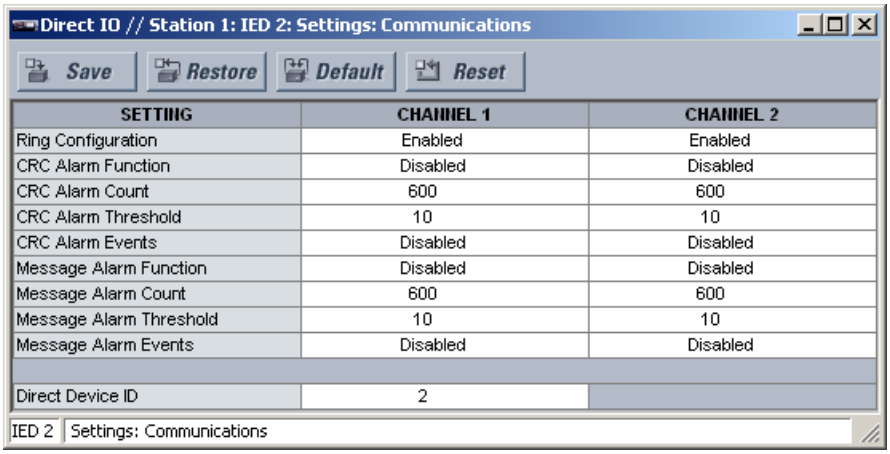
For UR Plus-series IED 1:

Figure 64: Direct input and output settings for IED 1



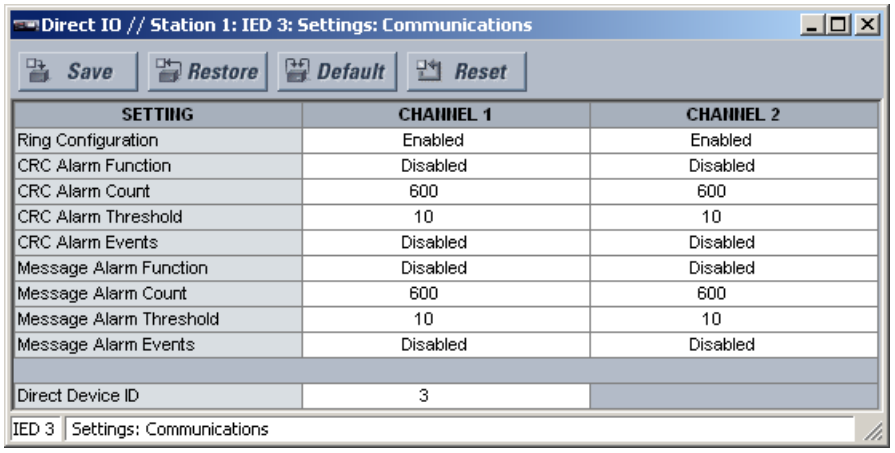
For UR^{Plus}-series IED 2:

Figure 65: Direct input and output settings for IED 2



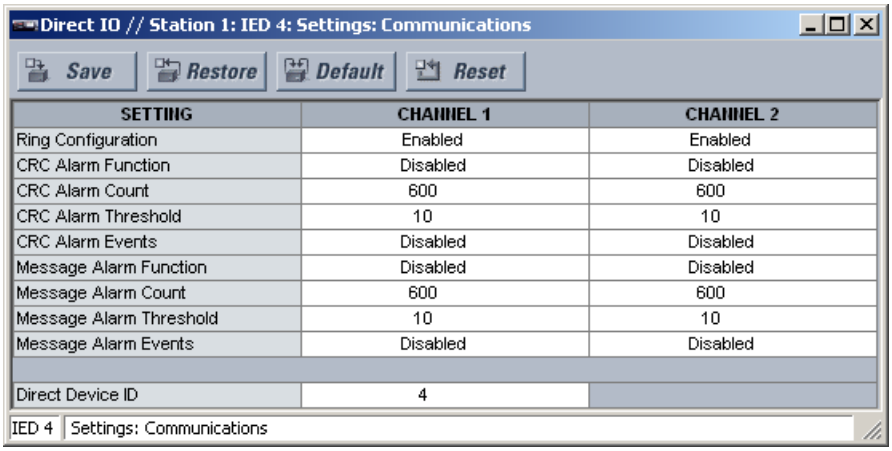
For UR^{Plus}-series IED 3:

Figure 66: Direct input and output settings for IED 3



For UR^{Plus}-series IED 4:

Figure 67: Direct input and output settings for IED 4



SETTING	CHANNEL 1	CHANNEL 2
Ring Configuration	Enabled	Enabled
CRC Alarm Function	Disabled	Disabled
CRC Alarm Count	600	600
CRC Alarm Threshold	10	10
CRC Alarm Events	Disabled	Disabled
Message Alarm Function	Disabled	Disabled
Message Alarm Count	600	600
Message Alarm Threshold	10	10
Message Alarm Events	Disabled	Disabled
Direct Device ID	4	

Message delivery time is approximately 0.2 of power system cycle (at 128 kbps) multiplied by the 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:

Table 4: Delivery times for healthy rings

Path	Delivery time
IED 1 to IED 2	0.2 of a power system cycle
IED 1 to IED 3	0.4 of a power system cycle
IED 1 to IED 4	0.2 of a power system cycle
IED 2 to IED 3	0.2 of a power system cycle
IED 2 to IED 4	0.4 of a power system cycle
IED 3 to IED 4	0.2 of a power system cycle

If one ring is broken (say TX2-RX2), then the delivery times are as follows:

Table 5: Delivery times for rings with break in TX2-RX2

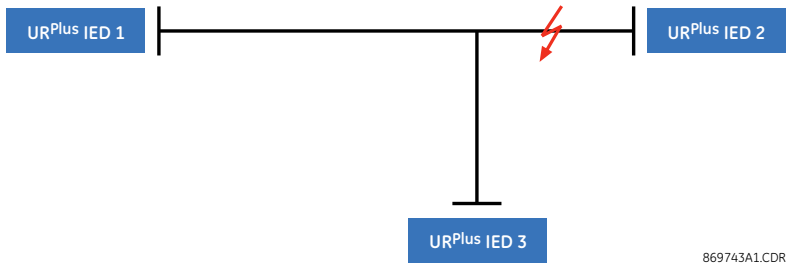
Path	Delivery time
IED 1 to IED 2	0.2 of a power system cycle
IED 1 to IED 3	0.4 of a power system cycle
IED 1 to IED 4	0.6 of a power system cycle
IED 2 to IED 3	0.2 of a power system cycle
IED 2 to IED 4	0.4 of a power system cycle
IED 3 to IED 4	0.6 of a power system cycle

A coordinating timer for this bus protection scheme could be selected to cover the worst case scenario (0.4 of a power system cycle). Upon detecting a broken ring, the coordination time should be adaptively increased to 0.6 of a power system cycle. The complete application requires addressing a number of issues, such as failure of both the communications rings, failure, or out-of-service conditions of one of the IEDs. Self-monitoring flags of the direct inputs and outputs feature would be primarily used to address these concerns.

Using direct inputs and outputs for pilot-aides schemes

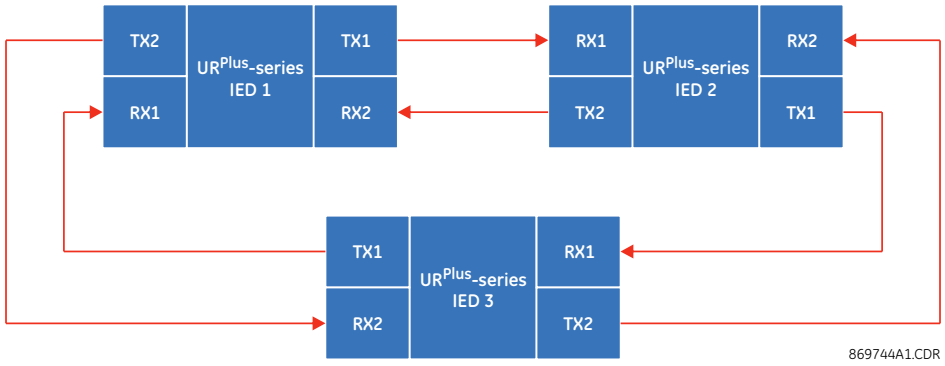
Consider the three-terminal line protection application shown here.

Figure 68: Three-terminal line application



A permissive pilot-aided or blocking scheme can be accomplished using a dual-ring configuration, shown as follows.

Figure 69: Dual-channel closed loop (dual-ring) configuration



Apply the following settings to implement this application. For all IEDs, set the inter-relay application for both channels as follows in the **Settings > Communications > Inter-Relay** menu.

Figure 70: Inter-relay communications settings for IED 1

Inter Relay // Station 1: IED 1: Settings: Communications

Save | Restore | Default | Reset

SETTING	CHANNEL 1	CHANNEL 2
Inter Relay Application	DIRECT I/O REDUNDANT	DIRECT I/O REDUNDANT
Inter Relay Baud Rate	128	128
Protocol Encoding	C37.94 Internal Clock	C37.94 Internal Clock

IED 1 | Settings: Communications

Figure 71: Inter-relay communications settings for IEDs 2 through 3

Inter Relay // Station 1: IED 2: Settings: Communications

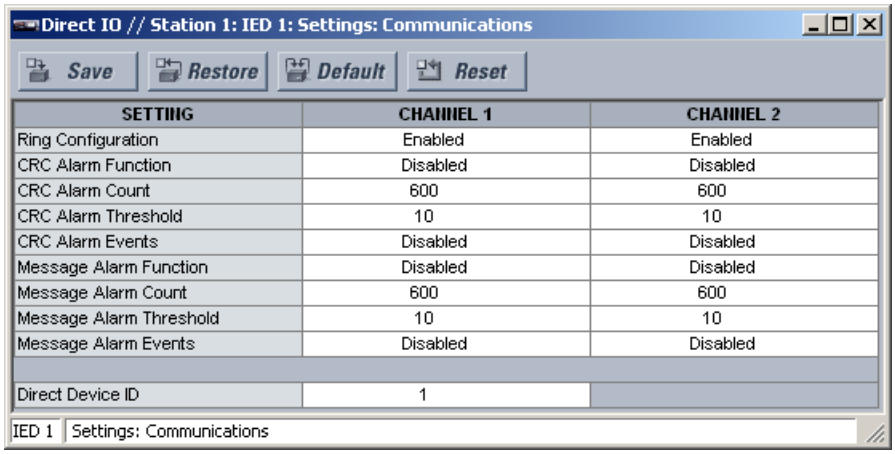
Save | Restore | Default | Reset

SETTING	CHANNEL 1	CHANNEL 2
Inter Relay Application	DIRECT I/O REDUNDANT	DIRECT I/O REDUNDANT
Inter Relay Baud Rate	128	128
Protocol Encoding	C37.94 External Clock	C37.94 External Clock

IED 2 | Settings: Communications

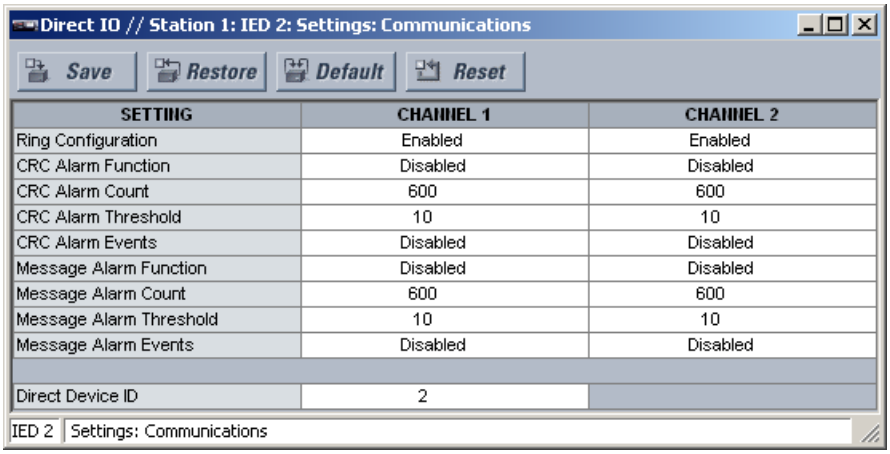
For URPlus-series IED 1:

Figure 72: Direct input and output settings for IED 1



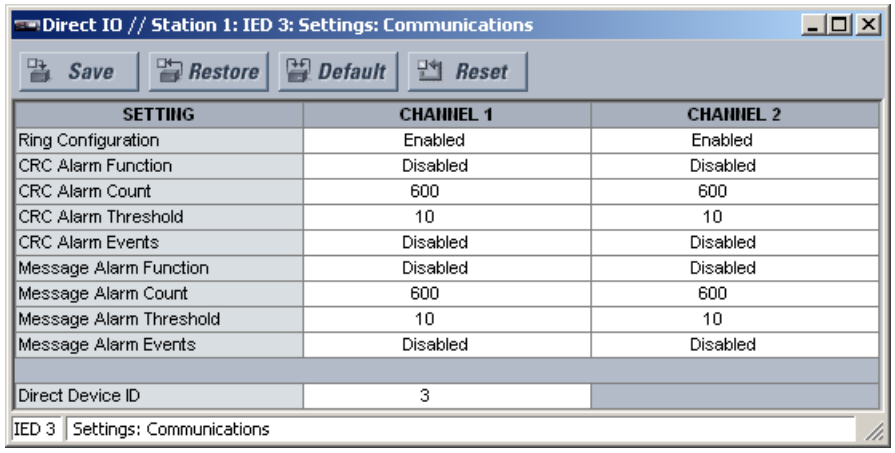
For UR^{Plus}-series IED 2:

Figure 73: Direct input and output settings for IED 2



For UR^{Plus}-series IED 3:

Figure 74: Direct input and output settings for IED 3



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

Table 6: Expected delivery times for healthy rings

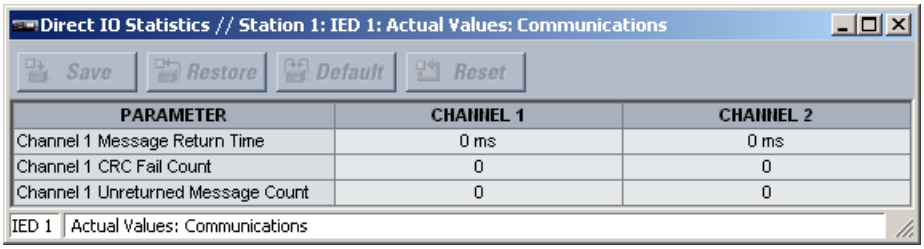
Path	Delivery time
IED 1 to IED 2	0.2 of a power system cycle
IED 1 to IED 3	0.2 of a power system cycle
IED 2 to IED 3	0.2 of a power system cycle

This configuration can be applied to both permissive and blocking schemes.

Direct inputs and outputs statistics

Select the **Actual Values > Communications > Direct IO Statistics** menu item to open the direct inputs and outputs statistics window.

Figure 75: Direct inputs and outputs statistics



The following actual values are available for each channel and are applicable to all direct inputs and direct outputs.

Message Return Time

Range: 0 to 10000 ms in steps of 1

This actual value displays the time taken for direct output messages to return to the sender. There are two return times (one for each channel) for dual-channel communications modules. The value is defaulted to the maximum "10000 ms" if the message is not received or if the ring configuration function setting is "Disabled".

CRC Fail Count

Range: 0 to 65535 in steps of 1

These actual values (one per communications channel) display the number of direct output messages that have been received but fail the CRC check. High values may indicate a problem with wiring or the communication channel on one or more devices. This value can be reset to zero using the Clear Direct I/O Counters command.

Unreturned Message Count

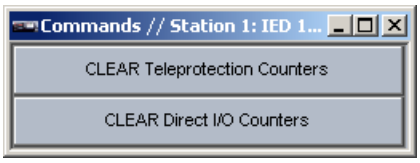
Range: 0 to 65535 in steps of 1

These actual values (one per communications channel) display the number of direct output messages that do not complete the trip around the communications ring. High values may indicate a problem with wiring or the communication channel on one or more devices. This value can be reset to zero using the Clear Direct I/O Counters command. If the **Message Alarm Function** setting is changed to "Disabled", then this value is frozen to the value at the time of change.

Direct inputs and outputs commands

Select the **Actual Values > Communications > Commands > Commands** menu item to open the inter-relay communications commands.

Figure 76: Inter-relay communications commands



The following command is available for the direct inputs and outputs.

Clear Direct I/O Counters

This command clears the statistic counters for the direct input/output CRC fail count and the unreturned message count.

Teleprotection inputs and outputs

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

Once teleprotection is enabled and the teleprotection inputs and outputs are configured, data packets are transmitted continuously every ¼ cycle (⅜ cycle if using C37.94 modules) from peer-to-peer. Security of communication channel data is achieved by using CRC-32 on the data packet. The baud rate between the peers must be the same for proper operation of the teleprotection feature.

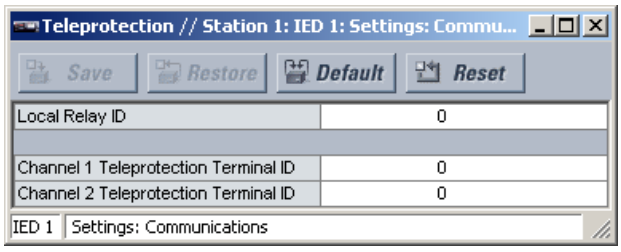
NOTE

Teleprotection communication is supported between UR^{Plus}-series IEDs or between a UR^{Plus}-series and a UR-series IED over the G.703, C37.94, and RS422 communication interfaces.

Teleprotection configuration

Select the **Settings > Communications > Teleprotection** menu item to open the main teleprotection configuration window.

Figure 77: Teleprotection configuration settings



The following teleprotection configuration settings are available.

Local Relay ID

Range: 0 to 255 in steps of 1

Default: 0

In installations that use multiplexers or modems, it is desirable to ensure that the data used by the devices protecting a given line is from the correct device. The teleprotection function performs this check by reading the message ID sent by transmitting UR^{Plus}-

series devices and comparing it to the programmed terminal IDs in the receiving device. Where redundancy is necessary the terminal IDs of both channels must be identical. Three-terminal applications can be achieved by programming distinct terminal IDs for each channel. The default value of "0" indicates that relay ID is not to be checked. The same local relay ID is transmitted over both channels.

Channel 1 Teleprotection Terminal ID

Range: 0 to 255 in steps of 1
Default: 0

This setting specifies the ID of the transmitting device for channel 1. See the description for the **Local Relay ID** for additional details.

Channel 2 Teleprotection Terminal ID

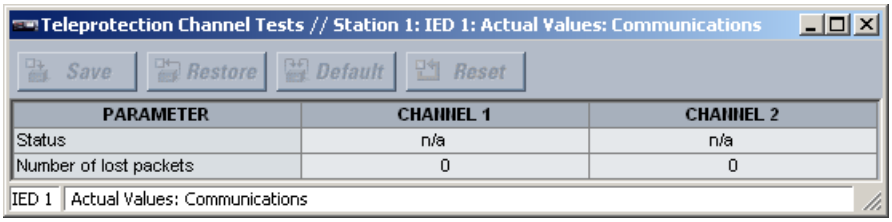
Range: 0 to 255 in steps of 1
Default: 0

This setting specifies the ID of the transmitting device for channel 2. See the description for the **Local Relay ID** for additional details.

Teleprotection channel tests

Select the **Actual Values > Communications > Teleprotection Channel Tests** menu item to open the teleprotection actual values window.

Figure 78: Teleprotection actual values



The following teleprotection actual values are available for each channel.

Status

Range: N/A, Fail, OK

This actual value represents the receiver status for each channel. If the value is "OK", teleprotection is enabled and data is being received from the remote terminal. If the value is "Fail", teleprotection is enabled and data is not being received from the remote terminal. If the value is "n/a", then teleprotection is disabled.

Number of Lost Packets

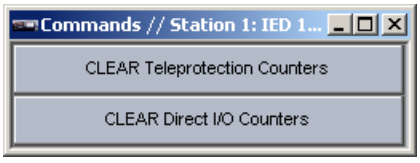
Range: 0 to 65535 in steps of 1

This actual value represents data packets lost in transmission. This value can be reset to zero using the Clear Teleprotection Counters command.

Teleprotection commands

Select the **Actual Values > Communications > Commands > Commands** menu item to open the inter-relay communications commands window.

Figure 79: Inter-relay communications commands



The following teleprotection command is available.

Clear Teleprotection Counters

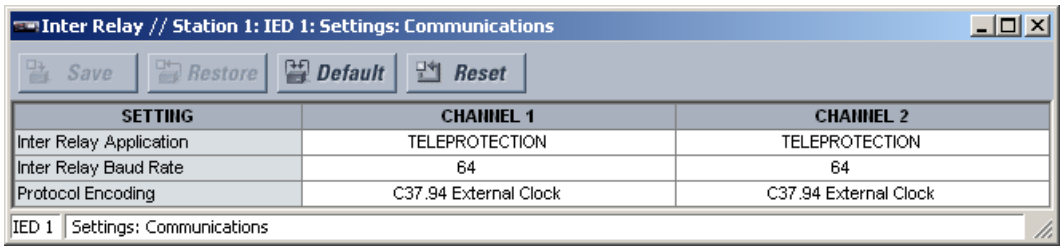
This command clears the number of teleprotection lost packets count.

Inter-relay communications

The inter-relay communications settings are used to configure inter-relay communications for direct inputs and outputs and teleprotection inputs and outputs.

Select the **Settings > Communications > Inter-Relay** menu item to open the inter-relay communications configuration window.

Figure 80: Inter-relay communications configuration settings



The following settings are available for each inter-relay communications channel.

Inter-Relay Application

Range: None, Direct I/O, Teleprotection, Direct I/O Redundant

Default: None

This setting selects the inter-relay communications application for each channel.

This setting can be selected as “Direct I/O”, “Direct I/O Redundant”, or “Teleprotection” to enable direct inputs and outputs. If a channel is set to “None”, then that transmitter’s output is disabled.

If the application is different for a channel pair (channels 1 and 2), then the channels are treated independently and provide 96 inputs and outputs per channel.

Select one of the redundancy values in cases where redundancy is important. Redundancy works on channel pairs (1 and 2). To enable redundancy for a channel pair, both channels 1 and 2 must be set to the same application setting and redundancy specified. Otherwise, the channels are treated independently. If channel redundancy is enabled, then channel 1 becomes the primary channel and channel 2 the secondary channel. In the event the primary channel fails, the data is accepted from the channel pair twin (channel 2).

In redundancy mode the secondary channels become dormant and report their direct input states as off. In this case, only the primary channel is active and the use of the secondary channel operands is not recommended. The user should program all logic to use the primary channel operands when using redundant mode. In redundancy setting mode, the channel 1 direct inputs and outputs are transmitted and received by both channels when the IEDs are configured in a redundant ring. This provides a greater level of security if one of the rings become disconnected. Use this mode when interfacing with UR-series devices.

Inter-Relay Baud Rate

Range: 64 kbps, 128 kbps

Default: 64 kbps

This setting selects the baud rate for each inter-relay communications channel. All interconnected devices must use the same baud rate for communications to operate properly.

Protocol Encoding

Range: Default, G.703 Octet Internal Clock, G.703 Octet External Clock, G.703 Internal Clock, G.703 External Clock, Diff. Manchester, C37.94 Internal Clock, C37.94 External Clock

Default: Default

For RS422 communications, only the "Default" value is available. For channels with G.703 communications, only the "Default", "G.703 Internal Clock", "G.703 Octet Internal Clock". "G.703 External Clock", and "G.703 Octet External Clock" values are available. For channels with fiber option communications, only the "Default", "Diff. Manchester", "C37.94 Internal Clock", and "C37.94 External Clock" values are available.

The "Default" value defaults the communications to a connection in a higher order system as shown in the following table.

Table 7: Default value encoding

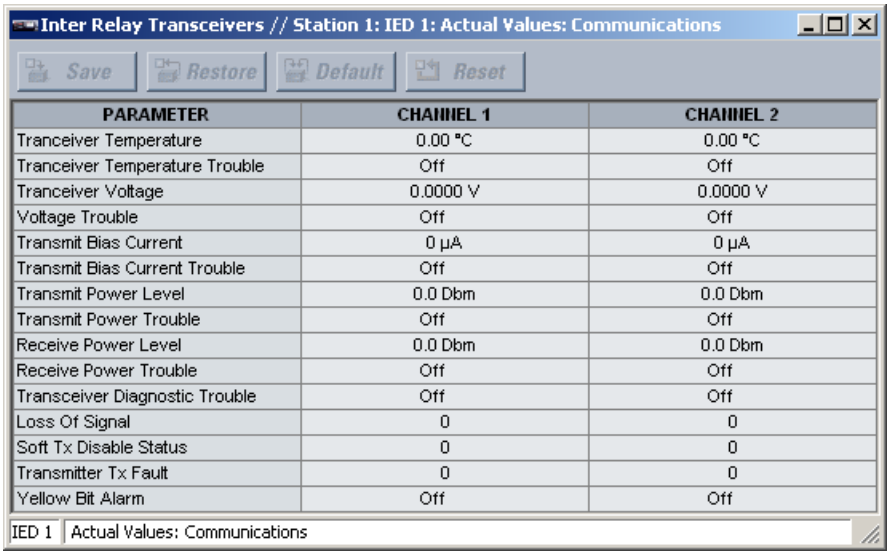
Protocol encoding	Channel type		
	G.703	Fiber	RS422
Octet timing	Enabled	N/A	N/A
Timing	External clock	External clock	N/A
Fiber protocol	N/A	C37.94	N/A

When an internal value is selected, the inter-relay communications card supplies the clock for communications. When an external value is selected, the clock is supplied by the external device connected to the inter-relay communications card.

Inter-relay communication actual values

The inter-relay actual values provide diagnostics to troubleshoot the inter-relay card in the event there is a problem. These values are useful for the factory and the user in the event the inter-relay card is not functioning properly. Each fiber transceiver contains a digital diagnostic monitoring interface (DDMI) that provides the transceiver actual values. Select the **Actual Values > Communications > Inter-Relay Transceivers** menu item to open the inter-relay communication actual values window.

Figure 81: Inter-relay communication actual values



PARAMETER	CHANNEL 1	CHANNEL 2
Tranceiver Temperature	0.00 °C	0.00 °C
Tranceiver Temperature Trouble	Off	Off
Tranceiver Voltage	0.0000 V	0.0000 V
Voltage Trouble	Off	Off
Transmit Bias Current	0 µA	0 µA
Transmit Bias Current Trouble	Off	Off
Transmit Power Level	0.0 Dbm	0.0 Dbm
Transmit Power Trouble	Off	Off
Receive Power Level	0.0 Dbm	0.0 Dbm
Receive Power Trouble	Off	Off
Transceiver Diagnostic Trouble	Off	Off
Loss Of Signal	0	0
Soft Tx Disable Status	0	0
Transmitter Tx Fault	0	0
Yellow Bit Alarm	Off	Off

The following inter-relay communication actual values are available for each channel.

Transceiver Temperature

Range: –99.99 to 300.00 °C

This value indicates the fiber transceiver temperature.

Transceiver Temperature Trouble

Range: On, Off

This value indicates whether the fiber transceiver temperature has exceeded the manufacturer's limit.

Transceiver Voltage

Range: 0.0000 to 6.5535 V in steps of 0.0001

This value indicates the fiber transceiver voltage.

Voltage Trouble

Range: On, Off

This value indicates whether the fiber transceiver voltage level is outside the manufacturer's limit.

Transmit Bias Current

Range: 0 to 65535 µA in steps of 1

This value indicates the fiber transceiver bias current level.

Transmit Bias Current Trouble

Range: On, Off

This value indicates whether the fiber transceiver bias current is outside the manufacturer's limit.

Transmit Power Level

Range: –3276.8 to 3276.8 dBm in steps of 0.1

This value indicates the fiber transceiver transmitter power level.

Transmit Power Level Trouble

Range: On, Off

This value indicates whether the fiber transceiver transmit power level is outside the manufacturer's limit.

Receive Power Level

Range: –3276.8 to 3276.8 dBm in steps of 0.1

This value indicates the fiber transceiver receive power level.

Receive Power Level Trouble

Range: On, Off

This value indicates the fiber transceiver receive power level is outside the manufacturer's limit.

Transceiver Diagnostic Trouble

Range: On, Off

This value indicates the fiber transceiver diagnostics module is not working properly.

Loss of Signal

Range: On, Off

This value indicates the loss of signal status for fiber and G.703 options. For the RS422 option this indicates no clock or incorrect clock.

Soft Tx Disable Status

Range: On, Off

This value indicates whether the fiber transceiver transmitter has been disabled. This occurs if the **Inter-Relay Application** is set to "None", causing the fiber transmitter to be disabled.

Transmitter Tx Fault

Range: On, Off

This value indicates there is a hardware problem with the fiber transmitter.

Yellow Bit Alarm

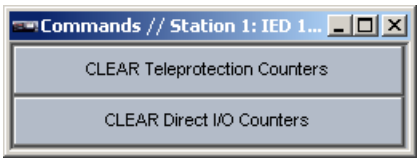
Range: On, Off

This indicates the yellow bit alarm status for the C37.94 protocol encoding if fiber is used.

Inter-relay communication commands

Select the **Actual Values > Communications > Commands > Commands** menu item to open the inter-relay communications commands window.

Figure 82: Inter-relay communication commands



The following commands are available for inter-relay communications.

Clear Teleprotection Counters

This command clears the **Number of Lost Packets** teleprotection actual value.

Clear Direct I/O Counters

This command clears all counters for the **CRC Fail Count** and **Unreturned Message Count** direct input and output actual values.

Communication logic operands

The following communication logic operands are available for the C90^{Plus}. They are listed alphabetically by operand syntax If required, these operands can be assigned user-defined names through the **Settings > Configure FlexOperands** menu item.

Direct device operands

CH 1 DIR DEV 1 OFF — Asserted when direct device 1 on channel 1 is off.

CH 1 DIR DEV 1 ON — Asserted when direct device 1 on channel 1 is on.

CH 2 DIR DEV 1 OFF — Asserted when direct device 1 on channel 2 is off.

CH 2 DIR DEV 1 ON — Asserted when direct device 1 on channel 2 is on.

CH 1 DIR DEV 2... — The operands listed above are available for direct devices 2 through 16 on channel 1.

CH 2 DIR DEV 2... — The operands listed above are available for direct devices 2 through 16 on channel 2.

Direct input and output operands

DIRECT INPUT 1 ON — Asserted when direct input 1 is on.

DIRECT INPUT 2 — The operands listed above are available for direct inputs 2 through 96.

Remote double-point status input operands

RemDPS Ip 1 BAD — Asserted when remote double-point status input 1 is in the bad state.

RemDPS Ip 1 INTERM — Asserted when remote double-point status input 1 is in the intermediate state.

RemDPS Ip 1 OFF — Asserted when remote double-point status input 1 is in the off (open) state.

RemDPS Ip 1 ON — Asserted when remote double-point status input 1 is in the on (closed) state.

RemDPS Ip 2 — The operands listed above are also available for remote double-point status inputs 2 through 16.

Teleprotection input and output operands

TELEPRO CH1 CRC FAIL — Asserted when the CRC detects packet corruption on teleprotection channel 1.

TELEPRO CH1 FAIL — Asserted when teleprotection inputs are not received for more than 4 cycles on channel 1.

TELEPRO CH1 FAIL OFF — Asserted when teleprotection has failed for channel 1.

TELEPRO CH1 PKT LOST — Asserted when the CRC detects a lost packet on teleprotection channel 1.

TELEPRO CH2 CRC FAIL — Asserted when the CRC detects packet corruption on teleprotection channel 2.

TELEPRO CH2 FAIL — Asserted when teleprotection inputs are not received for more than 4 cycles on channel 2.

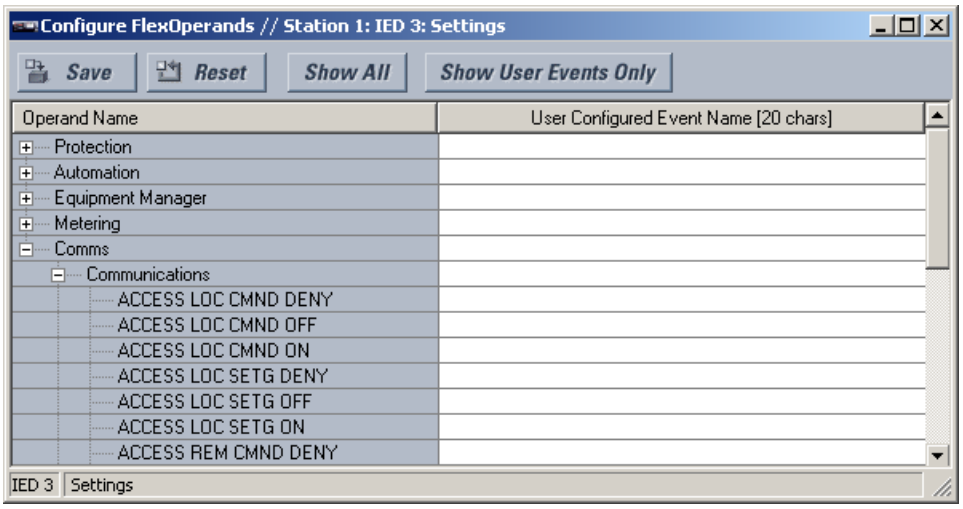
TELEPRO CH2 FAIL OFF — Asserted when teleprotection has failed for channel 2.

TELEPRO CH2 PKT LOST — Asserted when the CRC detects a lost packet on teleprotection channel 2.

Customizing the communication logic operands

Select the **Settings > Configure FlexOperands** menu item to open the user-configurable operands window.

Figure 83: User-configurable communication logic operands window



The left side of this screen displays all operands that are currently available to the C90^{Plus}. The communication logic operands are displayed by selecting the **Comms** tree item. Each operand can be renamed with a user-specified value to provide additional information or match specific applications.

User Configured Event Name

Range: up to 20 alphanumeric characters
Default: ---

Each available communications logic operand can be renamed to a user-specified value. This feature allows users to rename operands to allow for clearer identification or to match specific applications. The new operand name appears in protection and automation logic, in settings that take operands as their value, and in event reports.

Communication FlexAnalog parameters

The following communication FlexAnalog parameters (analog operands) are available for the C90^{Plus}. They are listed alphabetically by operand syntax.

Real time clock analog operands

Day of Month ..... Real time clock day of month value
Day of Week ..... Real time clock day of week value
Day of Year ..... Real time clock day of year value
Hour of Day ..... Real time clock hour of day value
Minute of Hour ..... Real time clock minutes of hour value
Month of Year ..... Real time clock month of year value
Second of Minute ..... Real time clock second of minute value
Year ..... Real time clock year value

GOOSE analog inputs analog operands

GOOSE Analog In 1 ..... Metered value for GOOSE analog input 1
GOOSE Analog In 2 ..... The value above is available for GOOSE analog input 2 to 128

C90Plus Controller

Chapter 7: Protection

This section outlines how to program the C90Plus protection features.

Protection overview

The C90Plus is an advanced logic controller specifically designed for use in substation environments and for the unique automation requirements of industrial and utility power systems. It provides powerful logic processing with deterministic execution of logic equations regardless of the amount of configured logic.

The C90Plus provides the tools and functionality necessary for creating customized automation and control schemes that include complete bay control, breaker monitoring and control, auto-restoration schemes, automatic bus transfer schemes, and load shedding schemes.

In addition, overcurrent and undervoltage protection, fault diagnostics, power metering, and RTU functions are provided. The C90Plus provides phase, neutral, and ground time overcurrent protection. The time overcurrent functions can be programmed with multiple curve shapes or FlexCurves for optimum coordination.

Introduction to protection elements

In the design of the URPlus-series protection system, the term *element* is used to describe a feature based around a comparator. The comparator is provided with an input (or set of inputs) that is tested against a programmed setting (or group of settings) to determine if the input is within the defined range that will set the output to logic 1, also referred to as *setting the flag*. A single comparator may make multiple tests and provide multiple outputs. For example, the time overcurrent comparator sets a pickup flag when the current input is above the setting and sets an operate flag when the input current has been at a level above the pickup setting for the time specified by the time-current curve settings. All comparators use analog parameter actual values as the input.

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

The main characteristics of an element are shown on the element logic diagram. This includes the inputs, settings, fixed logic, and the output operands generated.

Some settings for current and voltage elements are specified in per-unit (pu) calculated quantities. Per-unit quantities are calculated as follows.

$$\text{pu quantity} = \frac{\text{actual quantity}}{\text{base quantity}} \quad \textbf{Eq. 1}$$

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

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

$$\frac{13800\ \text{V}}{14400\ \text{V}} \times 120\ \text{V} = 115\ \text{V} \quad \textbf{Eq. 2}$$

For wye-connected VTs, the secondary nominal voltage (1 pu) is:

$$\frac{13800\ \text{V}}{14400\ \text{V}} \times \frac{120\ \text{V}}{\sqrt{3}} = 66.4\ \text{V} \quad \textbf{Eq. 3}$$

Many settings are common to most elements. The settings are as follows:

- **Function** settings: These settings program the element to be operational when selected as "Enabled". The factory default is "Disabled". Once programmed to "Enabled", any element associated with the function becomes active and all options become available.
- **Name** settings: These settings are used to uniquely identify an element.
- **Source** settings: These settings select the parameter or set of parameters to be monitored.
- **Pickup** settings: For simple elements, these settings are 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 causes the element to pickup.
- **Pickup Delay** setting: This setting sets a time-delay-on-pickup, or on-delay, for the duration between the pickup and operate output states.
- **Reset Delay** setting: This setting is used to set a time-delay-on-dropout, or off-delay, for the duration between the operate output state and the return to logic 0 after the input transits outside the defined pickup range.
- **Block** setting: The default output operand state of all comparators is a logic 0 or *flag not set*. The comparator remains in this default state until a logic 1 is asserted at the RUN input, allowing the test to be performed. If the RUN input changes to logic 0 at any time, the comparator returns to the default state. The RUN input is used to supervise the comparator. The BLOCK input is used as one of the inputs to RUN control.
- **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 as follows:
  - **<Element> PKP** (pickup)
  - **<Element> DPO** (dropout)
  - **<Element> OP** (operate)

The dropout 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.

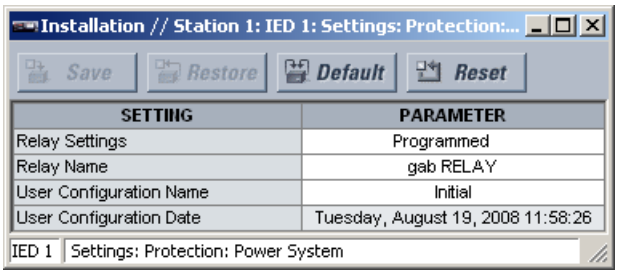
Power system

This section outlines settings relevant to the C90^{Plus} power system.

Installation settings

Select the **Settings > Protection > Power System > Installation** menu item to open the installation settings window.

Figure 1: Installation settings



The following settings are available.

Relay Settings

Range: Programmed, Not Programmed

Default: Not Programmed

To safeguard against the installation of a device without any entered settings, the C90^{Plus} does not allow signaling of any output relay until this setting value is "Programmed". This setting is defaulted to "Not Programmed" when at the factory. The UNIT NOT PROGRAMMED self-test error message is displayed until the relay is put into the programmed state.

Relay Name

Range: up to 20 alphanumeric characters

Default: -----

This setting allows the user to uniquely identify a relay. This name will appear on all generated reports.

User Configuration Name

Range: up to 20 alphanumeric characters

Default: Initial

This setting allows the user to provide a description for the settings that are loaded at a particular time (for example, "Spring-summer settings"). This description is displayed on the Product Information page of the front panel annunciator under the **Configuration** field.

User Configuration Date

Range: up to 20 alphanumeric characters

Default: -----

This setting records the date of last setting change through the EnerVista UR^{Plus} Setup software. Each time any settings are changed or a new settings file loaded, this value is updated. This description is also displayed on the Product Information page of the front panel annunciator under the **Date** field directly to the right of the **Configuration** field.

AC input modules

CT and VT input channels are contained in AC modules. The following input channel types are available:

- Three-phase voltage
- Single-phase auxiliary voltage
- Three-phase current
- Single-phase ground current

The AC modules calculate total waveform RMS levels, fundamental frequency phasors, and symmetrical components, as allowed by the hardware in each channel. These modules may calculate other parameters as directed by the CPU module.

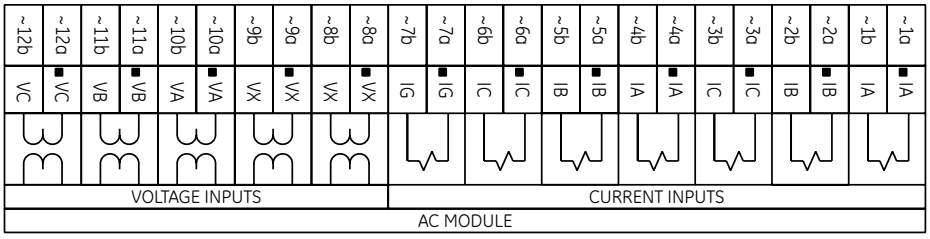
An AC module contains twelve input channels, numbered 1 through 12. The channel numbering corresponds to the module terminal numbering 1 through 12 and is arranged as follows:

- Channels 1, 2, and 3 form a three-phase current input
- Channels 4, 5, and 6 form a second three-phase current input
- Channel 7 is a single-phase current input
- Channels 8 and 9 are single-phase voltage inputs
- Channels 10, 11, and 12 form a three-phase voltage input

Channel groups are ordered sequentially from the block of lower-numbered channels to the block of higher-numbered channels, and from the AC module with the lowest slot position letter to the module with the highest slot position letter, as follows.

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

Figure 2: AC module bank configuration

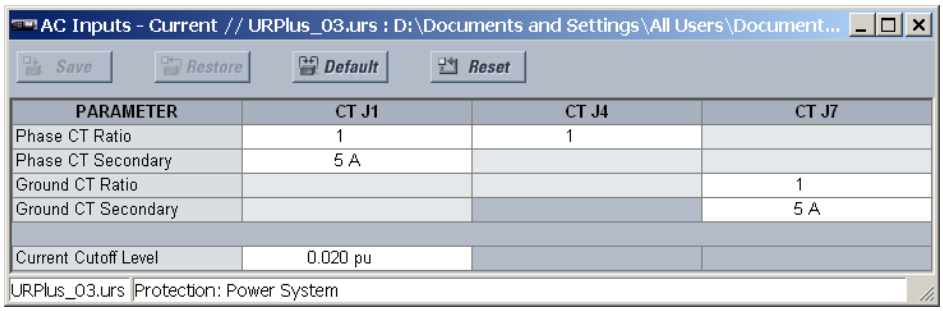


For three-phase channel groups, the number of the lowest numbered channel identifies the group. For example, J1 represents the three-phase channel set of J1, J2, and J3, where J is the slot letter and 1 is the first channel of the set of three channels. The first channel in the group is identified as phase A, the second channel as phase B, and the third channel as phase C.

Current inputs

Select the **Settings > Protection > Power System > AC Inputs - Current** menu item to open the current inputs configuration window.

Figure 3: Current inputs configuration settings



The current inputs configuration window allows the user to specify the parameters for each current input (represented by the module slot position letter). The **Phase CT Ratio** and **Ground CT Ratio** settings are used for calculation of primary metering values and for ratio matching when multiple CT inputs are added within a source. The **Phase CT Secondary** and **Ground CT Secondary** settings are used to derive secondary current values from per-unit settings used in protection elements. This setting is "1 A" or "5 A", depending on the hardware.

Since the phase CTs are connected in a wye (star) configuration, the calculated phasor sum of the three phase currents (IA + IB + IC = neutral current = 3I0) is used as the input for the neutral overcurrent elements. In addition, a zero-sequence (core-balance) CT that senses current in all of the circuit primary conductors, or a CT in a neutral grounding conductor, can be used.

The following current input settings are available.

Phase CT Ratio

Range: 1 to 65000 in steps of 1
Default: 1

This setting specifies the phase CT ratio for the corresponding current input. It is used for calculation of primary metering values and for ratio matching when multiple CT inputs are added within a source.

Phase CT Secondary

Range: 1 A, 5 A
Default: 5 A

This setting selects the phase CT secondary value. It is sued to derive secondary current values from per-unit settings used in protection elements.

Ground CT Ratio

Range: 1 to 65000 in steps of 1
Default: 1

This setting specifies the ground CT ratio for the corresponding current input. It is used for calculation of primary metering values and for ratio matching when multiple CT inputs are added within a source.

Ground CT Secondary

Range: 1 A, 5 A
Default: 5 A

This setting selects the ground CT secondary value. It is used to derive secondary current values from per-unit settings used in protection elements.

Current Cutoff Level

Range: 0.002 to 0.020 pu in steps of 0.001

Default: 0.020 pu

This setting modifies the current cut-off threshold. Very low currents (1 to 2% of the rated value) are very susceptible to noise. Some customers prefer very low currents to display as zero, while others prefer the current be displayed even when the value reflects noise rather than the actual signal. The C90^{Plus} 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. Raw current samples available via oscillography are not subject to cut-off.

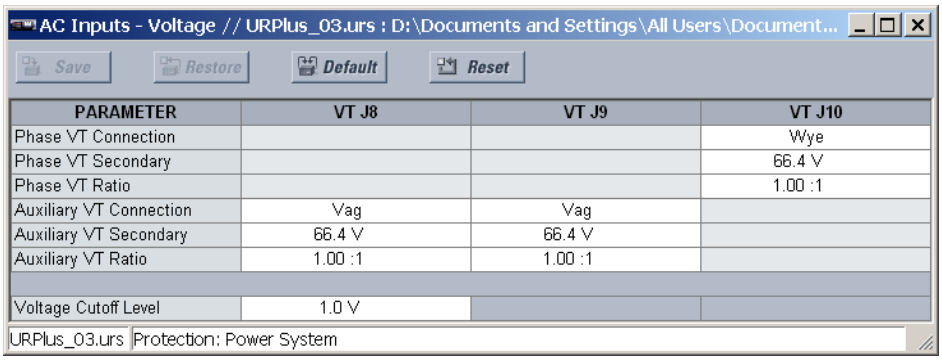
NOTE

Lower the **Current Cutoff Level** setting with care as the C90^{Plus} accepts lower signals as valid measurements. Unless dictated otherwise by a specific application, the default setting of "0.020 pu" is recommended.

Voltage inputs

Select the **Settings > Protection > Power System > AC Inputs - Voltage** menu item to open the voltage input configuration window.

Figure 4: Voltage input configuration settings



PARAMETER	VT J8	VT J9	VT J10
Phase VT Connection			Wye
Phase VT Secondary			66.4 V
Phase VT Ratio			1.00 :1
Auxiliary VT Connection	Vag	Vag	
Auxiliary VT Secondary	66.4 V	66.4 V	
Auxiliary VT Ratio	1.00 :1	1.00 :1	
Voltage Cutoff Level	1.0 V		

This menu allows the user to specify the parameters for each voltage input. The **Phase VT Ratio** and **Auxiliary VT Ratio** settings are used for calculation of primary metering values or matching primary voltage in a synchrocheck application. The **Phase VT Secondary** and **Auxiliary VT Secondary** settings are used to derive secondary voltage values from the per-unit settings used in protection elements. Protection functions that require phase-to-neutral or zero-sequence quantities do not function correctly for delta VT configurations.

The following voltage input settings are available.

Phase VT Connection

Range: Wye, Delta

Default: Wye

This setting specifies the phase VT connection type for the corresponding voltage input. An open-delta source VT connection would be entered as "Delta".

Phase VT Secondary

Range: 50.0 to 240.0 volts in steps of 0.1

Default: 66.4 volts

This setting specifies the nominal phase VT voltage for the corresponding voltage input. It is typically used to derive secondary voltage values from the per-unit settings used in protection elements.

The typical **Phase VT Secondary** setting is the phase-to-phase secondary voltage appearing at the relay input terminals when nominal voltage is applied to the VT primary. For example, on a system with a 13.8 kV nominal primary voltage and with a 14400:120 V VT in a delta connection, the secondary voltage is (13800 V / 14400) × 120 = 115 V. Thus, the **Phase VT Secondary** setting would be 115 volts.

Phase VT Ratio

Range: 1.00 to 24000.00 in steps of 0.01
Default: 1.00

This setting specifies the phase VT ratio for the corresponding voltage input. It is typically used for calculation of primary metering values or matching primary voltage in a synchrocheck application.

Auxiliary VT Connection

Range: Vag, Vbg, Vcg, Vab, Vbc, Vca, Vn
Default: Vag

This setting specifies the auxiliary VT connection type for the corresponding voltage input.

Auxiliary VT Secondary

Range: 50.0 to 240.0 volts in steps of 0.1
Default: 66.4 volts

This setting specifies the nominal auxiliary VT voltage for the corresponding voltage input. It is typically used to derive secondary voltage values from the per-unit settings used in protection elements.

Auxiliary VT Ratio

Range: 1.00 to 2400.00 in steps of 0.001
Default:

This setting specifies the auxiliary VT ratio for the corresponding voltage input. It is typically used for calculation of primary metering values or matching primary voltage in a synchrocheck application.

Voltage Cutoff Level

Range: 0.1 to 1.0 volts secondary in steps of 0.1
Default: 1.0 volts secondary

This setting specifies 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 C90^{Plus} 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 voltages, auxiliary voltages, and symmetrical components. The cut-off operation applies to quantities used for metering, protection, and control, as well as those used by communications protocols. Raw samples of the voltages available via oscillography are not subject cut-off.

NOTE

Lower the **Voltage Cutoff Level** setting with care as the C90^{Plus} accepts lower signals as valid measurements. Unless dictated otherwise by a specific application, the default setting of "1.0 V" is recommended.

Calculating the power cut-off level

The **Current Cutoff Level** and the **Voltage Cutoff Level** settings are used to determine the metered power cut-off levels. The power cut-off level is calculated as shown here. For delta connections, the power cut-off is calculated as follows:

$$\text{Three-phase power cut-off} = \frac{\sqrt{3} \times \text{Current Cutoff Level} \times \text{Voltage Cutoff Level} \times \text{VT primary} \times \text{CT primary}}{\text{VT secondary}} \quad \textbf{Eq. 4}$$

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

For wye connections, the three-phase and per-phase power cut-off values are calculated as follows:

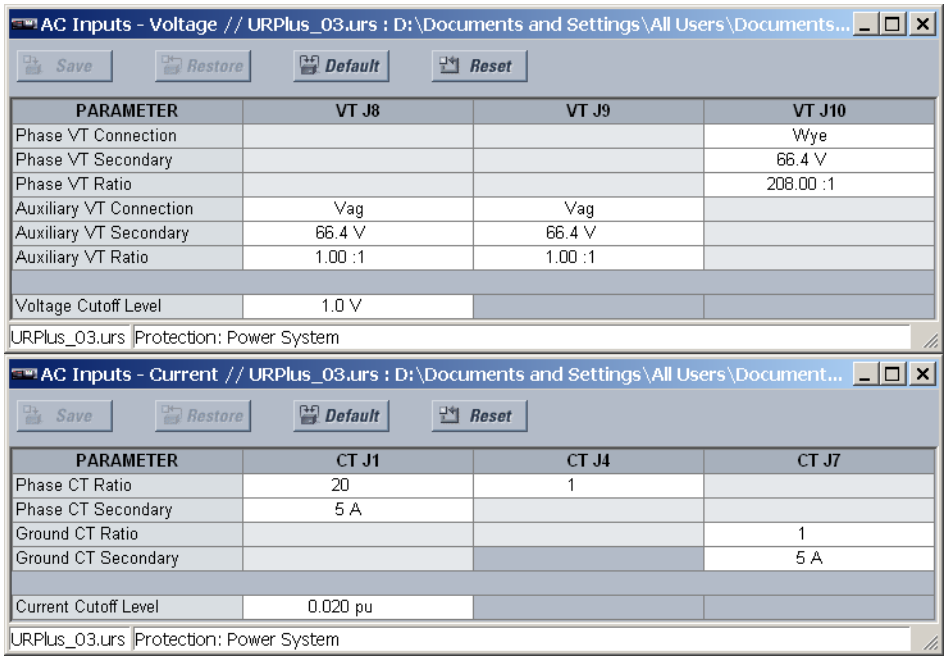
$$\text{Three-phase power cutoff} = \frac{3 \times \text{Current Cutoff Level} \times \text{Voltage Cutoff Level} \times \text{VT primary} \times \text{CT primary}}{\text{VT secondary}} \quad \textbf{Eq. 5}$$

$$\text{Per-phase power cutoff} = \frac{\text{Current Cutoff Level} \times \text{Voltage Cutoff Level} \times \text{VT primary} \times \text{CT primary}}{\text{VT secondary}} \quad \textbf{Eq. 6}$$

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

For example, given the following settings:

Figure 5: Typical power system settings



we have:

- CT primary = **Phase CT Ratio** × **Phase CT Secondary** = 20 × 5 A = 100 A.
- VT primary = **Phase VT Ratio** × **Phase VT Secondary** = 208 × 66.4 V = 13811.2 V.

The power cut-off is therefore:

$$\text{Three-phase power cut-off} = \frac{\sqrt{3} \times \text{Current Cutoff Level} \times \text{Voltage Cutoff Level} \times \text{VT primary} \times \text{CT primary}}{\text{VT secondary}}$$

$$= \frac{\sqrt{3} \times 0.02 \text{ pu} \times 1.0 \text{ V} \times 100 \text{ A} \times 13811.2 \text{ V}}{66.4 \text{ V}}$$

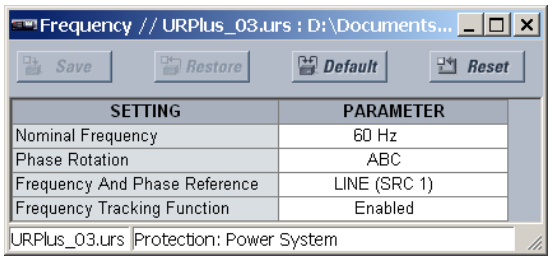
$$= 720.5 \text{ W} \quad \textbf{Eq. 7}$$

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

Power system frequency

Select the **Settings > Protection > Power System > Frequency** menu item to open the power system frequency configuration window.

Figure 6: System frequency configuration settings



The following settings are available.

Nominal Frequency

Range: 50 Hz, 60 Hz

Default: 60 Hz

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

Phase Rotation

Range: ABC, ACB

Default: ABC

The phase sequence of the power system is required to properly calculate sequence components and power parameters. This setting matches the power system phase sequence and informs the relay of the actual system phase sequence, either ABC or ACB. The C90^{Plus} AC inputs (labeled as A, B, and C) must be connected to system phases A, B, and C for correct operation.

Frequency and Phase Reference

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)

Default: LINE (SRC 1)

This setting determines which signal source is used (and hence which AC signal) for phase angle reference. The AC signal used is prioritized based on the inputs configured for the signal source. Phase voltages takes precedence, followed by auxiliary voltage, then phase currents, and finally ground current. For three-phase selection, phase A is used for angle referencing ($V_{ANGLE_REF} = V_A$), while the Clarke transformation of the phase signals is used for frequency metering and tracking ($V_{FREQ} = (2V_A - V_B - V_C) / 3$) for better performance during fault, open pole, and VT and CT fail conditions.

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

The reference signal phase angle 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^{Plus}-series devices if they have the same AC signal reference. These results in very precise correlation of time tagging in the event recorder between different UR^{Plus}-series devices provided the relays have an IRIG-B connection.

Frequency Tracking

Range: Disabled, Enabled

Default: Enabled

This setting is set to "Disabled" only in unusual circumstances; consult GE Digital Energy for special variable-frequency applications.

About AC sources

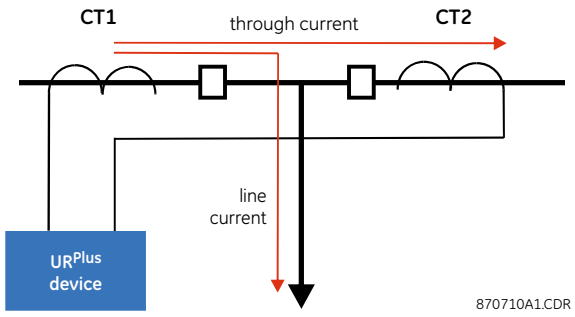
The C90^{Plus} can be used on systems with breaker-and-a-half or ring bus configurations. In these applications, each of the two three-phase sets of individual phase currents (one associated with each breaker) can be used as an input to a breaker failure element. The sum of both breaker phase currents and 3I_0 residual currents may be required for the circuit relaying and metering functions. For a three-winding transformer application, it may be necessary to calculate watts and vars for each of the three windings, using voltage from different sets of VTs. These requirements can be satisfied with a single C90^{Plus} equipped with sufficient CT and VT input channels by selecting the appropriate parameter measurement. A mechanism is provided to specify the AC parameter (or group of parameters) used as the input to the protection and control comparators and some metering elements.

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

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

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

Figure 7: Breaker-and-a-half scheme



In conventional analog or electronic relays, the sum of the currents is obtained from an appropriate external connection of all CTs through which any portion of the current for the element being protected could flow. Auxiliary CTs are required to perform ratio matching if the ratios of the primary CTs to be summed are not identical. In the C90^{Plus}, provisions have been included for all the current signals to be brought to the C90^{Plus} device where grouping, ratio correction and summation are applied internally via configuration settings. A major advantage of using internal summation is that the individual currents are available to the protection device; for example, as additional information to calculate a restraint current, or to allow the provision of additional protection features that operate on the individual currents such as breaker failure.

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

The internal grouping of current and voltage signals forms an internal source. This source can be given a specific name through the settings, and becomes available to protection and metering element in the C90^{Plus}. Individual names can be assigned to each source to clearly identify them for later use. For example, in the scheme shown above, a source configured as the sum of CT1 and CT2 can be assigned the name “Line Current”.

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

CT/VT input channel configuration

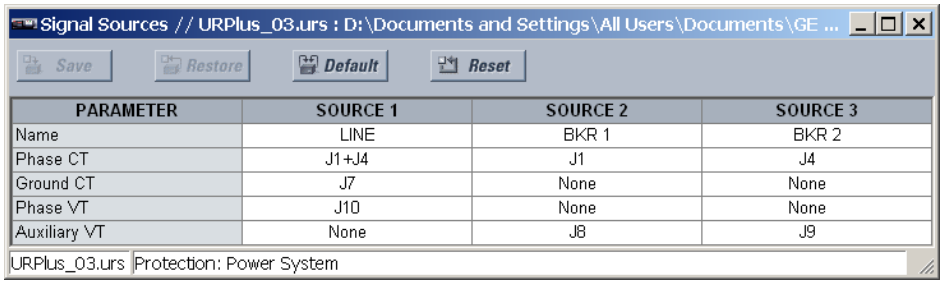
The previous section explains how the input channels are identified and configured to the specific application instrument transformers and the connections of these transformers. The specific parameters to be used by each measuring element and comparator, and some actual values are controlled by selecting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

The source is a logical group of current and voltage input channels selected by the user to facilitate this selection. With this mechanism, a user does not have to make multiple selections of voltage and current for those elements that need both parameters, such as a distance element or a watt calculation. It also gathers associated parameters for display purposes. The basic idea of arranging a source is to select a point on the power system where information is of interest. An application example of the grouping of parameters in a source is a transformer winding, on which a three-phase voltage is measured, and the sum of the currents from CTs on each of two breakers is required to measure the winding current flow.

Signal source settings

Select the **Settings > Protection > Power System > Signal Sources** menu item to open the protection sources configuration window.

Figure 8: Protection sources configuration settings



PARAMETER	SOURCE 1	SOURCE 2	SOURCE 3
Name	LINE	BKR 1	BKR 2
Phase CT	J1+J4	J1	J4
Ground CT	J7	None	None
Phase VT	J10	None	None
Auxiliary VT	None	J8	J9

Settings are available for all three sources. The “LINE”, “BKR1”, and “BKR2” text items can be replaced by with a user-defined name to uniquely identify the associated source.

It is possible to select the sum of two CTs for a protection source. The first channel displayed is the CT to which all others will be referred. For example, the selection “J1+J4” indicates the sum of each phase from channels J1 and J4, scaled to whichever CT has the higher ratio.

To configure the protection sources:

1. Specify the ratio and nominal secondary current for each CT input.
2. Specify the connection type, ratio, and nominal secondary voltage for each VT input.
3. Specify the configuration for each source, including the CTs to be summed together.

The following settings are available for each protection source.

Name

Range: up to 20 alphanumeric characters
Default: LINE

This setting specifies a name for the protection source.

Phase CT

Range: None, J1, J4, J1+J4, etc.
Default: J1+J4

This setting selects a phase CT or sum of phase CTs to represent the protection source.

Ground CT

Range: None, J7
Default: J7

This setting selects a ground CT to represent the protection source.

Phase VT

Range: None, J10
Default: J10

This setting selects a phase VT to represent the protection source.

Auxiliary VT

Range: None, J8, J9
Default: None

This setting selects an auxiliary VT to represent the protection source.

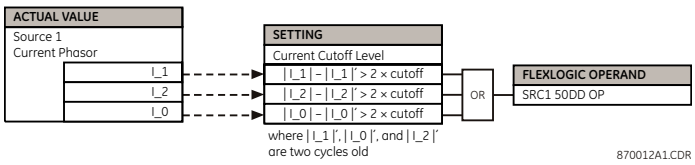
Internal disturbance detection

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

The disturbance detector responds to the changes in magnitude of the sequence currents. The disturbance detector also responds to the change in currents of twice the current cut-off level. The default cut-off threshold is 0.02 pu. As such, the disturbance detector responds to a change of 0.04 pu by default. The **Current Cutoff** setting (located in the **Settings > Protection > Power System > AC Input - Current** menu) controls the metering sensitivity of the disturbance detector.

The figure shows the source 1 disturbance detector logic. The logic is identical for all three sources.

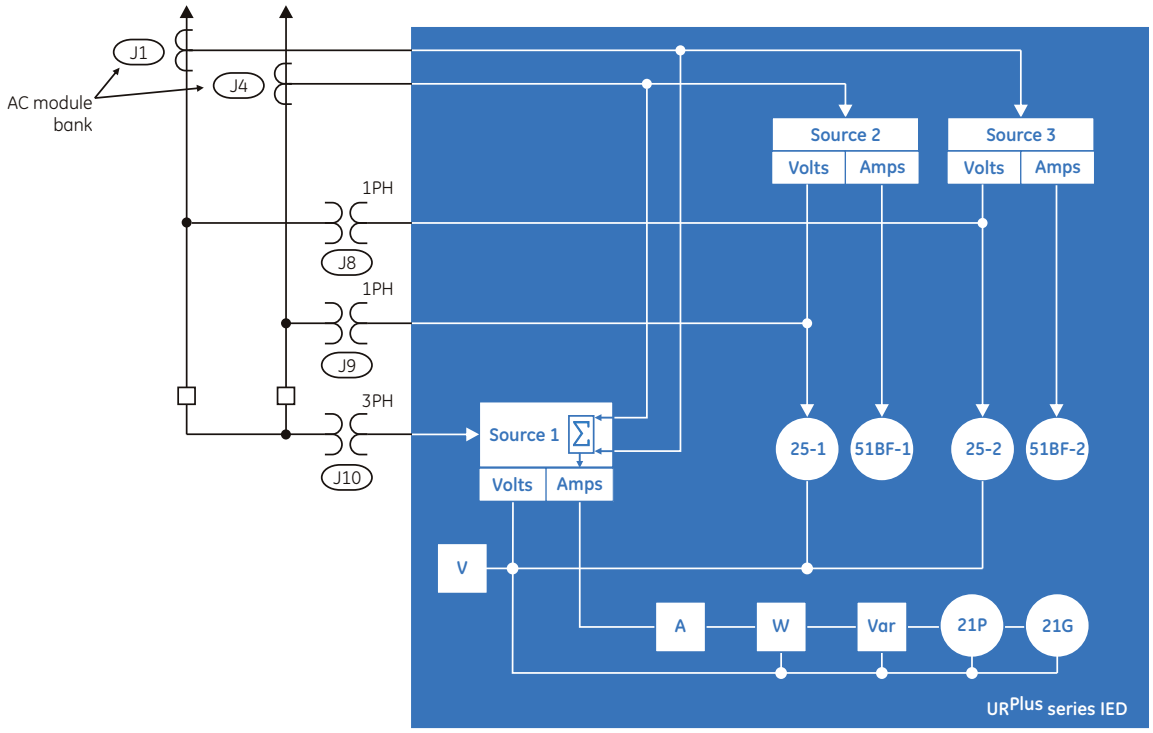
Figure 9: Disturbance detector logic scheme



Example use of sources

Consider a C90^{Plus} connected as shown. This configuration can be used on a transmission line connected into a breaker-and-a-half system. The figure shows the arrangement of sources used to provide the functions required in this application, and the AC module inputs used to provide the data.

Figure 10: Example use of sources



Grouped protection elements

Each protection element can be assigned up to six different sets of settings according to setting group designations 1 to 6. The performance of these elements is defined by the active setting group at a given time. Multiple setting groups allow the user to conveniently change protection settings for different operating situations (for example, altered power system configuration or season of the year). The active setting group can be preset or selected via the **Settings > Protection > Control > Setting Groups** menu item.

Current elements

This section outlines the current element settings.

Overview of time overcurrent curves

The inverse time overcurrent curves used by the time overcurrent elements are the IEEE, IEC, GE Type IAC, and I^2t standard curve shapes. This allows for simplified coordination with downstream devices. If however, none of these curve shapes is adequate, FlexCurves can be used to customize the inverse time curve characteristics. The definite time curve is also an option that may be appropriate if only simple protection is required.

The following overcurrent curve types are available:

- IEEE Extremely Inverse
- IEEE Very Inverse

- IEEE Moderately Inverse
- IEC Curve A (BS142)
- IEC Curve B (BS142)
- IEC Curve C (BS142)
- IAC Extremely Inverse
- IAC Very Inverse
- IAC Inverse
- IAC Short Inverse
- I^2t
- FlexCurves A, B, C, and D
- Recloser curves
- Definite Time

A multiplier (time dial) setting allows selection of a multiple of the base curve shape (where the time dial multiplier = 1) with the curve shape setting. Unlike the electromechanical time dial equivalent, operate times are directly proportional to the time multiplier setting value. For example, all times for a multiplier of 10 are 10 times the multiplier 1 or base curve values. Setting the multiplier to zero results in an instantaneous response to all current levels above pickup.

Time overcurrent time calculations are made with an internal energy capacity memory variable. When this variable indicates that the energy capacity has reached 100%, a time overcurrent element will operate. If less than 100% energy capacity is accumulated in this variable and the current falls below the dropout threshold of 97 to 98% of the pickup value, the variable must be reduced. Two methods of this resetting operation are available: instantaneous and timed. The instantaneous method 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 method can be used where the relay must coordinate with electromechanical relays.

IEEE curves

The IEEE time overcurrent curve shapes conform to industry standards and the IEEE C37.112-1996 curve classifications for extremely, very, and moderately inverse curves. The IEEE curves are derived by the operate and reset time equations.

$$T = \text{TDM} \times \left[\frac{A}{\left(\frac{I}{I_{pickup}} \right)^{p} - 1} + B \right] \qquad \textbf{Eq. 8}$$

$$T_{reset} = \text{TDM} \times \left[\frac{t_r}{1 - \left(\frac{I}{I_{pickup}} \right)^{2}} \right] \qquad \textbf{Eq. 9}$$

where

- $T_{operate}$ represents the operate time in seconds
- TDM represents the multiplier setting
- I represents the input current
- I_{pickup} represents the pickup current setting value
- A, B, and p are constants and are defined in the table
- T_{reset} represents reset time in seconds, assuming the energy capacity is 100% and the reset mode is timed
- t_r represents the characteristic constant and is defined in the table

Table 1: IEEE inverse time curve constants

IEEE curve shape	*A*	*B*	*p*	t_r
Extremely inverse	28.2	0.1217	2.0000	29.1
Very inverse	19.61	0.491	2.0000	21.6
Moderately inverse	0.0515	0.1140	0.020000	4.85

Table 2: IEEE curve trip times (in seconds)

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

IEC curves

For European applications, the C90^{Plus} offers three standard curves defined in IEC 255-4 and British standard BS142. These are defined as IEC curves A, B, and C. The IEC curves are derived by the operate and reset time equations.

$$T_{operate} = \text{TDM} \times \frac{K}{\left(\frac{I}{I_{pickup}}\right)^{E} - 1} \qquad \textbf{Eq. 10}$$

$$T_{reset} = \text{TDM} \times \frac{t_r}{1 - \left(\frac{I}{I_{pickup}}\right)^{2}} \qquad \textbf{Eq. 11}$$

where

- $T_{operate}$ represents the operate time in seconds
- TDM represents the multiplier setting
- I represents the input current
- I_{pickup} represents the pickup current setting value
- K and E are constants and are defined in the table
- T_{reset} represents reset time in seconds, assuming the energy capacity is 100% and the reset mode is timed
- t_r represents the characteristic constant and is defined in the table

Table 3: IEC (BS) inverse time curve constants

IEC 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 4: IEC (BS) curve trip times (in seconds)

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

IAC curves

The curves for the General Electric type IAC relay family are derived as follows:

$$T_{operate} = \text{TDM} \times \left(A + \frac{B}{\left(\frac{I}{I_{pickup}} - C \right)} + \frac{D}{\left(\frac{I}{I_{pickup}} - C \right)^2} + \frac{E}{\left(\frac{I}{I_{pickup}} - C \right)^3} \right) \quad \textbf{Eq. 12}$$

$$T_{reset} = \text{TDM} \times \frac{t_r}{1 - \left(\frac{I}{I_{pickup}} \right)^2} \quad \textbf{Eq. 13}$$

where

- $T_{operate}$ represents the operate time in seconds
- TDM represents the multiplier setting

- I represents the input current
- I_{pickup} represents the pickup current setting value
- A to E are constants and are defined in the table
- T_{reset} represents reset time in seconds, assuming the energy capacity is 100% and the reset mode is timed
- t_r represents the characteristic constant and is defined in the table

Table 5: GE type IAC inverse time curve constants

IAC curve shape	*A*	*B*	*C*	*D*	*E*	t_r
IAC extreme inverse	0.0040	0.6379	0.6200	1.7872	0.2461	6.008
IAC very inverse	0.0900	0.7955	0.1000	–1.2885	7.9586	4.678
IAC inverse	0.2078	0.8630	0.8000	–0.4180	0.1947	0.990
IAC short inverse	0.0428	0.0609	0.6200	–0.0010	0.0221	0.222

Table 6: GE type IAC 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
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:

$$T_{operate} = \text{TDM} \times \frac{100}{\left(\frac{I}{I_{pickup}}\right)^2} \qquad \textbf{Eq. 14}$$

$$T_{reset} = \text{TDM} \times \frac{100}{\left(\frac{I}{I_{pickup}}\right)^{-2}} \qquad \textbf{Eq. 15}$$

where

- $T_{operate}$ represents the operate time in seconds
- TDM represents the multiplier setting
- I represents the input current

- I_{pickup} represents the pickup current setting value
- T_{reset} represents reset time in seconds, assuming the energy capacity is 100% and the reset mode is timed

Table 7: I^2t 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
0.01	0.44	0.25	0.11	0.06	0.04	0.03	0.02	0.02	0.01	0.01
0.10	4.44	2.50	1.11	0.63	0.40	0.28	0.20	0.16	0.12	0.10
1.00	44.44	25.00	11.11	6.25	4.00	2.78	2.04	1.56	1.23	1.00
10.00	444.44	250.00	111.11	62.50	40.00	27.78	20.41	15.63	12.35	10.00
100.00	4444.4	2500.0	1111.1	625.00	400.00	277.78	204.08	156.25	123.46	100.00
600.00	26666.7	15000.0	6666.7	3750.0	2400.0	1666.7	1224.5	937.50	740.74	600.00

FlexCurves

The custom FlexCurve shapes are defined as follows:

$$T_{operate} = \text{TDM} \times \text{FlexCurve time at } \frac{I}{I_{pickup}} \text{ when } \frac{I}{I_{pickup}} \geq 1.00 \quad \textbf{Eq. 16}$$

$$T_{reset} = \text{TDM} \times \text{FlexCurve time at } \frac{I}{I_{pickup}} \text{ when } \frac{I}{I_{pickup}} \leq 0.98 \quad \textbf{Eq. 17}$$

where

- $T_{operate}$ represents the operate time in seconds
- TDM represents the multiplier setting
- I represents the input current
- I_{pickup} represents the pickup current setting value
- T_{reset} represents reset time in seconds, assuming the energy capacity is 100% and the reset mode is timed

Definite time curve

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

$$T_{operate} = \text{TDM in seconds, where } I > I_{pickup} \quad \textbf{Eq. 18}$$

$$T_{reset} = \text{TDM in seconds} \quad \textbf{Eq. 19}$$

where

- $T_{operate}$ represents the operate time in seconds
- TDM represents the multiplier setting
- I represents the input current
- I_{pickup} represents the pickup current setting value
- T_{reset} represents reset time in seconds, assuming the energy capacity is 100% and the reset mode is timed

Recloser curves

The C90^{Plus} uses the FlexCurve feature to facilitate the programming of 41 recloser curves. See the *FlexCurves* settings section for details on the recloser curves.

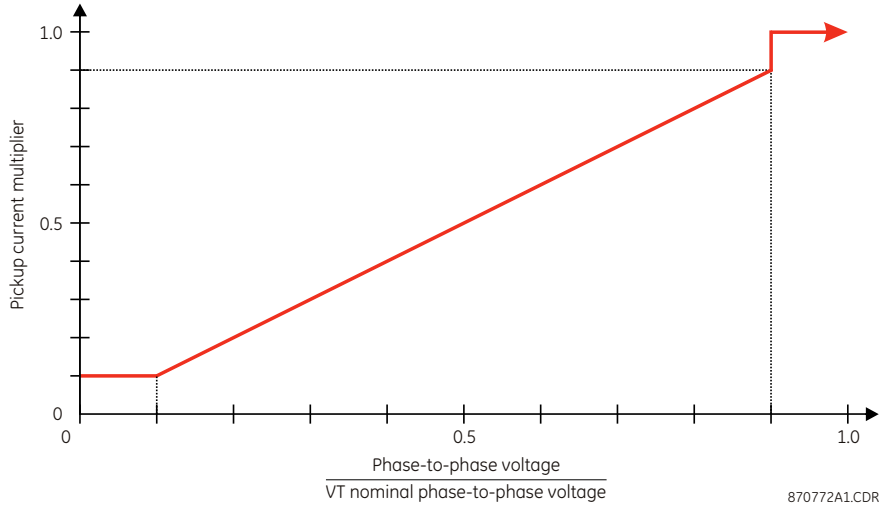
Phase time overcurrent

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

Two methods of resetting operation are available: timed and instantaneous. For example, if the element reset characteristic is set to instantaneous and the element is blocked, the time accumulator is cleared immediately.

The phase time overcurrent pickup can be dynamically reduced by a voltage restraint feature. This is accomplished via the multipliers corresponding to the phase-to-phase voltages of the voltage restraint characteristic curve. The pickup level is calculated as multiplier value times the programmed pickup. If the voltage restraint feature is disabled, the pickup level always remains at the set value.

Figure 11: Phase time overcurrent voltage restraint characteristic



Select the **Settings > Protection > Elements > Group 1 > Current > Phase TOC** menu item to open the phase time overcurrent configuration window.

Figure 12: Phase time overcurrent configuration settings

Phase TOC // URPlus_03.urs : D:\Documents and Settings\All Users\Documents\GE Po...

Save | Restore | Default | Reset

PARAMETER	PHASE TOC1	PHASE TOC2
Function	Disabled	Disabled
Signal Source	LINE (SRC 1)	LINE (SRC 1)
Input	Phasor	Phasor
Pickup	1.000 pu	1.000 pu
Curve	IEEE Mod Inv	IEEE Mod Inv
TD Multiplier	1.00	1.00
Reset	Instantaneous	Instantaneous
Voltage Restraint	Disabled	Disabled
Block A	OFF	OFF
Block B	OFF	OFF
Block C	OFF	OFF
Events	Disabled	Disabled

URPlus_03.urs | Protection: Elements: Group 1: Current

The following settings are available for each phase time overcurrent element.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the phase time overcurrent protection element.

Signal Source

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)
Default: LINE (SRC 1)

This setting selects the signal source for the phase time overcurrent protection element.

Input

Range: Phasor, RMS
Default: Phasor

This setting selects how phase current input quantities are interpreted by the C90^{Plus}. Inputs can be selected as fundamental phasor magnitudes or total waveform RMS magnitudes as required by the application.

Pickup

Range: 0.000 to 30.000 pu in steps of 0.001
Default: 1.000 pu

This setting specifies the phase time overcurrent pickup level in per-unit values.

Curve

Range: IEEE Mod Inv, IEEE Very Inv, IEEE Ext Inv, IEC Curve A, IEC Curve B, IEC Curve C, IEC Short Inv, IAC Ext Inv, IAC Very Inv, IAC Inverse, IAC Short Inv, I2t, Definite Time, FlexCurve A, FlexCurve B, FlexCurve C, FlexCurve D
Default: IEEE Mod Inv

This setting selects the time inverse overcurrent curve style.

TD Multiplier

Range: 0.00 to 600.00 in steps of 0.01
Default: 1.00

This setting specifies a multiple of the base curve shape specified by the **Curve** setting. Programming this value to zero results in an instantaneous response to all current levels above pickup.

Reset

Range: Instantaneous, Timed
Default: Instantaneous

The “Instantaneous” reset method 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” reset method can be used where the relay must coordinate with electromechanical relays.

Voltage Restraint

Range: Enabled, Disabled
Default:

This setting enables and disabled the phase time overcurrent voltage restraint feature.

Block A

Range: any FlexLogic operand or shared operand
Default: Off

Assertion of the operand assigned to this setting blocks phase A of the phase time overcurrent element.

Block B

Range: any FlexLogic operand or shared operand

Default: Off

Assertion of the operand assigned to this setting blocks phase B of the phase time overcurrent element.

Block C

Range: any FlexLogic operand or shared operand

Default: Off

Assertion of the operand assigned to this setting blocks phase C of the phase time overcurrent element.

Events

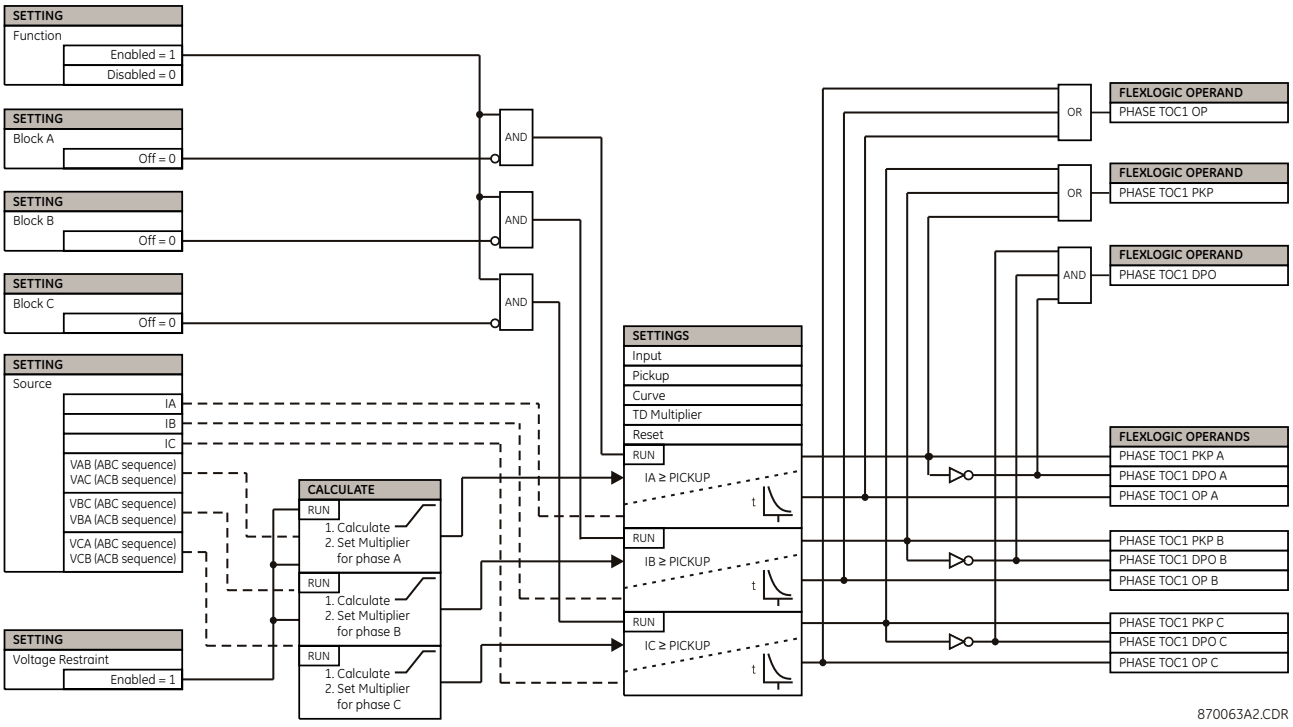
Range: Enabled, Disabled

Default: varies with UR^{Plus}-series model; refer to the EnerVista UR^{Plus} Setup software

This setting enables and disables the logging of phase time overcurrent events in the sequence of events recorder.

The logic for the phase time overcurrent 1 element is shown as follows. The logic is identical for all phase instantaneous overcurrent elements.

Figure 13: Phase time overcurrent 1 scheme logic

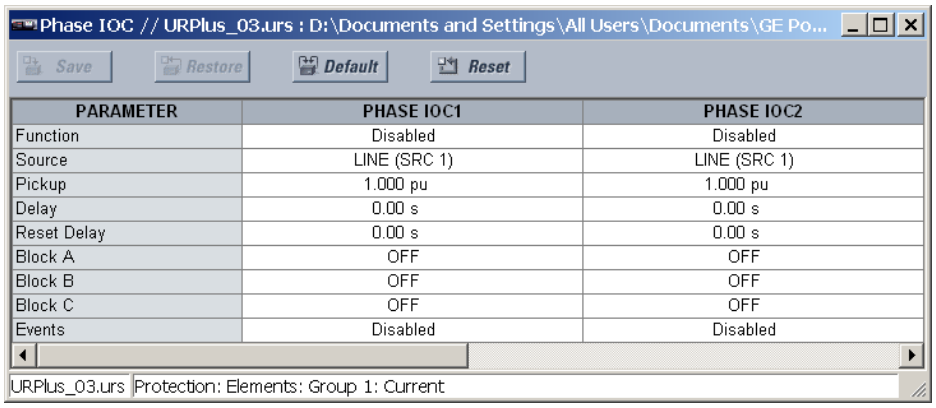


Phase instantaneous overcurrent

The phase instantaneous overcurrent element can be used as an instantaneous element with no intentional delay or as a definite time element. The input current is the fundamental phasor magnitude.

Select the **Settings > Protection > Elements > Group 1 > Current > Phase IOC** menu item to open the phase instantaneous overcurrent configuration window.

Figure 14: Phase instantaneous overcurrent configuration settings



The following settings are available for each phase instantaneous overcurrent element.

Function

Range: Enabled, Disabled

Default: Disabled

This setting enables and disables the phase instantaneous overcurrent protection element.

Source

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)

Default: LINE (SRC 1)

This setting selects the signal source for the phase instantaneous overcurrent protection element.

Pickup

Range: 0.000 to 30.000 pu in steps of 0.001

Default: 1.000 pu

This setting specifies the phase instantaneous overcurrent pickup level in per-unit values.

Delay

Range: 0.00 to 600.00 seconds in steps of 0.01

Default: 0.00 seconds

This setting delays the assertion of the PHASE IOC OP operands. It is used to achieve timing coordination with other elements and relays.

Reset Delay

Range: 0.00 to 600.00 seconds in steps of 0.01

Default: 0.00 seconds

This setting specifies a delay for the reset of the phase instantaneous overcurrent element between the operate output state and the return to logic 0 after the input passes outside the defined pickup range. This setting is used to ensure that the relay output contacts are closed long enough to ensure reception by downstream equipment.

Block A, Block B, Block C

Range: any FlexLogic operand or shared operand

Default: Off

Assertion of the operand assigned to these settings blocks phases A, B, and C, respectively, of the phase instantaneous overcurrent element.

Events

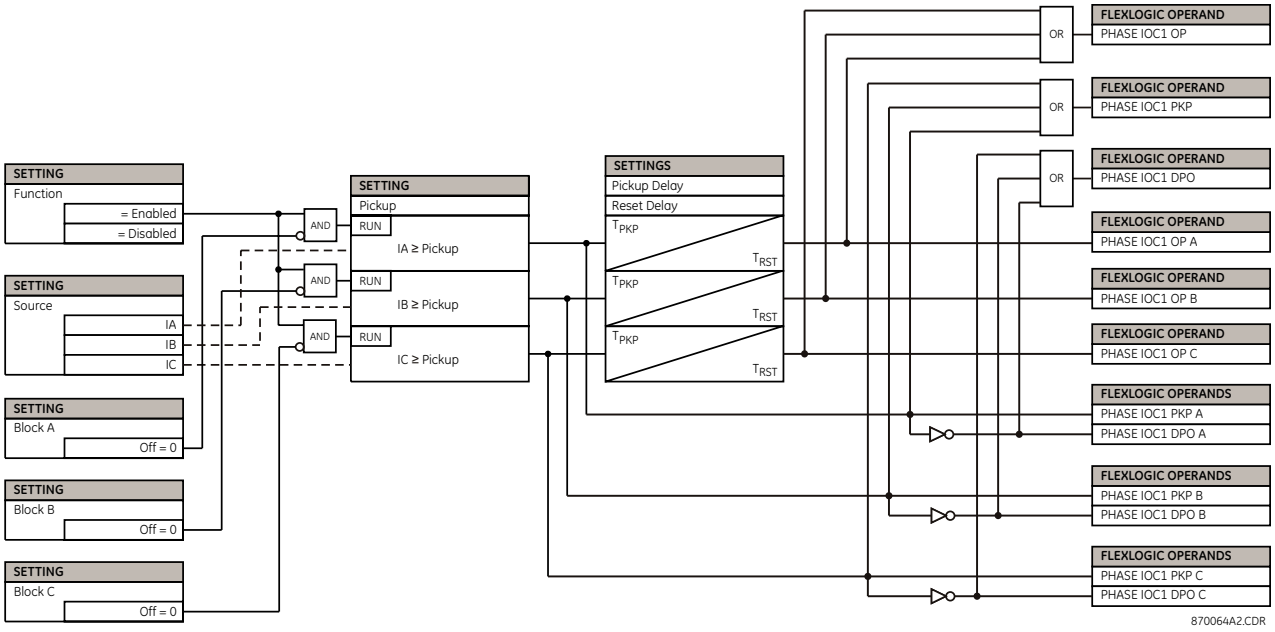
Range: Enabled, Disabled

Default: varies with UR^{Plus}-series model; refer to the EnerVista UR^{Plus} Setup software

This setting enables and disables the logging of phase instantaneous overcurrent events in the sequence of events recorder.

The figure shows the logic for the phase instantaneous overcurrent 1 element. The logic is identical for all phase instantaneous overcurrent elements.

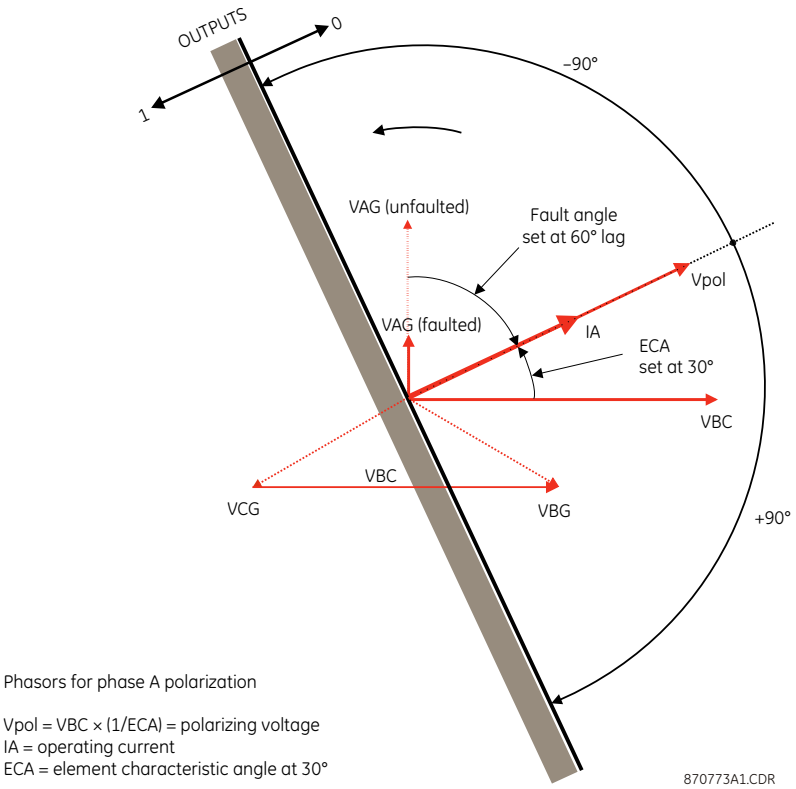
Figure 15: Phase instantaneous overcurrent 1 scheme logic



Phase directional overcurrent

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

Figure 16: Phase A directional polarization



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

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

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

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

Table 8: Phase directional overcurrent operating and polarizing signals

Phase	Operating signal	Polarizing signal	
		ABC phase sequence	ACB phase sequence
A	angle of IA	angle of VBC × (1∠ECA)	angle of VCB × (1∠ECA)
B	angle of IB	angle of VCA × (1∠ECA)	angle of VAC × (1∠ECA)
C	angle of IC	angle of VAB × (1∠ECA)	angle of VBA × (1∠ECA)

When the phase directional overcurrent element is disabled or the operating current is below 5% × CT nominal, the element output is logic 0.

When the phase directional overcurrent element is enabled, the operating current is above 5% × CT nominal, and the polarizing voltage is above the **Voltage Cut Off Level** setting value, the element output is dependent on the phase angle between the operating and polarizing signals. The element output is logic 0 when the operating current is within polarizing voltage ±90°; for all other angles, the element output is logic 1.

Once the voltage memory has expired, the phase overcurrent elements under directional control can be set to block or trip on overcurrent. When the **Block When Voltage Memory Expires** value is "Yes", the directional element will block the operation of any phase overcurrent element under directional control when voltage memory expires. When the **Block When Voltage Memory Expires** value is "No", the directional element allows tripping of phase overcurrent elements under directional control when voltage memory expires.

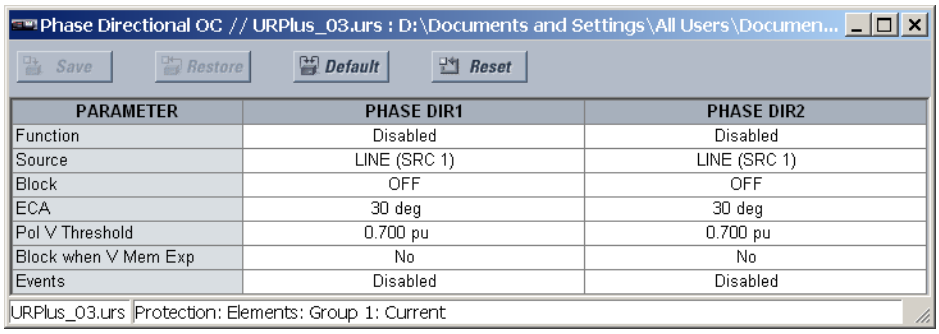
In all cases, directional blocking is permitted to resume when the polarizing voltage becomes greater than the polarizing voltage threshold.

NOTE

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

Select the **Settings > Protection > Elements > Group 1 > Current > Phase Directional OC** menu item to open the phase directional overcurrent configuration window.

Figure 17: Phase directional overcurrent configuration settings



PARAMETER	PHASE DIR1	PHASE DIR2
Function	Disabled	Disabled
Source	LINE (SRC 1)	LINE (SRC 1)
Block	OFF	OFF
ECA	30 deg	30 deg
Pol V Threshold	0.700 pu	0.700 pu
Block when V Mem Exp	No	No
Events	Disabled	Disabled

The following settings are available for each phase directional overcurrent element.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the phase directional overcurrent protection element.

Source

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)
Default: LINE (SRC 1)

This setting is used to select the source for the operating and polarizing signals. The operating current for the phase directional element is the phase current for the selected current source. The polarizing voltage is the line voltage from the phase VTs, based on the 90° or quadrature connection and shifted in the leading direction by the element characteristic angle (ECA).

Block

Range: any FlexLogic operand or shared operand
Default: Off

Assertion of the operand assigned to this setting blocks operation of the phase directional overcurrent element.

ECA

Range: 0 to 359° in steps of 1
Default: 30°

This setting specifies the element characteristic angle; that is, the angle by which the polarizing voltage is shifted in the leading direction to achieve dependable operation. In the design of the C90^{Plus} protection elements, a block is applied to an element by asserting logic 1 at the blocking input. The phase directional overcurrent element should be programmed via this setting so that the output is logic 1 for current in the non-tripping direction.

Polarizing Voltage Threshold

Range: 0.000 to 3.000 pu in steps of 0.001
Default: 0.700 pu

This setting is used to establish the minimum level of voltage for which the phase angle measurement is reliable. The setting is based on VT accuracy.

Block When Voltage Memory Expires

Range: Yes, No
Default: No

This setting is used to select the required operation upon expiration of voltage memory. When set to "Yes", the directional element blocks the operation of any phase overcurrent element under directional control, when voltage memory expires; when set to "No", the directional element allows tripping of phase overcurrent elements under directional control.

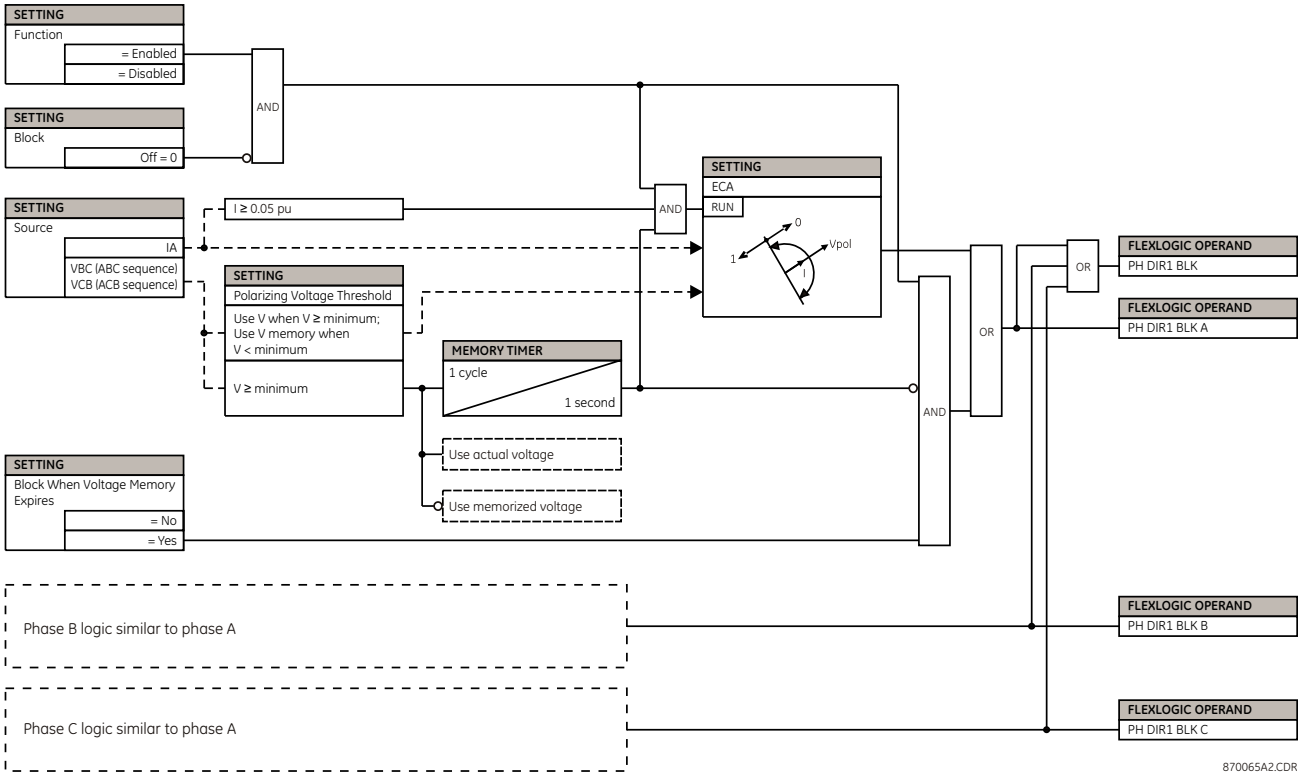
Events

Range: Enabled, Disabled
Default: varies with UR^{Plus}-series model; refer to the EnerVista UR^{Plus} Setup software

This setting enables and disables the logging of phase directional overcurrent events in the sequence of events recorder.

The figure shows the logic for the phase directional overcurrent 1 element. The logic is identical for all phase directional overcurrent elements.

Figure 18: Phase directional overcurrent 1 scheme logic



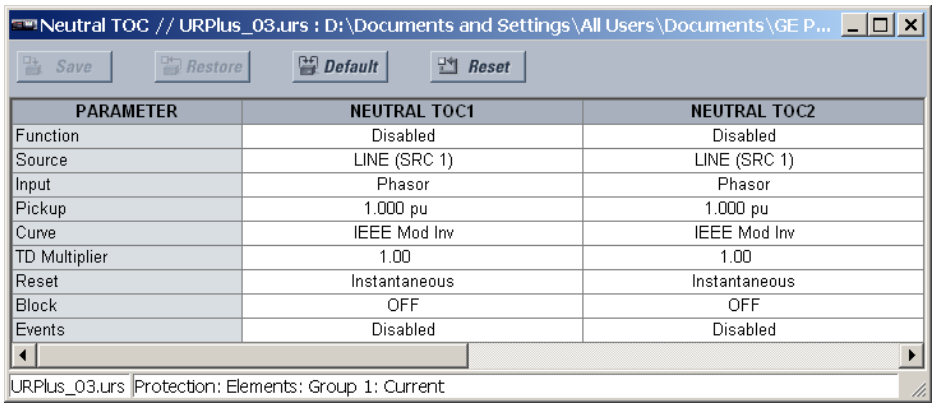
Neutral time overcurrent

The neutral time overcurrent element can provide a desired time-delay operating characteristic versus the applied current or be used as a simple definite time element. The neutral current input value is a quantity calculated as 3I_0 from the phase currents and may be programmed as fundamental phasor magnitude or total waveform RMS magnitude as required by the application.

Two methods of resetting operation are available: timed and instantaneous. When the element is blocked, the time accumulator resets according to the reset characteristic. For example, if the element reset characteristic is instantaneous and the element is blocked, the time accumulator is cleared immediately.

Select the **Settings > Protection > Elements > Group 1 > Current > Neutral TOC** menu item to open the neutral time overcurrent configuration window.

Figure 19: Neutral time overcurrent configuration settings



PARAMETER	NEUTRAL TOC1	NEUTRAL TOC2
Function	Disabled	Disabled
Source	LINE (SRC 1)	LINE (SRC 1)
Input	Phasor	Phasor
Pickup	1.000 pu	1.000 pu
Curve	IEEE Mod Inv	IEEE Mod Inv
TD Multiplier	1.00	1.00
Reset	Instantaneous	Instantaneous
Block	OFF	OFF
Events	Disabled	Disabled

The following settings are available for each neutral time overcurrent element.

Function

Range: Enabled, Disabled

Default: Disabled

This setting enables and disables the neutral time overcurrent protection element.

Source

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)

Default: LINE (SRC 1)

This setting selects the signal source for the neutral time overcurrent protection element.

Input

Range: Phasor, RMS

Default: Phasor

This setting selects how neutral current input quantities are interpreted by the C90^{Plus}. Inputs can be selected as fundamental phasor magnitudes or total waveform RMS magnitudes as required by the application.

Pickup

Range: 0.000 to 30.000 pu in steps of 0.001

Default: 1.000 pu

This setting specifies the neutral time overcurrent pickup level in per-unit values.

Curve

Range: IEEE Mod Inv, IEEE Very Inv, IEEE Ext Inv, IEC Curve A, IEC Curve B, IEC Curve C, IEC Short Inv, IAC Ext Inv, IAC Very Inv, IAC Inverse, IAC Short Inv, I2t, Definite Time, FlexCurve A, FlexCurve B, FlexCurve C, FlexCurve D

Default: IEEE Mod Inv

This setting selects the inverse time overcurrent curve style.

TD Multiplier

Range: 0.00 to 600.00 in steps of 0.01

Default: 1.00

This setting specifies a multiple of the base curve shape specified by the **Curve** setting. Programming this value to zero results in an instantaneous response to all current levels above pickup.

Reset

Range: Instantaneous, Timed

Default: Instantaneous

The "Instantaneous" reset method 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" reset method can be used where the relay must coordinate with electromechanical relays.

Block

Range: any FlexLogic operand or shared operand

Default: Off

Assertion of the operand assigned to this setting blocks operation of the neutral time overcurrent element.

Events

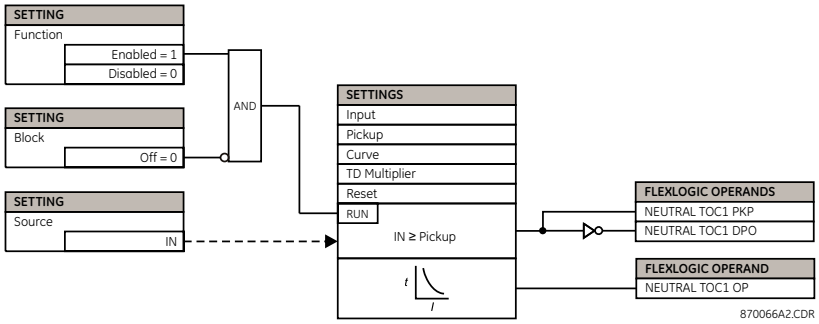
Range: Enabled, Disabled

Default: varies with UR^{Plus}-series model; refer to the EnerVista UR^{Plus} Setup software

This setting enables and disables the logging of neutral time overcurrent events in the sequence of events recorder.

The figure shows the logic for the neutral time overcurrent 1 element. The logic is identical for all neutral time overcurrent elements.

Figure 20: Neutral time overcurrent 1 logic



Neutral instantaneous overcurrent

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

$$I_{op} = 3 \times (I_0 - K \times I_1), \text{ where } k = \frac{1}{16} \qquad \textbf{Eq. 20}$$

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

- System unbalances under heavy load conditions
- Transformation errors of current transformers (CTs) during double-line and three-phase faults
- Switch-off transients during double-line and three-phase faults

The positive-sequence restraint must be considered when testing for pickup accuracy and response time (multiple of pickup). The operating quantity depends on how test currents are injected into the relay. For single-phase injection, the operating quantity is

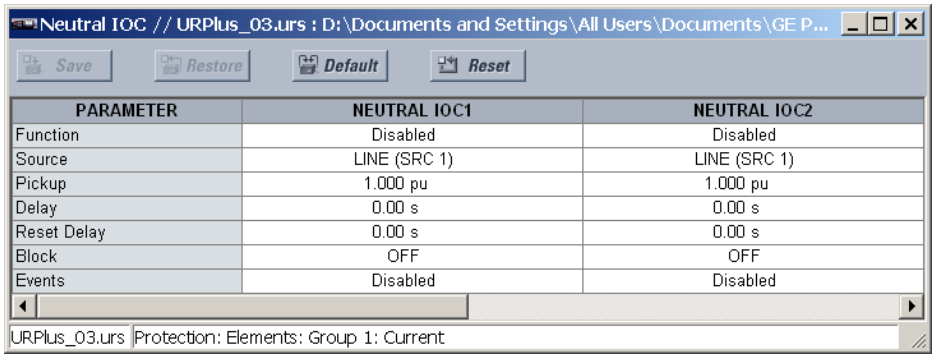
$$I_{op} = 0.9375 \times I_{injected} \qquad \textbf{Eq. 21}$$

For three-phase pure zero-sequence injection, the operating quantity is

$$I_{op} = 3 \times I_{injected} \qquad \textbf{Eq. 22}$$

Select the **Settings > Protection > Elements > Group 1 > Current > Neutral IOC** menu item to open the neutral instantaneous overcurrent configuration window.

Figure 21: Neutral instantaneous overcurrent configuration settings



The following settings are available for each neutral instantaneous overcurrent element.

Function

Range: Enabled, Disabled

Default: Disabled

This setting enables and disables the neutral instantaneous overcurrent protection element.

Source

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)

Default: LINE (SRC 1)

This setting selects the signal source for the neutral instantaneous overcurrent protection element.

Pickup

Range: 0.000 to 30.000 pu in steps of 0.001

Default: 1.000 pu

This setting specifies the neutral instantaneous overcurrent pickup level in per-unit values.

Delay

Range: 0.00 to 600.00 seconds in steps of 0.01

Default: 0.00 seconds

This setting delays the assertion of the NEUTRAL IOC OP operands. It is used to achieve timing coordination with other elements and relays.

Reset Delay

Range: 0.00 to 600.00 seconds in steps of 0.01

Default: 0.00 seconds

This setting specifies a delay for the reset of the neutral instantaneous overcurrent element between the operate output state and the return to logic 0 after the input passes outside the defined pickup range. This setting is used to ensure that the relay output contacts are closed long enough to ensure reception by downstream equipment.

Block

Range: any FlexLogic operand or shared operand

Default: Off

Assertion of the operand assigned to this setting blocks operation of the neutral instantaneous overcurrent element.

Events

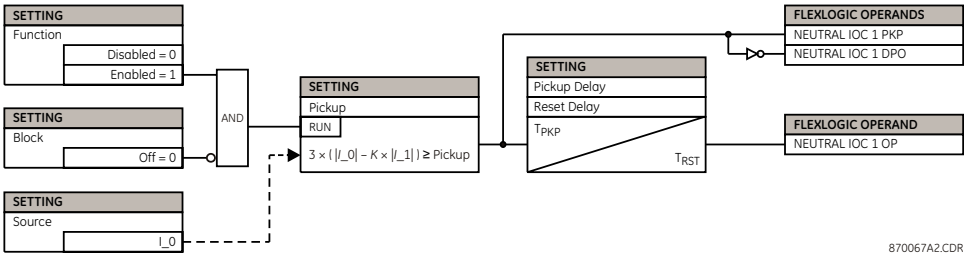
Range: Enabled, Disabled

Default: varies with UR^{Plus}-series model; refer to the EnerVista UR^{Plus} Setup software

This setting enables and disables the logging of neutral instantaneous overcurrent events in the sequence of events recorder.

The figure shows the logic for the neutral instantaneous overcurrent 1 element. The logic is identical for all neutral instantaneous overcurrent elements.

Figure 22: Neutral instantaneous overcurrent 1 scheme logic



Neutral directional overcurrent

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

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

$$I_{op} = 3 \times (|I_0| - K \times |I_1|) \quad \textbf{Eq. 23}$$

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

- System unbalances under heavy load conditions
- Transformation errors of current transformers (CTs) during double-line and three-phase faults
- Switch-off transients during double-line and three-phase faults

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

$$I_{op} = (1 - K) \times I_{injected} \quad \textbf{Eq. 24}$$

For three-phase pure zero-sequence injection, the operating quantity is

$$I_{op} = 3 \times I_{injected} \quad \textbf{Eq. 25}$$

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

The directional unit uses the zero-sequence current (I_0) or ground current (IG) for fault direction discrimination and may be programmed to use either zero-sequence voltage ("Calculated V0" or "Measured VX"), ground current (IG), or both for polarizing. The phasors for the neutral directional overcurrent element directional unit are described below, where V_0 is the zero-sequence voltage, I_0 is the zero-sequence current, ECA is the element characteristic angle, and IG is the ground current, and

$$V_0 = \frac{1}{3}(V_{AG} + V_{BG} + V_{CG}) \quad \textbf{Eq. 26}$$

$$I_0 = \frac{1}{3}I_N = \frac{1}{3}(I_A + I_B + I_C) \quad \textbf{Eq. 27}$$

Table 9: Phasors for "Calculated 3I_0" configuration

Polarizing mode	Direction	Compared phasors
Voltage	Forward	–V_0 + Z_offset × I_0 and I_0 × 1∠ECA
	Reverse	–V_0 + Z_offset × –I_0 and I_0 × 1∠ECA
Current	Forward	IG and I_0
	Reverse	IG and –I_0
Dual	Forward	–V_0 + Z_offset × I_0 and I_0 × 1∠ECA or IG and I_0
	Reverse	–V_0 + Z_offset × I_0 and I_0 × 1∠ECA or IG and –I_0

The operating current for overcurrent unit for the "Calculated 3I_0" configuration is

$$I_{op} = 3 \times (|I_0| - K \times |I_1| \quad \text{if } |I_1| > 0.8\,\text{pu}$$
$$I_{op} = 3 \times |I_0| \quad \text{if } |I_1| \le 0.8\ \text{pu} \qquad \textbf{Eq. 28}$$

Table 10: Phasors for "Measured IG" configuration

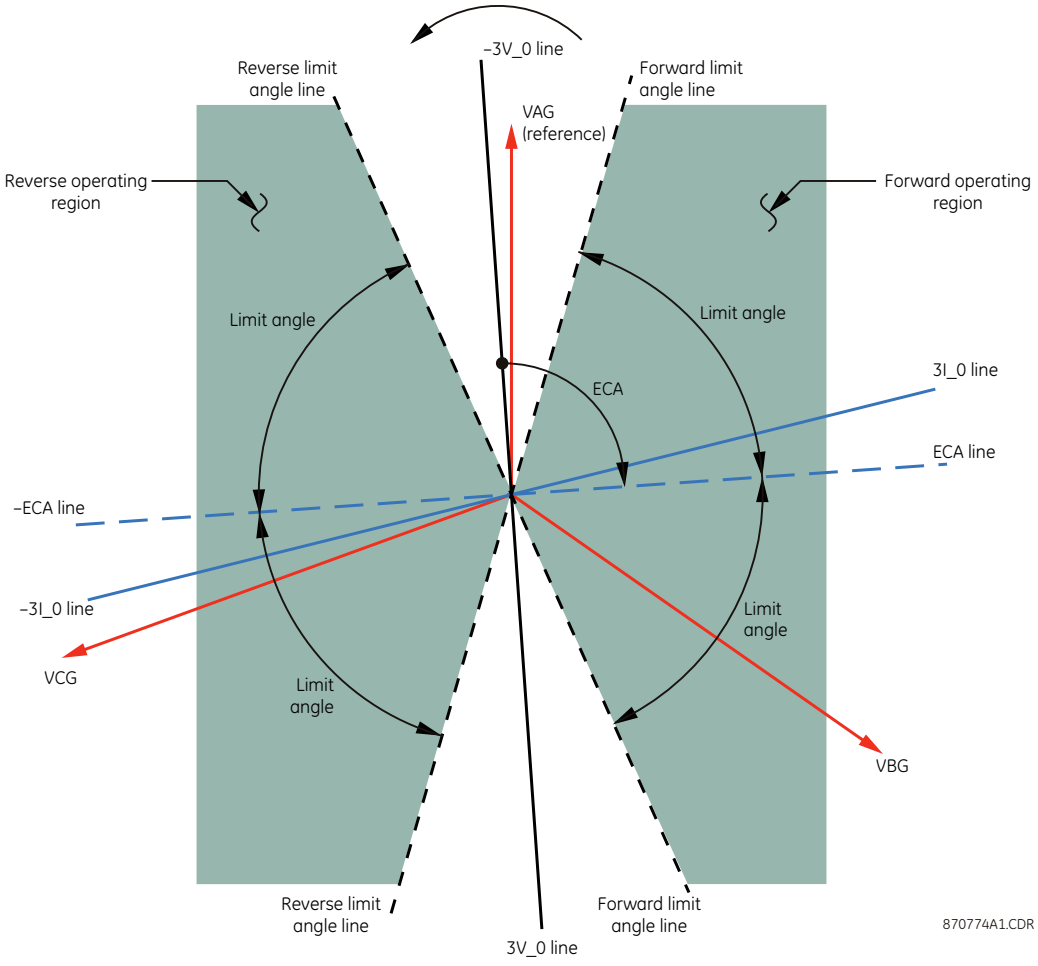
Polarizing mode	Direction	Compared phasors
Voltage	Forward	–V_0 + Z_offset × IG/3 and IG × 1∠ECA
	Reverse	–V_0 + Z_offset × –IG/3 and –IG × 1∠ECA

The operating current for overcurrent unit for the "Measured IG" configuration is

$$I_{op} = |IG| \qquad \textbf{Eq. 29}$$

When the **Polarizing Voltage** setting is programmed as "Measured VX", one-third of this voltage is used in place of V_0. The following figure explains the voltage polarized directional unit of the element and illustrates the phase angle comparator characteristics for a phase A to ground fault, with the element characteristic angle equal to 90° (center line of operating characteristic), forward limit angle equal to 80° (the ± angular limit with the ECA for operation), and reverse limit angle equal to 80° (the ± angular limit with the ECA for operation).

Figure 23: Neutral directional voltage polarized characteristics



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

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

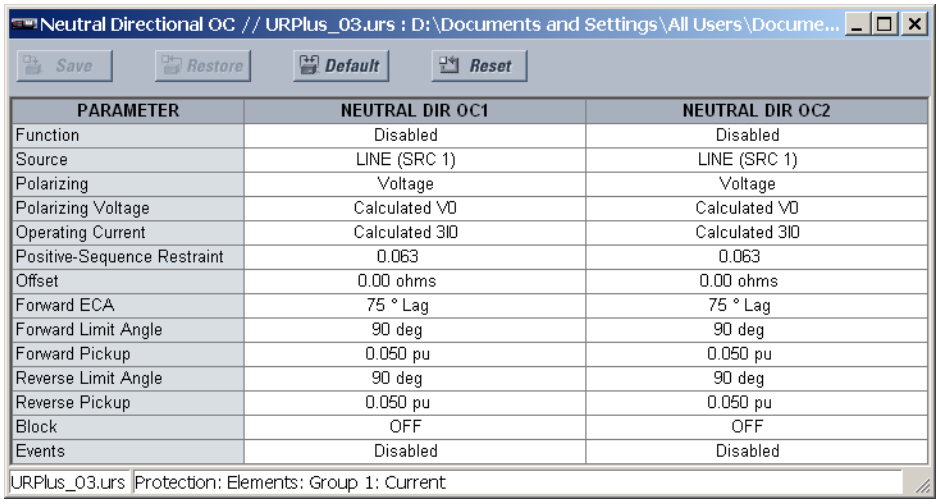
Take this bias into account when using the neutral directional overcurrent element to directionalize other protection elements.

NOTE

Proper application of this element requires that the operating current and the polarizing voltage (or current) be measured from the same side of the transformer.

Select the **Settings > Protection > Elements > Group 1 > Current > Neutral Directional OC** menu item to open the neutral directional overcurrent configuration window.

Figure 24: Neutral directional overcurrent configuration settings



PARAMETER	NEUTRAL DIR OC1	NEUTRAL DIR OC2
Function	Disabled	Disabled
Source	LINE (SRC 1)	LINE (SRC 1)
Polarizing	Voltage	Voltage
Polarizing Voltage	Calculated V0	Calculated V0
Operating Current	Calculated 3I0	Calculated 3I0
Positive-Sequence Restraint	0.063	0.063
Offset	0.00 ohms	0.00 ohms
Forward ECA	75 ° Lag	75 ° Lag
Forward Limit Angle	90 deg	90 deg
Forward Pickup	0.050 pu	0.050 pu
Reverse Limit Angle	90 deg	90 deg
Reverse Pickup	0.050 pu	0.050 pu
Block	OFF	OFF
Events	Disabled	Disabled

The following settings are available for each neutral directional overcurrent element.

Function

Default: Enabled, Disabled
Default: Disabled

This setting enables and disables the neutral directional overcurrent protection element.

Source

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)
Default: LINE (SRC 1)

This setting selects the signal source for the neutral directional overcurrent protection element.

Polarizing

Range: Voltage, Current, Dual
Default: Voltage

This setting selects the polarizing mode for the directional unit.

If voltage polarizing is selected, the element uses the zero-sequence voltage angle for polarization. The user can use either the zero-sequence voltage V_0 calculated from the phase voltages, or the zero-sequence voltage supplied externally as the auxiliary voltage Vx, both from the neutral directional **Source** setting.

The calculated V_0 can be used as polarizing voltage only if the voltage transformers are connected in Wye. The auxiliary voltage can be used as the polarizing voltage provided the **Auxiliary VT Connection** setting is "Vn" and the auxiliary voltage is connected to a zero-sequence voltage source (such as open delta connected secondary of VTs).

The zero-sequence (V_0) or auxiliary voltage (Vx), accordingly, must be higher than the Voltage Cutoff Level of the general voltage inputs (found under the **Protection > Power System > AC Inputs - Voltage** settings) to be validated for use as a polarizing signal. If the polarizing signal is invalid, neither forward nor reverse indication is given. In addition, the zero-sequence current (I_0) must be greater than the **Current Cutoff Level** setting value specified in the **Protection > Power System > AC Inputs – Current** menu.

If current polarizing is selected, the element uses the ground current angle connected externally and configured under the neutral directional **Source** setting for polarization. The ground CT must be connected between the ground and neutral point of an adequate local source of ground current. The ground current must be higher than 0.05 pu to be validated as a polarizing signal. If the polarizing signal is not valid, neither forward nor reverse indication is given.

For a choice of current polarizing, it is recommended that the polarizing signal be analyzed to ensure that a known direction is maintained irrespective of the fault location. For example, if using an autotransformer neutral current as a polarizing source, it should be ensured that a reversal of the ground current does not occur for a high-side fault. The low-side system impedance should be assumed minimal when checking for this condition. A similar situation arises for a wye/delta/wye transformer, where current in one transformer winding neutral may reverse when faults on both sides of the transformer are considered.

If dual polarizing is selected, the element performs both directional comparisons as described above. A given direction is confirmed if either voltage or current comparators indicate so. If a conflicting (simultaneous forward and reverse) indication occurs, the forward direction overrides the reverse direction.

Polarizing Voltage

Range: Calculated V0, Measured VX

Default: Calculated V0

This setting selects the polarizing voltage used by the directional unit when the voltage or dual polarizing mode is set. The polarizing voltage can be programmed to be either the zero-sequence voltage calculated from the phase voltages ("Calculated V0") or supplied externally as an auxiliary voltage ("Measured VX").

Operating Current

Range: Calculated 3I0, Measured IG

Default: Calculated 3I0

This setting indicates whether the 3I_0 current calculated from the phase currents, or the ground current shall be used by this protection. This setting acts as a switch between the neutral and ground modes of operation (ANSI devices 67N and 67G). If set to "Calculated 3I0", the element uses the phase currents and applies the positive-sequence restraint; if set to "Measured IG", the element uses ground current supplied to the ground CT of the CT bank configured as the neutral directional "Source". If this setting is "Measured IG", then the **Polarizing** setting must be "Voltage", as it is not possible to use the ground current as an operating and polarizing signal simultaneously.

Positive-Sequence Restraint

Range: 0.000 to 0.500 in steps of 0.001
Default: 0.063

This setting controls the amount of the positive-sequence restraint. Set to 0.063 for backward compatibility with firmware revisions 3.40 and earlier. Set to zero to remove the restraint. Set higher if large system unbalances or poor CT performance are expected.

Offset

Range: 0.00 to 250.00 ohms in steps of 0.01
Default: 0.00 ohms

This setting specifies the offset impedance used by this protection. The primary application for the offset impedance is to guarantee correct identification of fault direction on series compensated lines. In regular applications, the offset impedance ensures proper operation even if the zero-sequence voltage at the relaying point is very small. If this is the intent, the offset impedance is not larger than the zero-sequence impedance of the protected circuit. Practically, it is several times smaller. Enter the offset impedance in secondary ohms.

Forward ECA

Range: –90 to 90° in steps of 1
Default: –70°

This setting defines the characteristic angle (ECA) for the forward direction in the voltage polarizing mode. The current polarizing mode uses a fixed ECA of 0°. The ECA in the reverse direction is the angle set for the forward direction shifted by 180°.

Forward Limit Angle

Range: 40 to 90° in steps of 1
Default: 90°

This setting defines a symmetrical (in both directions from the ECA) limit angle for the forward direction.

Forward Pickup

Range: 0.006 to 30.000 pu in steps of 0.001
Default: 0.050 pu

This setting defines the pickup level for the overcurrent unit of the element in the forward direction. When selecting this setting it must be kept in mind that the design uses a positive-sequence restraint technique for the “Calculated 3I0” mode of operation.

Reverse Limit Angle

Range: 40 to 90° in steps of 1
Default: 90°

This setting defines a symmetrical (in both directions from the ECA) limit angle for the reverse direction.

Reverse Pickup

Range: 0.006 to 30.000 pu in steps of 0.001
Default: 0.050 pu

This setting defines the pickup level for the overcurrent unit of the element in the reverse direction. When selecting this setting it must be kept in mind that the design uses a positive-sequence restraint technique for the “Calculated 3I0” mode of operation.

Block

Range: any FlexLogic operand or shared operand
Default: Off

Assertion of the operand assigned to this setting blocks operation of the neutral directional overcurrent element.

Events

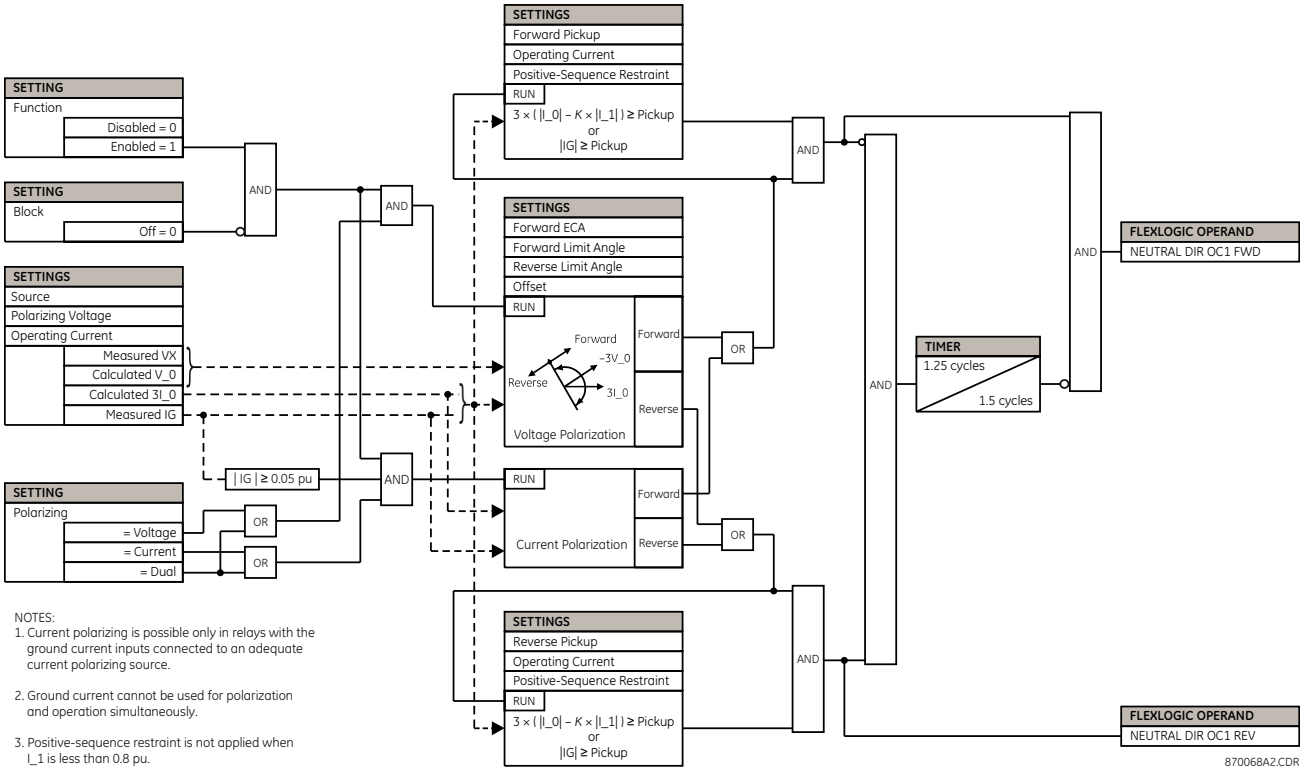
Range: Enabled, Disabled

Default: varies with UR^{Plus}-series model; refer to the EnerVista UR^{Plus} Setup software

This setting enables and disables the logging of neutral directional overcurrent events in the sequence of events recorder.

The figure shows the logic for the neutral directional overcurrent 1 element. The logic is identical for both neutral directional overcurrent elements.

Figure 25: Neutral directional overcurrent 1 scheme logic



Ground time overcurrent

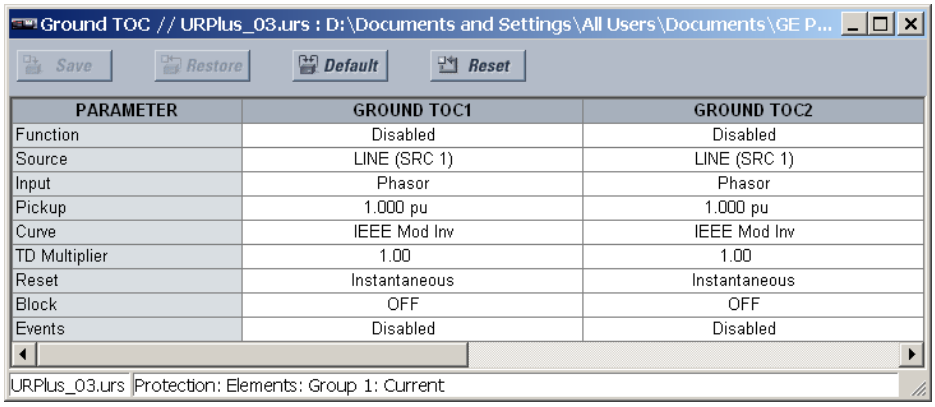
The ground time overcurrent element can provide a time-delay operating characteristic versus the applied current or be used as a simple definite time element. The ground current input value is the quantity measured by the ground input CT and is the fundamental phasor or RMS magnitude. Two methods of resetting operation are available; timed and instantaneous. When the element is blocked, the time accumulator resets according to the reset characteristic. For example, if the element reset characteristic is set to instantaneous and the element is blocked, the time accumulator is cleared immediately.

NOTE

These elements measure the current that is connected to the ground channel of an AC module. This channel can be equipped with a standard or sensitive input. The conversion range of a standard channel is from 0.02 to 46 times the CT rating. The conversion range of a sensitive channel is from 0.002 to 4.6 times the CT rating.

Select the **Settings > Protection > Elements > Group 1 > Current > Ground TOC** menu item to open the ground time overcurrent configuration window.

Figure 26: Ground time overcurrent configuration settings



PARAMETER	GROUND TOC1	GROUND TOC2
Function	Disabled	Disabled
Source	LINE (SRC 1)	LINE (SRC 1)
Input	Phasor	Phasor
Pickup	1.000 pu	1.000 pu
Curve	IEEE Mod Inv	IEEE Mod Inv
TD Multiplier	1.00	1.00
Reset	Instantaneous	Instantaneous
Block	OFF	OFF
Events	Disabled	Disabled

The following settings are available for each ground time overcurrent element.

Function

Range: Enabled, Disabled

Default: Disabled

This setting enables and disables the ground time overcurrent protection element.

Source

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)

Default: LINE (SRC 1)

This setting selects the signal source for the ground time overcurrent protection element.

Input

Range: Phasor, RMS

Default: Phasor

This setting selects how ground current input quantities are interpreted by the C90^{Plus}. Inputs can be selected as fundamental phasor magnitudes or total waveform RMS magnitudes as required by the application.

Pickup

Range: 0.000 to 30.000 pu in steps of 0.001

Default: 1.000 pu

This setting specifies the ground time overcurrent pickup level in per-unit values.

Curve

Range: IEEE Mod Inv, IEEE Very Inv, IEEE Ext Inv, IEC Curve A, IEC Curve B, IEC Curve C, IEC Short Inv, IAC Ext Inv, IAC Very Inv, IAC Inverse, IAC Short Inv, I2t, Definite Time, FlexCurve A, FlexCurve B, FlexCurve C, FlexCurve D

Default: IEEE Mod Inv

This setting selects the inverse time overcurrent curve style.

TD Multiplier

Range: 0.00 to 600.00 in steps of 0.01

Default: 1.00

This setting specifies a multiple of the base curve shape specified by the **Curve** setting. Programming this value to zero results in an instantaneous response to all current levels above pickup.

Reset

Range: Instantaneous, Timed

Default: Instantaneous

The "Instantaneous" reset method 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" reset method can be used where the relay must coordinate with electromechanical relays.

Block

Range: any FlexLogic operand or shared operand

Default: Off

Assertion of the operand assigned to this setting blocks operation of the ground time overcurrent element.

Events

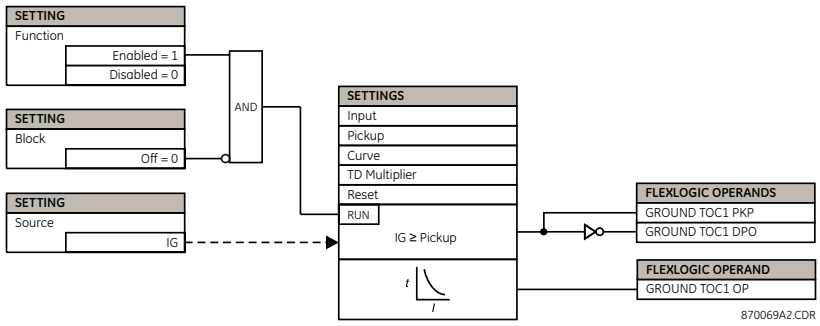
Range: Enabled, Disabled

Default: varies with UR^{Plus}-series model; refer to the EnerVista UR^{Plus} Setup software

This setting enables and disables the logging of ground time overcurrent events in the sequence of events recorder.

The figure shows the logic for the ground time overcurrent 1 element. The logic is identical for all ground time overcurrent elements.

Figure 27: Ground time overcurrent scheme logic



Ground instantaneous overcurrent

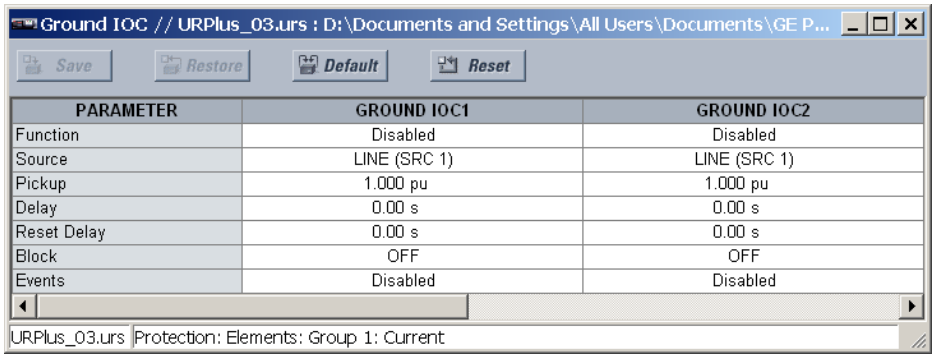
The ground instantaneous overcurrent element can be used as an instantaneous element with no intentional delay or as a definite time element. The ground current input is the quantity measured by the ground input CT and is the fundamental phasor magnitude.

NOTE

These elements measure the current that is connected to the ground channel of an AC module. This channel can be equipped with a standard or sensitive input. The conversion range of a standard channel is from 0.02 to 46 times the CT rating. The conversion range of a sensitive channel is from 0.002 to 4.6 times the CT rating.

Select the **Settings > Protection > Elements > Group 1 > Current > Ground IOC** menu item to open the ground instantaneous overcurrent configuration window.

Figure 28: Ground instantaneous overcurrent configuration settings



PARAMETER	GROUND IOC1	GROUND IOC2
Function	Disabled	Disabled
Source	LINE (SRC 1)	LINE (SRC 1)
Pickup	1.000 pu	1.000 pu
Delay	0.00 s	0.00 s
Reset Delay	0.00 s	0.00 s
Block	OFF	OFF
Events	Disabled	Disabled

The following settings are available for each ground instantaneous overcurrent element.

Function

Range: Enabled, Disabled

Default: Disabled

This setting enables and disables the ground instantaneous overcurrent protection element.

Source

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)

Default: LINE (SRC 1)

This setting selects the signal source for the ground instantaneous overcurrent protection element.

Pickup

Range: 0.000 to 30.000 pu in steps of 0.001

Default: 1.000 pu

This setting specifies the ground instantaneous overcurrent pickup level in per-unit values.

Delay

Range: 0.00 to 600.00 seconds in steps of 0.01

Default: 0.00 seconds

This setting delays the assertion of the GROUND IOC OP operands. It is used to achieve timing coordination with other elements and relays.

Reset Delay

Range: 0.00 to 600.00 seconds in steps of 0.01

Default: 0.00 seconds

This setting specifies a delay for the reset of the ground instantaneous overcurrent element between the operate output state and the return to logic 0 after the input passes outside the defined pickup range. This setting is used to ensure that the relay output contacts are closed long enough to ensure reception by downstream equipment.

Block

Range: any FlexLogic operand or shared operand

Default: Off

Assertion of the operand assigned to this setting blocks operation of the ground instantaneous overcurrent element.

Events

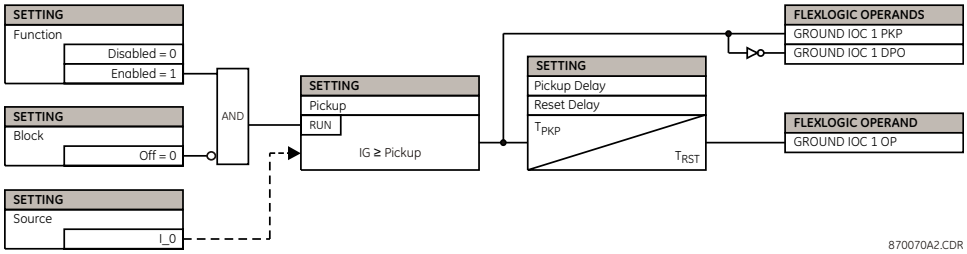
Range: Enabled, Disabled

Default: varies with UR^{Plus}-series model; refer to the EnerVista UR^{Plus} Setup software

This setting enables and disables the logging of ground instantaneous overcurrent events in the sequence of events recorder.

The figure shows the logic for the ground instantaneous overcurrent 1 element. The logic is identical for all ground instantaneous overcurrent elements.

Figure 29: Ground instantaneous overcurrent scheme logic



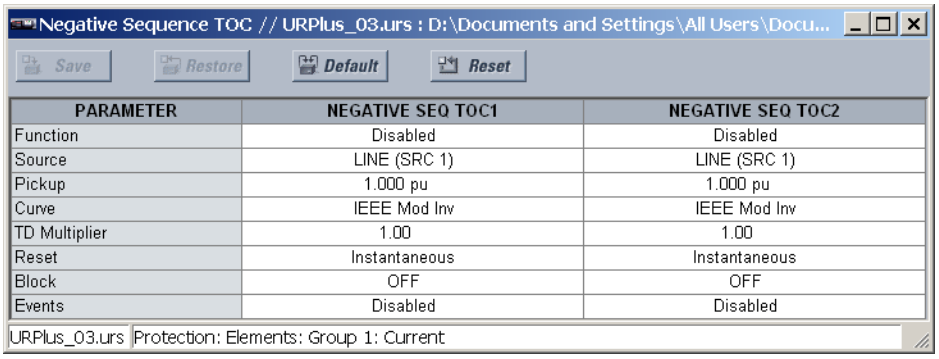
Negative-sequence time overcurrent

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

Two methods of resetting operation are available: timed and instantaneous. When the element is blocked, the time accumulator resets according to the reset characteristic. For example, if the element reset characteristic is set to instantaneous and the element is blocked, the time accumulator is cleared immediately.

Select the **Settings > Protection > Elements > Group 1 > Current > Negative Sequence TOC** menu item to open the negative-sequence time overcurrent configuration window.

Figure 30: Negative-sequence time overcurrent configuration settings



PARAMETER	NEGATIVE SEQ TOC1	NEGATIVE SEQ TOC2
Function	Disabled	Disabled
Source	LINE (SRC 1)	LINE (SRC 1)
Pickup	1.000 pu	1.000 pu
Curve	IEEE Mod Inv	IEEE Mod Inv
TD Multiplier	1.00	1.00
Reset	Instantaneous	Instantaneous
Block	OFF	OFF
Events	Disabled	Disabled

The following settings are available for each negative-sequence time overcurrent element.

Function

Range: Enabled, Disabled

Default: Disabled

This setting enables and disables the negative-sequence time overcurrent protection element.

Source

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)

Default: LINE (SRC 1)

This setting selects the signal source for the negative-sequence time overcurrent protection element.

Pickup

Range: 0.000 to 30.000 pu in steps of 0.001

Default: 1.000 pu

This setting specifies the neutral time overcurrent pickup level in per-unit values.

Curve

Range: IEEE Mod Inv, IEEE Very Inv, IEEE Ext Inv, IEC Curve A, IEC Curve B, IEC Curve C, IEC Short Inv, IAC Ext Inv, IAC Very Inv, IAC Inverse, IAC Short Inv, I2t, Definite Time, FlexCurve A, FlexCurve B, FlexCurve C, FlexCurve D

Default: IEEE Mod Inv

This setting selects the inverse time overcurrent curve style.

TD Multiplier

Range: 0.00 to 600.00 in steps of 0.01

Default: 1.00

This setting specifies a multiple of the base curve shape specified by the **Curve** setting. Programming this value to zero results in an instantaneous response to all current levels above pickup.

Reset

Range: Instantaneous, Timed

Default: Instantaneous

The "Instantaneous" reset method 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" reset method can be used where the relay must coordinate with electromechanical relays.

Block

Range: any FlexLogic operand or shared operand

Default: Off

Assertion of the operand assigned to this setting blocks operation of the negative-sequence time overcurrent element.

Events

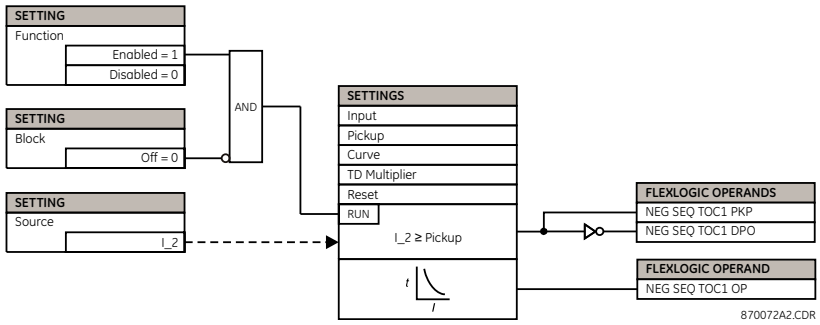
Range: Enabled, Disabled

Default: varies with UR^{Plus}-series model; refer to the EnerVista UR^{Plus} Setup software

This setting enables and disables the logging of negative-sequence time overcurrent events in the sequence of events recorder.

The figure shows the logic for the negative-sequence time overcurrent 1 element. The logic is identical for all negative-sequence time overcurrent elements.

Figure 31: Negative-sequence time overcurrent scheme logic



Negative-sequence instantaneous overcurrent

The negative-sequence instantaneous overcurrent element can be used as an instantaneous function with no intentional delay or as a definite time function. The element responds to the negative-sequence current fundamental frequency phasor magnitude (calculated from the phase currents) and applies a positive-sequence restraint for better performance: a small portion (12.5%) of the positive-sequence current magnitude is subtracted from the negative-sequence current magnitude when forming the operating quantity.

$$I_{op} = |I_2| - K \times |I_1| \quad \text{where } K = \frac{1}{8} \qquad \textbf{Eq. 30}$$

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

- System unbalances under heavy load conditions
- Transformation errors of current transformers (CTs) during three-phase faults
- Fault inception and switch-off transients during three-phase faults

The positive-sequence restraint must be considered when testing for pickup accuracy and response time (multiple of pickup). The operating quantity depends on how the test currents are injected into the relay. The operating quantity for single-phase injection is

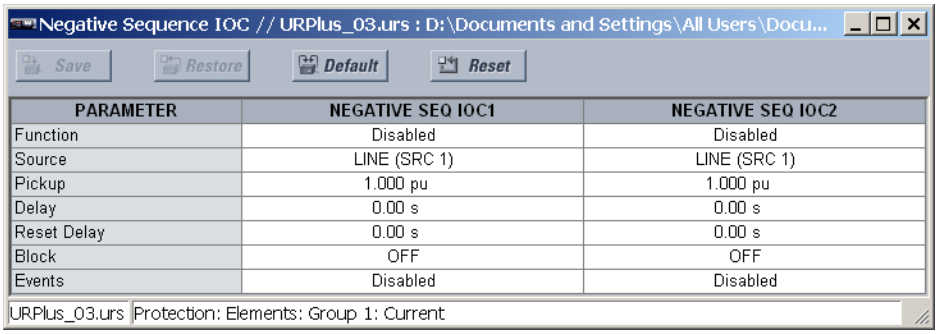
$$I_{op} = 0.2917 \times I_{injected} \qquad \textbf{Eq. 31}$$

The operating quantity for three-phase injection, opposite rotation, is

$$I_{op} = I_{injected} \qquad \textbf{Eq. 32}$$

Select the **Settings > Protection > Elements > Group 1 > Current > Negative Sequence IOC** menu item to open the negative-sequence instantaneous overcurrent configuration window.

Figure 32: Negative-sequence instantaneous overcurrent configuration settings



PARAMETER	NEGATIVE SEQ IOC1	NEGATIVE SEQ IOC2
Function	Disabled	Disabled
Source	LINE (SRC 1)	LINE (SRC 1)
Pickup	1.000 pu	1.000 pu
Delay	0.00 s	0.00 s
Reset Delay	0.00 s	0.00 s
Block	OFF	OFF
Events	Disabled	Disabled

The following settings are available for each negative-sequence instantaneous overcurrent element.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the negative-sequence instantaneous overcurrent protection element.

Source

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)
Default: LINE (SRC 1)

This setting selects the signal source for the negative-sequence instantaneous overcurrent protection element.

Pickup

Range: 0.000 to 30.000 pu in steps of 0.001

Default: 1.000 pu

This setting specifies the negative-sequence instantaneous overcurrent pickup level in per-unit values.

Delay

Range: 0.00 to 600.00 seconds in steps of 0.01

Default: 0.00 seconds

This setting delays the assertion of the NEG SEQ IOC OP operands. It is used to achieve timing coordination with other elements and relays.

Reset Delay

Range: 0.00 to 600.00 seconds in steps of 0.01

Default: 0.00 seconds

This setting specifies a delay for the reset of the phase instantaneous overcurrent element between the operate output state and the return to logic 0 after the input passes outside the defined pickup range. This setting is used to ensure that the relay output contacts are closed long enough to ensure reception by downstream equipment.

Block

Range: any FlexLogic operand or shared operand

Default: Off

Assertion of the operand assigned to this setting blocks operation of the negative-sequence instantaneous overcurrent element.

Events

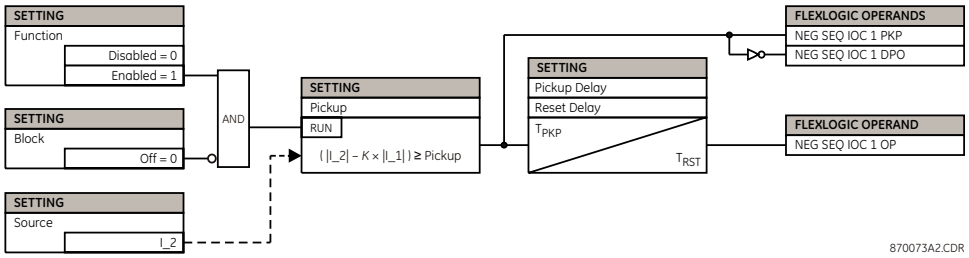
Range: Enabled, Disabled

Default: varies with UR^{Plus}-series model; refer to the EnerVista UR^{Plus} Setup software

This setting enables and disables the logging of negative-sequence instantaneous overcurrent events in the sequence of events recorder.

The figure shows the logic for the negative-sequence instantaneous overcurrent 1 element. The logic is identical for all negative-sequence instantaneous overcurrent elements.

Figure 33: Negative-sequence instantaneous overcurrent scheme logic



Negative-sequence directional overcurrent

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

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

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

$$I_{op} = |I_2| - K \times |I_1| \quad \text{or} \quad I_{op} = 3 \times (|I_0| - K \times |I_1|) \qquad \textbf{Eq. 33}$$

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

- System unbalances under heavy load conditions
- Transformation errors of current transformers (CTs)
- Fault inception and switch-off transients

The positive-sequence restraint must be considered when testing for pickup accuracy and response time (multiple of pickup). The positive-sequence restraint is removed for low currents. If the positive-sequence current is less than 0.8 pu, the restraint is removed by setting the constant *K* to zero. This facilitates response to high-resistance faults when the unbalance is very small and there is no danger of excessive CT errors, as the current is low.

The operating quantity depends on the way the test currents are injected into the C90^{Plus}. For single-phase injection, $I_{op} = ⅓ \times (1 - K) \times I_{injected}$ for I_2 mode and $I_{op} = (1 - K) \times I_{injected}$ for I_0 mode if $I_1 > 0.8$ pu.

The directional unit uses the negative-sequence current (I_2) and negative-sequence voltage (V_2).

The following tables define the negative-sequence directional overcurrent element.

Table 11: Negative-sequence directional overcurrent unit

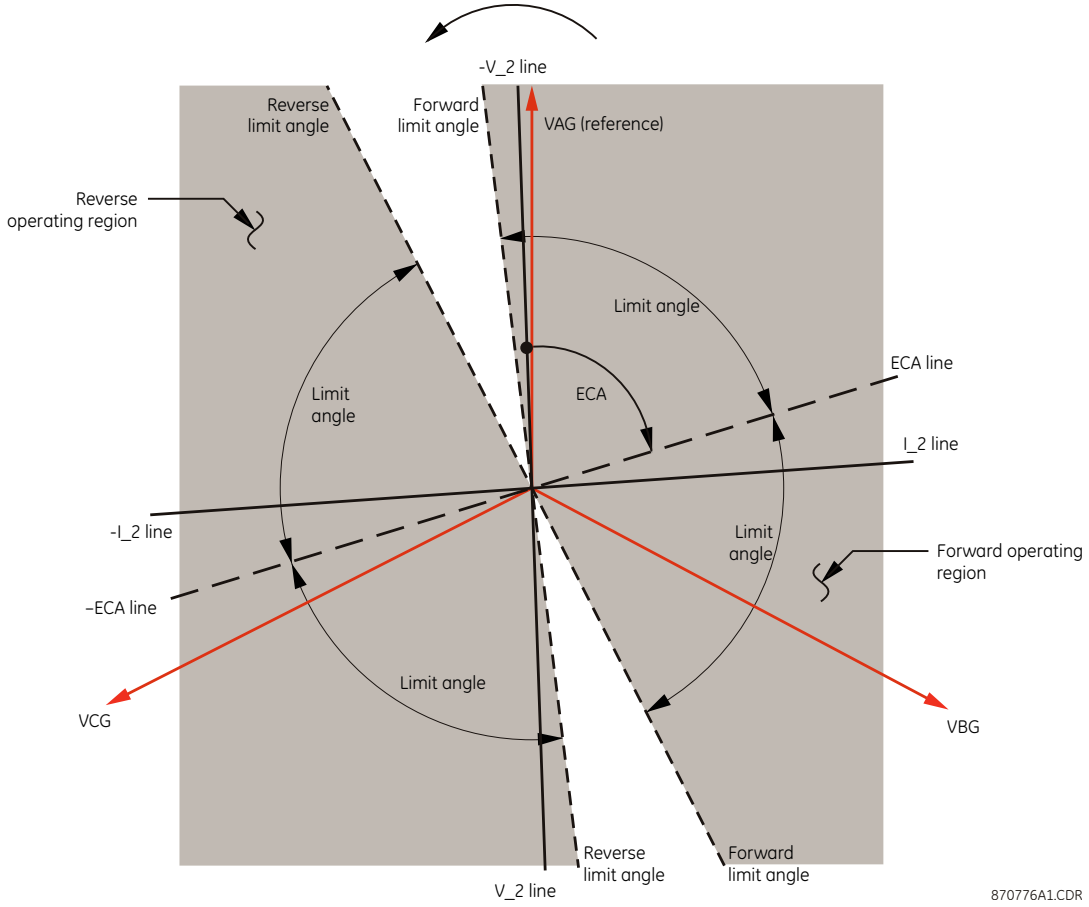
Mode	Operating current
Negative-sequence	$I_{op} = \|I_2\| - K \times \|I_1\|$
Zero-sequence	$I_{op} = 3 \times (\|I_0\| - K \times \|I_1\|)$ if $\|I_1\| > 0.8$ pu $I_{op} = 3 \times \|I_0\|$ if $\|I_1\| \leq 0.8$ pu

Table 12: Negative-sequence directional unit

Mode	Direction	Compared phasors
Negative-sequence	Forward	–V_2 + Z_offset × I_2 and I_2 × 1∠ECA
	Reverse	–V_2 + Z_offset × I_2 and –(I_2 × 1∠ECA)
Zero-sequence	Forward	–V_2 + Z_offset × I_2 and I_2 × 1∠ECA
	Reverse	–V_2 + Z_offset × I_2 and –(I_2 × 1∠ECA)

The negative-sequence voltage must be greater than the Voltage Cutoff Level of the general voltage inputs (found under the **Protection > Power System > AC Inputs - Voltage** settings) to be validated for use as a polarizing signal. If the polarizing signal is not validated neither forward nor reverse indication is given. In addition, the negative-sequence current (or zero-sequence current) must be greater than the **Current Cutoff Level** setting value specified in the **Protection > Power System > AC Inputs – Current** menu. The following figure explains the usage of the voltage polarized directional unit of the element.

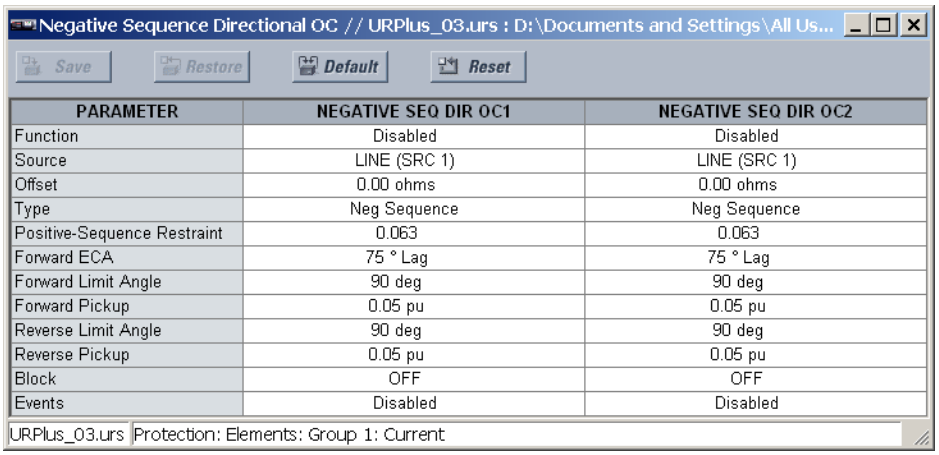
Figure 34: Negative-sequence directional characteristics



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

Select the **Settings > Protection > Elements > Group 1 > Current > Negative Sequence Directional OC** menu item to open the negative-sequence directional overcurrent configuration window.

Figure 35: Negative-sequence directional overcurrent configuration settings



PARAMETER	NEGATIVE SEQ DIR OC1	NEGATIVE SEQ DIR OC2
Function	Disabled	Disabled
Source	LINE (SRC 1)	LINE (SRC 1)
Offset	0.00 ohms	0.00 ohms
Type	Neg Sequence	Neg Sequence
Positive-Sequence Restraint	0.063	0.063
Forward ECA	75 ° Lag	75 ° Lag
Forward Limit Angle	90 deg	90 deg
Forward Pickup	0.05 pu	0.05 pu
Reverse Limit Angle	90 deg	90 deg
Reverse Pickup	0.05 pu	0.05 pu
Block	OFF	OFF
Events	Disabled	Disabled

The following settings are available for each negative-sequence directional overcurrent element.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the negative-sequence directional overcurrent protection element.

Source

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)
Default: LINE (SRC 1)

This setting selects the signal source for the negative-sequence directional overcurrent protection element.

Offset

Range: 0.00 to 250.00 ohms in steps of 0.01
Default: 0.00 ohms

This setting specifies the offset impedance used by this protection. The primary application for the offset impedance is to guarantee correct identification of fault direction on series compensated lines. In regular applications, the offset impedance ensures proper operation even if the negative-sequence voltage at the relaying point is very small. If this is the intent, the offset impedance shall not be larger than the negative-sequence impedance of the protected circuit. Practically, it is several times smaller. Enter the offset impedance in secondary ohms.

Type

Range: Neg Sequence, Zero Sequence
Default: Neg Sequence

This setting selects the operating mode for the overcurrent unit of the element. The choices are “Neg Sequence” and “Zero Sequence”. In some applications it is advantageous to use a directional negative-sequence overcurrent function instead of a directional zero-sequence overcurrent function as inter-circuit mutual effects are minimized.

Pos Seq Restraint

Range: 0.000 to 0.500 in steps of 0.001
Default: 0.063

This setting controls the amount of the positive-sequence restraint. Set to zero to remove the restraint. Set to a higher value if large system unbalances or poor CT performance are expected.

Forward ECA

Range: 0 to 90° Lag in steps of 1
Default: 75° Lag

This setting specifies the element characteristic angle (ECA) for the forward direction. The element characteristic angle in the reverse direction is the angle set for the forward direction shifted by 180°.

Forward Limit Angle

Range: 40 to 90° in steps of 1
Default: 90°

This setting specifies a symmetrical limit angle (in both directions from the element characteristic angle) for the forward direction.

Forward Pickup

Range: 0.015 to 30.000 pu in steps of 0.005
Default: 0.050 pu

This setting specifies the pickup level for the overcurrent unit in the forward direction. This pickup threshold applies to zero or negative-sequence current based on the **Type** setting. When specifying this setting, it must be kept in mind that the design uses a positive-sequence restraint technique.

Reverse Limit Angle

Range: 40 to 90° in steps of 1
Default: 90°

This setting specifies a symmetrical limit angle (in both directions from the element characteristic angle) for the reverse direction.

Reverse Pickup

Range: 0.015 to 30.000 pu in steps of 0.005
Default: 0.050 pu

This setting specifies the pickup level for the overcurrent unit in the reverse direction. This pickup threshold applies to zero or negative-sequence current based on the **Type** setting. When specifying this setting, it must be kept in mind that the design uses a positive-sequence restraint technique.

Block

Range: any FlexLogic operand or shared operand
Default: Off

Assertion of the operand assigned to this setting blocks operation of the negative-sequence directional overcurrent element.

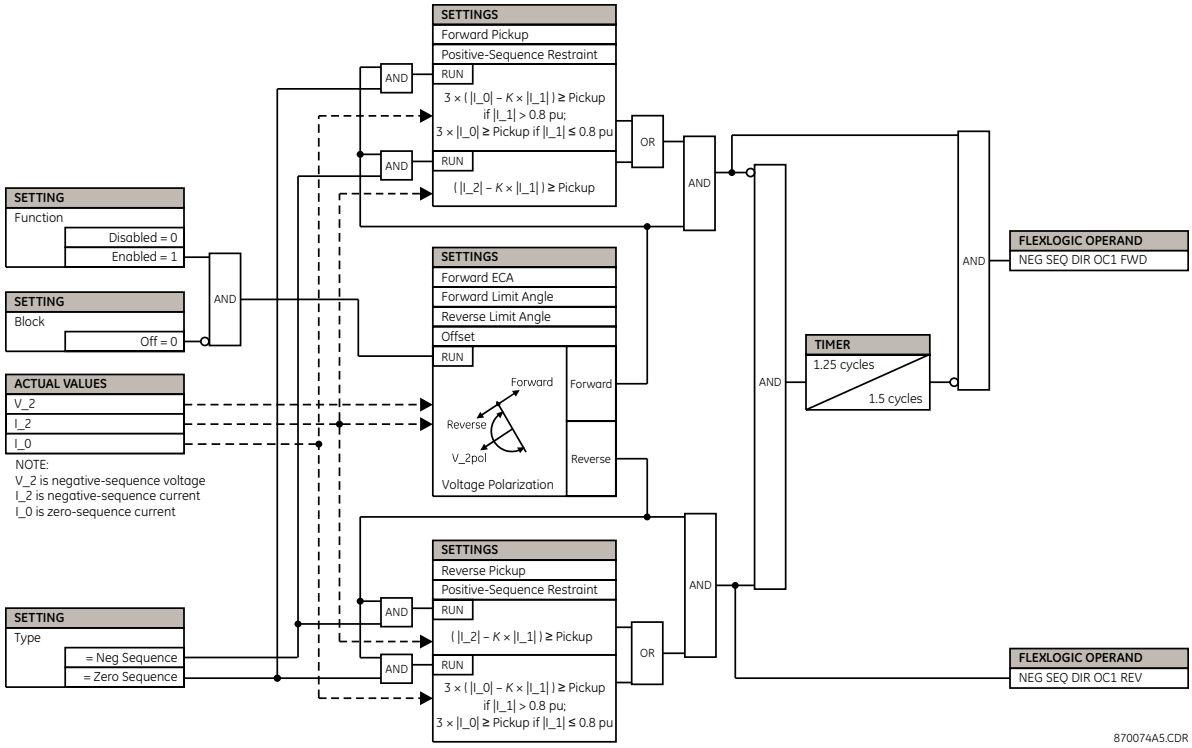
Events

Range: Enabled, Disabled
Default: varies with UR^{Plus}-series model; refer to the EnerVista UR^{Plus} Setup software

This setting enables and disables the logging of negative-sequence directional overcurrent events in the sequence of events recorder.

The figure shows the logic for the negative-sequence directional overcurrent 1 element. The logic is identical for all negative-sequence directional overcurrent elements.

Figure 36: Negative-sequence directional overcurrent scheme logic



Voltage elements

The voltage protection elements can be used for a variety of applications, such as undervoltage protection, permissive functions, and source transfer schemes.

For voltage sensitive loads, such as induction motors, a drop in voltage increases the drawn current which may cause dangerous overheating in the motor. The undervoltage protection feature can be used to either cause a trip or generate an alarm when the voltage drops below a specified voltage setting for a specified time delay.

For permissive functions, the undervoltage feature may be used to block the functioning of external devices by operating an output relay when the voltage falls below the specified voltage setting. The undervoltage feature may also be used to block the functioning of other elements through the block feature of those elements.

In source transfer schemes, a transfer signal may be generated to transfer a load from its normal source to a standby or emergency power source in the event of an undervoltage.

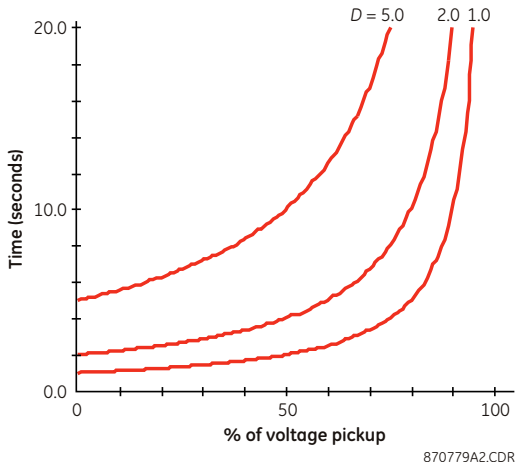
The undervoltage elements can be programmed to have a definite time delay characteristic. The definite time curve operates when the voltage drops below the pickup level for a specified period of time. The time delay is adjustable from 0 to 600.00 seconds in steps of 0.01. The undervoltage elements can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

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

$$T = \frac{D}{1 - \frac{V}{V_{pickup}}} \qquad \textbf{Eq. 34}$$

In this equation, T represents the operating time, D represents the undervoltage delay setting (D = 0.00 operates instantaneously), V represents the secondary voltage applied to the relay, and V_{pickup} represents the pickup level.

Figure 37: Inverse time undervoltage curves



NOTE

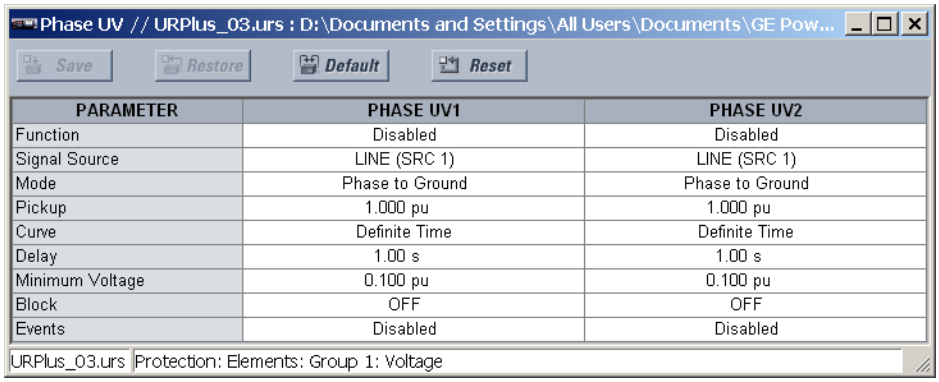
At 0% of pickup, the operating time is equivalent to the undervoltage delay setting.

Phase undervoltage

The phase undervoltage element may be used to give a desired time delay operating characteristic versus the applied fundamental voltage (phase-to-ground or phase-to-phase for wye VT connections, or phase-to-phase for delta VT connections) or as a definite time element. The element resets instantaneously if the applied voltage exceeds the dropout voltage.

Select the **Settings > Protection > Elements > Group 1 > Voltage > Phase UV** menu item to open the phase undervoltage configuration window.

Figure 38: Phase undervoltage configuration settings



PARAMETER	PHASE UV1	PHASE UV2
Function	Disabled	Disabled
Signal Source	LINE (SRC 1)	LINE (SRC 1)
Mode	Phase to Ground	Phase to Ground
Pickup	1.000 pu	1.000 pu
Curve	Definite Time	Definite Time
Delay	1.00 s	1.00 s
Minimum Voltage	0.100 pu	0.100 pu
Block	OFF	OFF
Events	Disabled	Disabled

The following settings are available for each phase undervoltage element.

Function

Range: Enabled, Disabled

Default: Disabled

This setting enables and disables the phase undervoltage protection element.

Signal Source

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)

Default: LINE (SRC 1)

This setting selects the signal source for the phase undervoltage protection element.

Mode

Range: Phase to Ground, Phase to Phase
Default: Phase to Ground

This setting selects the operating mode. Select phase-to-ground or phase-to-phase for wye VT connections, or phase-to-phase for delta VT connections.

Pickup

Range: 0.000 to 1.100 pu in steps of 0.001
Default: 1.000 pu

This setting specifies the phase undervoltage pickup level in per-unit values.

Curve

Range: Definite Time, Inverse Time
Default: Definite Time

This setting selects the desired time-delay operating characteristic versus the applied fundamental voltage or the definite time element.

Delay

Range: 0.00 to 600.00 seconds in steps of 0.01
Default: 1.00 seconds

This setting specifies the minimum operating time of the phase undervoltage element.

Minimum Voltage

Range: 0.000 to 3.000 pu in steps of 0.001
Default: 0.100 pu

This setting specifies the operating voltage in per-unit values below which the element is blocked. A value of "0" allows a dead source to be considered a fault condition.

Block

Range: any FlexLogic operand or shared operand
Default: Off

Assertion of the operand assigned to this setting blocks the phase undervoltage element.

Events

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the logging of phase undervoltage events in the sequence of events recorder.

The following protection FlexLogic operands are available for the phase undervoltage elements.

Phase undervoltage operands

PHASE UV1 DPO ..... Asserted when at least one phase of the phase undervoltage 1 element drops out.

PHASE UV1 DPO A ..... Asserted when phase A of the phase undervoltage 1 element drops out.

PHASE UV1 DPO B ..... Asserted when phase B of the phase undervoltage 1 element drops out.

PHASE UV1 DPO C ..... Asserted when phase C of the phase undervoltage 1 element drops out.

PHASE UV1 OP ..... Asserted when at least one phase of the phase undervoltage 1 element operates.

PHASE UV1 OP A ..... Asserted when phase A of the phase undervoltage 1 element operates.

PHASE UV1 OP B: Asserted when phase B of the phase undervoltage 1 element operates.

PHASE UV1 OP C: Asserted when phase C of the phase undervoltage 1 element operates.

PHASE UV1 PKP: Asserted when at least one phase of the phase undervoltage 1 element picks up.

PHASE UV1 PKP A: Asserted when phase A of the phase undervoltage 1 element picks up.

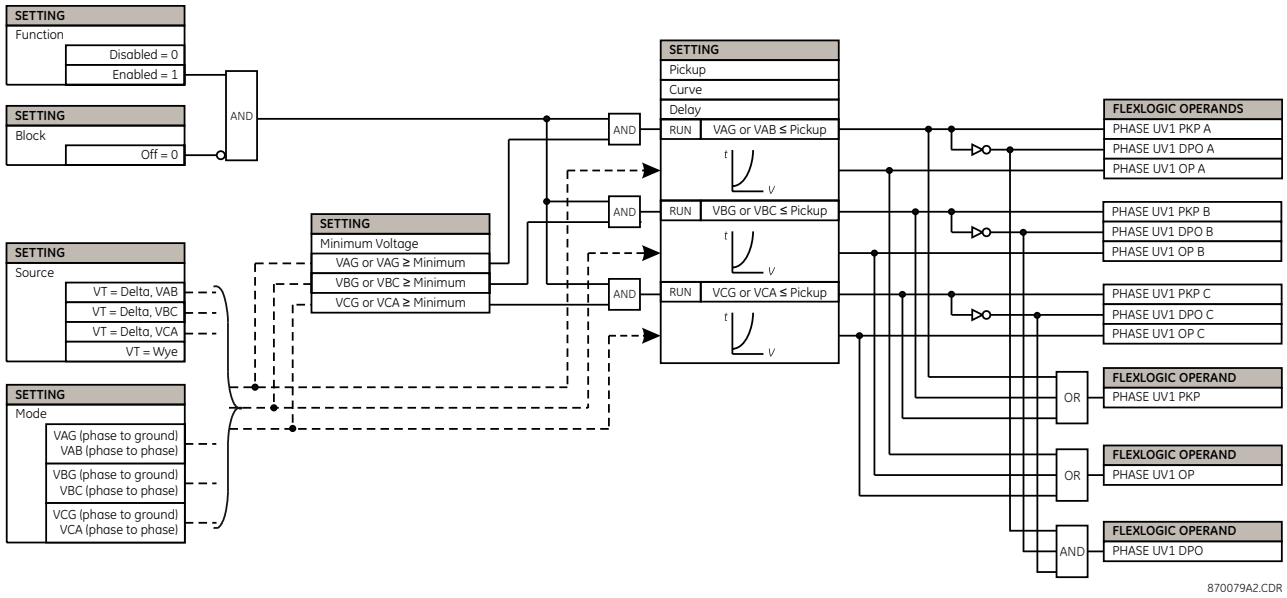
PHASE UV1 PKP B: Asserted when phase B of the phase undervoltage 1 element picks up.

PHASE UV1 PKP C: Asserted when phase C of the phase undervoltage 1 element picks up.

PHASE UV2: Same set of operands as shown above for the phase undervoltage 2 element.

The logic for the phase undervoltage 1 element is shown below. The logic is similar for all phase undervoltage elements.

Figure 39: Phase undervoltage 1 scheme logic

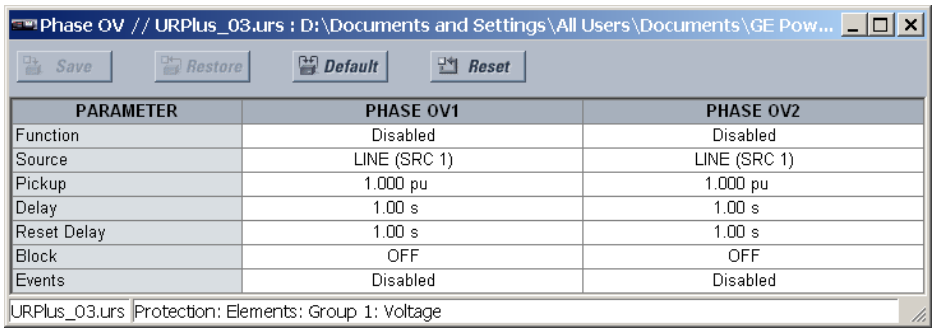


Phase overvoltage

The phase overvoltage element can be used as an instantaneous element with no intentional time delay or as a definite time element. The input voltage is the phase-to-phase voltage, either measured directly from delta-connected VTs or as calculated from phase-to-ground (wye) connected VTs. The specific voltages to be used for each phase are shown in the logic diagram.

Select the **Settings > Protection > Elements > Group 1 > Voltage > Phase OV** menu item to open the phase overvoltage configuration window.

Figure 40: Phase overvoltage configuration settings



PARAMETER	PHASE OV1	PHASE OV2
Function	Disabled	Disabled
Source	LINE (SRC 1)	LINE (SRC 1)
Pickup	1.000 pu	1.000 pu
Delay	1.00 s	1.00 s
Reset Delay	1.00 s	1.00 s
Block	OFF	OFF
Events	Disabled	Disabled

The following settings are available for each phase overvoltage element.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the phase overvoltage protection element.

Source

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)
Default: LINE (SRC 1)

This setting selects the signal source for the phase overvoltage protection element.

Pickup

Range: 0.000 to 3.000 pu in steps of 0.001
Default: 1.000 pu

This setting specifies the phase overvoltage pickup level in per-unit values.

Delay

Range: 0.00 to 600.00 seconds in steps of 0.01
Default: 1.00 seconds

This setting specifies the minimum operating time of the phase overvoltage element.

Reset Delay

Range: 0.00 to 600.00 seconds in steps of 0.01
Default: 1.00 seconds

This setting specifies the minimum reset time of the phase overvoltage element.

Block

Range: any FlexLogic operand or shared operand
Default: Off

Assertion of the operand assigned to this setting blocks the phase overvoltage element.

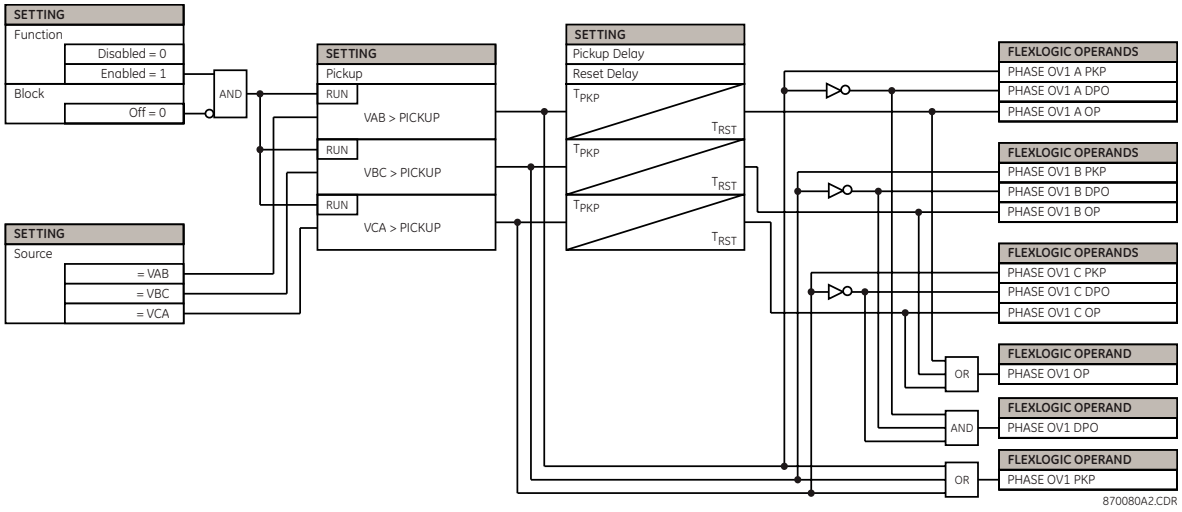
Events

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the logging of phase overvoltage events in the sequence of events recorder.

The figure shows the logic for the phase overvoltage 1 element. The logic is similar for all phase overvoltage elements.

Figure 41: Phase overvoltage scheme logic



Neutral overvoltage

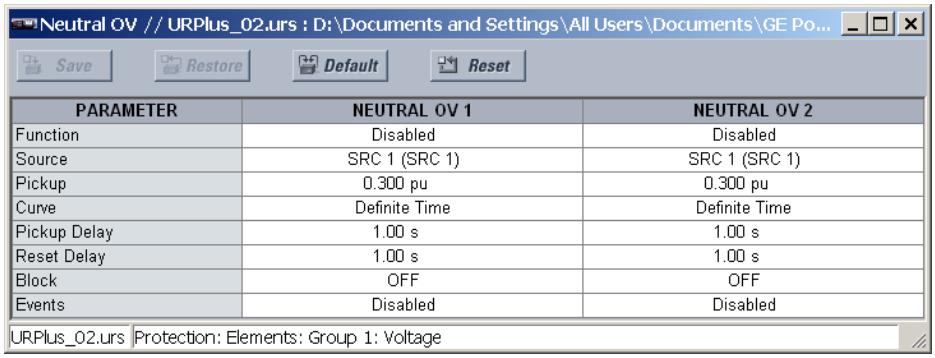
There are three neutral overvoltage elements available. The neutral overvoltage element can be used to detect asymmetrical system voltage condition due to a ground fault or to the loss of one or two phases of the source. The element responds to the system neutral voltage (3V_0), calculated from the phase voltages. The nominal secondary voltage of the phase voltage channels entered in the **Phase VT Secondary** setting is the per-unit base used when setting the pickup level.

The neutral overvoltage element can provide a time-delayed operating characteristic versus the applied voltage (initialized from FlexCurves A, B, or C) or be used as a definite time element. The source assigned to this element must be configured for a phase VT.

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

Select the **Settings > Protection > Elements > Group 1 > Voltage > Neutral OV** menu item to open the neutral overvoltage configuration window.

Figure 42: Neutral overvoltage configuration settings



PARAMETER	NEUTRAL OV 1	NEUTRAL OV 2
Function	Disabled	Disabled
Source	SRC 1 (SRC 1)	SRC 1 (SRC 1)
Pickup	0.300 pu	0.300 pu
Curve	Definite Time	Definite Time
Pickup Delay	1.00 s	1.00 s
Reset Delay	1.00 s	1.00 s
Block	OFF	OFF
Events	Disabled	Disabled

The following settings are available for each neutral overvoltage element.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the neutral overvoltage protection element.

Source

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)
Default: LINE (SRC 1)

This setting selects the signal source for the neutral overvoltage protection element.

Pickup

Range: 0.000 to 1.250 pu in steps of 0.001
Default: 0.300 pu

This setting specifies the neutral overvoltage pickup level in per-unit values.

Curve

Range: Definite Time, FlexCurve A, FlexCurve B, FlexCurve C
Default: Definite Time

This setting selects whether the neutral overvoltage element provides a time-delayed operating characteristic versus the applied voltage (FlexCurves A, B, or C) or is used as a definite time element.

Pickup Delay

Range: 0.00 to 600.00 seconds in steps of 0.01
Default: 1.00 seconds

This setting specifies the minimum operating time of the neutral overvoltage element. This setting applies only if the **Curve** setting is "Definite Time".

Reset Delay

Range: 0.00 to 600.00 seconds in steps of 0.01
Default: 1.00 seconds

This setting specifies the minimum reset time of the neutral overvoltage element.

Block

Range: any FlexLogic operand or shared operand
Default: Off

Assertion of the operand assigned to this setting blocks the neutral overvoltage element.

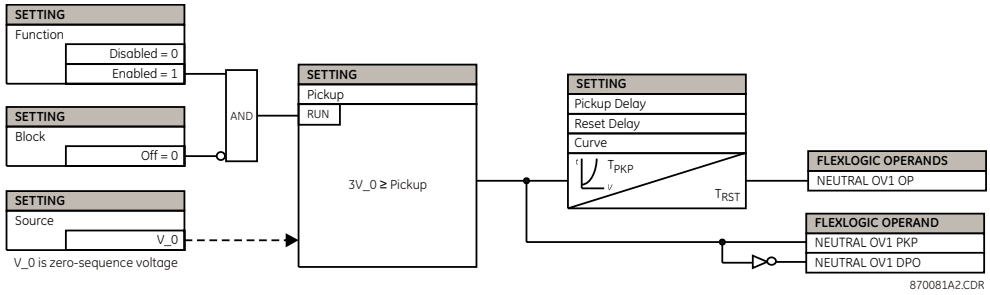
Events

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the logging of neutral overvoltage events in the sequence of events recorder.

The figure shows the logic for the neutral overvoltage 1 element. The logic is similar for all neutral overvoltage elements.

Figure 43: Neutral overvoltage scheme logic

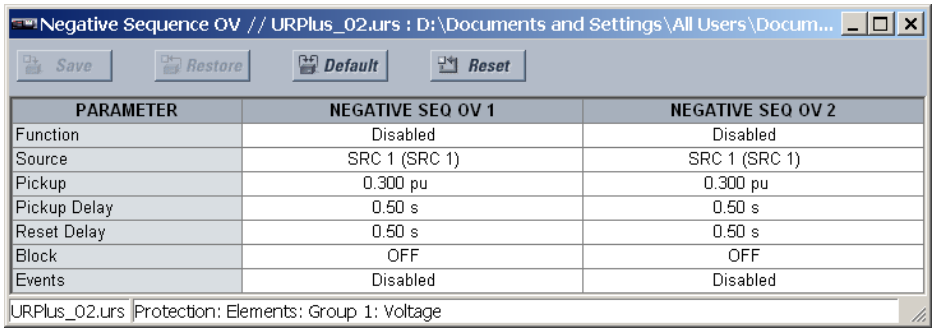


Negative-sequence overvoltage

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

Select the **Settings > Protection > Elements > Group 1 > Voltage > Negative Sequence OV** menu item to open the negative-sequence overvoltage configuration window.

Figure 44: Negative-sequence overvoltage configuration settings



PARAMETER	NEGATIVE SEQ OV 1	NEGATIVE SEQ OV 2
Function	Disabled	Disabled
Source	SRC 1 (SRC 1)	SRC 1 (SRC 1)
Pickup	0.300 pu	0.300 pu
Pickup Delay	0.50 s	0.50 s
Reset Delay	0.50 s	0.50 s
Block	OFF	OFF
Events	Disabled	Disabled

The following settings are available for each negative-sequence overvoltage element.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the negative-sequence overvoltage protection element.

Source

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)
Default: LINE (SRC 1)

This setting selects the signal source for the negative-sequence overvoltage protection element.

Pickup

Range: 0.000 to 1.250 pu in steps of 0.001
Default: 1.000 pu

This setting specifies the negative-sequence overvoltage pickup level in per-unit values.

Pickup Delay

Range: 0.00 to 600.00 seconds in steps of 0.01
Default: 1.00 seconds

This setting specifies the minimum operating time of the negative-sequence overvoltage element.

Reset Delay

Range: 0.00 to 600.00 seconds in steps of 0.01
Default: 1.00 seconds

This setting specifies the minimum reset time of the negative-sequence overvoltage element.

Block

Range: any FlexLogic operand or shared operand
Default: Off

Assertion of the operand assigned to this setting blocks the negative-sequence overvoltage element.

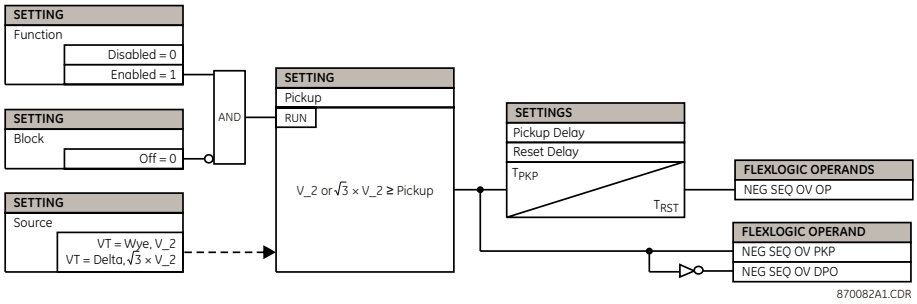
Events

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the logging of negative-sequence overvoltage events in the sequence of events recorder.

The figure shows the logic for the negative-sequence overvoltage 1 element. The logic is similar for all negative-sequence overvoltage elements.

Figure 45: Negative-sequence overvoltage scheme logic



Auxiliary undervoltage

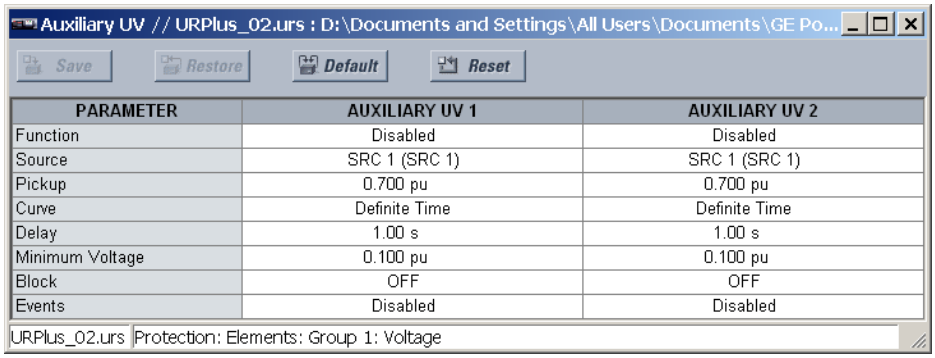
The auxiliary undervoltage element is intended for monitoring undervoltage conditions of the auxiliary voltage. The element pickup selects the voltage level at which the time undervoltage element starts timing. The nominal secondary voltage of the auxiliary voltage channel entered for the **Auxiliary VT Secondary** setting is the per-unit base used when setting the pickup level.

Both the **Pickup** and **Delay** settings establish the operating curve of the undervoltage element. The auxiliary undervoltage element can be programmed to use either definite time delay or inverse time delay characteristics.

The auxiliary undervoltage element resets instantaneously.

Select the **Settings > Protection > Elements > Group 1 > Voltage > Auxiliary UV** menu item to open the auxiliary undervoltage configuration window.

Figure 46: Auxiliary undervoltage configuration settings



PARAMETER	AUXILIARY UV 1	AUXILIARY UV 2
Function	Disabled	Disabled
Source	SRC 1 (SRC 1)	SRC 1 (SRC 1)
Pickup	0.700 pu	0.700 pu
Curve	Definite Time	Definite Time
Delay	1.00 s	1.00 s
Minimum Voltage	0.100 pu	0.100 pu
Block	OFF	OFF
Events	Disabled	Disabled

The following settings are available for each auxiliary undervoltage element.

Function

Range: Enabled, Disabled

Default: Disabled

This setting enables and disables the auxiliary undervoltage protection element.

Source

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)

Default: LINE (SRC 1)

This setting selects the signal source for the auxiliary undervoltage protection element.

Pickup

Range: 0.000 to 3.000 pu in steps of 0.001

Default: 0.700 pu

This setting specifies the auxiliary undervoltage pickup level in per-unit values.

Curve

Range: Definite Time, Inverse Time

Default: Inverse Time

This setting selects either the desired time-delay operating characteristic versus the applied fundamental voltage or the definite time characteristic for the auxiliary undervoltage element.

Delay

Range: 0.00 to 600.00 seconds in steps of 0.01

Default: 1.00 seconds

This setting selects the minimum operating time of the auxiliary undervoltage element.

Minimum Voltage

Range: 0.000 to 3.000 pu in steps of 0.001

Default: 0.100 pu

This setting specifies the operating voltage below which the auxiliary undervoltage element is blocked.

Block

Range: any FlexLogic operand or shared operand

Default: Off

Assertion of the operand assigned to this setting blocks the auxiliary undervoltage element.

Events

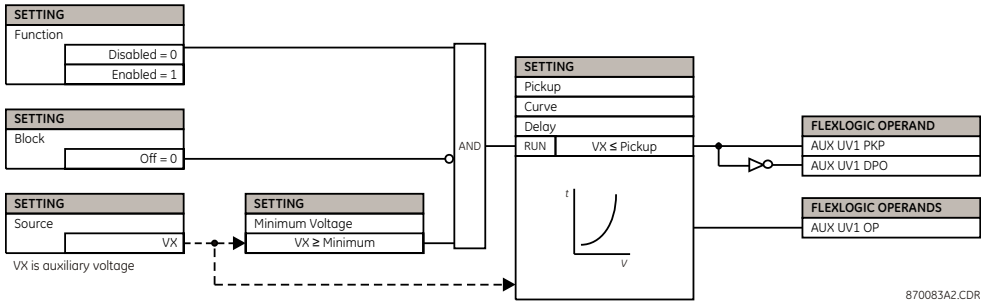
Range: Enabled, Disabled

Default: Disabled

This setting enables and disables the logging of auxiliary undervoltage events in the sequence of events recorder.

The figure shows the logic for the auxiliary undervoltage element. The logic is identical for all auxiliary undervoltage elements.

Figure 47: Auxiliary undervoltage scheme logic

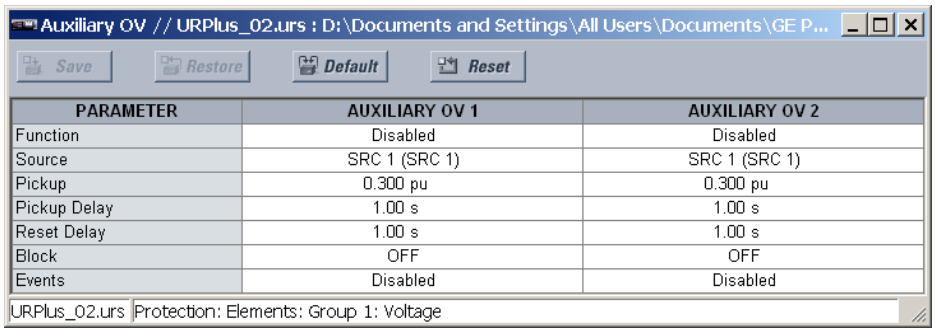


Auxiliary overvoltage

This element is intended for monitoring overvoltage conditions of the auxiliary voltage. A typical application for this element is monitoring the zero-sequence voltage (3V_0) supplied from an open-corner-delta VT connection. The nominal secondary voltage of the auxiliary voltage channel entered in the **Auxiliary VT Secondary** setting is the per-unit base used when setting the pickup level.

Select the **Settings > Protection > Elements > Group 1 > Voltage > Auxiliary OV** menu item to open the auxiliary overvoltage configuration window.

Figure 48: Auxiliary overvoltage configuration settings



PARAMETER	AUXILIARY OV 1	AUXILIARY OV 2
Function	Disabled	Disabled
Source	SRC 1 (SRC 1)	SRC 1 (SRC 1)
Pickup	0.300 pu	0.300 pu
Pickup Delay	1.00 s	1.00 s
Reset Delay	1.00 s	1.00 s
Block	OFF	OFF
Events	Disabled	Disabled

The following settings are available for each auxiliary overvoltage element.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the auxiliary overvoltage protection element.

Source

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)
Default: LINE (SRC 1)

This setting selects the signal source for the auxiliary overvoltage protection element.

Pickup

Range: 0.000 to 1.100 pu in steps of 0.001
Default: 0.300 pu

This setting specifies the auxiliary overvoltage pickup level in per-unit values.

Pickup Delay

Range: 0.00 to 600.00 seconds in steps of 0.01
Default: 1.00 seconds

This setting selects the minimum operating time of the auxiliary overvoltage element.

Reset Delay

Range: 0.00 to 600.00 seconds in steps of 0.01
Default: 1.00 seconds

This setting specifies the minimum reset time of the auxiliary overvoltage element.

Block

Range: any FlexLogic operand or shared operand
Default: Off

Assertion of the operand assigned to this setting blocks the auxiliary overvoltage element.

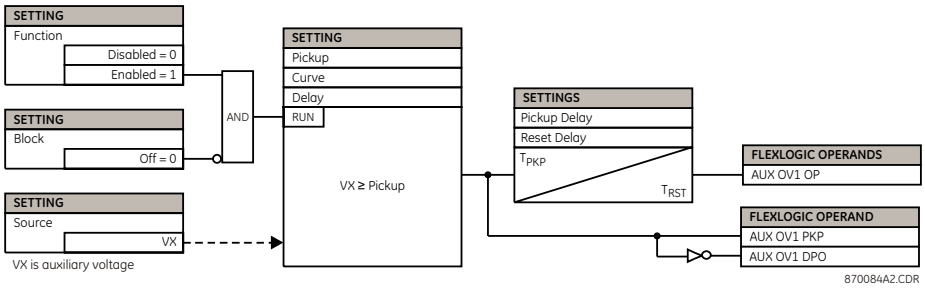
Events

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the logging of auxiliary overvoltage events in the sequence of events recorder.

The figure shows the logic for the auxiliary overvoltage element. The logic is identical for all auxiliary overvoltage elements.

Figure 49: Auxiliary overvoltage scheme logic



Sensitive directional power

The sensitive directional power element responds to three-phase directional power and is designed for reverse power and low forward power applications for synchronous machines or interconnections involving co-generation. The C90^{Plus}measures the three-phase power from either a full set of wye-connected VTs or a full set of delta-connected VTs. In the latter case, the two-wattmeter method is used. Refer to Metered values on page 486for details regarding the active and reactive powers used by the sensitive directional power element.

The sensitive directional power element has an adjustable characteristic angle and minimum operating power as shown in the directional power characteristic. The element responds to the following condition.

$$P\cos\theta + Q\sin\theta = S_{min} \qquad \textbf{Eq. 35}$$

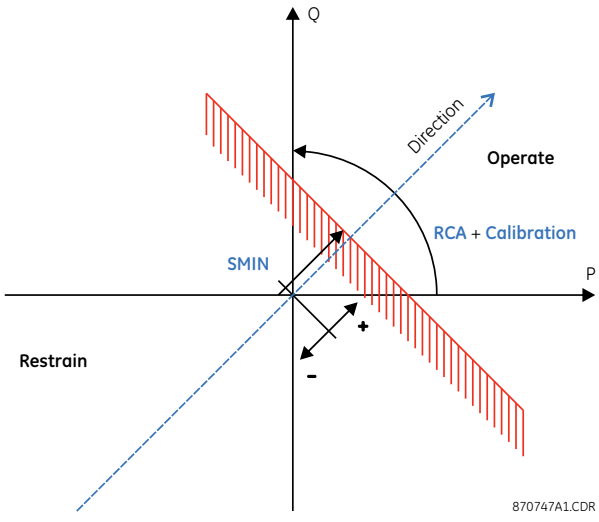
In the above equation:

- P and Q are active and reactive powers as measured per the UR^{Plus}-series metering conventions
- θ is a sum of the element characteristic (RCA) and calibration angles
- S_{min} is the minimum operating power

The operating quantity is displayed in the **Actual Values > Protection > Sensitive Directional Power** menu. The sensitive directional power element has two independent stages (with regards to the to the pickup and delay settings) for alarm and trip, respectively.

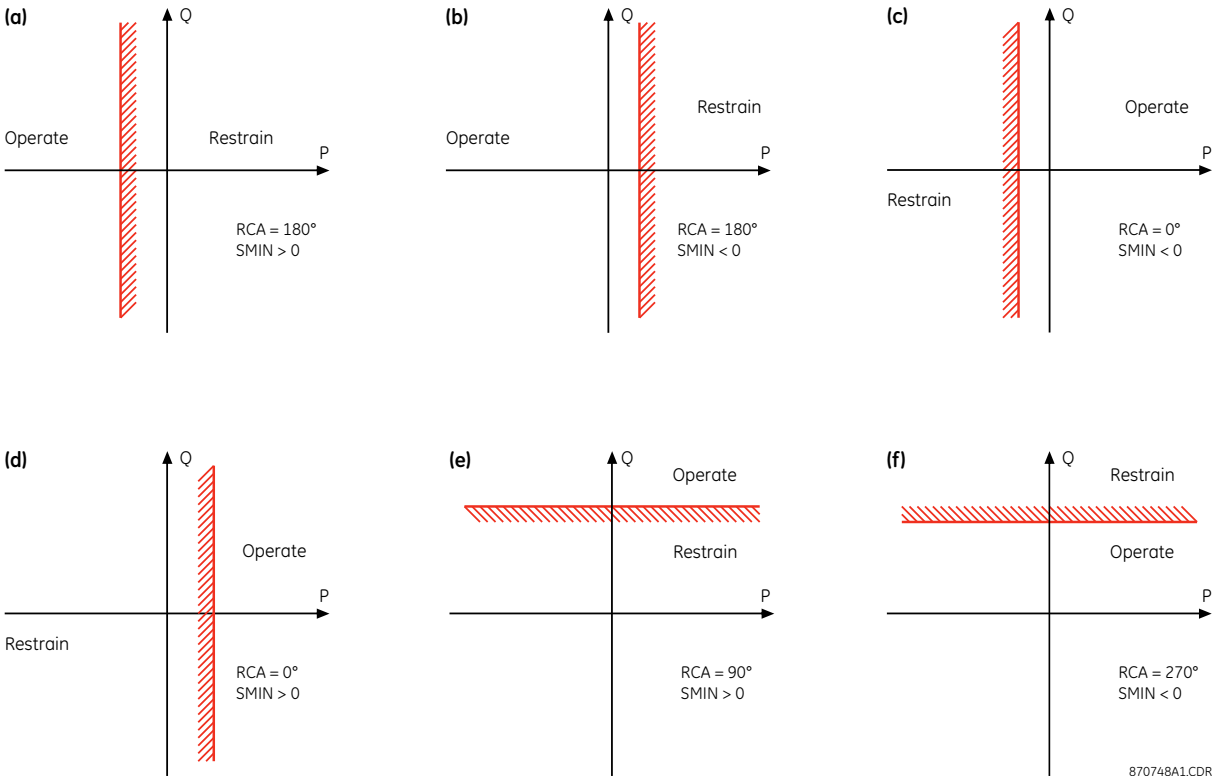
The following figure illustrates the directional power characteristic.

Figure 50: Sensitive directional power characteristic



By making the characteristic angle adjustable and providing for both negative and positive values of the minimum operating power, a variety of operating characteristics can be achieved as shown below. For example, section (a) in the figure below shows settings for reverse power, while section (b) shows settings for low forward power applications.

Figure 51: Sample applications for the sensitive directional power element



The following settings are available for each sensitive directional power element.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the sensitive directional power protection feature.

Signal Source

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)
Default: LINE (SRC 1)

This setting selects the signal source for sensitive directional power protection.

Sensitive Directional Power RCA

Range: 0° to 359° in steps of 1°
Default: 0°

This setting specifies the relay characteristic angle (RCA) for the sensitive directional power element. The application of this setting is threefold.

- It allows the element to respond to active power or reactive power in any direction (active overpower, reactive underpower, etc.).
- Together with a precise calibration angle, it allows compensation for any CT and VT angular errors to permit more sensitive settings.
- It allows for required direction in situations when the voltage signal is taken from behind a delta-wye connected power transformer and the phase angle compensation is required.

For example, the active overpower characteristic is achieved by programming this setting to "0°", reactive overpower by programming this setting to "90°", active underpower by programming this setting to "180°", and reactive underpower by programming this setting to "270°".

Sensitive Directional Power Calibration

Range: 0.00° to 0.95° in steps of 0.05°

Default: 0.00°

This setting allows the relay characteristic angle (RCA) to change in steps of 0.05°. This may be useful when a small difference in VT and CT angular errors is to be compensated to permit more sensitive settings. This setting virtually enables calibration of the directional power function in terms of the angular error of applied VTs and CTs. The element responds to the sum of the **Sensitive Directional Power RCA** setting and this setting.

Stage 1 SMIN, Stage 2 SMIN

Range: –1.200 to 1.200 pu in steps of 0.001

Default: 0.100 pu

These settings specify the minimum power as defined along the relay characteristic angle (RCA) stage 1 and stage 2 of the sensitive directional power element. Positive values imply a shift towards the operate region along the RCA line. Similarly, negative values imply a shift towards the restrain region along the RCA line. Together with the RCA, these settings enable a wide range of operating characteristics. These settings apply to three-phase power and are entered in per-unit (pu) values. The base quantity is 3 × VT pu base × CT pu base.

For example, a setting of 2% for a 200 MW machine is 0.02 × 200 MW = 4 MW. If 7.967 kV is a primary VT voltage and 10 kA is a primary CT current, then the source pu quantity is 239 MVA, and therefore SMIN should be set at 4 MW / 239 MVA = 0.0167 pu ≈ 0.017 pu. If the reverse power application is considered, then RCA = 180° and SMIN = 0.017 pu.The sensitive directional power element drops out if the magnitude of the positive-sequence current becomes virtually zero; that is, it drops below the cutoff level. For reverse power or low forward power applications for a synchronous machine, stage 1 is typically applied for alarming and stage 2 for tripping.

Stage 1 Delay, Stage 2 Delay

Range: 0.00 to 600.00 seconds in steps of 0.01

Default: 20.00 seconds

These settings specify the time delay for stages 1 and 2. For reverse power or low forward power applications for a synchronous machine, stage 1 is typically applied for alarming and stage 2 for tripping.

Block

Range: any FlexLogic operand or shared logic operand

Default: OFF

Assertion of the logic operand assigned to this setting blocks operation of the sensitive directional power element

Events

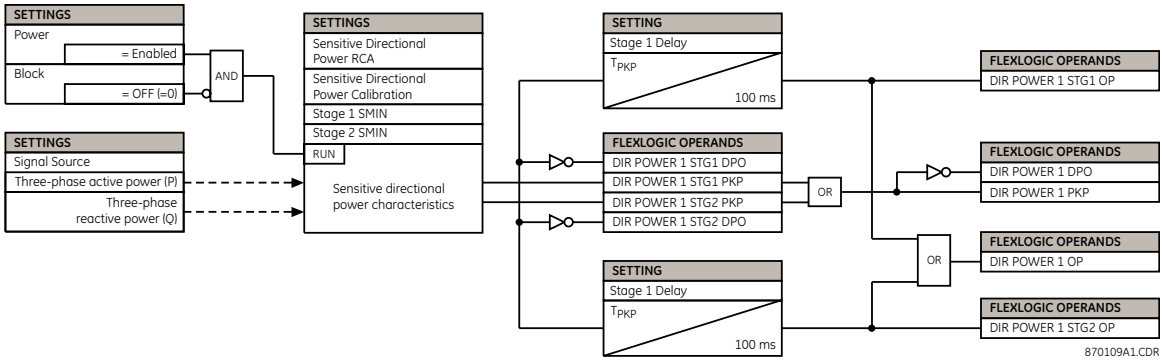
Range: Enabled, Disabled

Default: Disabled

This setting enables and disables the logging of sensitive directional power events in the sequence of events recorder.

The scheme logic for the sensitive directional power element is shown as follows.

Figure 52: Sensitive directional power scheme logic

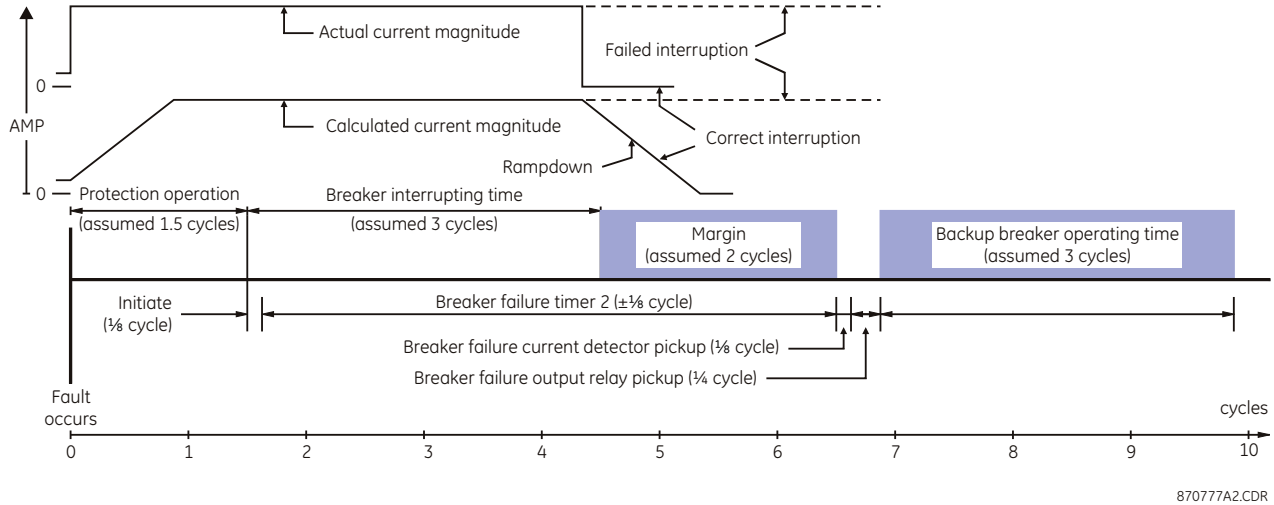


Breaker failure

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

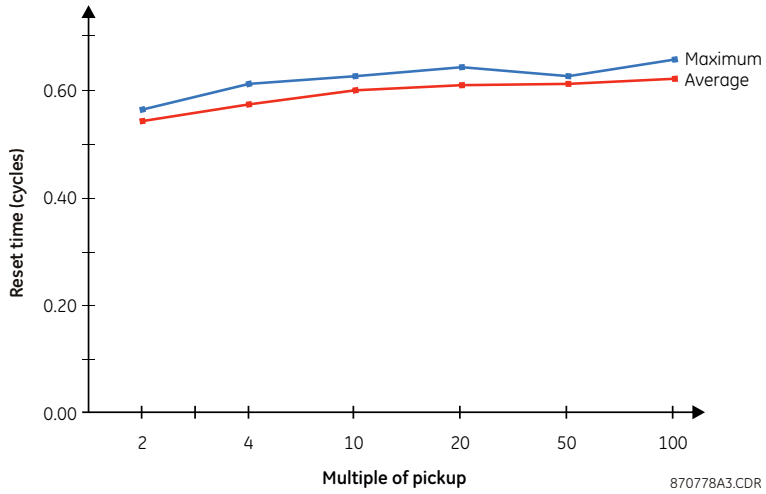
Two schemes are provided: one for three-pole tripping only and one for three pole plus single-pole operation. The philosophy used in these schemes is identical. The operation of a breaker failure element includes three stages: initiation, determination of a breaker failure condition, and output.

Figure 53: Breaker failure main path sequence



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

Figure 54: Breaker failure current supervision reset time



Breaker failure initiation stage

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

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

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

Determination of a breaker failure condition

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

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

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

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

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

Breaker failure scheme outputs

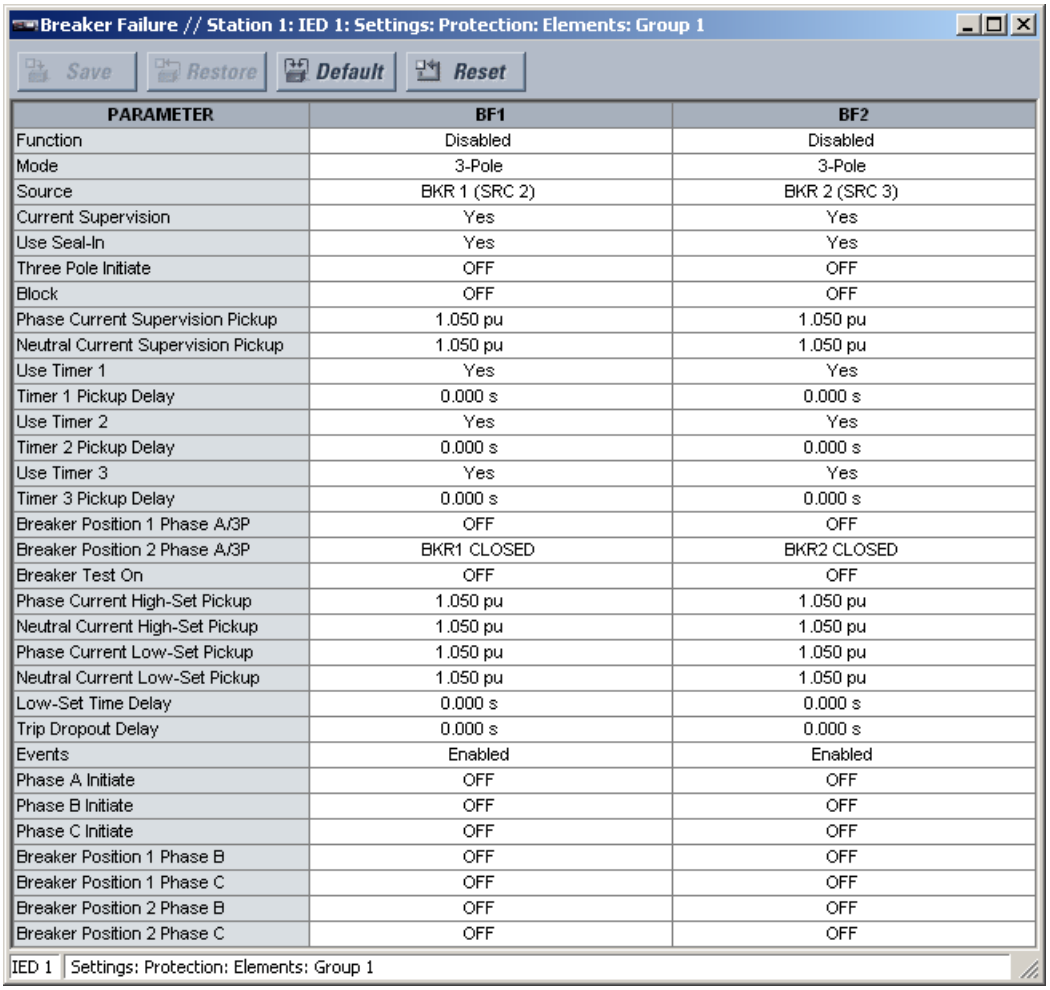
The outputs from the breaker failure scheme are

- FlexLogic operands that report on the operation of portions of the scheme
- A 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.
- Illumination of a front panel annunciator message or messages

Breaker failure settings and logic

Select the **Settings > Protection > Elements > Group 1 > Breaker Failure** menu item to open the breaker failure configuration window.

Figure 55: Breaker failure configuration settings



PARAMETER	BF1	BF2
Function	Disabled	Disabled
Mode	3-Pole	3-Pole
Source	BKR 1 (SRC 2)	BKR 2 (SRC 3)
Current Supervision	Yes	Yes
Use Seal-In	Yes	Yes
Three Pole Initiate	OFF	OFF
Block	OFF	OFF
Phase Current Supervision Pickup	1.050 pu	1.050 pu
Neutral Current Supervision Pickup	1.050 pu	1.050 pu
Use Timer 1	Yes	Yes
Timer 1 Pickup Delay	0.000 s	0.000 s
Use Timer 2	Yes	Yes
Timer 2 Pickup Delay	0.000 s	0.000 s
Use Timer 3	Yes	Yes
Timer 3 Pickup Delay	0.000 s	0.000 s
Breaker Position 1 Phase A/3P	OFF	OFF
Breaker Position 2 Phase A/3P	BKR1 CLOSED	BKR2 CLOSED
Breaker Test On	OFF	OFF
Phase Current High-Set Pickup	1.050 pu	1.050 pu
Neutral Current High-Set Pickup	1.050 pu	1.050 pu
Phase Current Low-Set Pickup	1.050 pu	1.050 pu
Neutral Current Low-Set Pickup	1.050 pu	1.050 pu
Low-Set Time Delay	0.000 s	0.000 s
Trip Dropout Delay	0.000 s	0.000 s
Events	Enabled	Enabled
Phase A Initiate	OFF	OFF
Phase B Initiate	OFF	OFF
Phase C Initiate	OFF	OFF
Breaker Position 1 Phase B	OFF	OFF
Breaker Position 1 Phase C	OFF	OFF
Breaker Position 2 Phase B	OFF	OFF
Breaker Position 2 Phase C	OFF	OFF

The following settings are available for each breaker failure element.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the breaker failure protection element.

Mode

Range: 1-Pole, 3-Pole
Default: 1-Pole

This setting selects the breaker failure operating mode: single-pole or three-pole.

Source

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)
Default: LINE (SRC 1)

This setting selects the signal source for the breaker failure protection element.

Current Supervision

Range: Yes, No
Default: Yes

If set to "Yes", the breaker failure element will only be initiated if current flowing through the breaker is above the supervision pickup level.

Use Seal-In

Range: Yes, No

Default: Yes

If set to "Yes", the breaker failure element will only be sealed-in if current flowing through the breaker is above the supervision pickup level.

Three Pole Initiate

Range: any FlexLogic operand or shared operand

Default: Off

This setting selects the operand that will initiate three-pole tripping of the breaker when asserted.

Block

Range: any FlexLogic operand or shared operand

Default: Off

Assertion of the operand assigned to this setting blocks operation of the breaker failure element.

Phase Current Supervision Pickup

Range: 0.001 to 30.000 pu in steps of 0.001

Default: 1.050 pu

This setting specifies the phase current initiation and seal-in supervision level. Generally, this setting should detect the lowest expected fault current on the protected breaker. It can be set as low as necessary (lower than breaker resistor current or lower than load current). High-set and low-set current supervision will ensure correct operation.

Neutral Current Supervision Pickup

Range: 0.001 to 30.000 pu in steps of 0.001

Default: 1.050 pu

This setting specifies the neutral current initiate and seal-in supervision level. Generally, this setting should detect the lowest expected fault current on the protected breaker. Neutral current supervision is used only in the three phase scheme to provide increased sensitivity. This setting is valid only for three-pole tripping schemes.

Use Timer 1

Range: Yes, No

Default: Yes

If this setting value is "Yes", the early path is operational.

Timer 1 Pickup Delay

Range: 0.000 to 65.535 seconds in steps of 0.001

Default: 0 seconds

Timer 1 is set to the shortest time required for breaker auxiliary contact Status-1 to open, from the time the initial trip signal is applied to the breaker trip circuit, plus a safety margin.

Use Timer 2

Range: Yes, No

Default: Yes

If this setting value is "Yes", the main path is operational.

Timer 2 Pickup Delay

Range: 0.000 to 65.535 seconds in steps of 0.001

Default: 0 seconds

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 the UR^{Plus}-series devices, 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.

Use Timer 3

Range: Yes, No
Default: Yes

If this setting value is "Yes", the slow path is operational.

Timer 3 Pickup Delay

Range: 0.000 to 65.535 seconds in steps of 0.001
Default: 0 seconds

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.

Breaker Position 1 Phase A/3P

Range: any FlexLogic operand or shared operand
Default: Off

This setting selects the operand that represents the protected breaker early-type auxiliary switch contact (52/a). When using the single-pole breaker failure scheme, this operand represents the protected breaker early-type auxiliary switch contact on pole A. This is normally a non-multiplied form-A contact. The contact may even be adjusted to have the shortest possible operating time.

Breaker Position 2 Phase A/3P

Range: any FlexLogic operand or shared operand
Default: Off

This setting selects the operand that represents the breaker normal-type auxiliary switch contact (52/a). When using the single-pole breaker failure scheme, this operand represents the protected breaker auxiliary switch contact on pole A. This may be a multiplied contact.

Breaker Test On

Range: any FlexLogic operand or shared operand
Default: Off

This setting selects the operand that represents the breaker in-service/out-of-service switch set to the out-of-service position.

Phase Current High-Set Pickup

Range: 0.001 to 30.000 pu in steps of 0.001
Default: 1.050 pu

This setting specifies the phase current output supervision level. Generally, this setting should detect the lowest expected fault current on the protected breaker, before a breaker opening resistor is inserted.

Neutral Current High-Set Pickup

Range: 0.001 to 30.000 pu in steps of 0.001

Default: 1.050 pu

This setting specifies the neutral current output supervision level. Generally, this setting should detect the lowest expected fault current on the protected breaker, before a breaker opening resistor is inserted. Neutral current supervision is used only in the three pole scheme to provide increased sensitivity. This setting is valid only for three-pole breaker failure schemes.

Phase Current Low-Set Pickup

Range: 0.001 to 30.000 pu in steps of 0.001

Default: 1.050 pu

This setting specifies the phase current output supervision level. Generally, this setting should detect the lowest expected fault current on the protected breaker, after a breaker opening resistor is inserted (approximately 90% of the resistor current).

Neutral Current Low-Set Pickup

Range: 0.001 to 30.000 pu in steps of 0.001

Default: 1.050 pu

This setting specifies the neutral current output supervision level. Generally, this setting should detect the lowest expected fault current on the protected breaker, after a breaker opening resistor is inserted (approximately 90% of the resistor current). This setting is valid only for three-pole breaker failure schemes.

Low-Set Time Delay

Range: 0.000 to 65.535 seconds in steps of 0.001

Default: 0.000 seconds

This setting specifies the pickup delay for current detection after opening resistor insertion.

Trip Dropout Delay

Range: 0.000 to 65.535 seconds in steps of 0.001

Default: 0.000 seconds

This setting specifies the time for which the trip output is sealed-in. This timer must be coordinated with the automatic reclosing scheme of the failed breaker, to which the breaker failure element sends a cancel reclosure signal. Reclosure of a remote breaker can also be prevented by holding a transfer trip signal on longer than the reclaim time.

Events

Range: Enabled, Disabled

Default: Enabled

This setting enables and disables the logging of breaker failure events in the sequence of events recorder.

Phase A Initiate, Phase B Initiate, Phase C Initiate

Range: any FlexLogic operand or shared operand

Default: Off

These settings select operands to initiate phase A, B, and C single-pole tripping of the breaker and the phase A, B, or C portion of the scheme, accordingly. These settings are only valid for single-pole breaker failure schemes.

Breaker Position 1 Phase B

Range: any FlexLogic operand or shared operand
Default: Off

This setting selects the operand to represent the protected breaker early-type auxiliary switch contact on pole B. This contact is normally a non-multiplied form-A contact. The contact may even be adjusted to have the shortest possible operating time. This setting is valid only for single-pole breaker failure schemes.

Breaker Position 1 Phase C

Range: any FlexLogic operand or shared operand
Default: Off

This setting selects the operand to represent the protected breaker early-type auxiliary switch contact on pole C. This contact is normally a non-multiplied form-A contact. The contact may even be adjusted to have the shortest possible operating time. This setting is valid only for single-pole breaker failure schemes.

Breaker Position 2 Phase B

Range: any FlexLogic operand or shared operand
Default: Off

This setting selects the operand that represents the protected breaker normal-type auxiliary switch contact on pole B (52/a). This may be a multiplied contact. This setting is valid only for single-pole breaker failure schemes.

Breaker Position 2 Phase C

Range: any FlexLogic operand or shared operand
Default: Off

This setting selects the operand that represents the protected breaker normal-type auxiliary switch contact on pole C (52/a). This may be a multiplied contact. For single-pole operation, the scheme has the same overall general concept except that it provides re-tripping of each single pole of the protected breaker. The approach shown in the following single pole tripping diagram uses the initiating information to determine which pole is supposed to trip. The logic is segregated on a per-pole basis. The overcurrent detectors have ganged settings. This setting is valid only for single-pole breaker failure schemes.

Upon operation of the breaker failure element for a single pole trip command, a three-pole trip command should be given via the BKR FAIL 1 TRIP OP output operand.

The logic for the breaker failure element is shown in the following figures. The logic is identical for both breaker failure elements.

Figure 56: Breaker failure single-pole logic, sheet 1 of 3

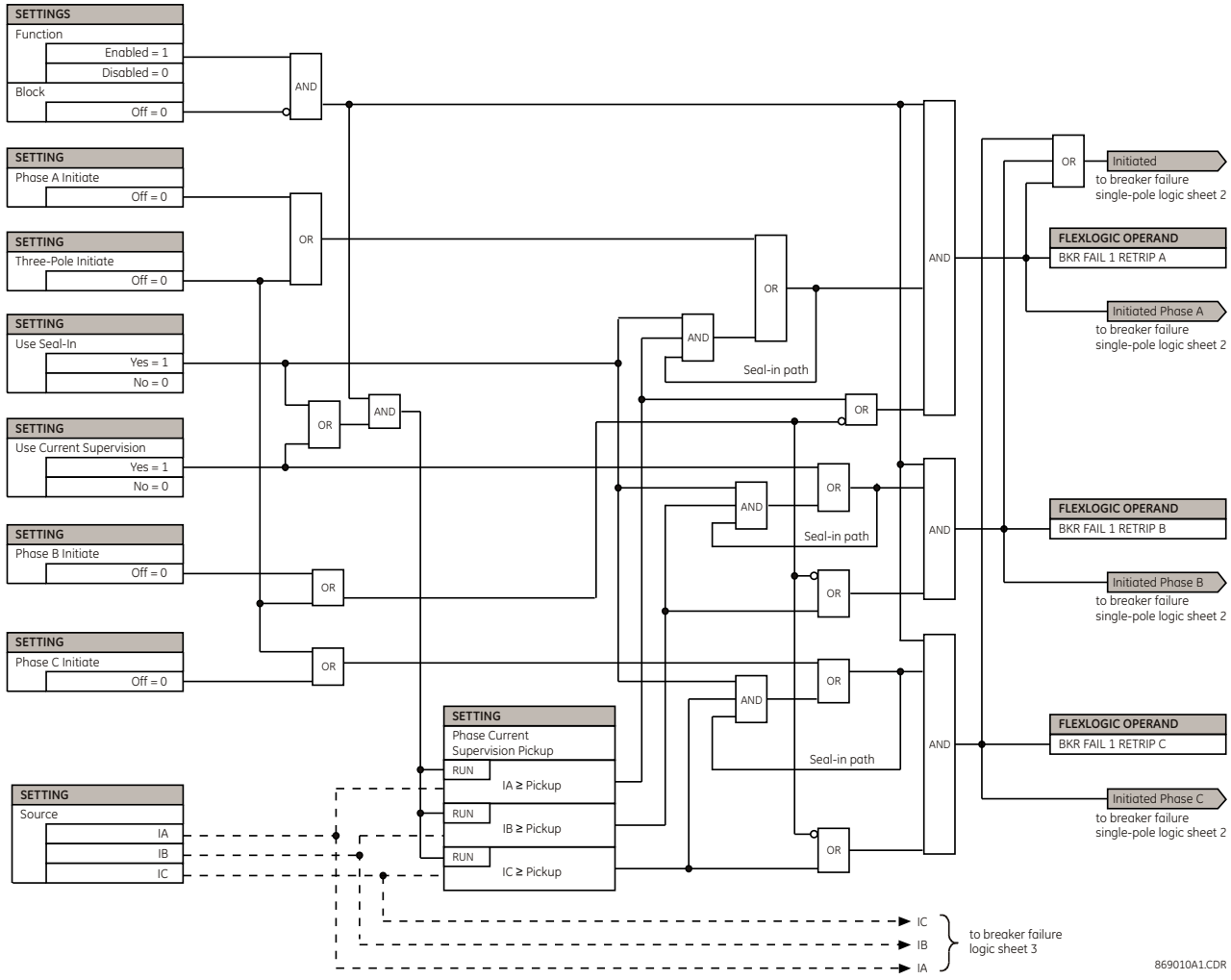


Figure 57: Breaker failure single-pole logic, sheet 2 of 3

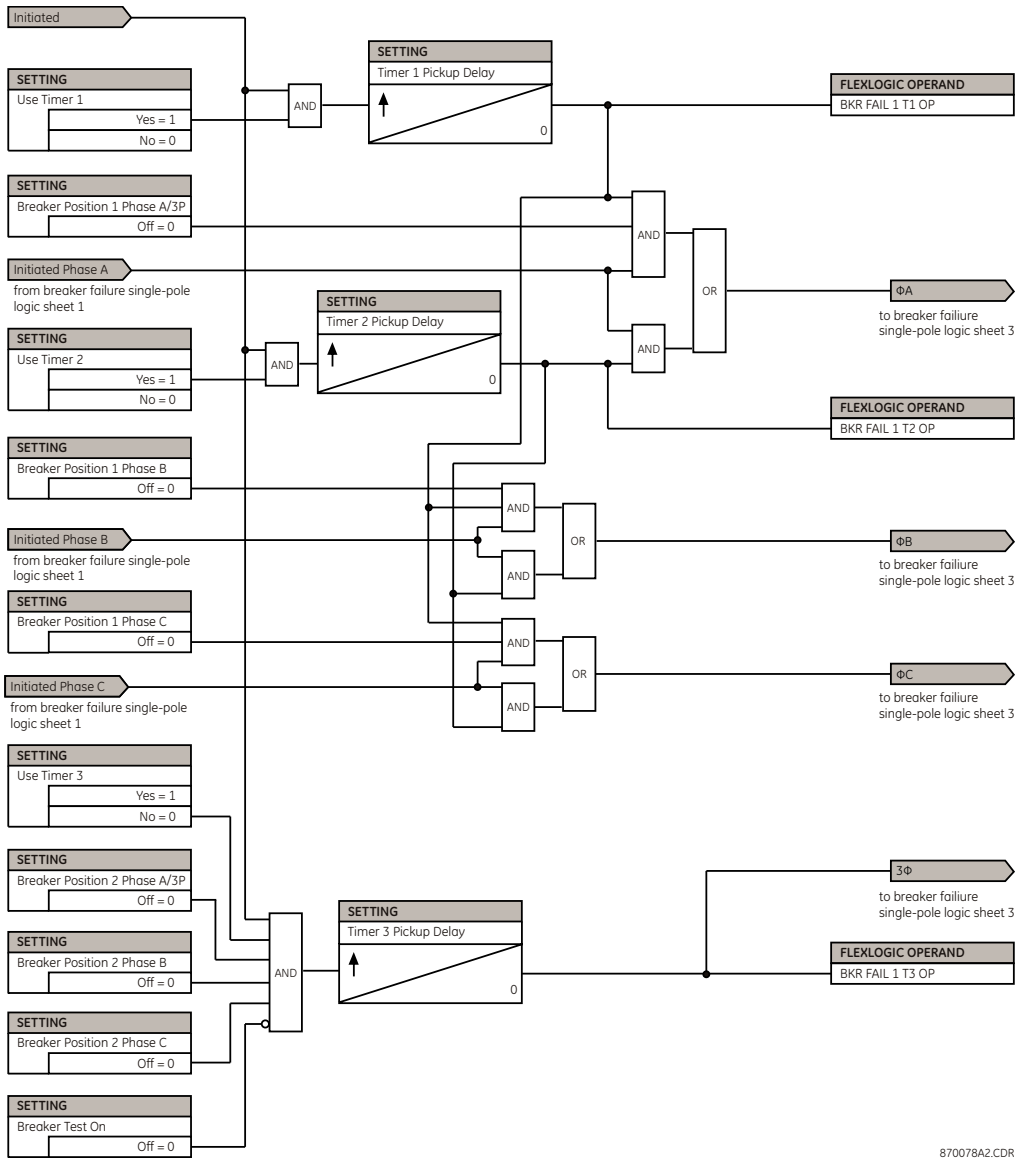


Figure 58: Breaker failure single-pole logic, sheet 3 of 3

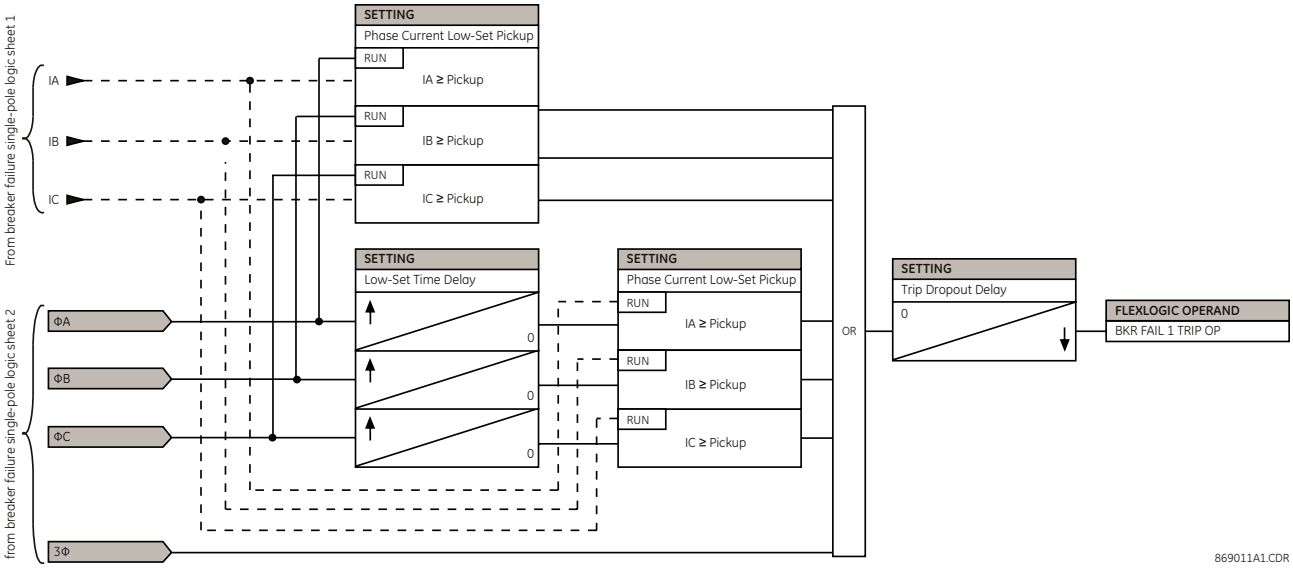


Figure 59: Breaker failure three-pole logic, sheet 1 of 3

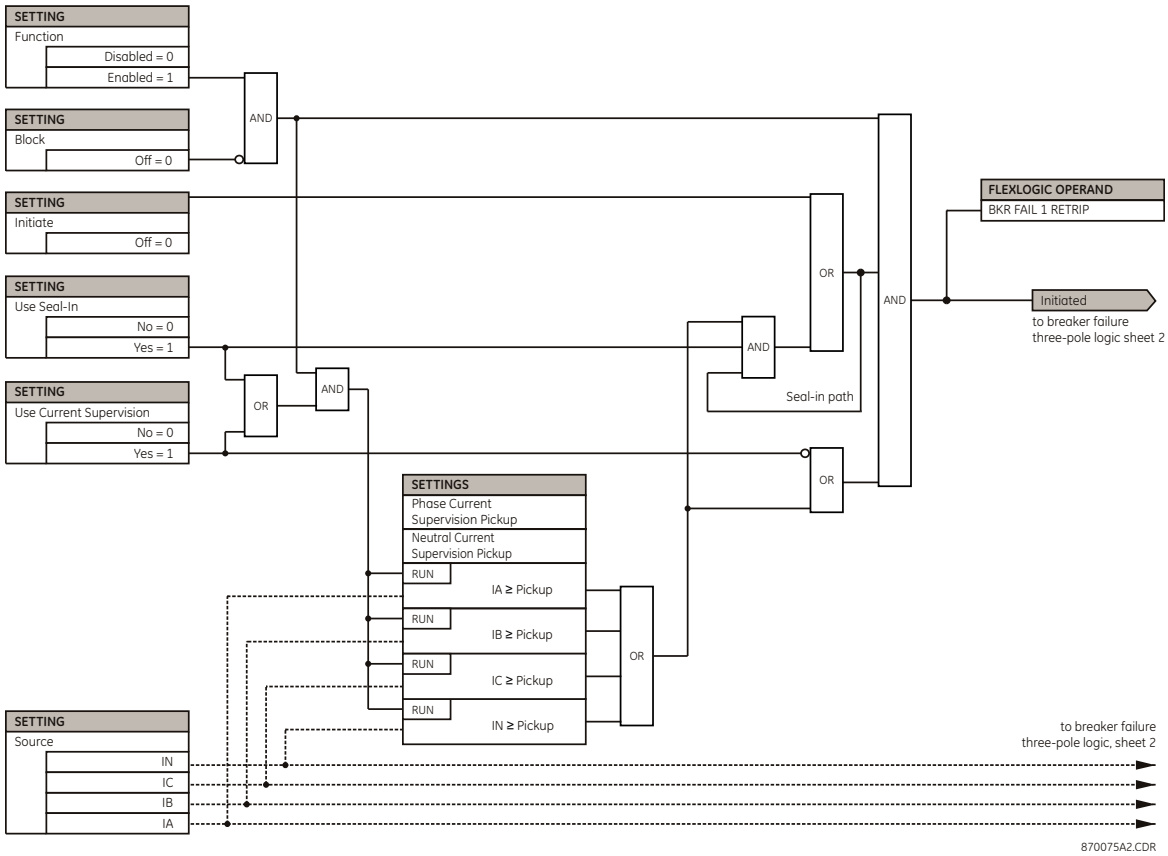


Figure 60: Breaker failure three-pole logic, sheet 2 of 3

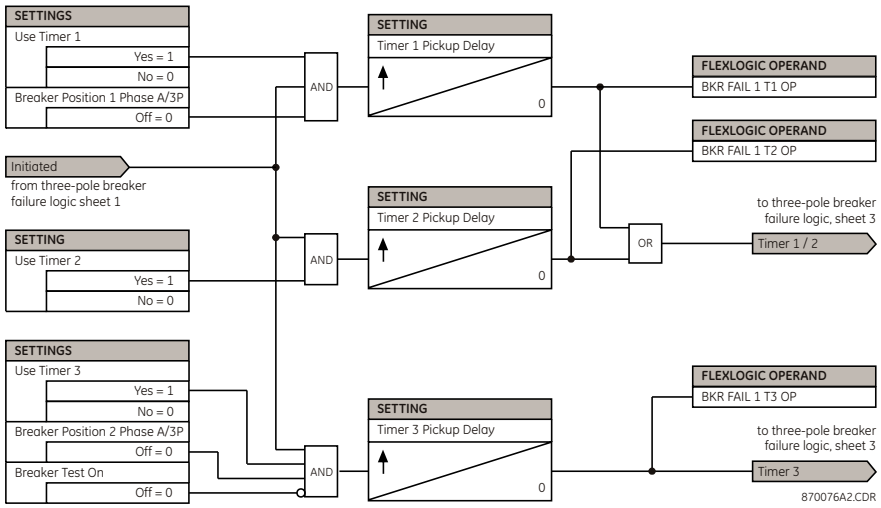
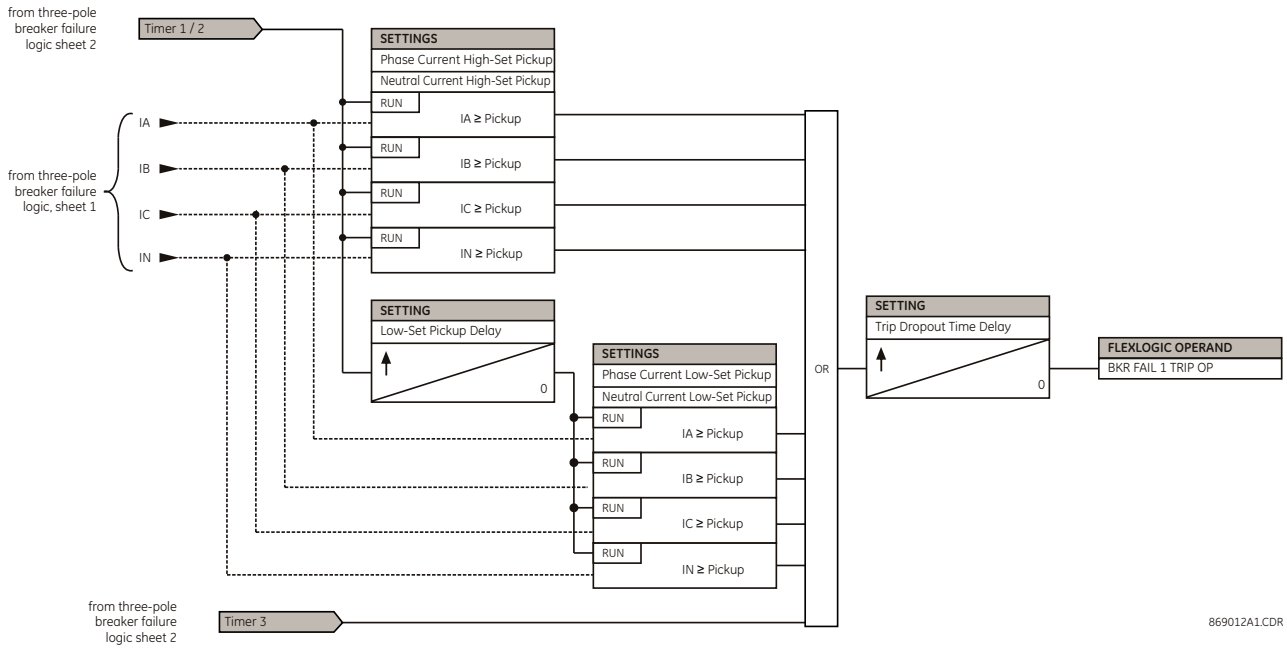


Figure 61: Breaker failure three-pole logic, sheet 3 of 3



Control elements

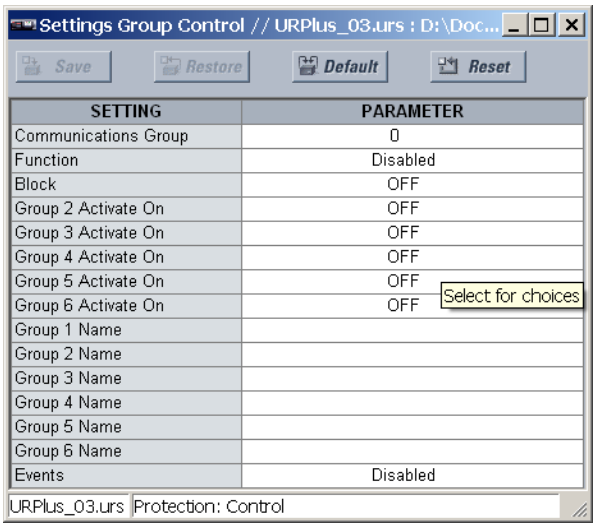
Control elements generally are used for control rather than protection.

Setting group control

The setting groups control function activates and deactivates of up to six setting groups.

Select the **Settings > Protection > Control > Setting Group Control** menu item to access the setting group control settings.

Figure 62: Setting group control configuration



The following settings are available for setting groups control. The **Current Setting Group** actual value is also displayed in this menu.

Function

Range: Enabled, Disabled
Default: Disabled

This setting is used to enable and disable the setting groups control functionality.

Block

Range: any FlexLogic operand or shared operand
Default: OFF

This setting prevents the active setting group from changing when the assigned operand is asserted. This can be useful in applications where it is undesirable to change the settings under certain conditions, such as the breaker being open.

Group 2 Activate On, Group 3 Activate On, Group 4 Activate On, Group 5 Activate On, Group 6 Activate On

Range: any FlexLogic operand or shared operand
Default: OFF

Each of these settings selects an operand which, when set, activates the corresponding setting group for use by any grouped element. A priority scheme ensures that only one group is active at a given time. The highest-numbered group activated by these settings takes priority over the lower-numbered groups. There is no activation setting group 1 (the default active group) since group 1 automatically becomes active when there is no other group active.

Group 1 Name, Group 2 Name, Group 3 Name, Group 4 Name, Group 5 Name, Group 6 Name

Range: up to 16 alphanumeric characters
Default: empty

These settings allows to user to assign a name to each of the six settings groups.

Events

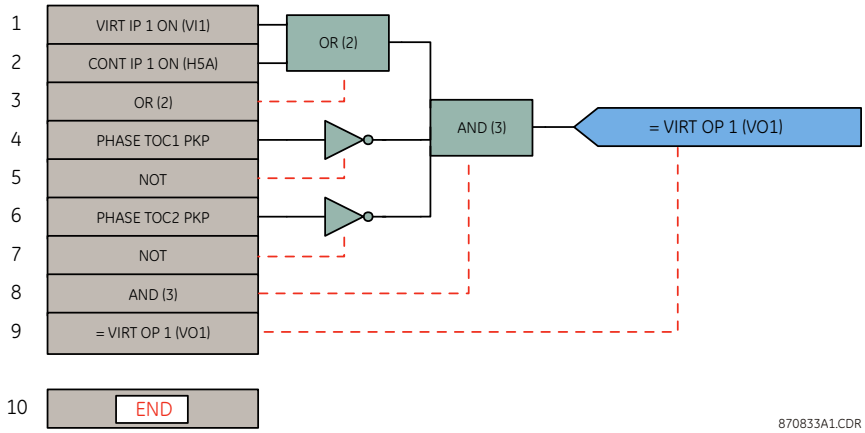
Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the logging of setting group control events in the sequence of events recorder.

FlexLogic control of a settings group

The relay can be set up via a protection FlexLogic equation to receive requests to activate or de-activate a particular non-default settings group. The following FlexLogic equation illustrates requests via remote communications (for example, VIRT IP 1 ON) or from a local contact input (for example, CONT 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 VIRT OP 1 operand is used to control the "On" state of a particular settings group.

Figure 63: FlexLogic control of a settings group



FlexMatrix

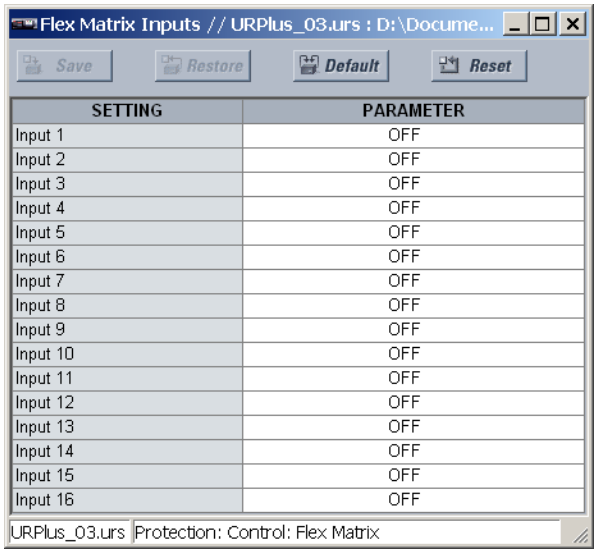
The FlexMatrix allows up to 16 inputs to be aggregated and conditioned for tripping or auxiliary functions. Up to eight output signals can be derived from the input signals. Outputs can be configured for latching (lockout) and can also have a programmable pickup and dropout delay.

In a typical application, the FlexLogic operands from protection functions are assigned as inputs to the FlexMatrix. Each output can be assigned to a specific task, such as tripping the breaker or blocking a protection element.

FlexMatrix inputs

Select the **Settings > Protection > Control > FlexMatrix > FlexMatrix Inputs** menu item to access the FlexMatrix input settings.

Figure 64: FlexMatrix input configuration settings



The following setting is available for each of the 16 FlexMatrix inputs.

Input 1, Input 2,..., Input 16

Range: any FlexLogic operand or shared operand

Default: OFF

The operand assigned to this setting can be re-assigned to any or all of the FlexMatrix outputs.

FlexMatrix configuration

Select the **Settings > Protection > Control > FlexMatrix > FlexMatrix** menu item to access the FlexMatrix™ configuration settings.

Figure 65: FlexMatrix configuration settings

Flex Matrix // URPlus_03.urs : D:\Documents and Settings\All Users\Documents\GE Power Management\URPLUS\Data\: Prot...

Save | Restore | Default | Reset

PARAMETER	FLEX MATRIX 1	FLEX MATRIX 2	FLEX MATRIX 3
Function	Disabled	Disabled	Disabled
Name	Flexmat 1	Flexmat 2	Flexmat 3
Input 1 Enable	Disabled	Disabled	Disabled
Input 2 Enable	Disabled	Disabled	Disabled
Input 3 Enable	Disabled	Disabled	Disabled
Input 4 Enable	Disabled	Disabled	Disabled
Input 5 Enable	Disabled	Disabled	Disabled
Input 6 Enable	Disabled	Disabled	Disabled
Input 7 Enable	Disabled	Disabled	Disabled
Input 8 Enable	Disabled	Disabled	Disabled
Input 9 Enable	Disabled	Disabled	Disabled
Input 10 Enable	Disabled	Disabled	Disabled
Input 11 Enable	Disabled	Disabled	Disabled
Input 12 Enable	Disabled	Disabled	Disabled
Input 13 Enable	Disabled	Disabled	Disabled
Input 14 Enable	Disabled	Disabled	Disabled
Input 15 Enable	Disabled	Disabled	Disabled
Input 16 Enable	Disabled	Disabled	Disabled
Block	OFF	OFF	OFF
Pickup Delay	0.000	0.000	0.000
Dropout Delay	0.000	0.000	0.000
Latching	Disabled	Disabled	Disabled
Reset	OFF	OFF	OFF
Events	Enabled	Enabled	Enabled

URPlus_03.urs | Protection: Control: Flex Matrix

The following settings are available for each of the eight FlexMatrix elements.

Function

Range: Enabled, Disabled

Default: Disabled

This setting enables or disables the FlexMatrix element.

Name

Range: 12 alphanumeric characters

Default: Flexmat 1

This setting specifies the name associated with a particular FlexMatrix element.

Input 1 Enable, Input 2 Enable,..., Input 16 Enable

Range: Enabled, Disabled

Default: Disabled

These settings enable and disable the 16 FlexMatrix inputs for each FlexMatrix. These inputs can be assigned FlexLogic operands or shared operands, which can then be assigned to any or all of the FlexMatrix outputs.

Block

Range: any FlexLogic operand or shared operand
Default: OFF

Assertion of the operand assigned to this setting blocks operation of the FlexMatrix element.

Pickup Delay

Range: 0.000 to 60.000 seconds in steps of 0.001
Default: 0.000 seconds

This setting specifies the delay by which to extend the FlexMatrix pickup.

Dropout Delay

Range: 0.000 to 60.000 seconds in steps of 0.001
Default: 0.000 seconds

This setting specifies the delay by which to extend the FlexMatrix dropout.

Latching

Range: Enabled, Disabled
Default: Disabled

When this setting is enabled, the FlexMatrix output is latched until the reset input is asserted.

Reset

Range: any FlexLogic operand or shared operand
Default: OFF

Assertion of the operand assigned to this setting resets the FlexMatrix output when latching is enabled.

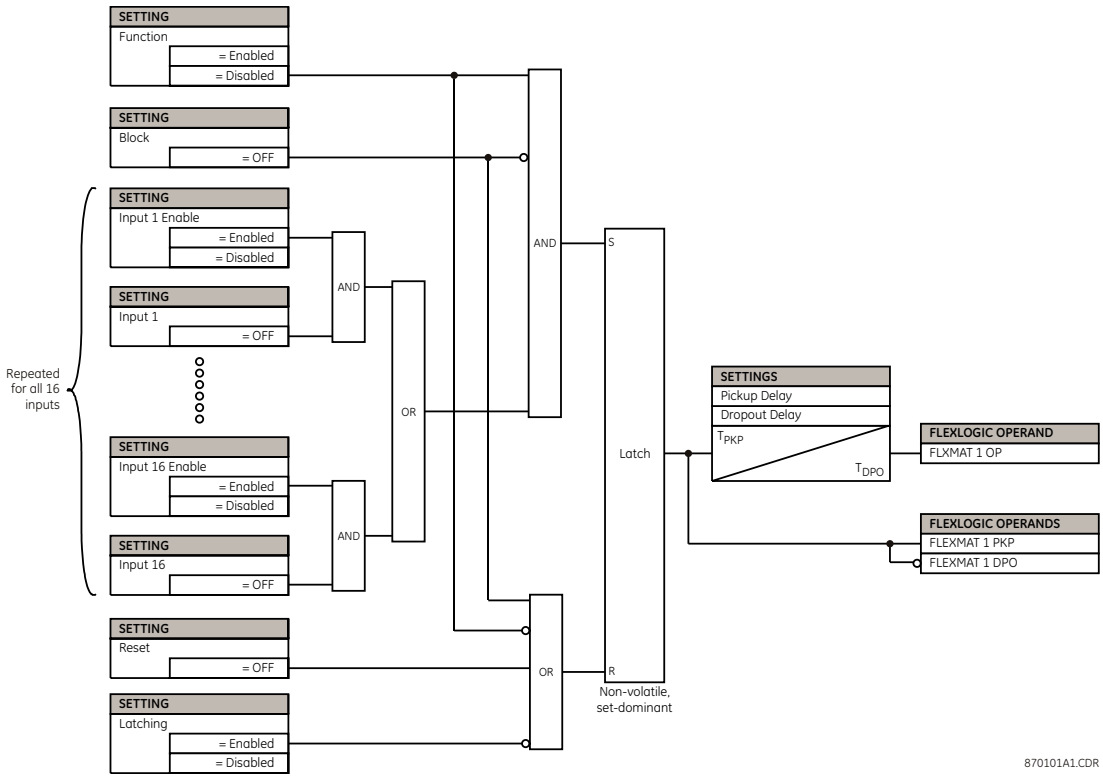
Events

Range: Enabled, Disabled
Default: Enabled

This setting enables and disables the logging of FlexMatrix events in the sequence of events recorder.

The figure shows the logic for FlexMatrix 1. The logic is identical for all eight FlexMatrix elements.

Figure 66: FlexMatrix scheme logic



Small signal oscillation detection

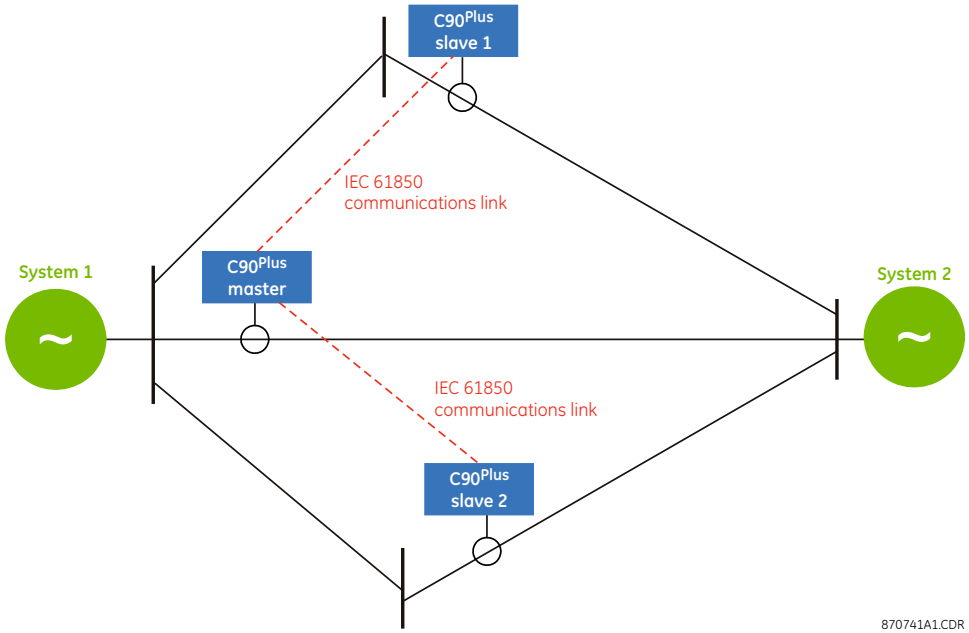
Stability is required in any electrical power system containing generators and loads. This stability can be represented as the equilibrium point between the mechanical input torque of the generator rotors and the electrical force transmitted to each load. If there is any disturbance in the system, the equilibrium point is upset and may cause the system to collapse if it is severe enough. As a result, two stability factors should be measured to ensure the system is protected from collapsing: transient stability and small-signal stability. Transient stability is related to severe and large swings in load or generation capacity, whereas small signal (or small disturbance) stability is related to oscillators in the system that may cause a complete blackout if not detected. This is of particular interest in modern power systems which tend to operate near their limits. The C90^{Plus} can detect these small disturbances and provide an alarm. It can also be configured to send a trip signal to prevent a system collapse.

The small signal oscillation detector element detects small signal oscillation of selected analogue quantities (for example real power or frequency) on the interconnections between different power systems. There are two elements provided with a selectable frequency band of interest. Each element has two stages, one for alarm action and another for trip action. Small signal oscillations can be detected using local measurement only or local and remote measurements taken at approximately same instance at some fixed rate (for example, 100 ms). In this case, the remote and local values can be summed and processed using single-cycle Fourier filter. The magnitude of the low frequency signal (for example, in the range of 0.1 to 0.2 Hz) is compared with a threshold and after a specified time delay, a trip or alarm action will be issued by the C90^{Plus}. Typical analogue quantities used for small signal oscillations include frequency and real power.

When remote analogue values are used, there is one dedicated master device that collects analogue data over the IEC 61850 protocol from slave devices and execute an algorithm to detect small signal oscillations. The master device will send a request at a fixed 100 ms

time interval. Upon receipt of the data, the master device will align the received data with the local data, remove the DC component, and filter using a low pass filter with a cutoff frequency of 2 Hz. The master device will then measure the low frequency signal frequency and phasor magnitude to compare with a user-selected threshold. Correct operation of the algorithm is dependent on the correct setup and mapping of IEC 61850 analogue values.

Figure 67: Topology of the system and data collection



Small signal oscillation signal detector settings

Select the **Settings > Protection > Control > Small Signal Oscillation Detectors > Signal Detectors** menu item to open the small signal oscillation signal detector settings window.

Figure 68: Small signal oscillation detector settings

Signal Detectors // URPlus01.urs : I:\: Protection: Control: Signal Oscillation Detectors

Save | Restore | Default | Reset

SETTINGS	DETECTOR 1 VALUES	DETECTOR 2 VALUES
Function	Disabled	Disabled
Input 1	OFF	OFF
Input 2	OFF	OFF
Input 3	OFF	OFF
Input 4	OFF	OFF
Input 5	OFF	OFF
Input 6	OFF	OFF
Low Freq	0.1 Hz	0.1 Hz
High Freq	0.2 Hz	0.2 Hz
Alarm Pickup	0.20 pu	0.20 pu
Trip Pickup	0.20 pu	0.20 pu
Deadband	0.10 pu	0.10 pu
Alarm Delay	10.00 s	10.00 s
Trip Delay	5.00 s	5.00 s
Block	OFF	OFF
Events	Disabled	Disabled

URPlus01.urs | Protection: Control: Signal Oscillation Detectors

The following settings are available for both signal detectors.

Function

Range: Disabled, Enabled

Default: Disabled

This setting enables and disables the small signal oscillation detection (SSOD) element.

Input 1, Input 2, Input 3, Input 4, Input 5, Input 6

Range: any FlexAnalog parameter, SSOD Slave 1 Input, SSOD Slave 2 Input,..., SSOD Slave 6 Input

Default: OFF

These settings select any local or remote over IEC 61850 analogue quantity to be processed by the small signal oscillation detection algorithm. The local signal is used to determine the base of the measured quantity. The user must ensure that selected remote analog signals have the same units as the local signal. The base units are the same used for FlexElements. For example, if real power is selected at the master device, then $P_{base} = V_{prim} \times I_{prim}$, where V_{prim} and I_{prim} are the nominal primary line-to-line voltage and current based on the values of VT and primary CT current at the master device. If frequency is chosen, then f_{base} is 1 Hz.

Low Frequency

Range: 0.08 to 1.00 Hz in steps of 0.02

Default: 0.1 Hz

This setting specifies the lower frequency value of the frequency band of interest. If measured frequency is outside the frequency band of interest, then the magnitude of the oscillating signal is not measured and output is not given.

High Frequency

Range: 0.08 to 1.00 Hz in steps of 0.02

Default: 0.2 Hz

This setting specifies the higher frequency value of the frequency band of interest. If measured frequency is outside the frequency band of interest, then the magnitude of the oscillating signal is not measured and output is not given.

Alarm Pickup

Range: 0.02 to 10.00 pu in steps of 0.01

Default: 0.20 pu

This setting specifies the pickup level for the alarm stage of the small signal oscillation detection element. The calculated value is the RMS magnitude of the measured low frequency phasor.

Trip Pickup

Range: 0.05 to 10.00 pu in steps of 0.01

Default: 0.20 pu

This setting specifies the pickup level for the trip stage of the small signal oscillation detection element. The calculated value is the RMS magnitude of the measured low frequency phasor.

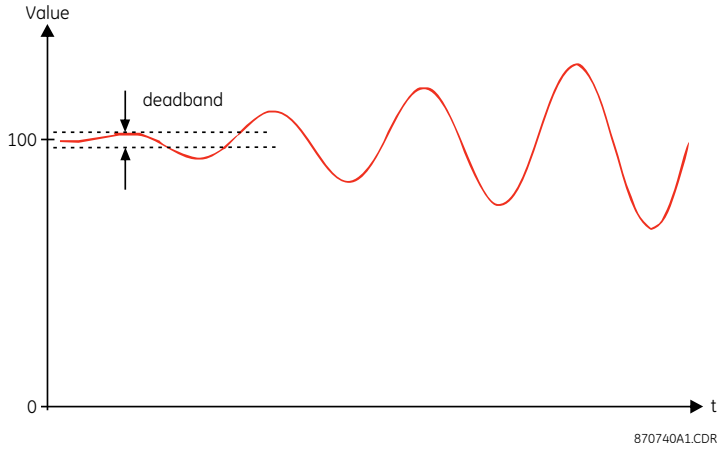
Deadband

Range: 0.01 to 2.00 pu in steps of 0.01

Default: 0.10 pu

This setting specifies the deadband of the measured analog signal. If the signal is inside the deadband, then the oscillation is not detected. When signal is outside the deadband, then the signal frequency and magnitude of the low frequency phasor are measured. This value should typically be set to 0.25 of the **Alarm Pickup** setting.

Figure 69: Signal deadband example



Alarm Delay

Range: 0.00 to 600.00 seconds in steps of 0.01
Default: 10.00 seconds

This setting specifies the pickup time delay of the alarm stage of the element.

Trip Delay

Range:
Default:

This setting specifies the pickup time delay of the trip stage of the element.

Block

Range: any FlexLogic operand or shared operand
Default: OFF

Assertion of the operand assigned to this setting blocks operation of the small signal oscillation detection element.

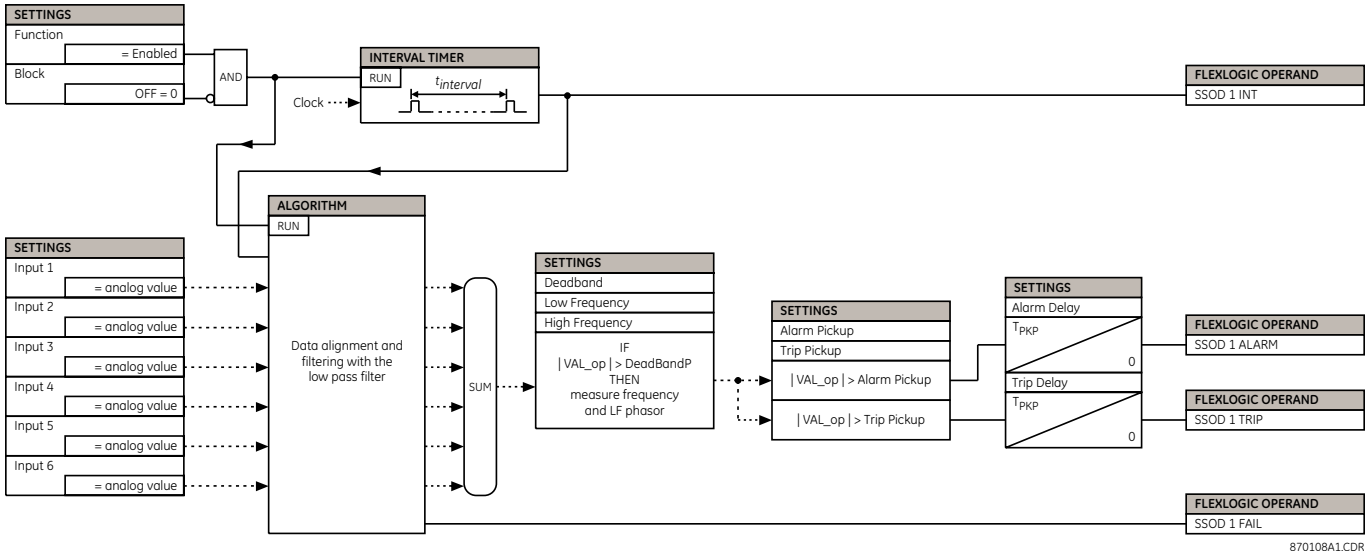
Events

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the logging of small signal oscillation detection events in the sequence of events recorder.

The logic for the small signal oscillation detection 1 element is shown below. The logic is identical for both small signal oscillation detection elements.

Figure 70: Small signal oscillation detection logic

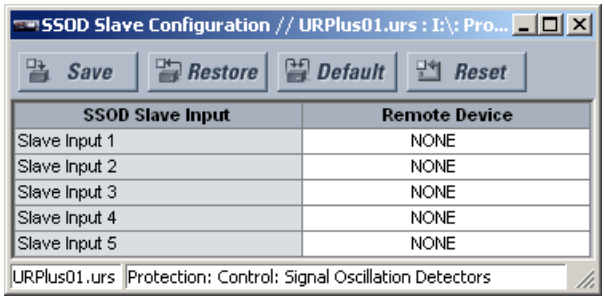


Small signal oscillation slave configuration

Remote devices (slaves) received analog values over IEC 61850 can by configured for use by the small signal oscillation detection element. The GGIO6 dataset allocated for use with this element must correctly configured in configurable GOOSE, remote devices and remote inputs setting menus.

Select the **Settings > Protection > Control > Small Signal Oscillation Detectors > SSOD Slave Configuration** menu item to open the small signal oscillation detector slave configuration settings window.

Figure 71: Small signal oscillation slave configuration settings



The following settings are available for the small signal oscillation detector.

Slave Input 1, Slave Input 2, Slave Input 3, Slave Input 4, Slave Input 5

Range: None, Remote Device 1, Remote Device 2, Remote Device 3,..., Remote Device 32
Default: None

These settings select the remote devices to use as slave inputs for the small signal oscillation detector.

VT fuse failure

Every signal source includes a fuse failure scheme.

The VT fuse failure detector can be used to raise an alarm or block elements that can operate incorrectly for a full or partial loss of AC potential caused by one or more blown fuses. Some elements that might be blocked (via the Block setting) include voltage restrained overcurrent and directional current.

There are two classes of fuse failure that can occur, as follows:

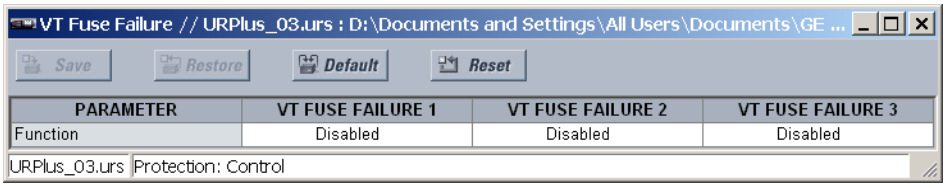
- Class A — Loss of one or two phases
- Class B — Loss of all three phases

Different means of detection are required for each class. An indication of class A failures is a significant level of negative-sequence voltage, whereas an indication of class B failures is when positive-sequence current is present and there is an insignificant amount of positive-sequence voltage. These noted indications of fuse failure could also be present when faults are present on the system, so a means of detecting faults and inhibiting fuse failure declarations during these events is provided. Once the fuse failure condition is declared, it is sealed-in until the cause that generated it disappears.

An additional condition is introduced to inhibit a fuse failure declaration when the monitored circuit is de-energized; positive-sequence voltage and current are both below threshold levels.

Select the **Settings > Protection > Control > VT Fuse Failure** menu item to access the VT fuse failure settings.

Figure 72: VT fuse failure configuration settings



The following setting is available for each VT fuse failure element.

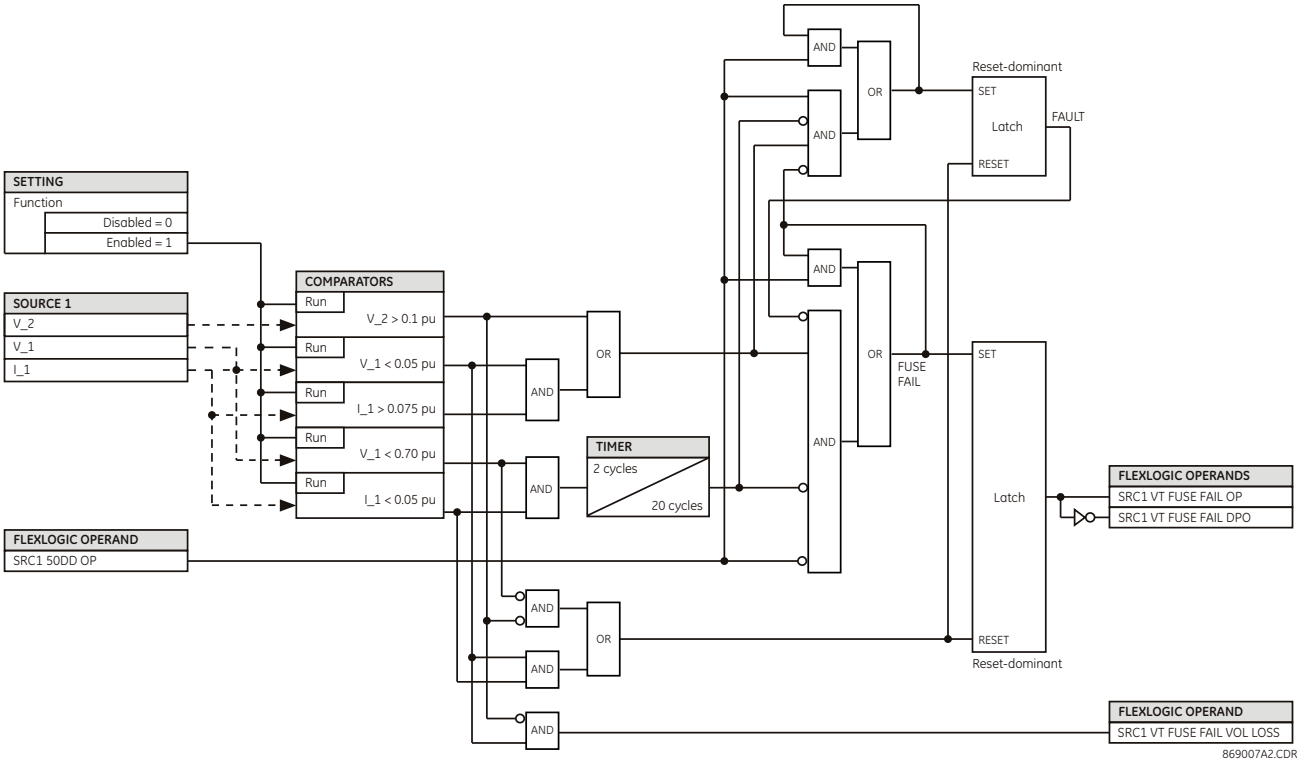
Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the fuse failure feature for each source.

The figure shows the VT fuse failure logic.

Figure 73: VT fuse failure scheme logic



Autoreclose

The autoreclose scheme is intended for use on transmission lines with circuit breakers operated in both the single-pole and three-pole modes, in one or two breaker arrangements. The autoreclose scheme provides four programs with different operating cycles, depending on the fault type. Each of the four programs can be set to trigger up to four reclosing attempts. The second, third, and fourth attempts always perform three-pole reclosing and have independent dead time delays.

When used in two breaker applications, the reclosing sequence is selectable. The reclose signal can be sent to one selected breaker only, to both breakers simultaneously or to both breakers in sequence (one breaker first and then, after a delay to check that the reclose was successful, to the second breaker). When reclosing in sequence, the first breaker should reclose with either the single-pole or three-pole dead time according to the fault type and reclose mode; the second breaker should follow the successful reclosure of the first breaker. When reclosing simultaneously, for the first shot both breakers should reclose with either the single-pole or three-pole dead time, according to the fault type and the reclose mode.

The signal used to initiate the autoreclose scheme is the trip output from protection. This signal can be single-pole tripping for single-phase faults and three phase tripping for multiphase faults. The autoreclose scheme has five operating states.

Table 13: Autoreclose operating states

State	Characteristics
Enabled	Scheme is permitted to operate
Disabled	Scheme is not permitted to operate
Reset	Scheme is permitted to operate and shot count is reset to 0
Reclose in progress	Scheme has been initiated but the reclose cycle is not finished (successful or not)
Lockout	Scheme is not permitted to operate until reset received

Autoreclose programs

The autorecloser provides four programs that can cause from one to four reclose attempts (shots). After the first shot, all subsequent reclosings are always three-pole. If the maximum number of shots selected is 1 (only one reclose attempt) and the fault is persistent, after the first reclose the scheme goes to lockout upon another initiate signal.

For the three-pole reclose programs (the "3 Pole-A" and "3 Pole-B" mode values), an AR FORCE 3-P FlexLogic operand is set. This operand can be used in connection with the tripping logic to cause a three-pole trip for single-phase faults.

Table 14: Autoreclose programs

Mode setting	First shot		Second shot		Third shot		Fourth shot	
	single-phase fault	multi-phase fault	single-phase fault	multi-phase fault	single-phase fault	multi-phase fault	single-phase fault	multi-phase fault
"1 & 3 Pole"	1 POLE	3 POLE	3 POLE or LOCKOUT	3 POLE or LOCKOUT	3 POLE or LOCKOUT	3 POLE or LOCKOUT	3 POLE or LOCKOUT	3 POLE or LOCKOUT
"1 Pole"	1 POLE	LOCKOUT	3 POLE or LOCKOUT	3 POLE or LOCKOUT	3 POLE or LOCKOUT	3 POLE or LOCKOUT	3 POLE or LOCKOUT	3 POLE or LOCKOUT
"3 Pole-A"	3 POLE	LOCKOUT	3 POLE or LOCKOUT	LOCKOUT	3 POLE or LOCKOUT	LOCKOUT	3 POLE or LOCKOUT	LOCKOUT
"3 Pole-B"	3 POLE	3 POLE	3 POLE or LOCKOUT	3 POLE or LOCKOUT	3 POLE or LOCKOUT	3 POLE or LOCKOUT	3 POLE or LOCKOUT	3 POLE or LOCKOUT

In the "1 & 3 Pole" mode, the autorecloser starts the **1-P Dead Time** timer for the first shot if the autoreclose is single-phase initiated, the **3-P Dead Time 1** timer if the autoreclose is three-pole initiated, and the **3-P Dead Time 2** timer if the autoreclose is three-phase time delay initiated. If two or more shots are enabled, the second, third, and fourth shots are always three-pole and start the **3-P Dead Time 2** through **3-P Dead Time 4** timers.

In the "1 Pole" mode, the autorecloser starts the **1-P Dead Time** for the first shot if the fault is single-phase. If the fault is three-phase or a three-pole trip on the breaker occurred during the single-pole initiation, the scheme goes to lockout without reclosing. If two or more shots are enabled, the second, third, and fourth shots are always three-pole and start the **3-P Dead Time 2** through **3-P Dead Time 4** timers.

In the "3 Pole-A" mode, the autorecloser is initiated only for single-phase faults, although the trip is three-pole. The autorecloser uses the **3-P Dead Time 1** for the first shot if the fault is single-phase. If the fault is multi-phase the scheme will go to lockout without reclosing. If two or more shots are enabled, the second, third, and fourth shots are always three-phase and start the **3-P Dead Time 2** through **3-P Dead Time 4** timers.

In the "3 Pole-B" mode, the autorecloser is initiated for any type of fault and starts the **3-P Dead Time 1** for the first shot. If the initiating signal is AR 3P TD INIT, the scheme starts the **3-P Dead Time 2** for the first shot. If two or more shots are enabled, the second, third, and fourth shots are always three-phase and start the **3-P Dead Time 2** through **3-P Dead Time 4** timers.

Basic reclosing operation

Reclosing is enabled via settings and dynamically disabled from a block signal or a manual close. Once enabled, a reclose is initiated through the **1-Pole Initiate** and **3-Pole Initiate** user-programmable inputs. There are three initiate programs: single-pole initiate, three-

pole initiate, and three-pole time delay initiate. Any of these reclose initiate signals starts the reclose cycle and sets the reclose-in-progress (AR RIP) operand. The reclose-in-progress operand is sealed-in until the lockout or reset signal appears.

Figure 74: Autoreclose scheme enable logic

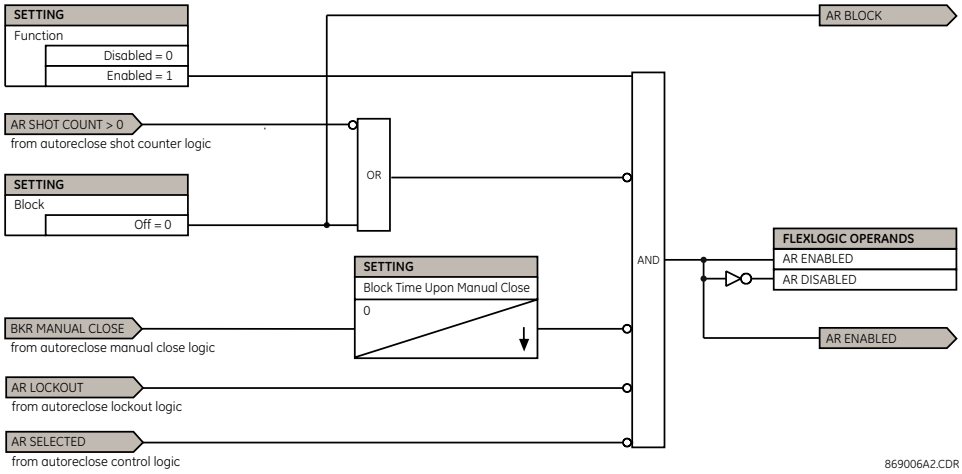
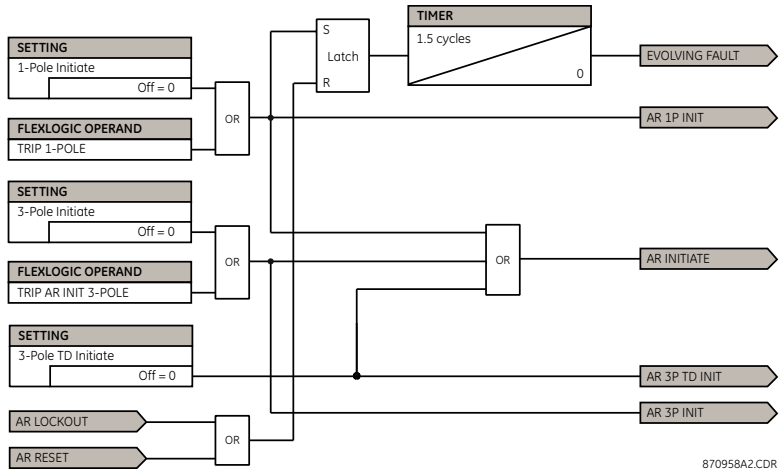
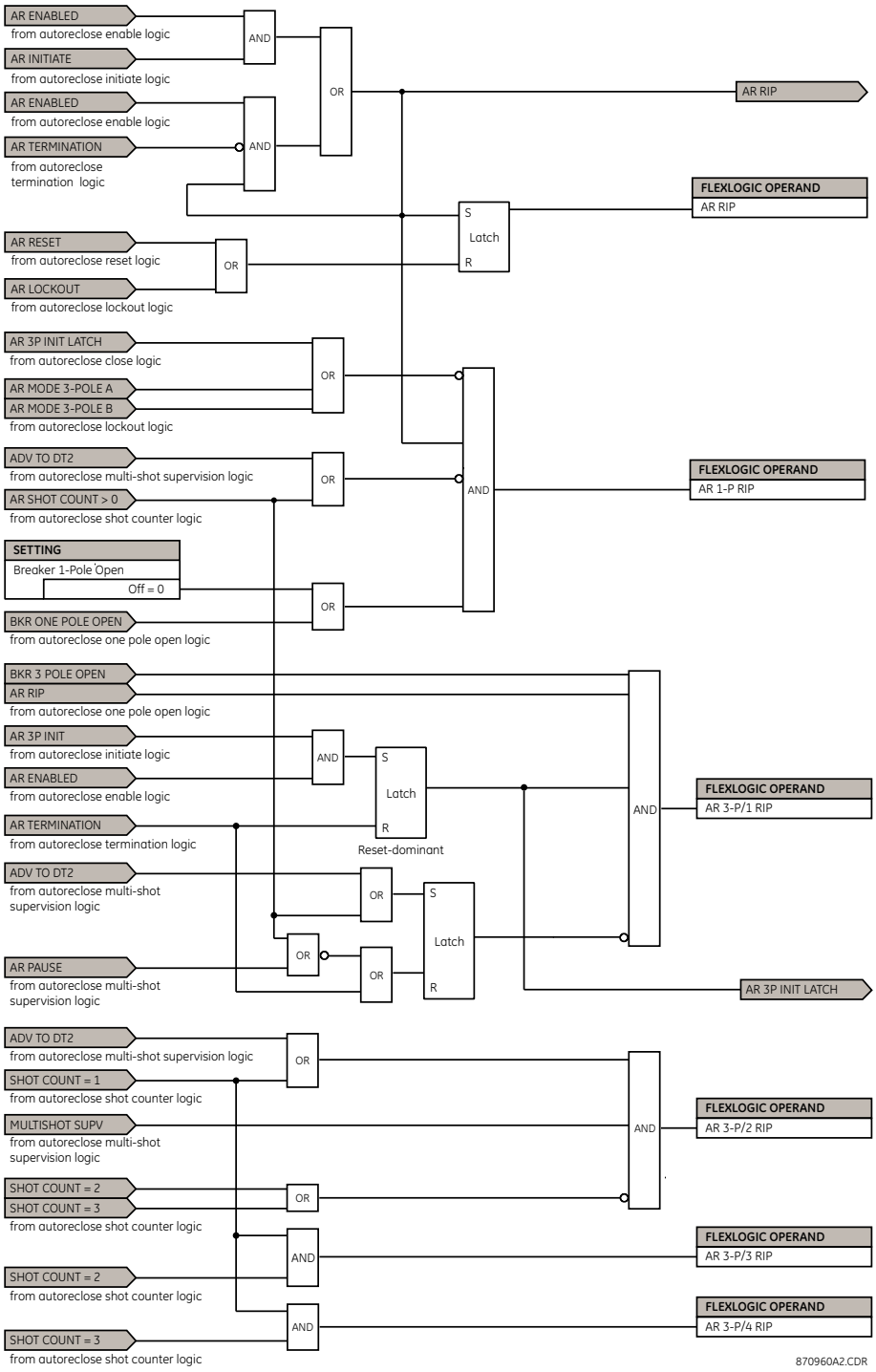


Figure 75: Autoreclose scheme initiate logic



A reclose initiate signal will send the scheme into the reclose-in-progress (RIP) state and assert the AR RIP operand. Once the breaker has opened, the scheme is latched into the reclose-in-progress state and resets only when an AR CLS BKR 1 (autoreclose breaker 1) or AR CLS BKR 2 (autoreclose breaker 2) operand is generated or the scheme goes to the lockout state.

Figure 76: Autoreclose scheme reclose-in-progress logic



After entering the reclose-in-progress state, a close command is issued after the dead time delay. The dead time for the initial reclose operation is determined by either the **1-P Dead Time**, **3-P Dead Time 1**, or **3-P Dead Time 2** setting, depending on the fault type and the mode selected. After the dead time interval, the scheme asserts the AR CLOSE BKR 1 or AR CLOSE BKR 2 operands, as determined by the sequence selected. These operands are latched until the breaker closes or the scheme goes to reset or lockout.

Figure 77: Autoreclose scheme breaker close logic

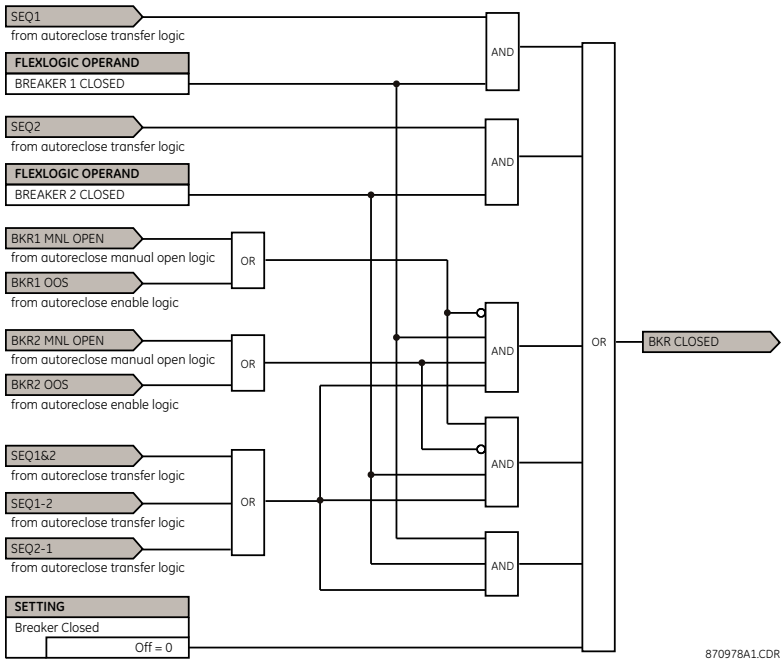


Figure 78: Autoreclose scheme close breaker 1 or 2 logic

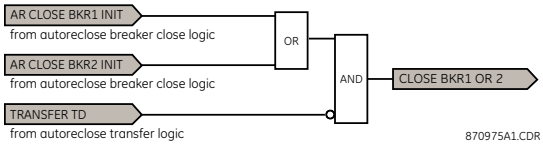
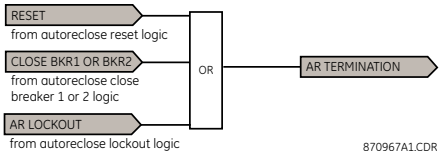


Figure 79: Autoreclose scheme termination



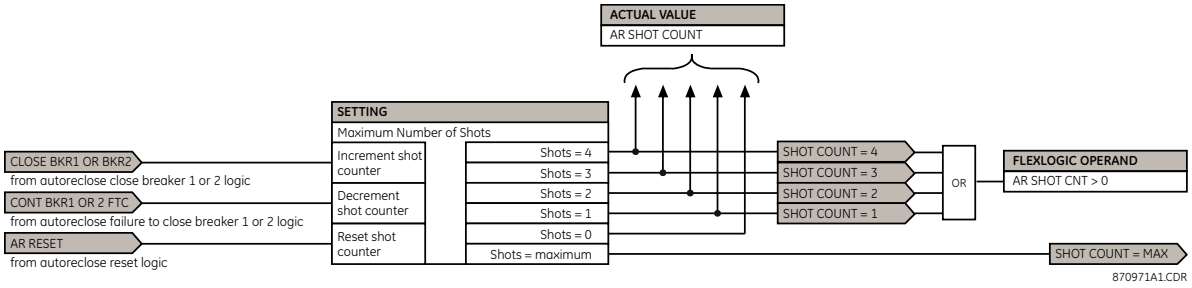
Multi-shot operation

The **Maximum Number of Shots** setting defines the number of reclose attempts. After each reclose the shot counter is incremented.

If **Maximum Number of Shots** is set to "1", the shot counter is set to 1 upon the first reclose. At reclosing, the fault is again detected by protection and reclose is initiated. The breaker is tripped three-pole through the AR SHOT COUNT >0 operand that sets the AR FORCE 3P operand. Because the shot counter has reached the maximum number of shots permitted, the scheme is sent to the lockout state.

If **Maximum Number of Shots** is set to "2", the shot counter is set to 1 upon the first reclose. At reclosing, the fault is again detected by protection and reclose is initiated. The breaker is tripped three-pole through the AR SHOT COUNT >0 operand that will set the AR FORCE 3P operand. After the second reclose the shot counter is set to 2. Upon reclosing, the fault is again detected by protection, the breaker is tripped three-pole, and reclose is initiated again. Because the shot counter has reached the maximum number of shots permitted, the scheme is sent to the lockout state.

Figure 80: Autoreclose scheme shot counter logic

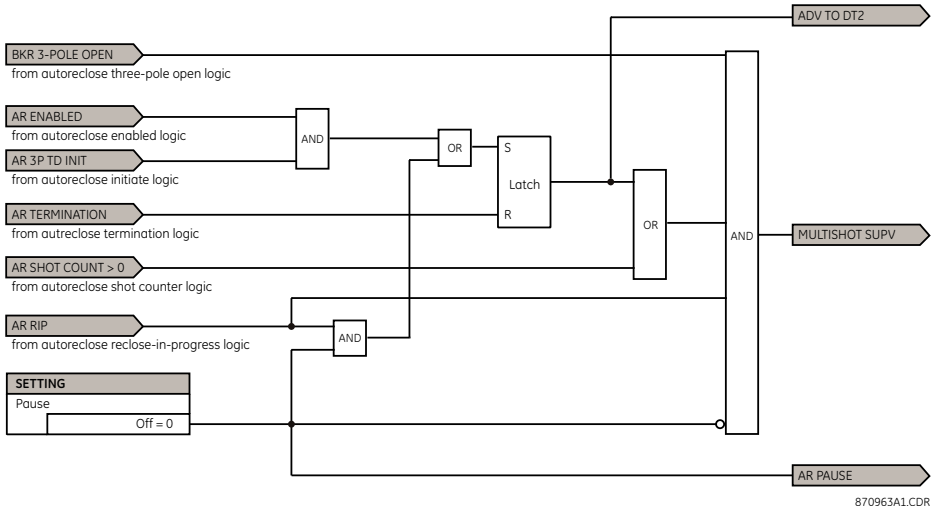


Autoreclose pause input

The autoreclose pause input offers the possibility of freezing the autoreclose cycle until the pause signal disappears. This may be done when a trip occurs and simultaneously or previously, some conditions are detected such as out-of step or loss of guard frequency, or a remote transfer trip signal is received. The pause signal blocks all three dead timers. When the pause signal disappears, the autoreclose cycle is resumed by initiating the AR 3-P DEAD TIME 2 operand.

This feature can be also used when a transformer is tapped from the protected line and a reclose is not desirable until the transformer is removed from the line. In this case, the reclose scheme is paused until the transformer is disconnected. The AR PAUSE input forces a three-pole trip through the **3-P Dead Time 2** path.

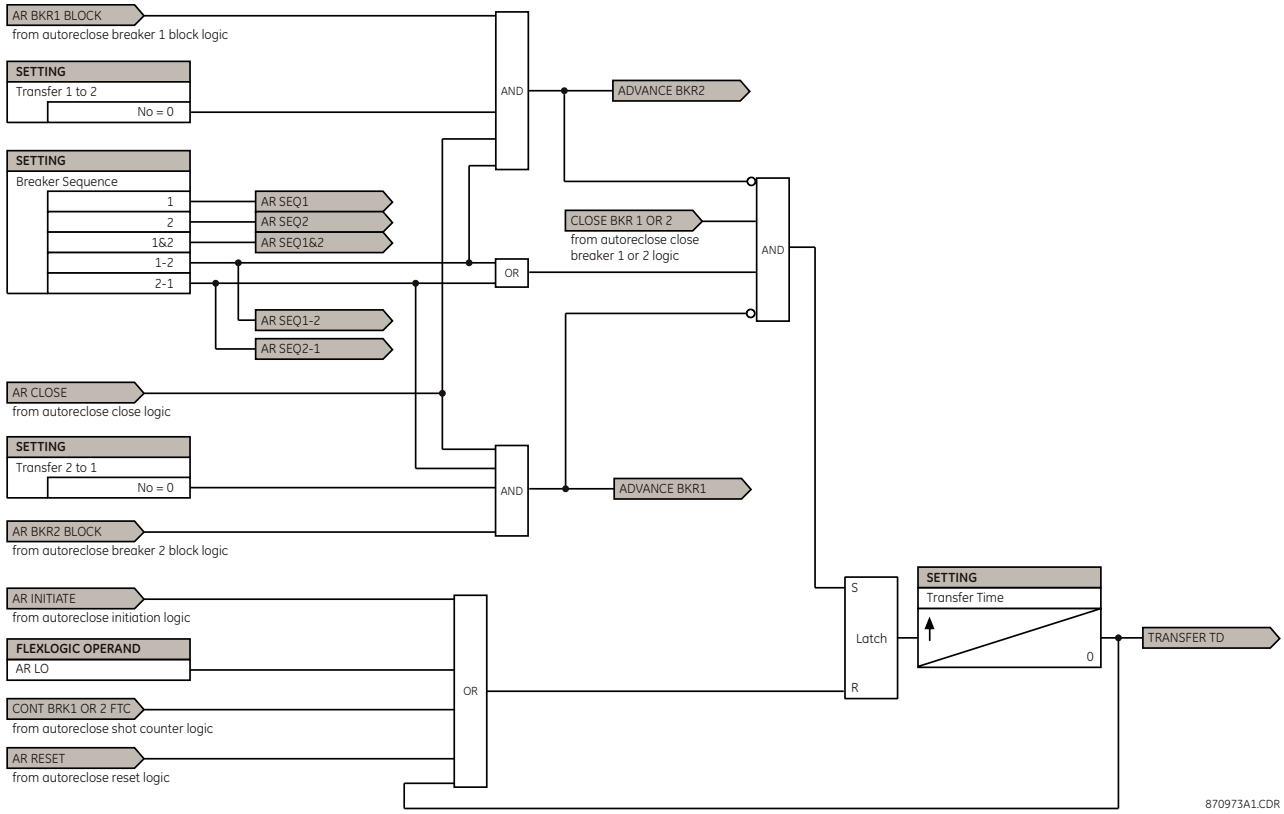
Figure 81: Autoreclose multi-shot supervision logic



Dual breaker operation

The general operation for two breaker reclosing on a permanent fault is the same as that outlined for the single breaker application, except as follows, which assumes the **Breaker Sequence** setting is "1-2" (reclose breaker 1 before breaker 2). The signal output from the dead time timers passes through the breaker selection logic to initiate reclosing of breaker 1. The CLOSE BREAKER 1 signal initiates the transfer timer. After the reclose of the first breaker, the fault is again detected by the protection, the breaker is tripped three-pole and the autoreclose scheme is initiated. The INITIATE signal stops the transfer timer. After the three-pole dead time times out, the CLOSE BREAKER 1 signal closes the first breaker again and starts the transfer timer. Since the fault is permanent, the protection trips again and initiates the autoreclose scheme that is sent to lockout by the SHOT COUNT = MAX signal.

Figure 82: Autoreclose scheme transfer logic



When the 1-2 reclosing sequence is selected and breaker 1 is blocked (the AR BKR1 BLK operand is set) the reclose signal can be transferred direct to breaker 2 if the **Transfer 1 to 2** setting is "Yes". If the setting is "No", the scheme will be sent to lockout by the incomplete sequence timer.

When the 2-1 reclosing sequence is selected and breaker 2 is blocked (the AR BKR2 BLK operand is set) the reclose signal can be transferred direct to breaker 1 if **Transfer 2 to 1** setting is "Yes". If set to "No", the scheme will be sent to lockout by the incomplete sequence timer or if it is out-of-service or open prior to the reclose-in-progress. In this case, the scheme can be configured to transfer close command immediately to the second breaker via the **Transfer 1 to 2** and **Transfer 2 to 1** settings.

For two-breaker reclosing on a transient fault, the reset timer is started when the first reclose output signal is sent to close breaker 1. The CLOSE BREAKER 1 signal initiates the transfer timer that times out and sends the close signal to the second breaker. If the reclosure sequence is successful (both breakers closed and there is no initiating signal), the reset timer will time out and return the scheme to the reset state with the shot counter set to 0. The scheme will now be ready for a new reclose cycle.

A typical reclosing sequence for the "1 & 3 Pole" mode is shown below for a single-pole fault, two shots, with successful reclosure. The following two options are available if the selected breaker sequence is "1–2" or "2–1", and the breaker fails to close after the first or second reclose attempt.

- If the **Breaker 1 Failure Option** or **Breaker 2 Failure Option** is set to "Lockout", the scheme will go to lockout state.
- If the **Breaker 1 Failure Option** or **Breaker 2 Failure Option** is set to "Continue", the reclose process will continue with breaker 2. At the same time, the shot counter will be decreased (since the closing process was not completed).

Figure 83: Autoreclose scheme failure-to-close logic

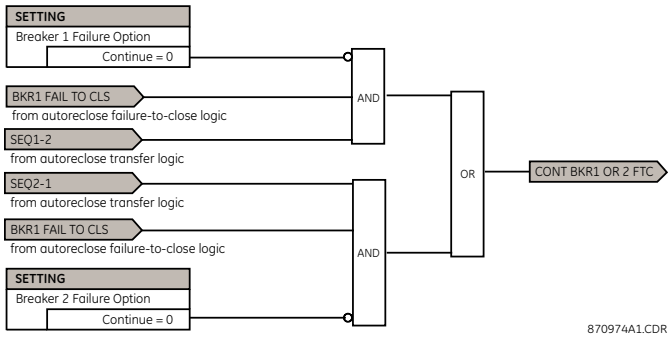
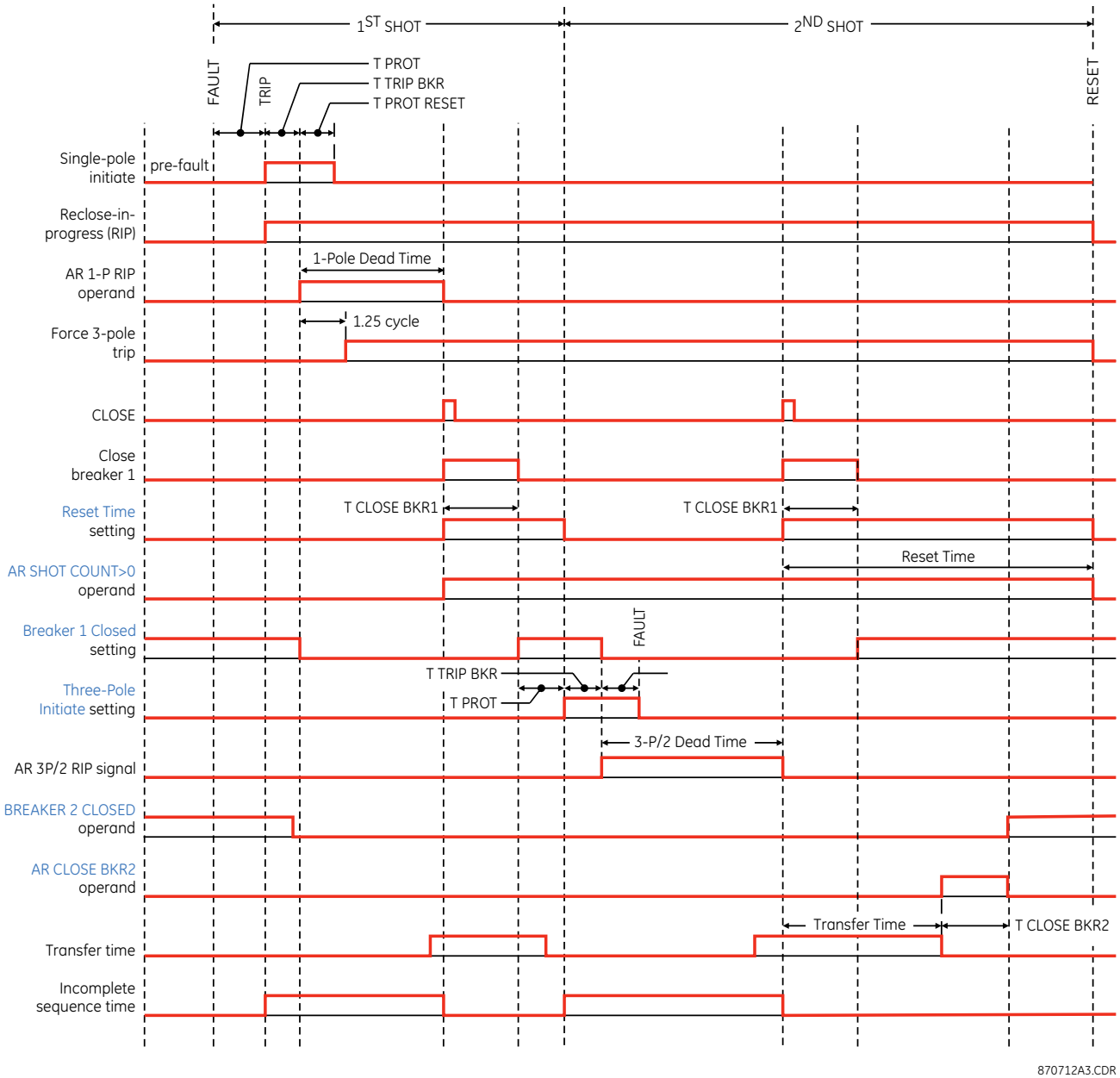


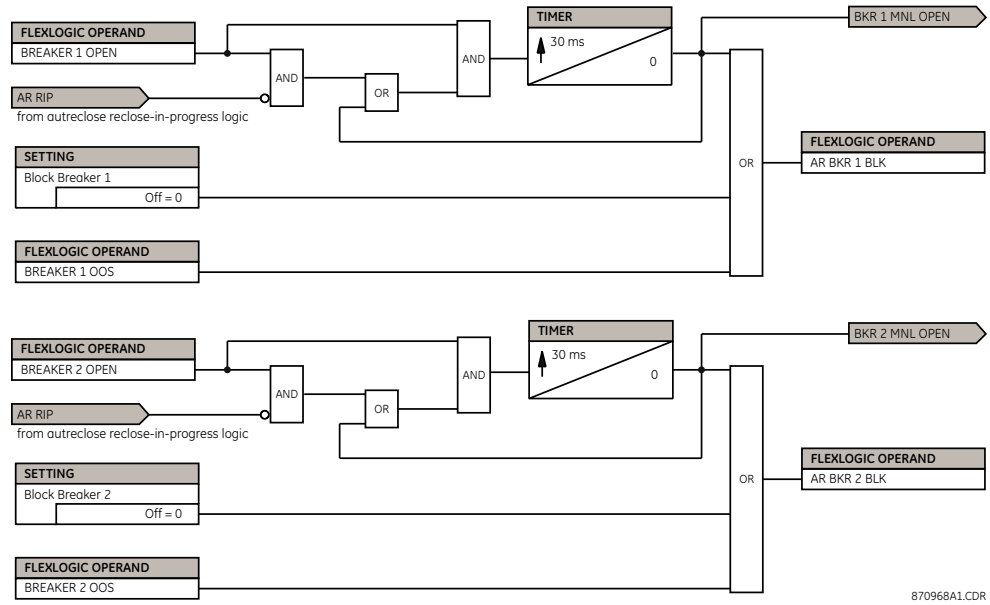
Figure 84: Typical autoreclose sequence



Breaker block

A reclose command to a breaker is inhibited if it receives a user-defined block input or if it is out-of-service. A logic circuit is also provided that inhibits a breaker reclose if that breaker was open in advance of a reclose initiate input to the recloser. This logic circuit resets when the breaker is closed.

Figure 85: Autoreclose scheme breaker block logic

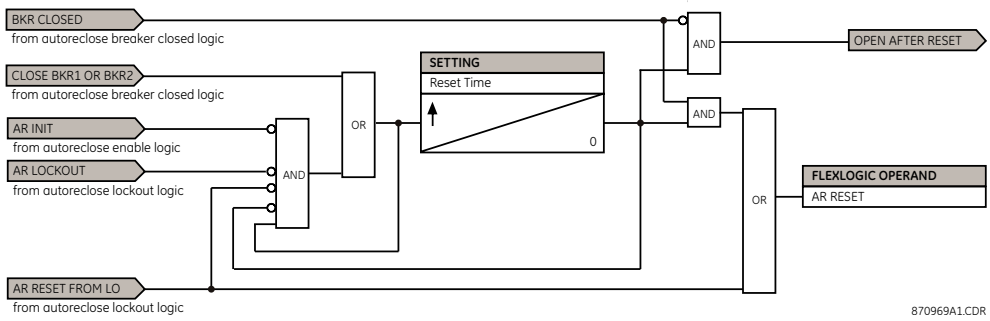


Reset after reclosure

For single breaker reclosing on a transient fault, the reset timer is started when a reclose output signal is sent to close the breaker. If the reclosure sequence is successful (there is no initiating signal and the breaker is closed) the reset timer times out, returning the scheme to the reset state with the shot counter set to 0 and ready for a new reclose cycle.

In two breaker schemes, if one breaker is in the out-of-service state and the other is closed at the end of the reset time, the scheme is also reset. If at the end of the reset time at least one breaker, which is not in the out-of-service state, is open the scheme is sent to lockout. The reset timer is stopped if the reclosure sequence is not successful: an initiating signal present or the scheme is in lockout state. The reset timer is also stopped if the breaker is manually closed or the scheme is otherwise reset from lockout.

Figure 86: Autoreclose scheme reset logic



Autoreclose lockout

When a reclose sequence is started by an initiate signal, the autoreclose scheme moves into the reclose-in-progress state and starts the incomplete sequence timer. The setting of this timer determines the maximum time interval allowed for a single reclose shot. If a close breaker 1 or 2 signal is not present before this time expires, the scheme enters the lockout state.

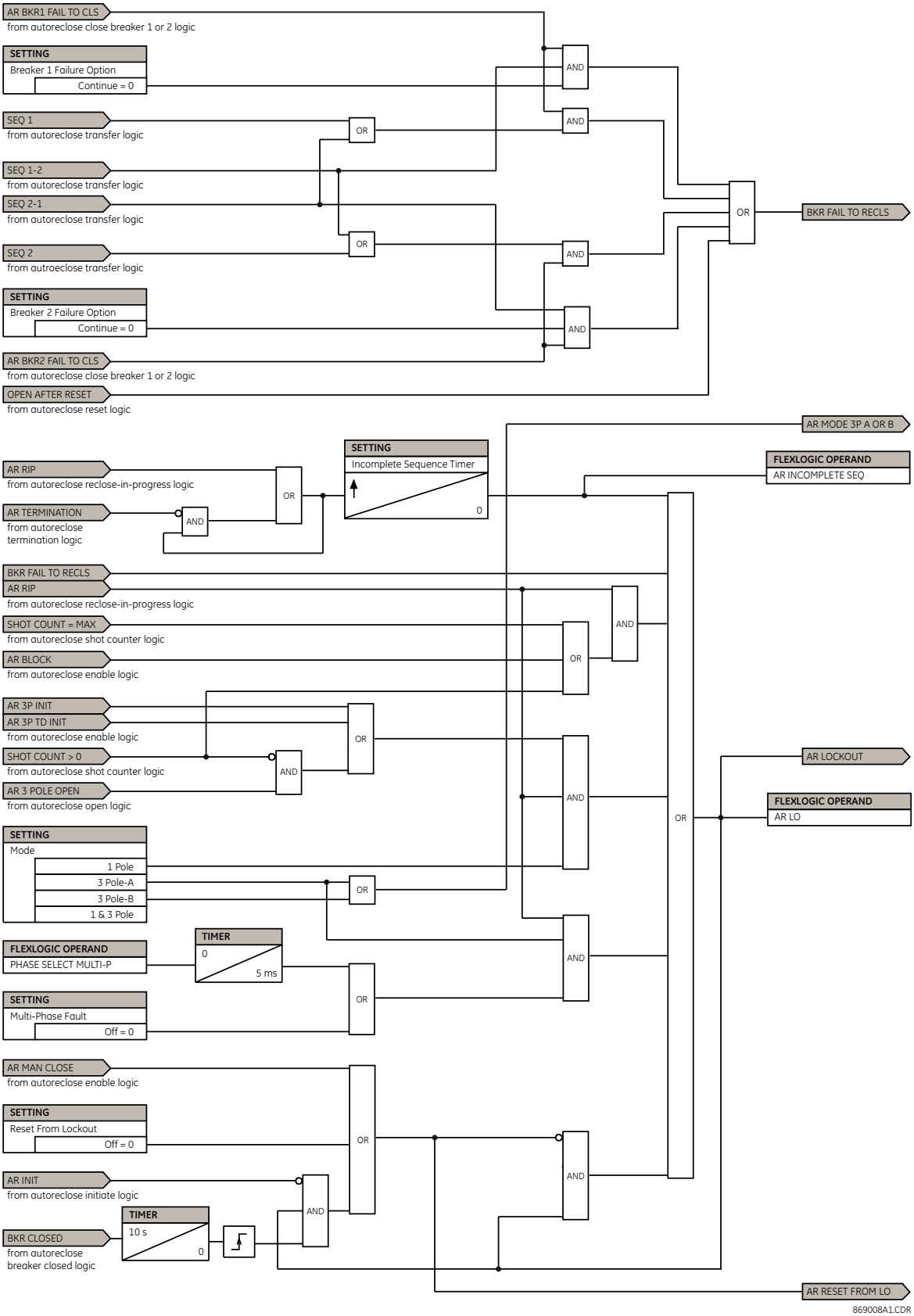
There are four other conditions that can take the scheme to the lockout state.

- Receipt of the Block input while in the reclose-in-progress state
- The reclosing program logic: when a three-phase initiate is present and the autoreclose mode is either "1 Pole" or "3 Pole-A" (three-pole autoreclose for single-pole faults only)
- Initiation of the scheme when the count is at the maximum allowed
- If at the end of the reset time at least one breaker, which is not in the out-of-service state, is open the scheme is sent to lockout. The scheme is also sent to lockout if one breaker fails to reclose and the setting **Breaker Failure Option** setting is "Lockout".

Once the lockout state is set, it remains latched until one or more of the following occurs:

- The scheme is intentionally reset from lockout, employing the **Reset** setting of the autorecloser
- The breaker or breakers are manually closed from the panel switch, SCADA, or other remote control through the **Breaker Manual Close** setting
- Ten seconds after breaker control detects that the breaker or breakers were closed

Figure 87: Autoreclose scheme lockout logic

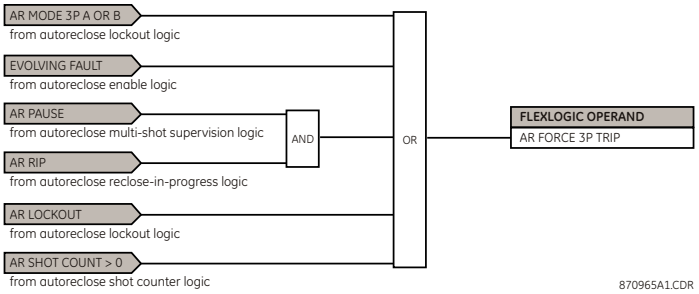


Force three-pole tripping

The reclosing scheme contains logic that is used to signal trip logic that three-pole tripping is required for certain conditions. This signal is activated by any of the following conditions:

- The autoreclose scheme is paused after it was initiated
- The autoreclose scheme is paused
- The autoreclose scheme is in the lockout state
- The autoreclose mode is programmed for three-pole operation
- The shot counter is not at 0; that is, the scheme is not in the reset state. This ensures a second trip is three-pole when reclosing onto a permanent single phase fault.
- 1.25 cycles after the single-pole reclose is initiated by the AR 1P INIT signal

Figure 88: Autoreclose force three-pole trip logic



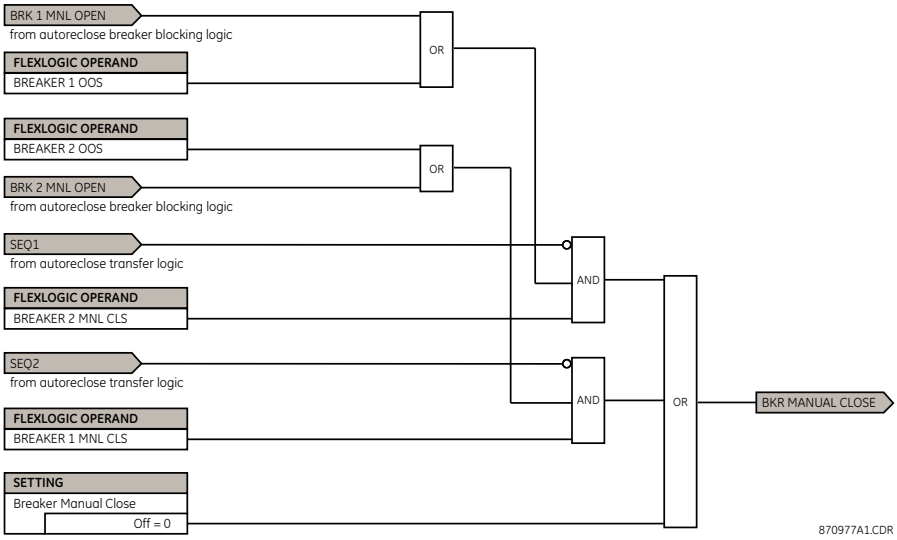
Terminal manual close

The manual close logic receives the manual close signal from each of the breakers and derives a manual close signal for the local terminal. The manual close is declared when

- Breaker 1 issues a manual close and sequence 2 is not selected and breaker 2 is either open or out-of-service
- Breaker 2 issues a manual close and sequence 1 is not selected and breaker 1 is either open or out-of-service

Alternately, a user-defined setting is available to generate this signal.

Figure 89: Autoreclose scheme manual close logic



Terminal closed

The close logic uses the status of each breaker to determine whether the terminal is closed. For single breaker applications, it is necessary to monitor the closed status of the particular breaker. For dual breaker applications, the logic checks that either or both breakers are closed and not out-of-service. Alternately, a user-defined setting is available to generate this signal.

Figure 90: Autoreclose scheme closing logic, sheet 1 of 2

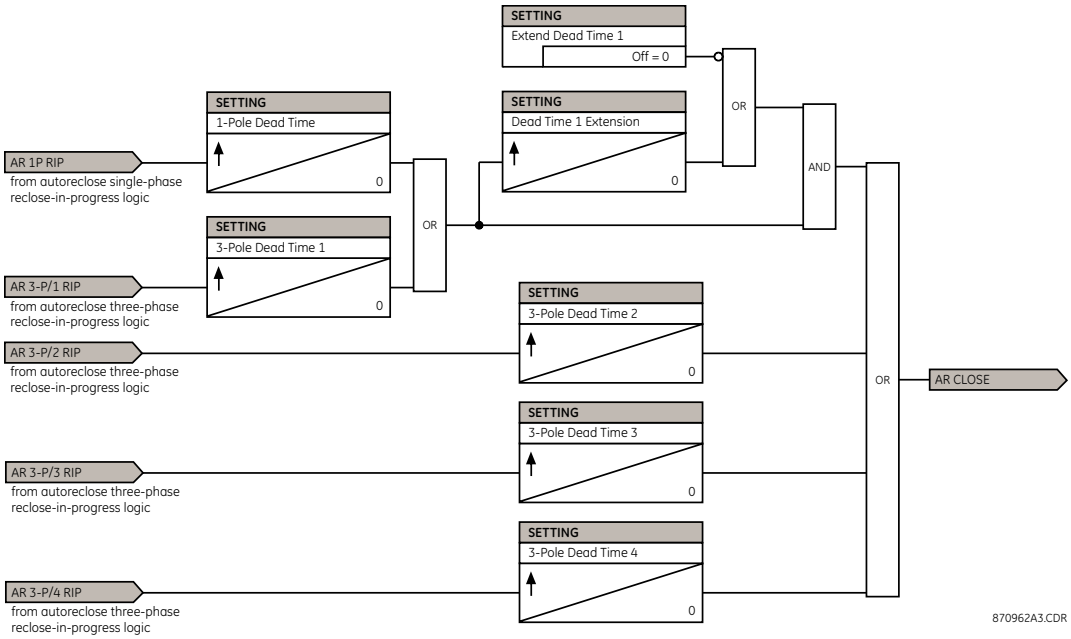
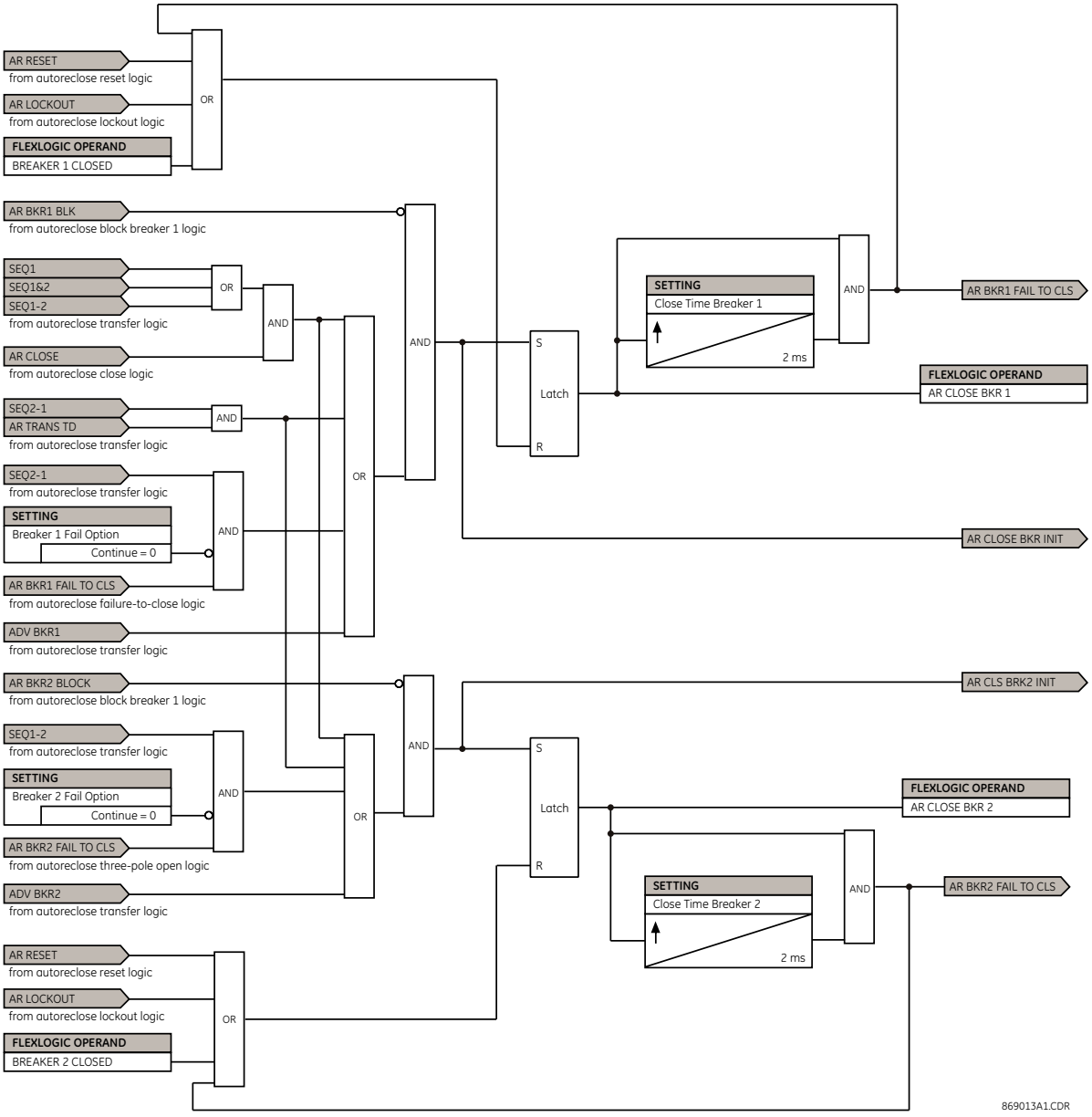


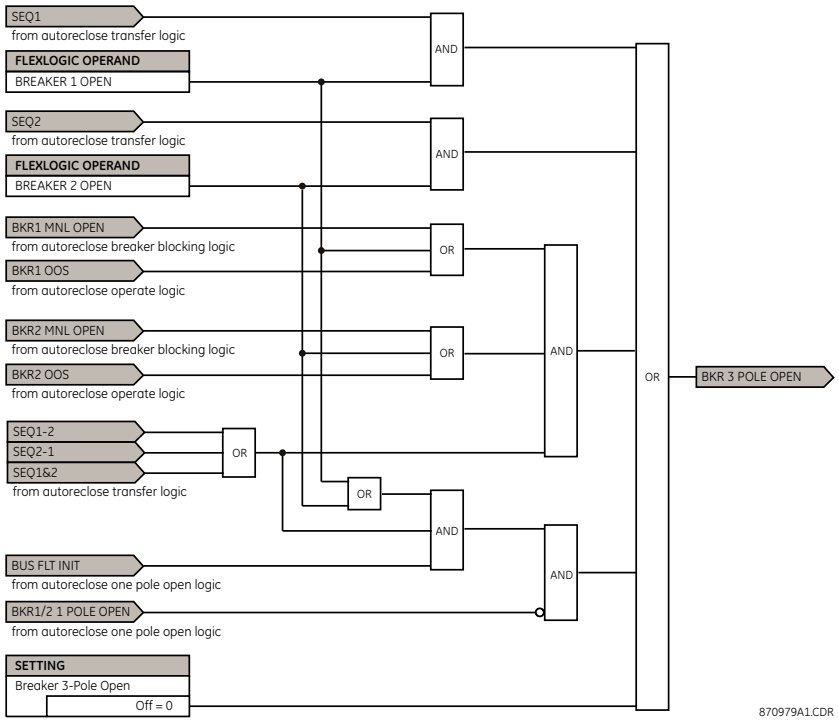
Figure 91: Autoreclose scheme closing logic, sheet 2 of 2



Terminal three-pole open

The autoreclose scheme employs dedicated logic to determine if all three poles are opened at the local terminal. This signal is used in the preceding logic. For single breaker operation, the breaker status is sufficient to derive this signal. For dual breaker operation both breakers must either be open or out-of-service. If one breaker has been opened from a bus protection, the **Bus Fault Initiate** setting can be used to declare the terminal opened when either breaker is opened. Alternately, a user-defined setting is available to generate this signal.

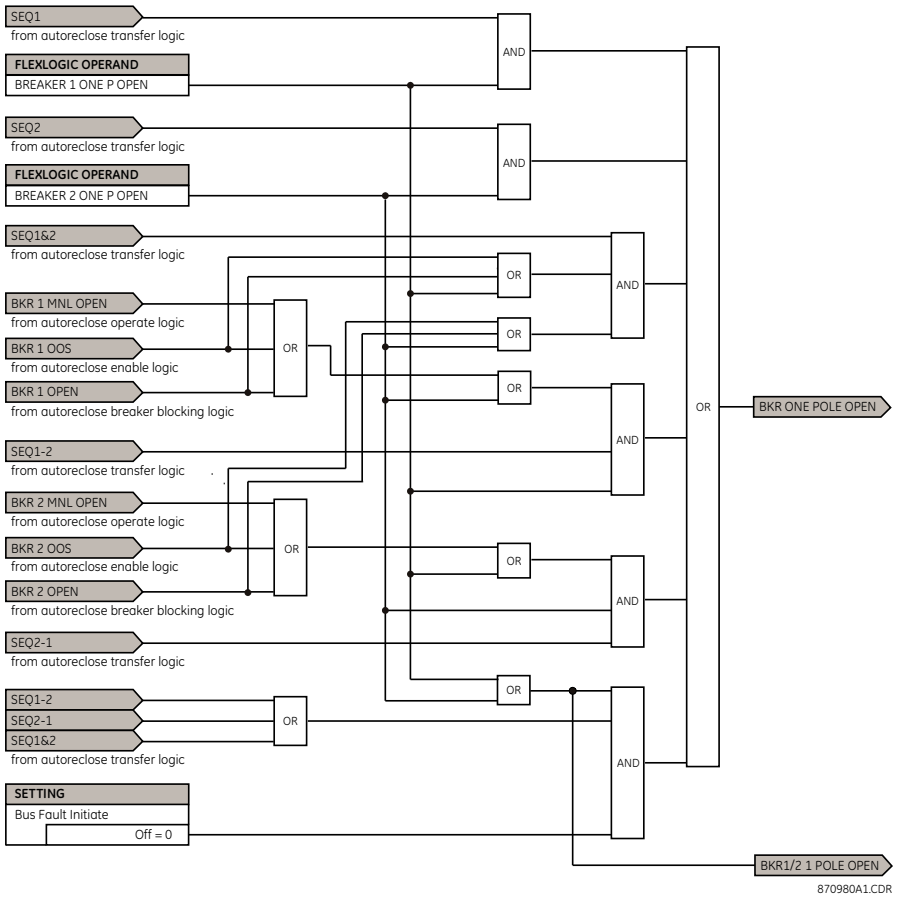
Figure 92: Terminal three-pole open logic



Terminal one-pole open

The autoreclose scheme also has dedicated logic to determine if one pole is opened at the local terminal. For single breaker operation, the BREAKER 1 ONE P OPEN or BREAKER 2 ONE P OPEN operand is used to derive this signal. For the 1&2 sequence, both breakers must either declare one pole open or be open or out-of-service. For the 1-2 sequence, breaker 1 must declare one pole open and breaker 2 must declare one pole open or be open or out-of-service. For the 2-1 sequence, breaker 2 must declare one pole open and breaker 1 must declare one pole open or be open or out-of-service. Alternately, a user-defined setting is available to generate this signal.

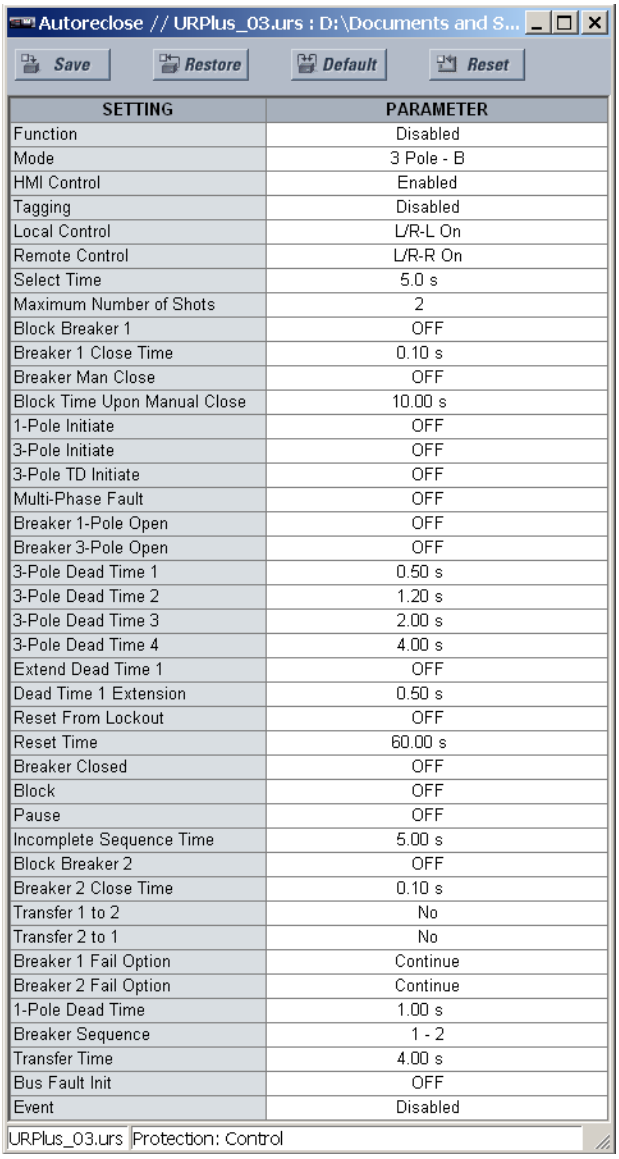
Figure 93: Terminal one-pole open logic



Autoreclose settings

Select the **Settings > Protection > Control > Autoreclose** menu item to access the autoreclose settings.

Figure 94: Autoreclose settings window



SETTING	PARAMETER
Function	Disabled
Mode	3 Pole - B
HMI Control	Enabled
Tagging	Disabled
Local Control	L/R-L On
Remote Control	L/R-R On
Select Time	5.0 s
Maximum Number of Shots	2
Block Breaker 1	OFF
Breaker 1 Close Time	0.10 s
Breaker Man Close	OFF
Block Time Upon Manual Close	10.00 s
1-Pole Initiate	OFF
3-Pole Initiate	OFF
3-Pole TD Initiate	OFF
Multi-Phase Fault	OFF
Breaker 1-Pole Open	OFF
Breaker 3-Pole Open	OFF
3-Pole Dead Time 1	0.50 s
3-Pole Dead Time 2	1.20 s
3-Pole Dead Time 3	2.00 s
3-Pole Dead Time 4	4.00 s
Extend Dead Time 1	OFF
Dead Time 1 Extension	0.50 s
Reset From Lockout	OFF
Reset Time	60.00 s
Breaker Closed	OFF
Block	OFF
Pause	OFF
Incomplete Sequence Time	5.00 s
Block Breaker 2	OFF
Breaker 2 Close Time	0.10 s
Transfer 1 to 2	No
Transfer 2 to 1	No
Breaker 1 Fail Option	Continue
Breaker 2 Fail Option	Continue
1-Pole Dead Time	1.00 s
Breaker Sequence	1 - 2
Transfer Time	4.00 s
Bus Fault Init	OFF
Event	Disabled

The following settings are available for the autoreclose element.

Function

Range: Disabled, Enabled

Default: Disabled

This setting enables and disables the autoreclose scheme.

Mode

Range: 1 & 3 Pole, 1 Pole, 3 Pole-A, 3 Pole-B

Default: 1 & 3 Pole

This setting selects the autoreclose operating mode, which functions in conjunction with signals received at the initiation inputs.

Select Time

Range: 1.0 to 30.0 seconds in steps of 0.1
Default: 5 seconds

This setting specifies the maximum permissible time from selection of autoreclose and a control action.

Maximum Number of Shots

Range: 1, 2, 3, 4
Default: 2

This setting specifies the number of reclosures attempted before reclosure goes to lockout when the fault is permanent.

Block Breaker 1

Range: any FlexLogic operand or shared operand
Default: Off

This setting selects an operand that will block the reclose command for breaker 1. This condition can include breaker low air pressure, reclose in progress on another line (for the central breaker in a breaker and a half arrangement), or a sum of conditions combined in FlexLogic.

Close Time Breaker 1

Range: 0.00 to 655.35 seconds in steps of 0.01
Default: 0.10 seconds

This setting specifies the closing time for breaker 1 from the moment the CLOSE command is sent to the moment the contacts are closed.

Breaker Manual Close

Range: any FlexLogic operand or shared operand
Default: Off

This setting selects an operand that represents a manual close command to a breaker associated with the autoreclose scheme.

Block Time Upon Manual Close

Range: 0.00 to 655.35 seconds in steps of 0.01
Default: 10.00 seconds

The autoreclose scheme can be disabled for a programmable time delay after an associated circuit breaker is manually commanded to close, preventing reclosing onto an existing fault such as grounds on the line. This delay must be longer than the slowest expected trip from any protection not blocked after manual closing. If the autoreclose scheme is not initiated after a manual close and this time expires, the autoreclose scheme is set to the reset state.

1-Pole Initiate

Range: any FlexLogic operand or shared operand
Default: Off

This setting selects an operand used to initiate single-pole autoreclosure.

3-Pole Initiate

Range: any FlexLogic operand or shared operand
Default: Off

This setting selects an operand used to initiate three-pole autoreclosure. The first timer (**3-Pole Dead Time 1**) can be used for a high-speed autoreclosure.

3-Pole TD Initiate

Range: any FlexLogic operand or shared operand
Default: Off

This setting selects an operand used to initiate three-pole autoreclosure. The second timer (**3-Pole Dead Time 2**) can be used for a time-delay autoreclosure.

Multi-Phase Fault

Range: any FlexLogic operand or shared operand
Default: Off

This setting selects an operand used to indicate a multi-phase fault. The operand value should be zero for single-phase to ground faults.

Breaker 1-Pole Open

Range: any FlexLogic operand or shared operand
Default: Off

This setting selects an operand to indicate that the breaker or breakers have opened correctly following a single-phase to ground fault. The autoreclose scheme can then start timing the single-pole dead time. For example, if the reclose sequence is "1-2", breaker 1 should trip single-pole and breaker 2 should trip three-pole).

The scheme has a pre-wired input that indicates breaker status.

Breaker 3-Pole Open

Range: any FlexLogic operand or shared operand
Default: Off

This setting selects an operand to indicate that the breaker or breakers have opened three-pole and the autoreclose scheme can start timing the three-pole dead time. The scheme has a pre-wired input that indicates breaker status.

3-Pole Dead Time 1

Range: 0.00 to 655.35 seconds in steps of 0.01
Default: 0.50 seconds

This setting specifies the dead time following the first three-pole trip. This intentional delay can be used for a high-speed three-pole autoreclose. However, it should be set longer than the estimated de-ionizing time following the three-pole trip.

3-Pole Dead Time 2

Range: 0.00 to 655.35 seconds in steps of 0.01
Default: 1.20 seconds

This setting specifies the dead time following the second three-pole trip or initiated by the **3-Pole Time Delay Initiate** setting. This intentional delay is typically used for a time delayed three-pole autoreclose (as opposed to high speed three-pole autoreclose).

3 Pole Dead Time 3

Range: 0.00 to 655.35 seconds in steps of 0.01
Default: 2.00 seconds

This setting specifies the dead time following the third three-pole trip.

3-Pole Dead Time 4

Range: 0.00 to 655.35 seconds in steps of 0.01
Default: 4.00 seconds

This setting specifies the dead time following the fourth three-pole trip.

Extend Dead Time 1

Range: any FlexLogic operand or shared operand
Default: Off

This setting selects an operand that will adapt the duration of the dead time for the first shot to the possibility of non-simultaneous tripping at the two line ends. Typically this is the operand set when the communication channel is out-of-service.

Dead Time 1 Extension

Range: 0.00 to 655.35 seconds in steps of 0.01
Default: 0.50 seconds

This setting specifies the length of the dead time 1 extension for possible non-simultaneous tripping of the two ends of the line.

Reset

Range: any FlexLogic operand or shared operand
Default: Off

This setting selects the operand that forces the autoreclose scheme from any state to reset. Typically this is a manual reset from lockout, local or remote.

Reset Time

Range: 0.00 to 655.35 seconds in steps of 0.01
Default: 60.00 seconds

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

Breaker Closed

Range: any FlexLogic operand or shared operand
Default: Off

This setting selects an operand that indicates that the breaker(s) are closed at the end of the reset time and the scheme can reset.

Block

Range: any FlexLogic operand or shared operand
Default: Off

This setting selects the operand that blocks the autoreclose scheme (it can be a sum of conditions such as time delayed tripping, breaker failure, and differential protection). If the block signal is present before autoreclose scheme initiation the AR DISABLED FlexLogic operand will be set. If the block signal occurs when the scheme is in the reclose-in-progress state the scheme is sent to lockout.

Pause

Range: any FlexLogic operand or shared operand
Default: Off

This setting offers the ability to freeze the autoreclose cycle until the pause signal disappears. This may be done when a trip occurs and simultaneously or previously, some conditions are detected such as out-of step or loss of guard frequency, or a remote transfer trip signal is received. The autoreclose cycle is resumed when the pause signal disappears. This feature can also be used when a transformer is tapped from the protected line and a reclose is not desirable until the it is disconnected from the line. In this situation, the reclose scheme is 'paused' until the transformer is disconnected.

Incomplete Sequence Time

Range: 0 to 655.35 seconds in steps of 0.01

Range: 5.00 seconds

This setting specifies the maximum time interval allowed for a single reclose shot. It is started whenever a reclosure is initiated and is active until the CLOSE BKR1 or CLOSE BKR2 signal is sent. If all conditions allowing a breaker closure are not satisfied when this time expires, the scheme goes to lockout. The minimum permissible setting is established by the **3-Pole Dead Time 2** timer setting. Settings beyond this will determine the wait time for the breaker to open so that the reclose cycle can continue and/or for the **Pause** signal to reset and allow the reclose cycle to continue and/or for the AR BKR1(2) BLK signal to disappear and allow the AR CLOSE BKR1(2) signal to be sent.

Block Breaker 2

Range: any FlexLogic operand or shared operand

Default: Off

This setting selects an operand that will block the reclose command for breaker 2. This condition can include breaker low air pressure, reclose in progress on another line (for the central breaker in a breaker and a half arrangement), or a sum of conditions combined in FlexLogic.

Close Time Breaker 2

Range: 0.00 to 655.35 seconds in steps of 0.01

Default: 0.10 seconds

This setting specifies the closing time for breaker 2 from the moment the CLOSE command is sent to the moment the contacts are closed.

Transfer 1 to 2

Range: Yes, No

Default: No

This setting establishes how the scheme performs when the breaker closing sequence is "1-2" and Breaker 1 is blocked. When set to "Yes", the closing command is transferred directly to breaker 2 without waiting for the set transfer time. When set to "No", the closing command is blocked by the AR BKR1 BLK signal and the scheme is sent to lockout by the incomplete sequence timer.

Transfer 2 to 1

Range: Yes, No

Default: No

This setting establishes how the scheme performs when the breaker closing sequence is "2-1" and breaker 2 is blocked. When set to "Yes", the closing command is transferred direct to breaker 1 without waiting the transfer time. When set to "No", the closing command is blocked by the AR BKR2 BLK signal and the scheme is sent to lockout by the incomplete sequence timer.

Breaker 1 Failure Option

Range: Continue, Lockout

Default: Continue

This setting establishes how the scheme performs when the breaker closing sequence is "1-2" and breaker 1 has failed to close. When set to "Continue", the closing command is transferred to breaker 2, which continues the reclosing cycle until successful (the scheme resets) or unsuccessful (the scheme goes to lockout). When set to "Lockout" the scheme goes to lockout without attempting to reclose breaker 2.

Breaker 2 Failure Option

Range: Continue, Lockout

Default: Continue

This setting establishes how the scheme performs when the breaker closing sequence is "2-1" and breaker 2 has failed to close. When set to "Continue", the closing command is transferred to breaker 1, which continues the reclosing cycle until successful (the scheme resets) or unsuccessful (the scheme goes to lockout). When set to "Lockout", the scheme goes to lockout without attempting to reclose breaker 1.

1-Pole Dead Time

Range: 0 to 655.35 seconds in steps of 0.01

Default: 1.00 seconds

Set this intentional delay setting greater than the estimated de-ionizing time after the first single-pole trip.

Breaker Sequence

Range: 1, 2, 1&2, 1-2, 2-1

Default: 1-2

This setting selects the breaker reclose sequence. Select "1" to reclose breaker 1 only, "2" for reclose breaker 2 only, "1&2" to reclose both breakers simultaneously, "1-2" to reclose breakers sequentially with breaker 1 first, and "2-1" to reclose breakers sequentially with breaker 2 first.

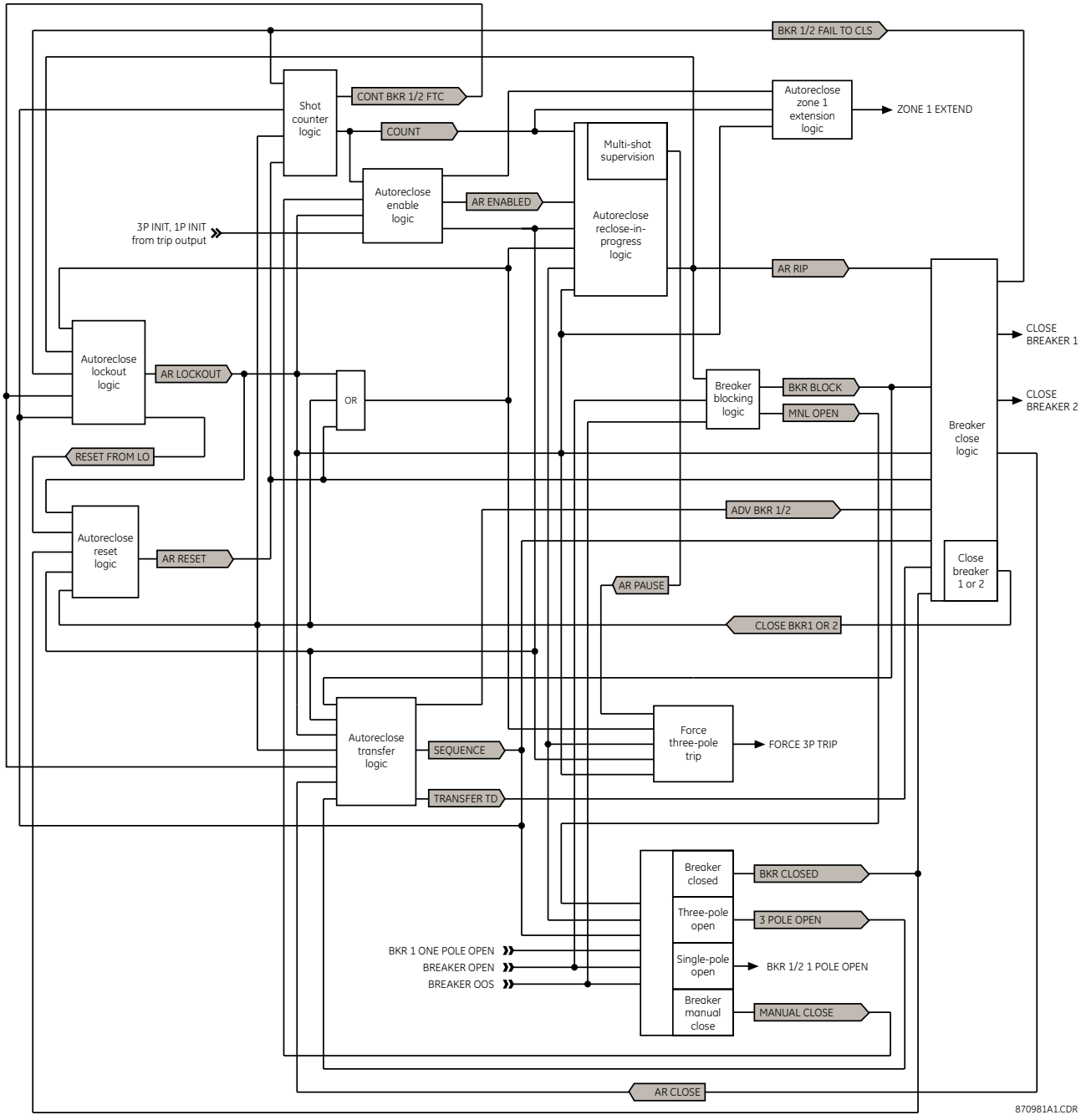
Bus Fault Initiate

Range: any FlexLogic operand or shared operand

Default: OFF

This setting is used in breaker-and-a-half applications to allow the autoreclose control function to perform reclosing with only one breaker previously opened by bus protection. For line faults, both breakers must open for the autoreclose reclosing cycles to take effect.

Figure 95: Final autoreclose signal flow logic



Front panel status and control

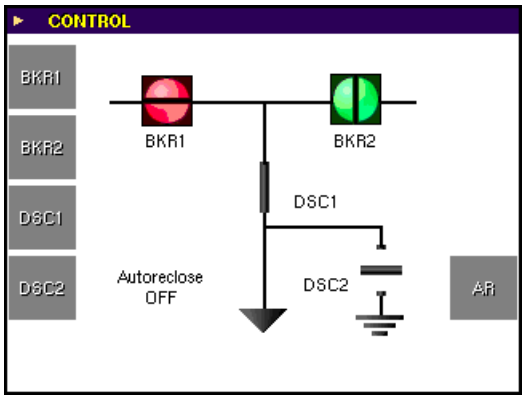
If the autoreclose function is enabled, an indication appears on the screen. This indication indicates the operational status of the autoreclose function as defined here.

Table 15: Autoreclose front panel indications

Indication	FlexLogic operand
Autoreclose ON	AR ENABLED
Autoreclose OFF	AR DISABLED
Autoreclose In Progress	AR RIP
Autoreclose Locked Out	AR LO

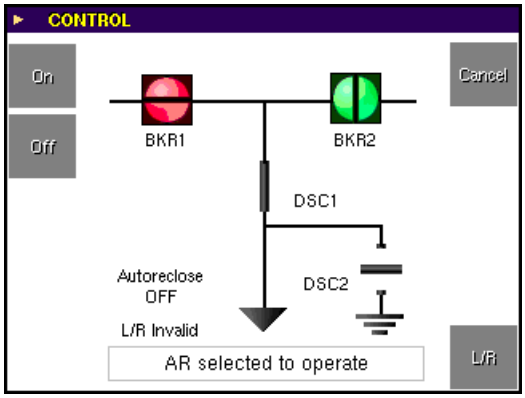
Autoreclose control is available at the top level screen by pressing the **AR** pushbutton. If local control is not asserted for autoreclose, then the **AR** pushbutton is grey and inoperable. The local control status of a device is obtained from the autoreclose control logic.

Figure 96: Autoreclose control enabled display



Once autoreclose control is selected, the message AR selected to operate is displayed and pushbuttons appear for the autoreclose control options.

Figure 97: Autoreclose control selected display



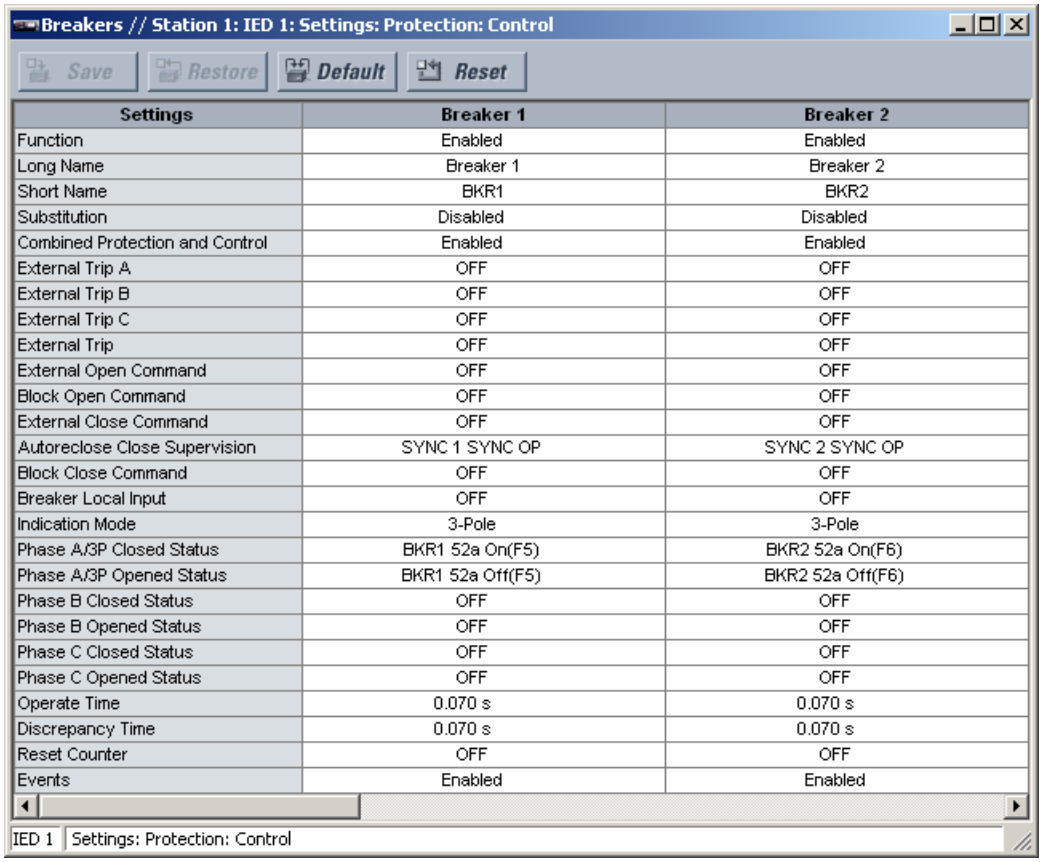
If tagging has been enabled, a **TAG** pushbutton appears on this screen. When the **TAG** pushbutton is operated, a small T is displayed next to the autoreclose indication, and the on and off operations are inhibited. When a device is tagged, the **TAG** pushbutton changes to an **UNTAG** pushbutton.

Breaker configuration

The breaker configuration element contains the auxiliary logic for status and serves as the interface for opening and closing of the breaker from protection and automation functions. The logic also permits a manual substitution of the position indication.

Select the **Settings > Protection > Control > Breakers** menu item to open the breaker control configuration window.

Figure 98: Breaker configuration settings



Settings	Breaker 1	Breaker 2
Function	Enabled	Enabled
Long Name	Breaker 1	Breaker 2
Short Name	BKR1	BKR2
Substitution	Disabled	Disabled
Combined Protection and Control	Enabled	Enabled
External Trip A	OFF	OFF
External Trip B	OFF	OFF
External Trip C	OFF	OFF
External Trip	OFF	OFF
External Open Command	OFF	OFF
Block Open Command	OFF	OFF
External Close Command	OFF	OFF
Autoreclose Close Supervision	SYNC 1 SYNC OP	SYNC 2 SYNC OP
Block Close Command	OFF	OFF
Breaker Local Input	OFF	OFF
Indication Mode	3-Pole	3-Pole
Phase A/3P Closed Status	BKR1 52a On(F5)	BKR2 52a On(F6)
Phase A/3P Opened Status	BKR1 52a Off(F5)	BKR2 52a Off(F6)
Phase B Closed Status	OFF	OFF
Phase B Opened Status	OFF	OFF
Phase C Closed Status	OFF	OFF
Phase C Opened Status	OFF	OFF
Operate Time	0.070 s	0.070 s
Discrepancy Time	0.070 s	0.070 s
Reset Counter	OFF	OFF
Events	Enabled	Enabled

The following settings are available to each of the breakers. The default values outlined are applicable to breaker 1.

Function

Range: Enabled, Disabled
Default: Enabled

This setting enables the breaker position indications and control logic. If disabled, all outputs and front panel indications are switched off.

Long Name

Range: 20 alphanumeric characters
Default: Breaker 1

This setting is used to identify the primary device for control confirmations on the front panel interface and in the event record.

Short Name

Range: up to 6 alphanumeric characters
Default: BKR1

This setting identifies the primary device pushbuttons and indications on the front panel interface.

Substitution

Range: Enabled, Disabled
Default: Disabled

This setting allows the position indication of the breaker to be substituted with a manually entered value.

Combined Protection and Control

Range: Enabled, Disabled

Default: Enabled

If this setting is enabled, the tripping signals from the trip output scheme are logically ORed with the open signal from the breaker control scheme.

External Trip A, External Trip B, External Trip C

Range: any FlexLogic operand or shared operand

Default: Off

These settings assign an operand (usually an external contact input) to the breaker trip pole A, B, and C reporting contact.

External Open Command

Range: any FlexLogic operand or shared operand

Default: Off

This setting assigns an operand that creates a programmable signal to operate an output relay to open the breaker.

Block Open Command

Range: any FlexLogic operand or shared operand

Default: Off

This setting selects an operand that prevents opening of the breaker. This setting can be used for select-before-operate functionality or to block operation from a panel switch or from SCADA.

External Close Command

Range: any FlexLogic operand or shared operand

Default: Off

This setting assigns an operand that creates a programmable signal to operate an output relay to close the breaker.

Autoreclose Close Supervision

Range: any FlexLogic operand or shared operand

Default: SYNC 1 SYNC OP

This setting selects an operand to supervise the closing of the breaker from autoreclose. If no supervision is required, this setting should be programmed as “On”.

Block Close Command

Range: any FlexLogic operand or shared operand

Default: Off

This setting selects an operand that prevents closing of the breaker. This setting can be used for select-before-operate functionality or to block operation from a panel switch or from SCADA.

Breaker Local Input

Range: any FlexLogic operand or shared operand

Default: OFF

Closing or opening of the breaker through the breaker interlock element is inhibited if the operand assigned to this setting is asserted.

Indication Mode

Range: 3 Pole, 1 Pole

Default: 3 Pole

If “3 Pole” is selected, the breaker indications are derived from a single status input (or pair of status inputs). If “1 Pole” is selected, the breaker indications are derived from three status inputs (or pairs of status inputs).

Phase A/3P Closed Status

Range: any FlexLogic operand or shared operand
Default: BKR1 52a On

The operand selected by this setting is used to derive three-pole or phase A breaker position indications from a normally-opened (52a) status input.

Phase A/3P Opened Status

Range: any FlexLogic operand or shared operand
Default: BKR1 52a Off

The operand selected by this setting is used to derive three-pole or phase A breaker position indications from a normally-closed (52b) status input. If unavailable, the closed status input can be inverted to provide this signal.

Phase B Closed Status

Range: any FlexLogic operand or shared operand
Default: Off

The operand selected by this setting is used to derive the phase B breaker position indication from a normally-opened (52a) status input. This input is not required if the indication mode is single-pole.

Phase B Opened Status

Range: any FlexLogic operand or shared operand
Default: Off

The operand selected by this setting is used to derive the phase B breaker position indication from a normally-closed (52b) status input. If unavailable, the closed status input can be inverted to provide this signal. This input is not required if the indication mode is single-pole.

Phase C Closed Status

Range: any FlexLogic operand or shared operand
Default: Off

The operand selected by this setting is used to derive the phase B breaker position indication from a normally-opened (52a) status input. This input is not required if the indication mode is single-pole.

Phase C Opened Status

Range: any FlexLogic operand or shared operand
Default: Off

The operand selected by this setting is used to derive the phase B breaker position indication from a normally-closed (52b) status input. If unavailable, the closed status input can be inverted to provide this signal. This input is not required if the indication mode is single-pole.

Operate Time

Range: 0.000 to 2.000 seconds in steps of 0.001
Default: 0.070 seconds

This setting specifies a timer that is asserted when both the normally open and normally closed breaker indications are reset. When the timer expires, a bad status is indicated for the breaker. This timer setting should be set equal to the normal operating time for the breaker.

Discrepancy Time

Range: 0.000 to 2.000 seconds in steps of 0.001
Default: 0.070 seconds

This setting specifies a timer that is asserted when the three breaker poles are not all opened or not all closed. This timer setting should be set greater than the longest expected time for which the three breaker poles disagree.

Reset Counter

Range: any FlexLogic operand or shared operand
Default: Off

Assertion of the operand assigned to this setting resets the breaker operation counters.

Events

Range: Enabled, Disabled
Default: Enabled

This settings enables the recording of breaker configuration events in the sequence of events record.

Figure 99: Breaker configuration logic, sheet 1 of 4

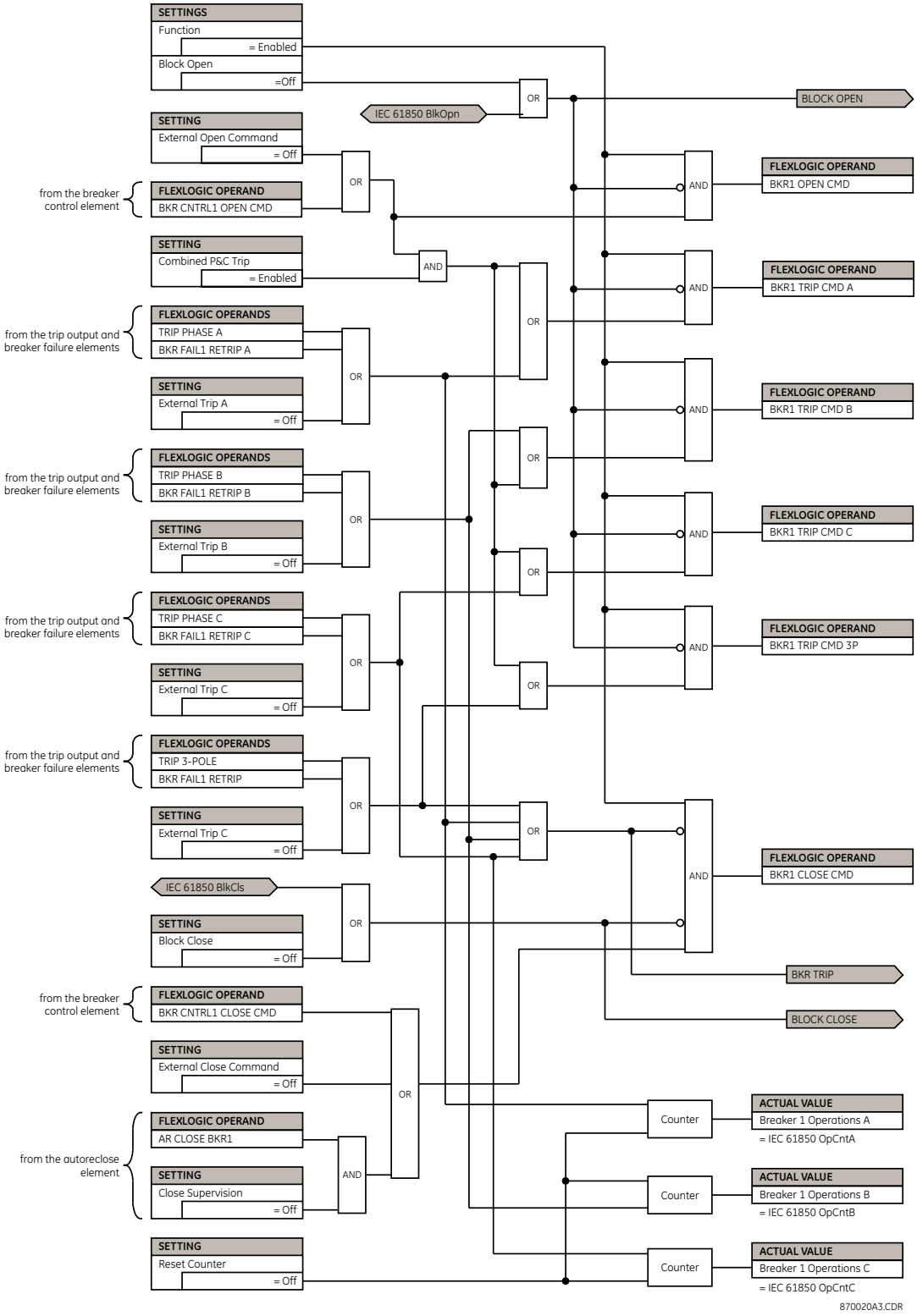


Figure 100: Breaker configuration logic, sheet 2 of 4

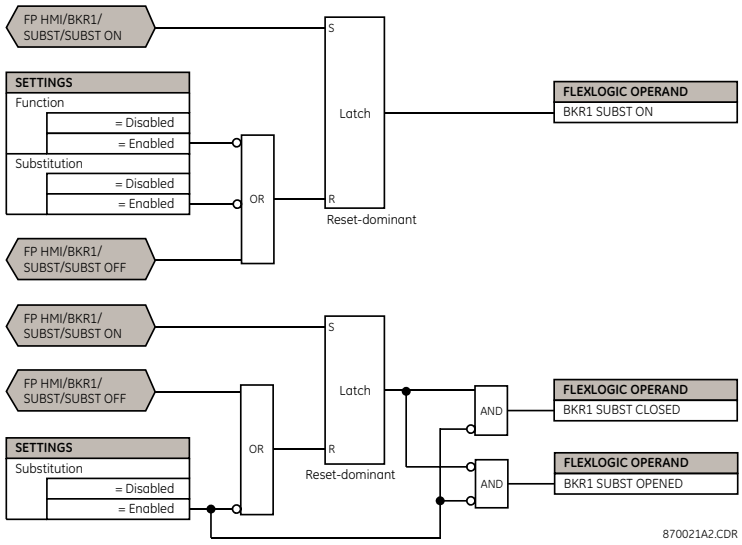


Figure 101: Breaker configuration logic, sheet 3 of 4

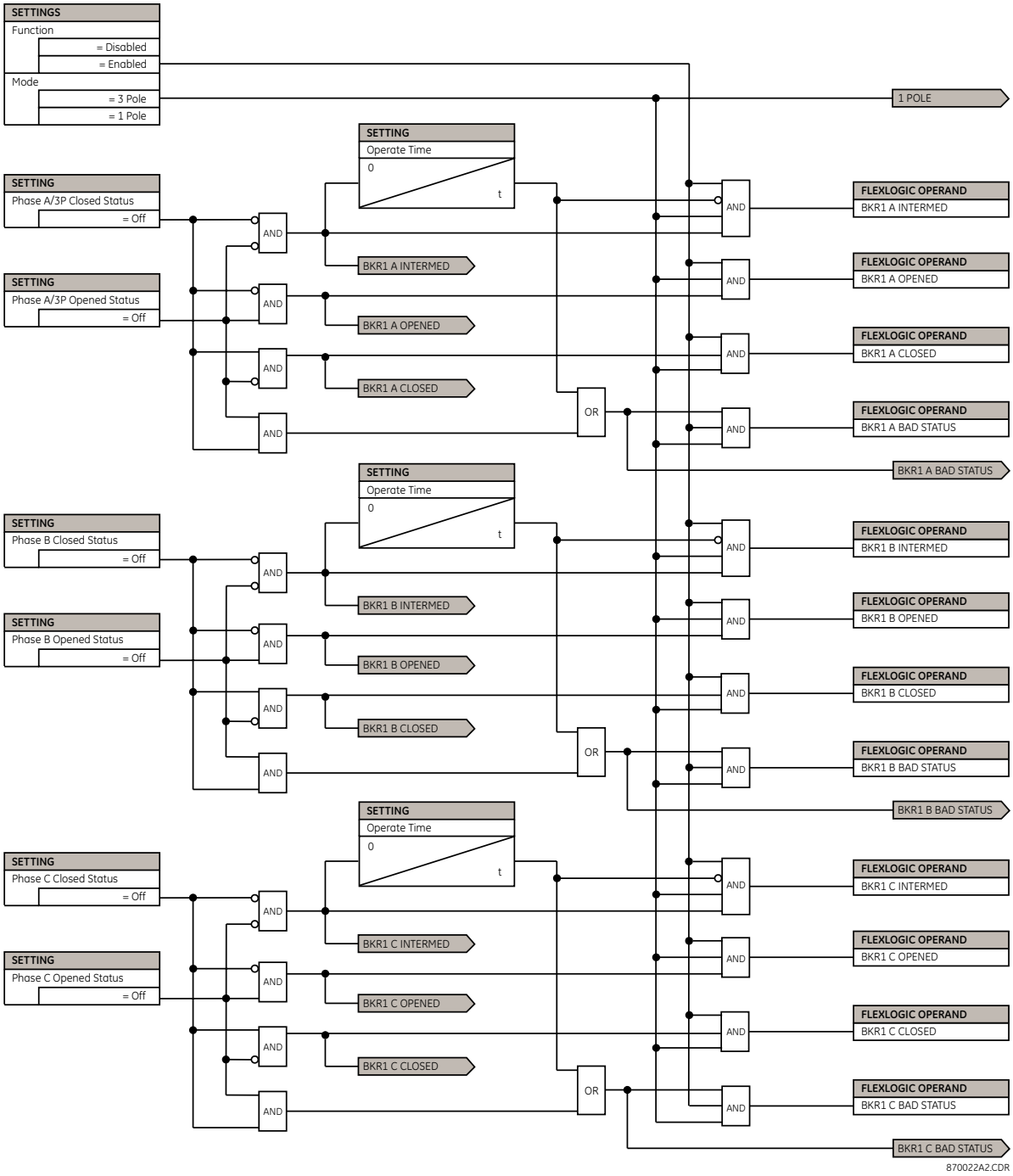
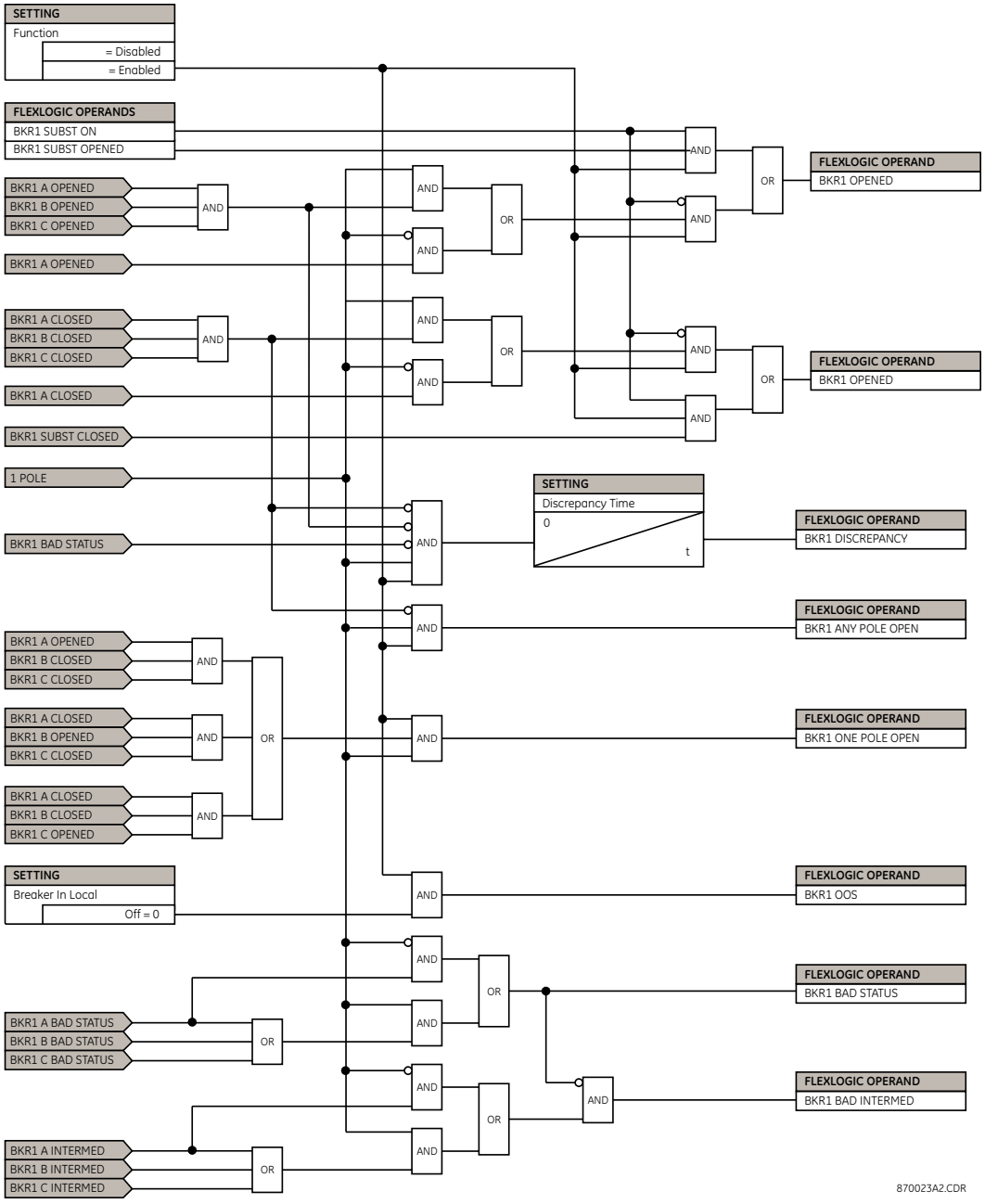


Figure 102: Breaker configuration logic, sheet 4 of 4



Breaker flashover

The detection of breaker flashover is based on the following condition:

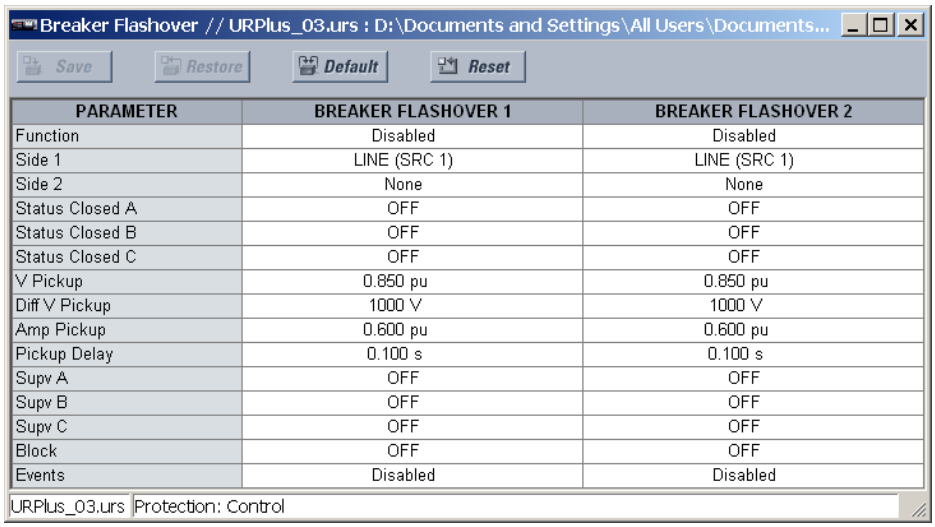
1. Breaker open
2. Voltage drop measured from either side of the breaker during the flashover period
3. Voltage difference drop
4. Measured flashover current through the breaker

Furthermore, the breaker flashover scheme is applicable for cases where either one or two sets of three-phase voltages are available across the breaker.

Breaker flashover settings

Select the **Settings > Protection > Control > Breaker Flashover** menu item to open the breaker flashover configuration window.

Figure 103: Breaker flashover configuration settings



PARAMETER	BREAKER FLASHOVER 1	BREAKER FLASHOVER 2
Function	Disabled	Disabled
Side 1	LINE (SRC 1)	LINE (SRC 1)
Side 2	None	None
Status Closed A	OFF	OFF
Status Closed B	OFF	OFF
Status Closed C	OFF	OFF
V Pickup	0.850 pu	0.850 pu
Diff V Pickup	1000 V	1000 V
Amp Pickup	0.600 pu	0.600 pu
Pickup Delay	0.100 s	0.100 s
Supv A	OFF	OFF
Supv B	OFF	OFF
Supv C	OFF	OFF
Block	OFF	OFF
Events	Disabled	Disabled

The following settings are available for each breaker flashover element.

Function

Range: Enabled, Disabled

Default: Disabled

This setting enables and disabled the breaker flashover protection element.

Side 1

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)

Default: LINE (SRC 1)

This setting specifies a signal source used to provide three-phase voltages and three-phase currents from one side of the current breaker. The source selected as a setting and must be configured with breaker phase voltages and currents, even if only three (3) VTs are available across the breaker.

Side 2

Range: None, LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)

Default: varies with UR^{Plus}-series model; refer to the EnerVista UR^{Plus} Setup software

This setting specifies a signal source used to provide another set of three phase voltages whenever six VTs are available across the breaker.

Status Closed A, Status Closed B, Status Closed C

Range: any FlexLogic operand or shared operand

Default: BKR1 CLOSED

These settings specify operands to indicate the open status of the breaker. A separate operand can be selected to detect individual breaker pole status and provide flashover detection. The recommended setting is 52a breaker contact or another operand defining the breaker poles open status.

Voltage Pickup

Range: 0.000 to 1.500 pu in steps of 0.001
Default: 0.850 pu

This setting specifies a pickup level for the phase voltages from both sides of the breaker. If six VTs are available, opening the breaker leads to two possible combinations – live voltages from only one side of the breaker, or live voltages from both sides of the breaker. Either case sets the scheme ready for flashover detection upon detection of voltage above the selected value. Set this value to 85 to 90% of the nominal voltage.

Voltage Difference Pickup

Range: 0 to 100000 volts in steps of 1
Default: 1000 volts

This setting specifies a pickup level for the phase voltage difference when two VTs per phase are available across the breaker. The pickup voltage difference should be below the monitored voltage difference when close or open breaker resistors are left in service. The setting is selected as primary volts difference between the sources.

Current Pickup

Range: 0.000 to 1.500 pu in steps of 0.001
Default: 0.600 pu

This setting specifies the normal load current which can flow through the breaker. Depending on the flashover protection application, the flashover current can vary from levels of the charging current when the line is de-energized (all line breakers open), to well above the maximum line (feeder) load (line/feeder connected to load).

Pickup Delay

Range: 0.000 to 65.535 seconds in steps of 0.001
Default: 0.100 seconds

This setting specifies the time delay to operate the breaker flashover element after a pickup condition is detected.

Supervision A, Supervision B, Supervision C

Range: any FlexLogic operand or shared operand
Default: OFF

These settings specify operands (per breaker pole) that supervise the operation of the element per phase. Supervision can be provided by operation of other protection elements, breaker failure, and close and trip commands. A six-cycle time delay applies after the selected operand resets.

Block

Range: any FlexLogic operand or shared operand
Default: OFF

Assertion of the operand assigned to this setting blocks operation of the breaker flashover element.

Events

Range: Enabled, Disabled
Default: varies with UR^{Plus}-series model; refer to the EnerVista UR^{Plus} Setup software

This setting enables and disables the logging of breaker flashover events in the sequence of events recorder.

The figures show the logic for the breaker flashover element.

Figure 104: Breaker flashover scheme logic, sheet 1 of 2

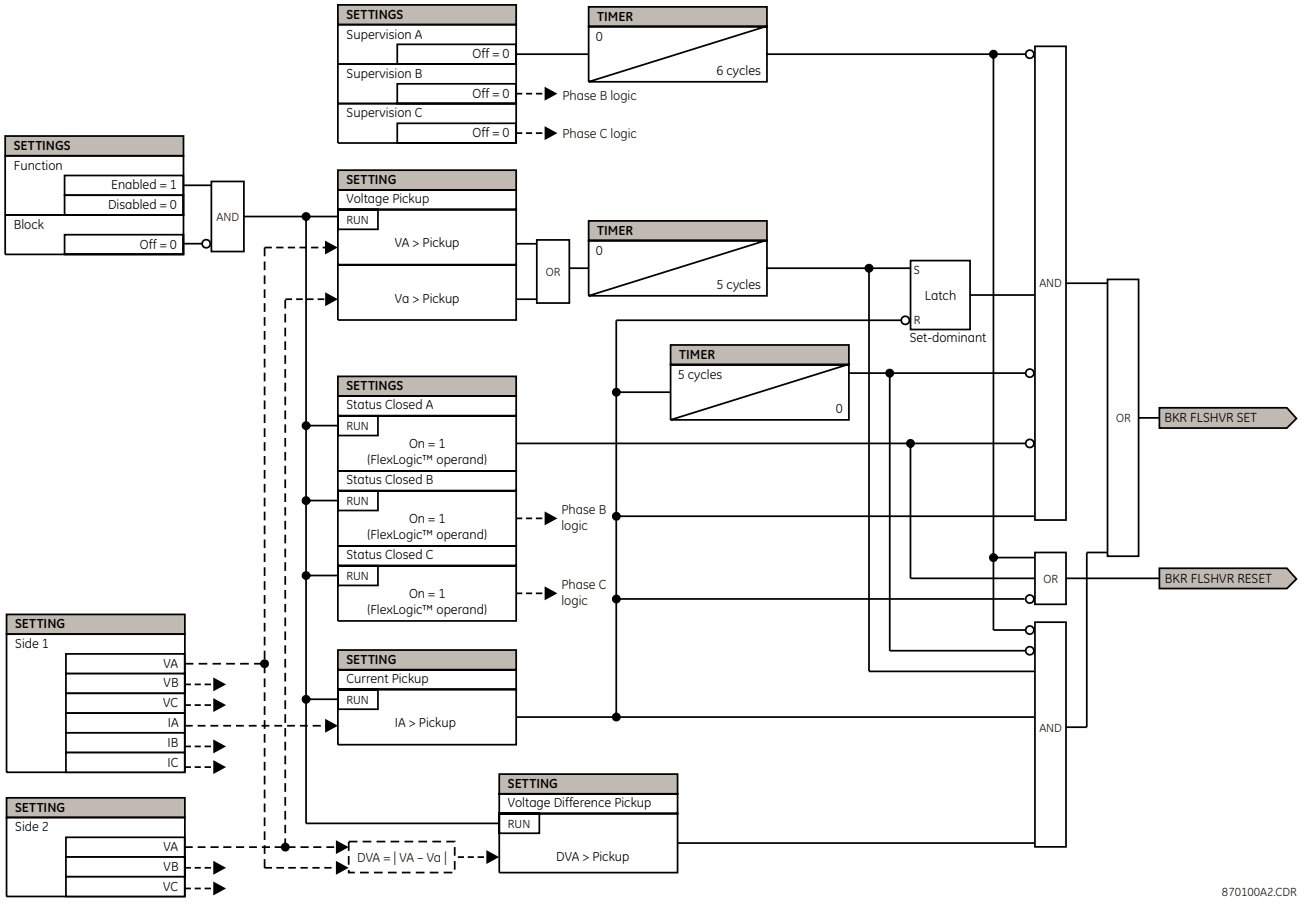
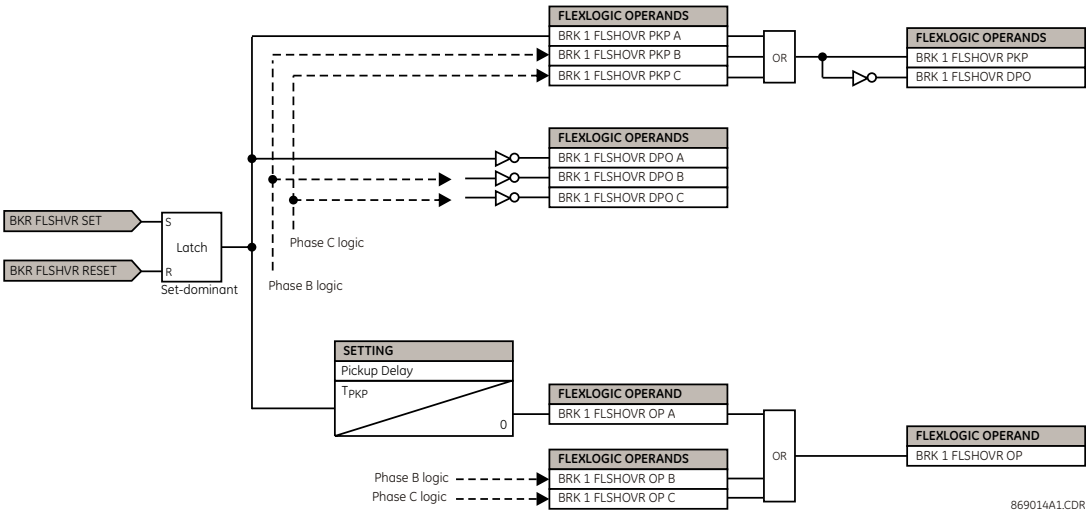


Figure 105: Breaker flashover scheme logic, sheet 2 of 2



Three VT breaker flashover application

When only one set of VTs is available across the breaker, set the Side 2 setting to "None". To detect an open breaker condition in this application, the scheme checks if the per-phase voltages were recovered (picked up), the status of the breaker is open (contact input

indicating the breaker status is off), and no flashover current is flowing. A contact showing the breaker status must be provided to the relay. The voltage difference is not considered as a condition for open breaker in this part of the logic.

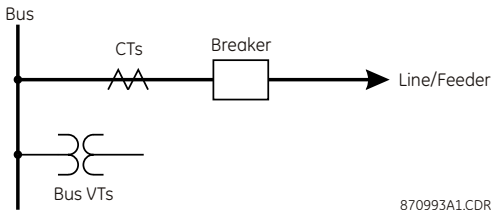
NOTE

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

The flashover detection resets if the current drops back to zero, the breaker closes, or the selected FlexLogic operand for supervision changes to high. Using supervision through the **Supervision A** through **Supervision C** settings is recommended by selecting a trip operand that does not allow the flashover element to pickup prior to the trip. The flashover detection can be used for external alarm, re-tripping the breaker, or energizing the lockout relay.

Consider the configuration shown.

Figure 106: Breaker flashover application example



The source 1 (SRC1) phase currents are feeder CTs and phase voltages are bus VTs, and contact input 1 is set as breaker 52a contact. The conditions prior to flashover detection are

1. 52a status = 0
2. VAg, VBg, or VCg is greater than the pickup setting
3. IA, IB, IC = 0; no current flows through the breaker
4. ΔVA is greater than pickup (not applicable in this scheme)

The conditions at flashover detection are

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

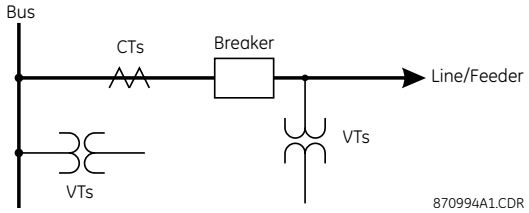
Six VT breaker flashover application

The per-phase voltage difference approaches zero when the breaker is closed. The is well below any typical minimum pickup voltage. Select the level of the **Voltage Difference Pickup** setting to be less than the voltage difference measured across the breaker when the close or open breaker resistors are left in service. Prior to flashover, the voltage difference is larger than the **Voltage Difference Pickup** setting. This applies to either the difference between two live voltages per phase or when the voltage from one side of the breaker has dropped to zero (line de-energized), at least one per-phase voltage is larger than the **Voltage Pickup** setting, and no current flows through the breaker poles. During breaker flashover, the per-phase voltages from both sides of the breaker drops below the pickup value defined by the **Voltage Pickup** setting, the voltage difference drops below the pickup setting, and flashover current is detected. These flashover conditions initiate FlexLogic pickup operands and start the **Pickup Delay** timer.

This application does not require detection of breaker status via a 52a contact, as it uses a voltage difference larger than the **Voltage Difference Pickup** setting. However, monitor the breaker contact to ensure scheme stability.

Consider the configuration shown.

Figure 107: Breaker flashover application example



The source 1 (SRC1) phase currents are CTs and phase voltages are bus VTs. The source 2 (SRC2) phase voltages are line VTs. Contact input 1 is set as the breaker 52a contact (optional).

The conditions prior to flashover detection are

1. ΔVA is greater than pickup
2. VAg, VBg, or VCg is greater than the pickup setting
3. IA, IB, IC = 0; no current flows through the breaker
4. 52a status = 0 (optional)

The conditions at flashover detection are

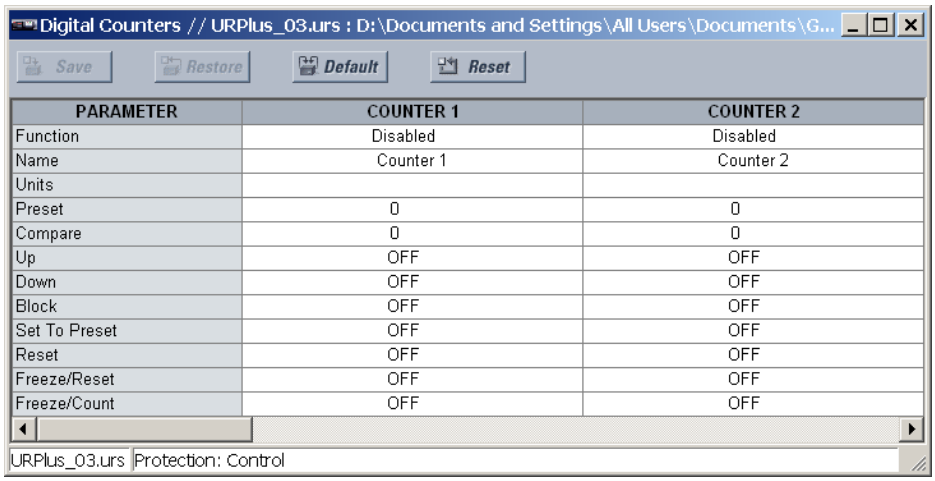
1. ΔVA is less than pickup
2. VAg, VBg, or VCg is lower than the pickup setting
3. IA, IB, or IC is greater than the pickup current flowing through the breaker
4. 52a status = 0 (optional)

Digital counters

There are eight identical digital counters in the C90^{Plus}. A digital counter counts the number of state transitions from logic 0 to logic 1. The counter is used to count operations such as element pickup, changes of state of an external contact (for example, a breaker auxiliary switch), or pulses from a watt-hour meter.

Select the **Settings > Protection > Control > Digital Counters** menu item to open the digital counters configuration window.

Figure 108: Digital counters configuration settings



PARAMETER	COUNTER 1	COUNTER 2
Function	Disabled	Disabled
Name	Counter 1	Counter 2
Units		
Preset	0	0
Compare	0	0
Up	OFF	OFF
Down	OFF	OFF
Block	OFF	OFF
Set To Preset	OFF	OFF
Reset	OFF	OFF
Freeze/Reset	OFF	OFF
Freeze/Count	OFF	OFF

The following settings are available for each digital counter.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the digital counter.

Name

Range: up to 12 alphanumeric characters
Default: Counter 1

An alphanumeric name may be assigned to a digital counter for diagnostic, setting, and event recording purposes. The "Counter 1" text in event records and FlexLogic operands are replaced by the text programmed in this setting.

Units

Range: up to 6 alphanumeric characters
Default: empty

This setting assigns a label to identify the unit of measure pertaining to the digital transitions to be counted. The units label appears in the corresponding actual values status.

Preset

Range: –2 147 483 648 to 2 147 483 647 in steps of 1
Default: 0

This setting specifies the count to a required preset value before counting operations begin, as in the case where a substitute relay is to be installed in place of an in-service relay, or while the counter is running.

Compare

Range: –2 147 483 648 to 2 147 483 647 in steps of 1
Default: 0

This setting specifies the value to which the accumulated count value is compared. Three FlexLogic output operands are provided to indicate if the present value is greater than the set value (Counter 1 HI), equal to the set value (Counter 1 EQL), or less than the set value (Counter 1 LO).

Up

Range: any FlexLogic operand
Default: Off

This setting selects the FlexLogic operand for incrementing the counter. If an enabled up input is received when the accumulated value is at the limit of 2 147 483 647 counts, the counter rolls over to –2 147 483 648 counts.

Down

Range: any FlexLogic operand or shared operand
Default: OFF

This setting selects an operand for decrementing the counter. If an enabled down input is received when the accumulated value is at the limit of –2 147 483 648 counts, the counter will rollover to 2 147 483 647 counts.

Block

Range: any FlexLogic operand or shared operand
Default: OFF

This setting selects an operand for blocking the counting operation. All counter operands are blocked upon assertion of this operand.

Set To Preset

Range: any FlexLogic operand or shared operand
Default: OFF

This setting selects an operand used to set the count to the preset value and functions as follows.

- The counter will be set to the preset value when the counter is enabled and the operand assigned to the **Set To Preset** setting is asserted (logic 1). When the counter is enabled and the operand assigned to the **Set To Preset** value is logic 0, the counter will be set to 0.
- The counter will be set to the preset value when the counter is running and operand assigned to the **Set To Preset** setting changes the state from 0 to 1. If the operand assigned to the **Set To Preset** setting changes from 1 to 0 while the counter is running, there is no effect on the count.
- The counter will be set to the preset value when a reset or reset/freeze command is sent to the counter and the operand assigned to the **Set To Preset** setting is logic 1. When a reset or reset/freeze command is sent to the counter and the operand assigned to the **Set To Preset** setting is logic 0, the counter will be set to 0.

Reset

Range: any FlexLogic operand or shared operand
Default: OFF

This setting selects an operand for setting the count to either 0 or the preset value depending on the state of the operand assigned to the **Set To Preset** setting.

Freeze/Reset

Range: any FlexLogic operand or shared operand
Default: OFF

This setting selects an operand for capturing (freezing) the accumulated count value into a separate register with the date and time of the operation, and resetting the count to 0.

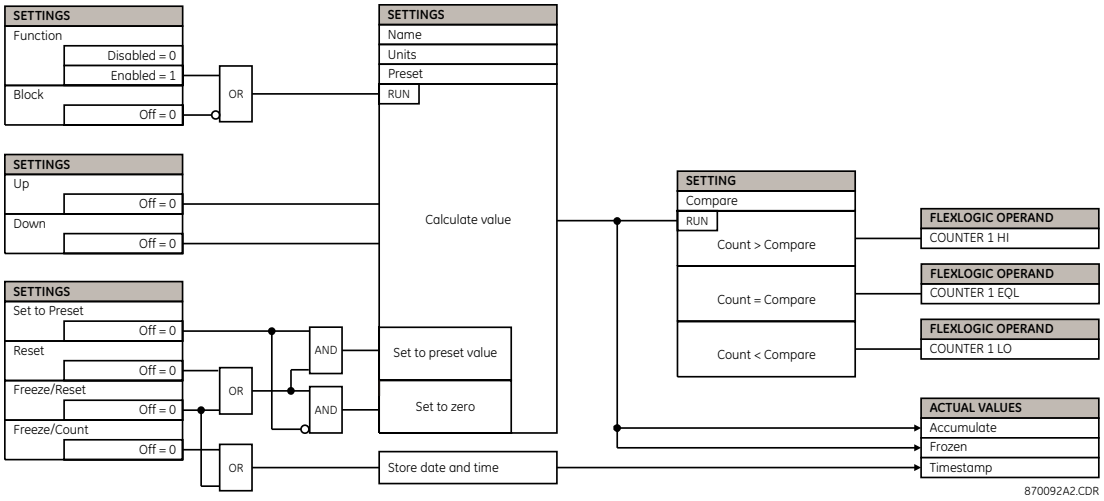
Freeze/Count

Range: any FlexLogic operand or shared operand
Default: OFF

This setting selects an operand for capturing (freezing) the accumulated count value into a separate register with the date and time of the operation, and continuing counting. The present accumulated value and captured frozen value with the associated date and time stamp are available as actual values. If control power is interrupted, the accumulated and frozen values are saved into non-volatile memory during the power down operation.

The figure shows the digital counter logic. The logic is identical for all digital counters.

Figure 109: Digital counter scheme logic



FlexCurves

There are four user-programmable FlexCurves available with the C90^{Plus} system, labeled A, B, C, and D.

The curve shapes for the four FlexCurves are derived from the following equations:

$$T_{operate} = \text{TDM} \times \left(T_{flex} \text{ at } \frac{I}{I_{pickup}} \right), \text{ when } \frac{I}{I_{pickup}} \geq 1.00 \quad \textbf{Eq. 36}$$

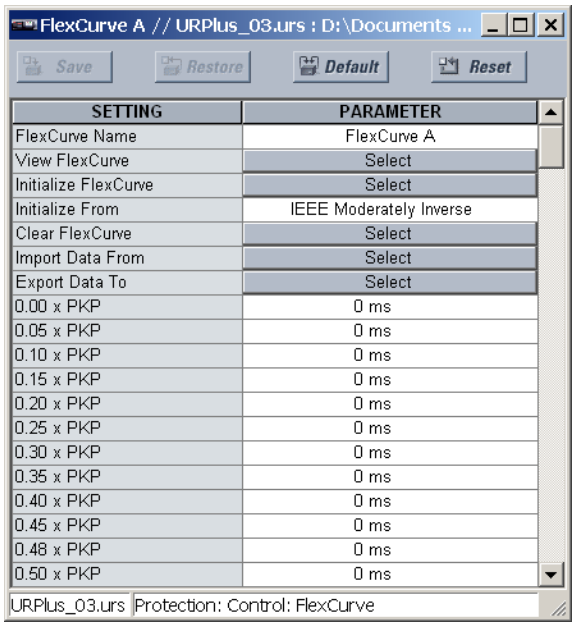
$$T_{reset} = \text{TDM} \times \left(T_{flex} \text{ at } \frac{I}{I_{pickup}} \right), \text{ when } \frac{I}{I_{pickup}} \leq 0.98 \quad \textbf{Eq. 37}$$

where $T_{operate}$ represents the operate time in seconds, TDM represents the multiplier setting, I represents the input current, I_{pickup} represents the value of the pickup current setting, T_{flex} represents the FlexCurve time in seconds, and T_{reset} represents the reset time in seconds.

FlexCurve settings

Select the **Settings > Protection > Control > FlexCurves > FlexCurve A** menu item to access the FlexCurve A settings. The same group of settings is available for FlexCurves B, C, and D.

Figure 110: FlexCurve configuration settings



The following settings are available for each custom FlexCurve.

FlexCurve Name

Range: up to 20 alphanumeric characters
Default: FlexCurve A

This setting specifies a user-defined name for the FlexCurve.

Initialize From

Range: IEEE Moderately Inverse, IEEE Very Inverse, IEEE Extremely Inverse, IEC Curve A, IEC Curve B, IEC Curve C, IEC Short Inverse, IAC Extreme Inv, IAC Very Inverse, IAC Inverse, IAC Short Inverse, I Squared T, Recloser Curve, FlexCurve A, FlexCurve B, FlexCurve C, FlexCurve D
Default: IEEE Moderately Inverse

This setting specifies a curve to use as a base for a custom FlexCurve. When the **Initialize FlexCurve** button is clicked, the pickup settings will be populated with values specified by the curve selected in this setting.

0.00 × Pickup, 0.05 × Pickup,..., 20.00 × Pickup

Range: 0 to 65535 ms in steps of 1
Default: 0 ms

These settings specify the time 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 or operate time for each selected pickup point.

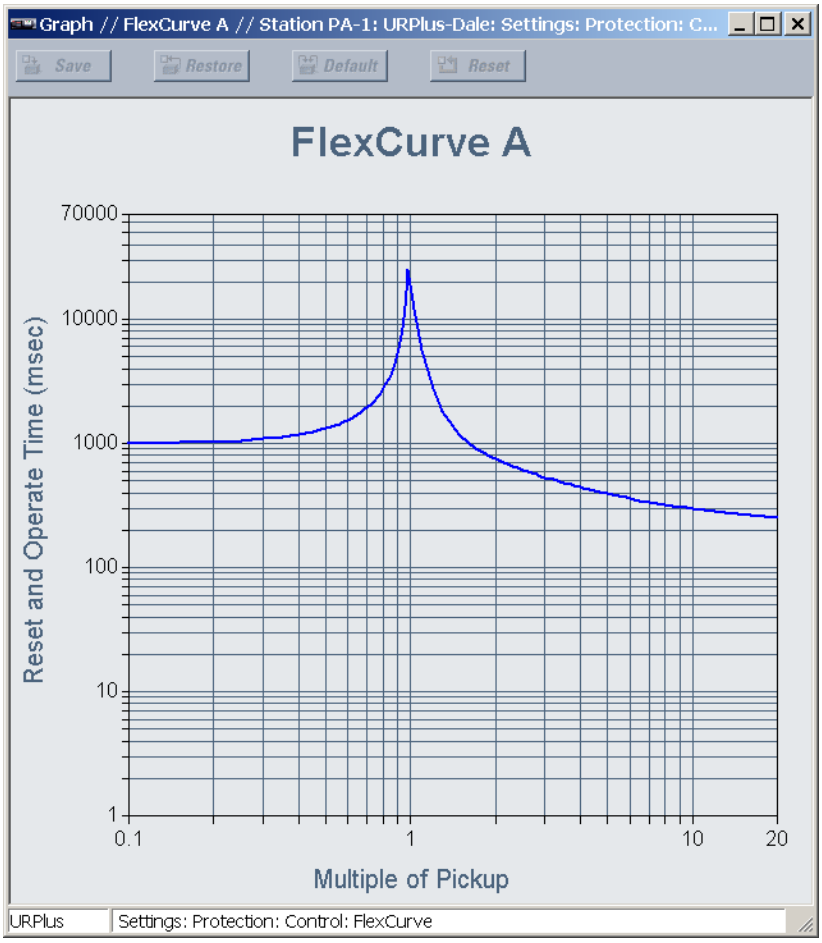
NOTE

Special care must be applied when setting the two points that are close to the multiple of pickup of 1; that is, 0.98 pu and 1.03 pu. It is recommended to set the two times to a similar value; otherwise, the linear approximation may result in undesired behavior for the operating quantity that is close to 1.00 pu.

FlexCurve software features

The EnerVista software allows for easy configuration and management of FlexCurves and their associated data points. Click the **View FlexCurve** button to graphically display the selected FlexCurve.

Figure 111: FlexCurve display example



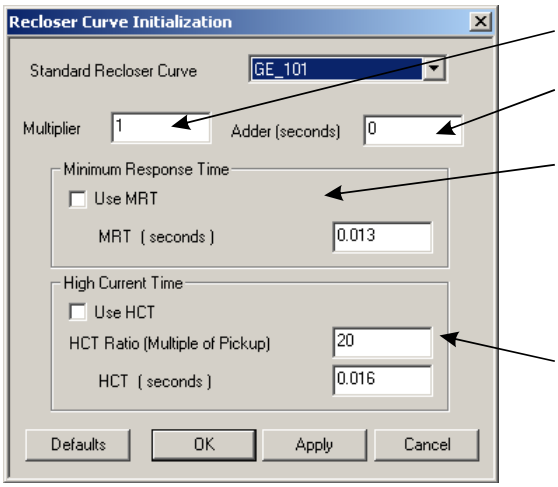
Prospective FlexCurves can be configured from a selection of standard curves to provide the best approximate fit, then specific data points can be edited afterwards. Click the **Initialize FlexCurve** button to populate the pickup values with the points from the curve specified by the **Initialize From** setting. These values can then be edited to create a custom curve. Note that the pickup multiples start at zero (implying the reset time), operating time below pickup, and operating time above pickup. Click the **Clear FlexCurve** button to reset all pickup values to zero.

Curve data can be imported from CSV (comma-separated values) files by clicking the **Import Data From** button. Likewise, curve data can be saved in CSV format by clicking the **Export Data To** button. CSV is a delimited data format with fields separated by the comma character and records separated by new lines. Refer to IETF RFC 4180 for additional details.

Recloser curve editing

Recloser curve selection is special in that recloser curves can be shaped into a composite curve with a minimum response time and a fixed time above a specified pickup multiples. There are 41 recloser curve types supported. These definite operating times are useful to coordinate operating times, typically at higher currents and where upstream and downstream protective devices have different operating characteristics. The recloser curve configuration window shown below appears when the **Initialize From** setting is set to "Recloser Curve" and the **Initialize FlexCurve** button is clicked.

Figure 112: Recloser curve initialization



Multiplier: Scales (multiplies) the curve operating times

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

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

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

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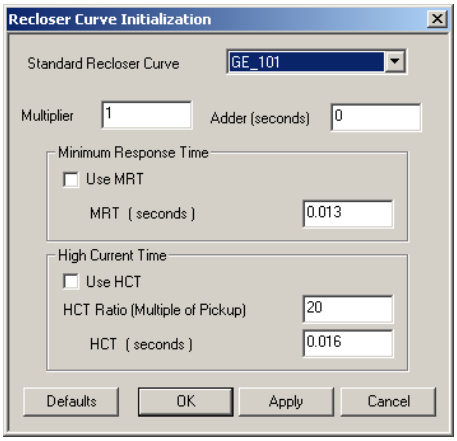
NOTE

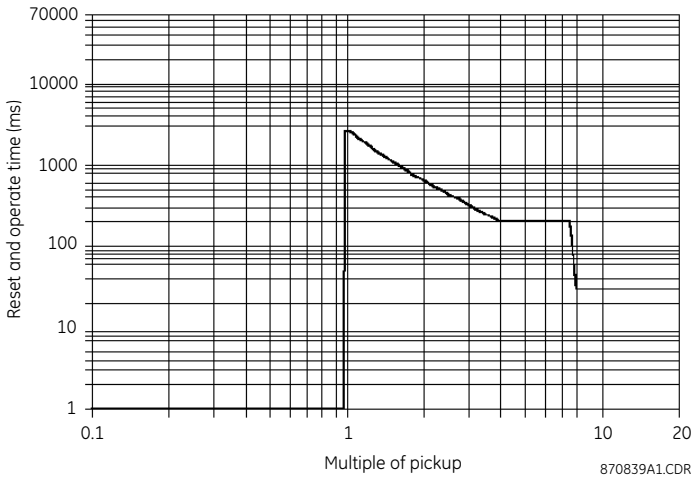
The multiplier and adder settings only affect the curve portion of the characteristic and not the MRT and HCT settings. The HCT settings override the MRT settings for multiples of pickup greater than the HCT ratio.

Composite recloser curve example

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

Figure 113: Composite recloser curve with HCT disabled

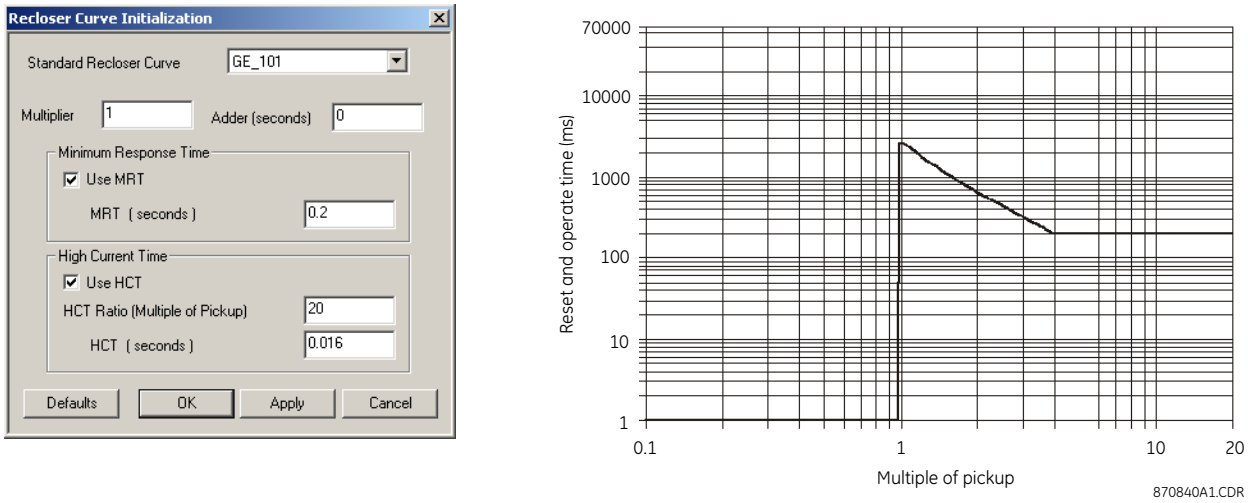




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With the HCT feature enabled, the operating time reduces to 30 ms for pickup multiples exceeding eight times pickup.

Figure 114: Composite recloser curve with HCT enabled



NOTE

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

Protection inputs and outputs

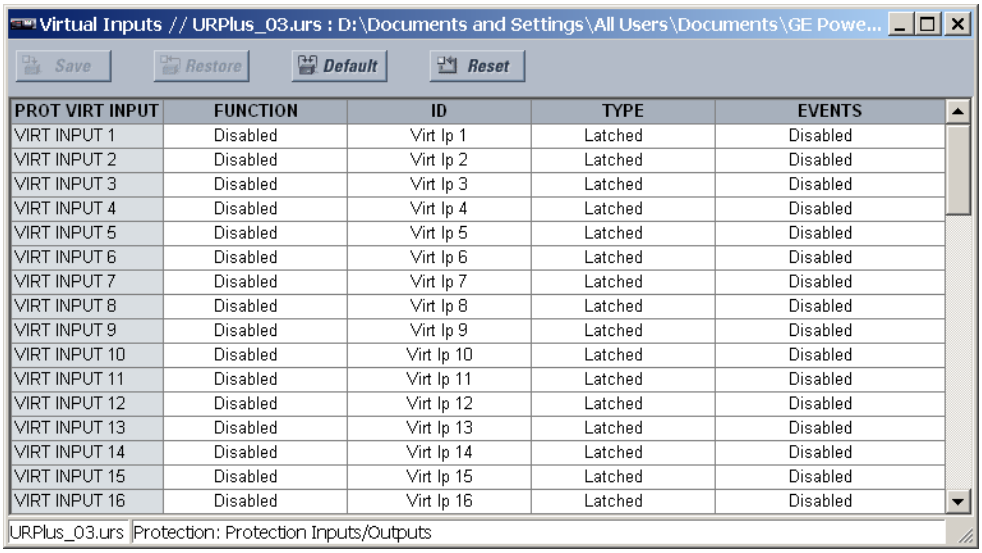
Three groupings of protection inputs and outputs are defined: physical, shared, and virtual. Within these three groupings there are two types: analog and digital.

Protection virtual inputs

There are 64 virtual inputs that can be individually programmed to respond to input signals from the front panel interface and communications protocols. All virtual input operands are defaulted to off (logic 0) unless the appropriate input signal is received.

Select the **Settings > Protection > Protection Inputs/Outputs > Virtual Inputs** menu item to access the protection virtual input configuration settings.

Figure 115: Protection virtual inputs configuration settings



PROT VIRT INPUT	FUNCTION	ID	TYPE	EVENTS
VIRT INPUT 1	Disabled	Virt Ip 1	Latched	Disabled
VIRT INPUT 2	Disabled	Virt Ip 2	Latched	Disabled
VIRT INPUT 3	Disabled	Virt Ip 3	Latched	Disabled
VIRT INPUT 4	Disabled	Virt Ip 4	Latched	Disabled
VIRT INPUT 5	Disabled	Virt Ip 5	Latched	Disabled
VIRT INPUT 6	Disabled	Virt Ip 6	Latched	Disabled
VIRT INPUT 7	Disabled	Virt Ip 7	Latched	Disabled
VIRT INPUT 8	Disabled	Virt Ip 8	Latched	Disabled
VIRT INPUT 9	Disabled	Virt Ip 9	Latched	Disabled
VIRT INPUT 10	Disabled	Virt Ip 10	Latched	Disabled
VIRT INPUT 11	Disabled	Virt Ip 11	Latched	Disabled
VIRT INPUT 12	Disabled	Virt Ip 12	Latched	Disabled
VIRT INPUT 13	Disabled	Virt Ip 13	Latched	Disabled
VIRT INPUT 14	Disabled	Virt Ip 14	Latched	Disabled
VIRT INPUT 15	Disabled	Virt Ip 15	Latched	Disabled
VIRT INPUT 16	Disabled	Virt Ip 16	Latched	Disabled

The following settings are available for each protection virtual input. The default values outlined are for virtual input 1.

Function

Range: Enabled, Disabled

Default: Disabled

If this setting is "Disabled", the virtual input is forced to off (logic 0) regardless of any attempt to alter the input. If set to "Enabled", the input operates as shown on the logic diagram and generates output logic operands in response to received input signals and the applied settings.

ID

Range: up to 12 alphanumeric characters

Default: Virt Ip 1

This setting specifies an identifier that can be assigned to each virtual input.

Type

Range: Self-Reset, Latched

Default: Latched

There are two types of operation: self-reset and latched. If this settings is "Self-Reset", the output operand is asserted (logic 1) for only one evaluation of the protection FlexLogic equations and then return to 0 when the input signal transits from off to on. If set to "Latched", the virtual input sets the state of the output operand to the same state as the most recent received input.

NOTE

The self-reset operating mode generates an output operand for a single evaluation of FlexLogic equations. If the operand is to be used anywhere other than internally in an automation logic equation, it will likely have to be lengthened in time. A FlexLogic timer with a delayed reset can perform this function.

Events

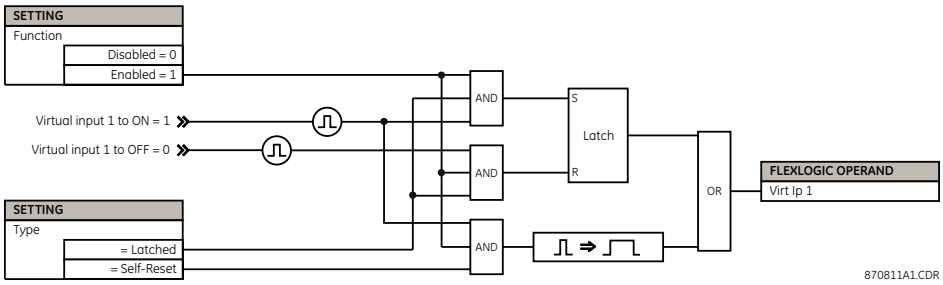
Range: Enabled, Disabled

Default: Disabled

When this setting is "Enabled", every change in the protection virtual input state triggers an event in the sequence of events recorder.

The figure shows the protection virtual input logic. The logic is identical for all protection virtual inputs.

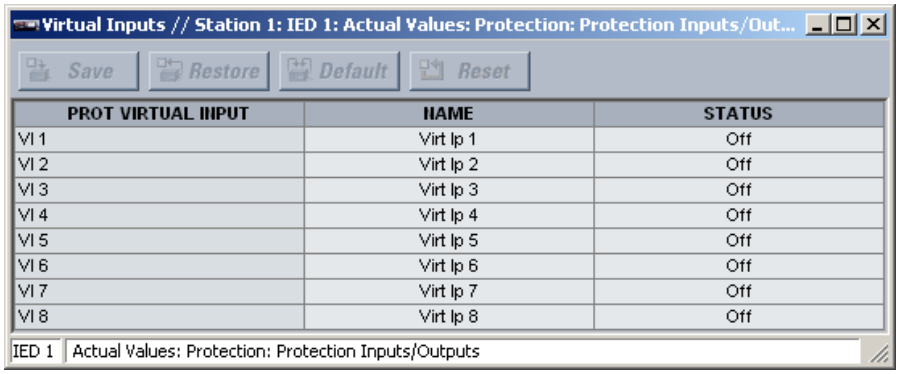
Figure 116: Protection virtual input logic



Protection virtual input actual values

Select the **Actual Values > Protection > Protection Inputs/Outputs > Virtual Inputs** menu item to open the protection virtual input actual values window.

Figure 117: Protection virtual input actual values



PROT VIRTUAL INPUT	NAME	STATUS
VI 1	Virt Ip 1	Off
VI 2	Virt Ip 2	Off
VI 3	Virt Ip 3	Off
VI 4	Virt Ip 4	Off
VI 5	Virt Ip 5	Off
VI 6	Virt Ip 6	Off
VI 7	Virt Ip 7	Off
VI 8	Virt Ip 8	Off

The following actual values are available for all enabled protection virtual inputs.

Name

Range: up to 12 alphanumeric characters

This value displays the programmed **ID** for the corresponding protection virtual input.

Status

Range: On, Off

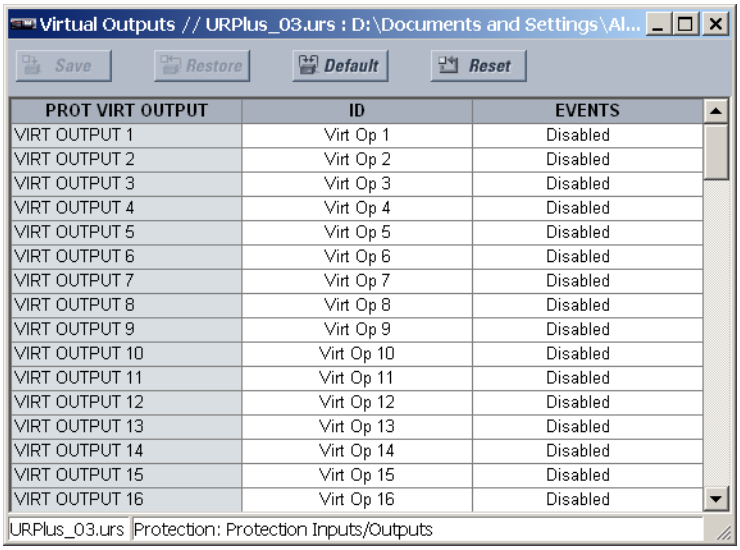
This value indicates the logic state of the virtual input.

Protection virtual outputs

There are 96 virtual outputs that may be assigned via FlexLogic. Virtual outputs are resolved in each pass through the evaluation of FlexLogic equations.

Select the **Settings > Protection > Protection Inputs/Outputs > Virtual Outputs** menu item to access the protection virtual output configuration settings.

Figure 118: Protection virtual output settings



The following settings are available for each protection virtual output. If not assigned, the virtual output is forced to off (logic 0).

ID

Range: up to 12 alphanumeric characters
Default: Virt Op 1

This setting specifies an identifier that can be assigned to each protection virtual output.

Events

Range: Enabled, Disabled
Default: Disabled

When this setting is "Enabled", every change in the protection virtual output state triggers an event in the sequence of events recorder.

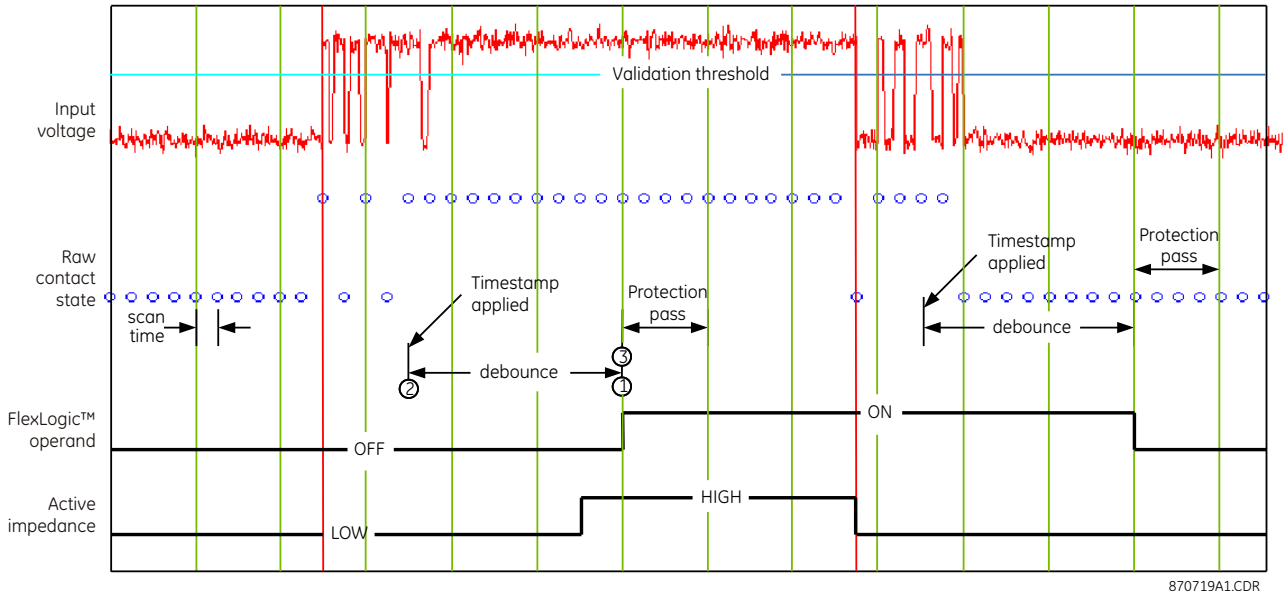
Contact input configuration

The C90^{Plus} can monitor the status of up to 115 field contacts. Each input can be wetted from the C90^{Plus} 48 volt auxiliary supply or from an external power supply. Each contact input has a dedicated delay timer for filtering of contact bouncing. The C90^{Plus} can also detect an oscillating input via the chatter feature. Each contact input active impedance circuitry to provide security against false turn-on of an input due to excessive stray capacitance of field wiring.

A raw status is scanned synchronously for all contact inputs at the rate of 0.25 ms, as shown in the following figure. A new contact input state must be maintained for a user-programmable debounce time for the C90^{Plus} to validate the new contact state. The debounce time is set at 2.0 ms in the figure; as such, the eighth sample validates the change of state (mark 1 in the figure). Once validated (de-bounced), the contact input asserts a corresponding FlexLogic operand and logs an event (if event logging is enabled).

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 2 in the figure).

Figure 119: Contact input debouncing mechanism and time-stamping



Protection elements, as well as FlexLogic equations and timers, are executed sixteen 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 (mark 3 in the figure). The update is performed at the beginning of the protection pass so all protection functions and protection 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 a maximum of one protection pass (depending on system frequency if frequency tracking is 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 0.25 ms scan rate, the time resolution for the input contact is less than 1 ms.

For example, sixteen protection passes per cycle on a 60 Hz system correspond to a protection pass every 1.04 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 + 1.04 = 4.04 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 ms accuracy using the time of the first scan corresponding to the new state. 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 OFF-ON and ON-OFF transitions.

The active impedance feature controls the input impedance presented to the system according to the current state of the input. When the contact input circuitry initially detects a voltage increase, it draws 10 mA of current. If the state change is due to a transient coupled through the stray capacitance of the field wiring, then the high current sink charges the capacitance causing the transient to rapidly decay. If voltage increase is due to a state change of the field contact, then the increased current has no impact on the

input voltage, and the state change is validated. Once the input has been declared to be on, the input circuitry reduces the current drawn to 1 mA to minimize the power dissipated by the input.

NOTE

The contact input update time is 1 ms. However, depending on where the contact input status change is triggered within a one millisecond window, the worst-case contact input recognition time is 2 ms.

Contact input and output default assignment

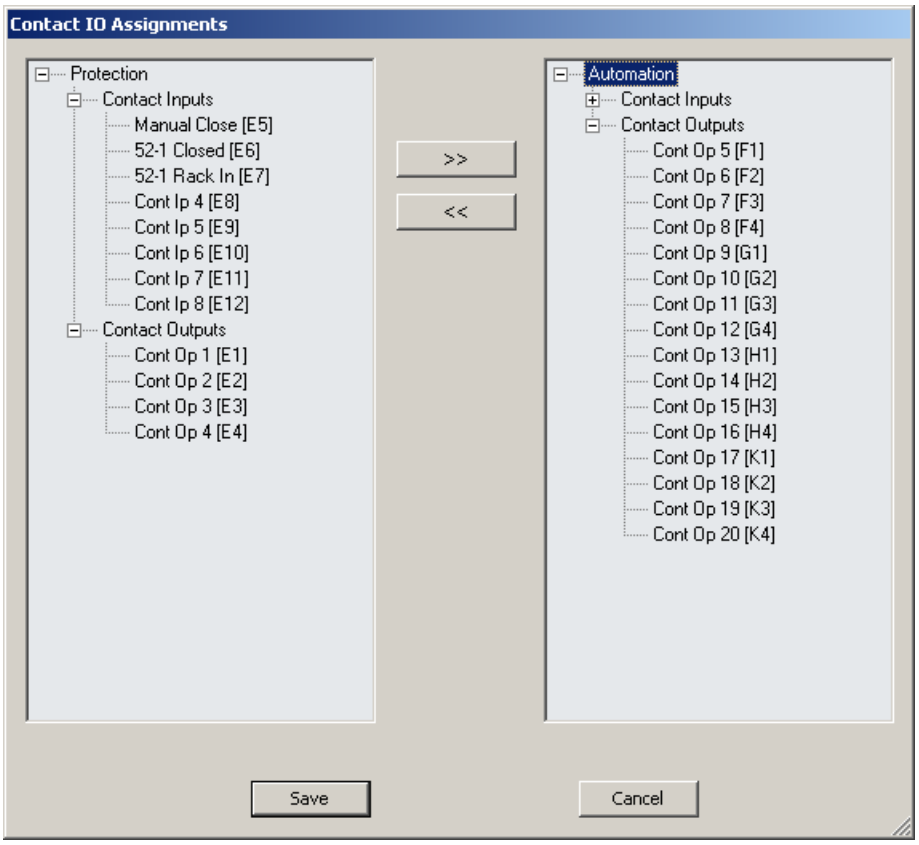
When a new settings file is created, the available contacts are automatically assigned to the protection or automation functions according to the following convention:

- First I/O module → protection
- All subsequent I/O modules → automation

For example, if a C90^{Plus} is configured with contact input/output cards in slots E, F, and G, then the inputs and outputs associated with slot E are assigned to protection and the inputs and outputs associated with slots F and G are assigned to automation.

These default assignments may be changed to match the requirements of the application. This is done by right-clicking on the setting filename and choosing the menu **Manage Settings File > I/O Assignments** menu item. The following window displays.

Figure 120: Contact input and output assignments



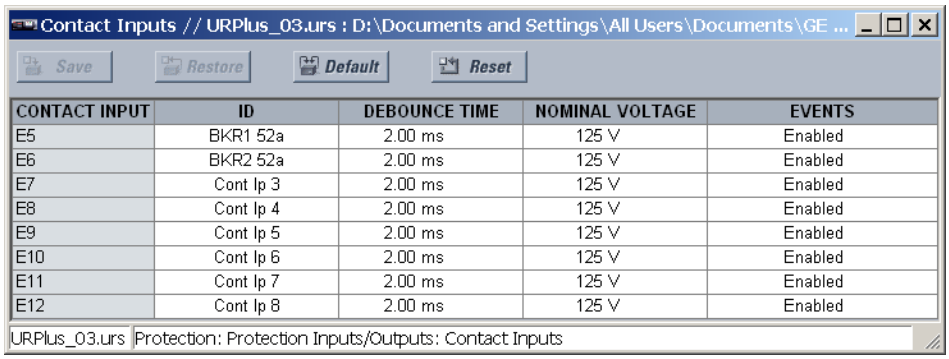
All available contact inputs and output can be reassigned using the **>>** and **<<** buttons.

Contact input settings

When the input detects a voltage decrease, the input circuitry draws 10 mA of current. If the voltage decrease is due to a state change then the voltage quickly decreases, speeding up the recognition of the reset of the field contact.

Select the **Settings > Protection > Protection Inputs/Outputs > Contact Inputs > Contact Inputs** menu item to access the contact input configuration settings.

Figure 121: Contact input configuration settings



CONTACT INPUT	ID	DEBOUNCE TIME	NOMINAL VOLTAGE	EVENTS
E5	BKR1 52a	2.00 ms	125 V	Enabled
E6	BKR2 52a	2.00 ms	125 V	Enabled
E7	Cont Ip 3	2.00 ms	125 V	Enabled
E8	Cont Ip 4	2.00 ms	125 V	Enabled
E9	Cont Ip 5	2.00 ms	125 V	Enabled
E10	Cont Ip 6	2.00 ms	125 V	Enabled
E11	Cont Ip 7	2.00 ms	125 V	Enabled
E12	Cont Ip 8	2.00 ms	125 V	Enabled

The contact inputs menu contains configuration settings for each contact input. Upon startup, the relay processor determines (from an assessment of the installed modules) which contact inputs are available and then displays settings for only those inputs. The following settings are available for each contact input.

ID

Range: up to 12 alphanumeric characters

Default: Cont Ip 1

An alphanumeric ID may be assigned to a contact input for diagnostic, setting, and event recording purposes. The "CONTACT IP 1" text in event records and FlexLogic operands are replaced by the text programmed in this setting.

Debounce Time

Range: 1.5 to 16.0 ms in steps of 0.25

Default: 2.0 ms

This setting defines the time required for the contact to overcome contact bouncing conditions. As this time differs for different contact types and manufacturers, program it as a maximum contact debounce time (per manufacturer specifications) plus additional margin to ensure proper operation.

Nominal Voltage

Range: 24 to 250 volts in steps of 1

Default: 125 volts

This setting specifies the range required to validate a closed contact input. This range is fixed at 70 to 130% of this setting value, with an absolute minimum of 20 volts and an absolute maximum of 285 volts.

Table 16: Nominal voltage setting for typical battery voltages

Nominal voltage	Validation threshold
24 V	20 V
48 V	33.6 V
125 V	87.5 V
250 V	175 V

Events

Range: Enabled, Disabled

Default: Disabled

If this setting is "Enabled", every change in the contact input state triggers an event in the event recorder.

Contact input chatter detection

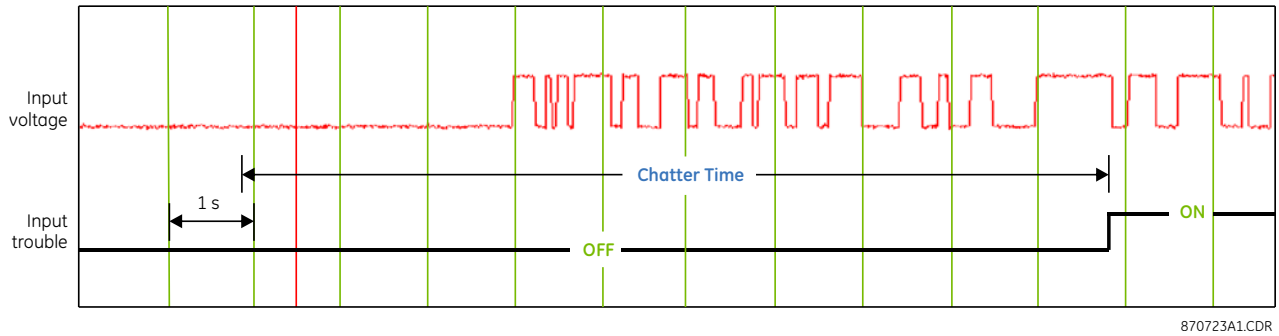
The C90^{Plus} has a chatter detection feature. When enabled, the IED monitors the number of state changes that occur within a set duration. If this value exceeds a set value, then a trouble condition is declared for the input and the CONTACT INPUT TROUBLE operand asserts.

The input trouble alarm impacts relay functionality as follows:

- FlexLogic operands: operand state is blocked
- DNP 3.0 communications: reporting of the input is blocked
- IEC 60870-5-104 communications: reporting of the input is blocked
- IEC 61850 GSSE and IEC 61850 GOOSE: reporting of the input is blocked
- Sequence of events recorder: reporting of the input is blocked

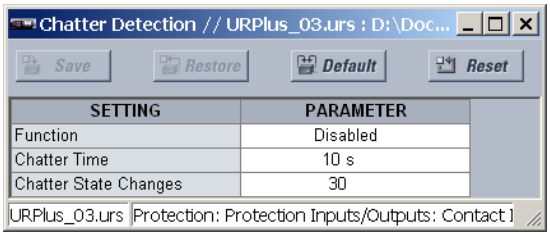
The trouble condition resets if the input undergoes no state changes for a duration equal to twice the chatter time setting.

Figure 122: Chatter detection example



Select the **Settings > Protection > Protection Inputs/Outputs > Contact Inputs > Chatter Detection** menu item to access the contact input chatter detection settings.

Figure 123: Contact input chatter detection configuration



The following settings are applied to all available protection and automation contact inputs.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the chatter detection feature.

Chatter Time

Range: 1 to 100 seconds in steps of 1
Default: 10 seconds

This setting specifies the time window that the relay contacts are monitored for contact input state changes.

Chatter State Changes

Range: 10 to 100 in steps of 1

Default: 30

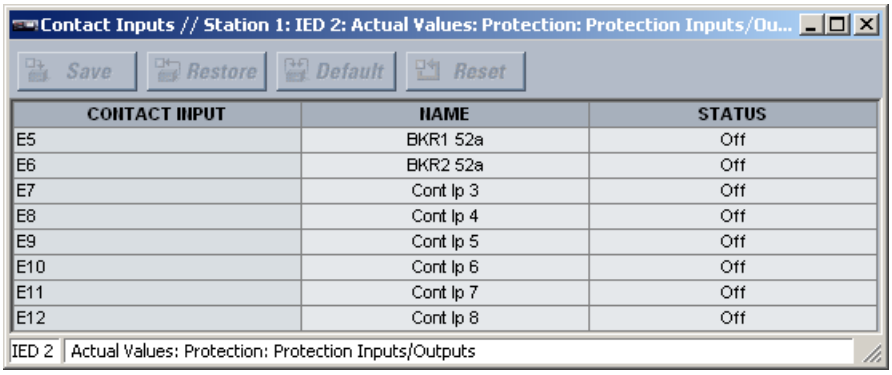
This setting specifies the number of state changes that must occur in the time window defined by the **Chatter Time** setting before issuing the trouble operand.

Since chatter detection is a hardware diagnostic, a trouble indication is logged regardless of the **Events** setting being enabled or disabled for a particular input.

Protection contact input actual values

Select the **Actual Values > Protection > Protection Inputs/Outputs > Contact Inputs** menu item to open the protection contact input actual values window.

Figure 124: Protection contact input actual values



CONTACT INPUT	NAME	STATUS
E5	BKR1 52a	Off
E6	BKR2 52a	Off
E7	Cont Ip 3	Off
E8	Cont Ip 4	Off
E9	Cont Ip 5	Off
E10	Cont Ip 6	Off
E11	Cont Ip 7	Off
E12	Cont Ip 8	Off

The following actual values are available for all protection contact inputs.

Name

Range: up to 12 alphanumeric characters

This value displays the programmed **ID** for the corresponding protection contact input.

Status

Range: On, Off

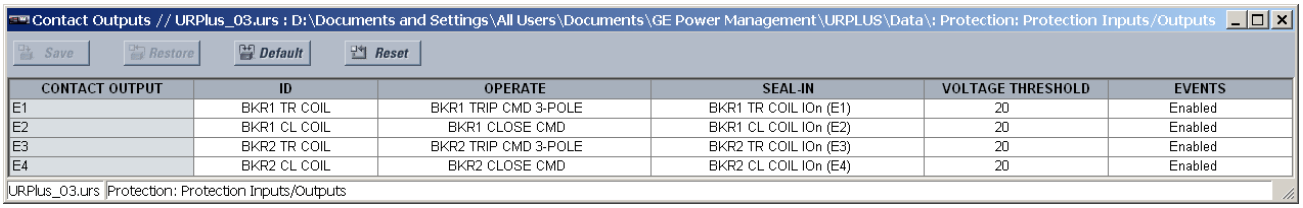
This value indicates the logic state of the protection contact input.

Contact outputs

Upon startup of the unit, the main processor determines from an assessment of the modules installed in the chassis which contact outputs are available and present the settings for only these outputs.

Select the **Settings > Protection > Protection Inputs/Outputs > Contact Outputs** menu item to access the contact output configuration settings.

Figure 125: Protection contact output configuration settings



CONTACT OUTPUT	ID	OPERATE	SEAL-IN	VOLTAGE THRESHOLD	EVENTS
E1	BKR1 TR COIL	BKR1 TRIP CMD 3-POLE	BKR1 TR COIL IOn (E1)	20	Enabled
E2	BKR1 CL COIL	BKR1 CLOSE CMD	BKR1 CL COIL IOn (E2)	20	Enabled
E3	BKR2 TR COIL	BKR2 TRIP CMD 3-POLE	BKR2 TR COIL IOn (E3)	20	Enabled
E4	BKR2 CL COIL	BKR2 CLOSE CMD	BKR2 CL COIL IOn (E4)	20	Enabled

The following settings are available for all contact outputs.

ID

Range: up to 12 alphanumeric characters
Default: Cont Op 1

This setting specifies an alphanumeric identifier for the contact output.

Operate

Range: any FlexLogic operand or shared operand
Default: as shown above

This setting selects an operand (virtual output, element state, contact input, or virtual input) that operates the contact output when asserted.

Seal-In

Range: any FlexLogic operand or shared operand
Default: as shown above

This setting selects an operand (virtual output, element state, contact input, or virtual input) that seals-in the contact output when asserted.

Voltage Threshold

Range: 20 to 250 volts in steps of 1
Default: 20

This setting specifies determines the level at which the Contact Op 1 VOn and Contact Op 1 VOff operands function. It is only shown for contact outputs that have monitoring.

Events

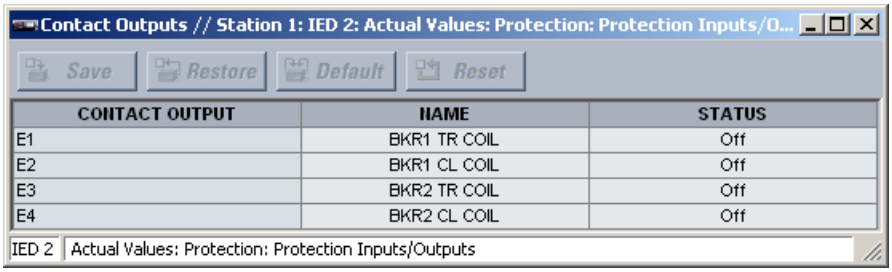
Range: Enabled, Disabled
Default: Enabled

If this setting is "Enabled", every change in the contact output state triggers an event in the sequence of events recorder.

Protection contact output actual values

Select the **Actual Values > Protection > Protection Inputs/Outputs > Contact Outputs** menu item to open the protection contact output actual values window.

Figure 126: Protection contact output actual values



The following actual values are available for all protection contact outputs.

Name

Range: up to 12 alphanumeric characters

This value displays the programmed ID for the corresponding protection contact output.

Status

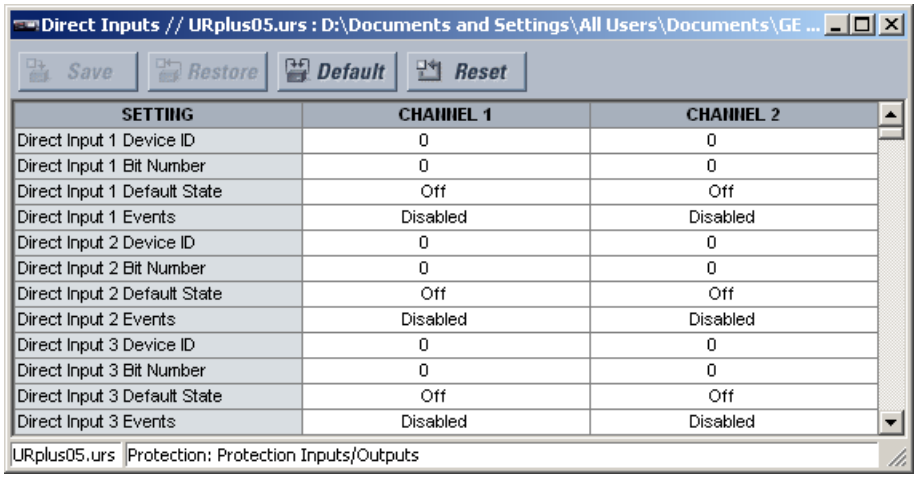
Range: On, Off, VOn, VOff, IOn, IOff

This value indicates the logic state of the protection contact output.

Direct inputs

These settings specify how the direct input information is processed. Select the **Protection > Protection Inputs/Outputs > Direct Inputs** menu item to open the direct inputs configuration window.

Figure 127: Direct inputs configuration settings



The following settings are available all direct inputs. The settings outlined are for direct input 1.

Direct Input 1 Device ID

Range: 0 to 16 in steps of 1
Default: 0

This setting represents the source of the direct input. The specified direct input is driven by the device identified here.

Direct Input 1 Bit Number

Range: 0 to 96 in steps of 1
Default: 0

This setting specifies the bit number to extract the state for this direct input. The corresponding direct input is driven by the bit identified here. This setting also corresponds to the direct output number of the sending device.

Direct Input 1 Default State

Range: On, Off, Latest/On, Latest/Off
Default: Off

This setting represents the state of the direct input when the associated direct device is offline. The following choices are available:

- A value of "On" defaults the input to logic 1
- A value of "Off" defaults the input to logic 0
- A value of "Latest/On" freezes the input in case of lost communications. If the latest state is not known (such as after relay power-up but before the first communication exchange) the input will default to logic 1. When communication resumes, the input becomes fully operational.
- A value of "Latest/Off" freezes the input in case of lost communications. If the latest state is not known (such as after relay power-up but before the first communication exchange) the input will default to logic 0. When communication resumes, the input becomes fully operational.

Direct Input 1 Events

Range: Enabled, Disabled

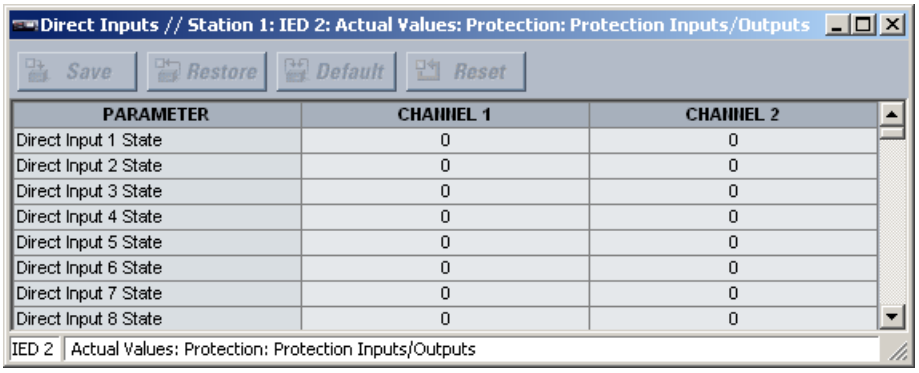
Default: Disabled

This setting enables and disables the logging of direct input events in the sequence of events recorder.

Direct input states

Select the **Actual Values > Protection > Protection Inputs/Outputs > Direct Inputs** menu item to open the direct input states window.

Figure 128: Direct inputs states



The following actual values are available for all direct inputs, where input 1 is used as the example.

Direct Input 1 State

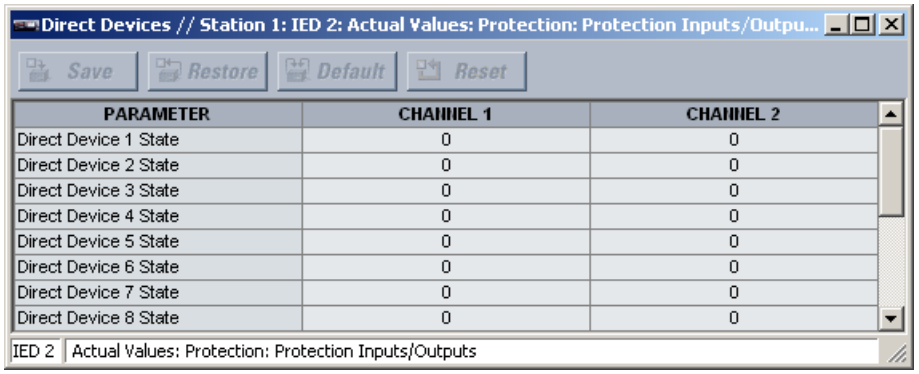
Range: 0, 1

This value displays the current state of the direct input. A value of "0" indicates off and a value of "1" indicates on.

Direct device states

Select the **Actual Values > Protection > Protection Inputs/Outputs > Direct Devices** menu item to open the direct device states window.

Figure 129: Direct device states



The following actual values are available for all direct devices. The actual values outlined are for direct device 1.

Direct Device 1 State

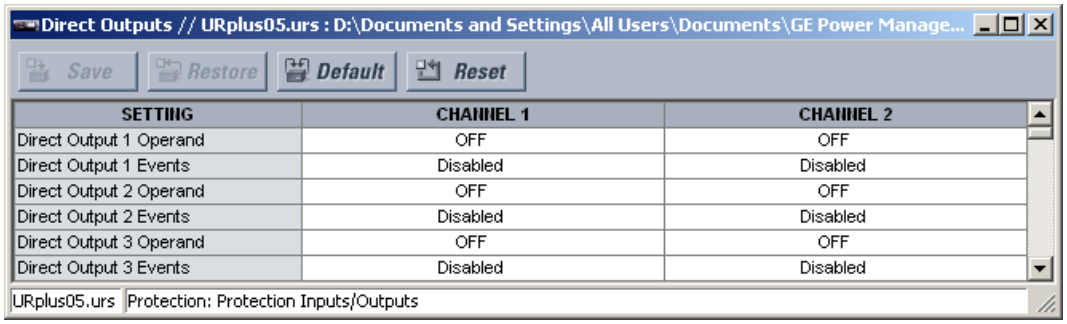
Range: Offline, Online

This value displays the current state of the direct device.

Direct outputs

These settings specify how the direct output information is processed. Select the **Settings > Protection Inputs/Outputs > Direct Outputs** menu item to open the direct outputs configuration window.

Figure 130: Direct output configuration settings



The following settings are available for all direct outputs. The default values outlined are for direct output 1.

Direct Input 1 Operand

Range: any FlexLogic operand
Default: Off

This setting specifies the FlexLogic operand that determines the state of the direct output.

Direct Input 1 Events

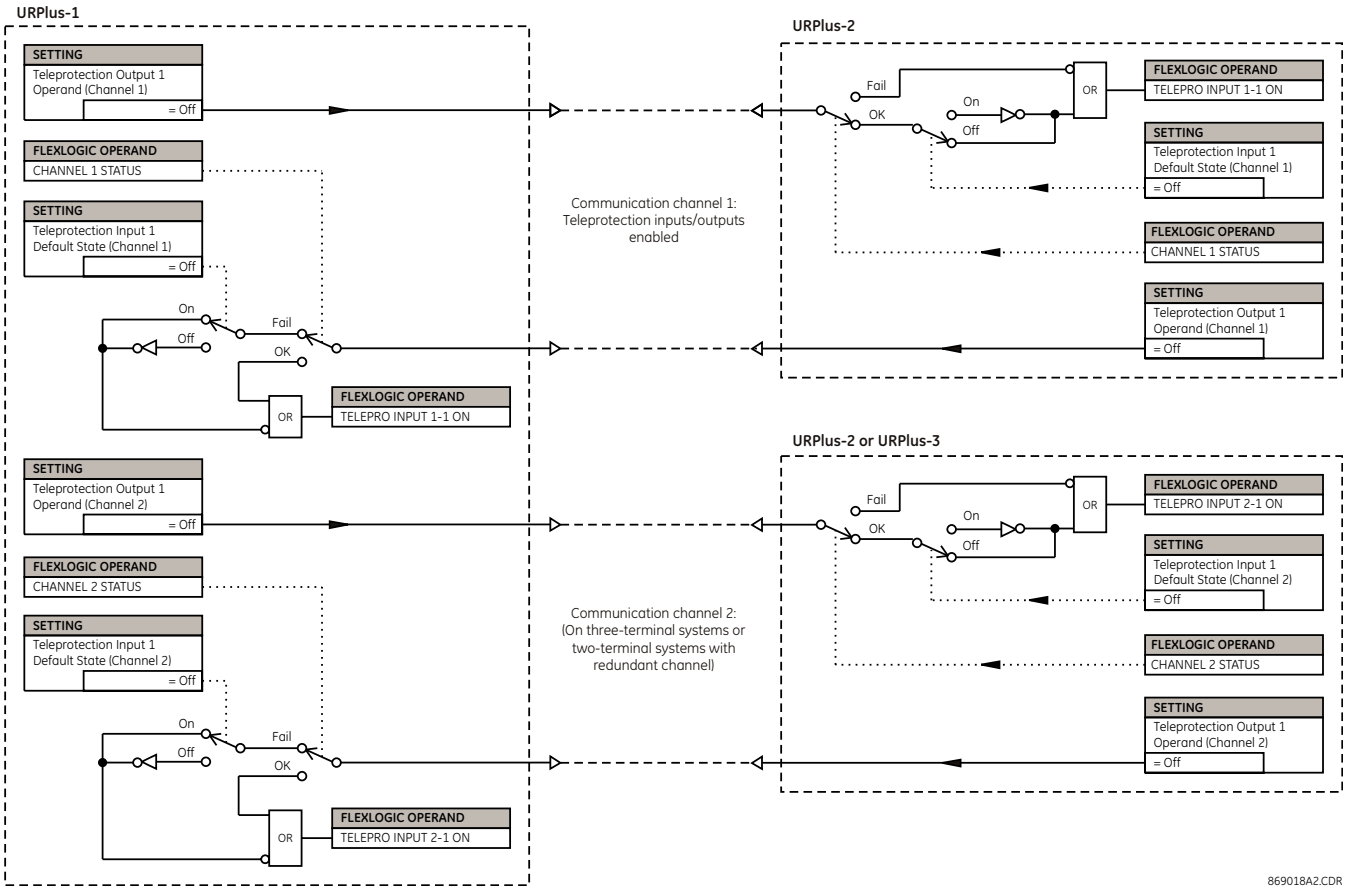
Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the logging of direct output events in the sequence of events recorder.

Teleprotection inputs and outputs

The C90^{Plus} provides 16 teleprotection inputs on communications channel 1 (numbered 1-1 through 1-16) and 16 teleprotection inputs on communications channel 2 (on two-terminals two-channel and three-terminal systems only, numbered 2-1 through 2-16). The remote relay connected to channels 1 and 2 of the local relay is programmed by assigning FlexLogic operands to be sent via the selected communications channel. This allows the user to create distributed protection and control schemes via dedicated communications channels. Some examples are directional comparison pilot schemes and direct transfer tripping. Note that failures of communications channels affect teleprotection functionality. The teleprotection function must be enabled to utilize the inputs.

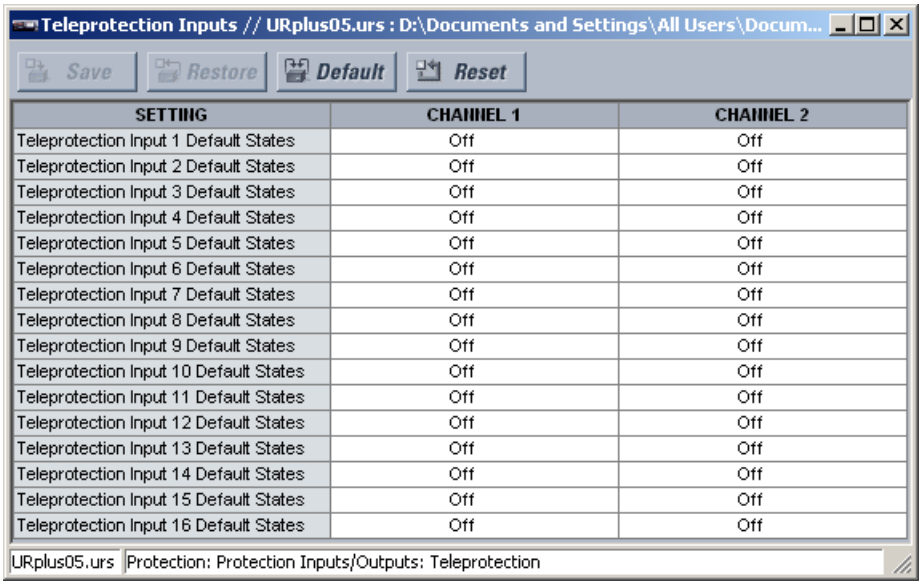
Figure 131: Teleprotection inputs and outputs processing



Teleprotection input settings

Select the **Settings > Protection > Protection Inputs/Outputs > Teleprotection > Teleprotection Inputs** menu item to open the teleprotection inputs configuration window.

Figure 132: Teleprotection inputs configuration settings



SETTING	CHANNEL 1	CHANNEL 2
Teleprotection Input 1 Default States	Off	Off
Teleprotection Input 2 Default States	Off	Off
Teleprotection Input 3 Default States	Off	Off
Teleprotection Input 4 Default States	Off	Off
Teleprotection Input 5 Default States	Off	Off
Teleprotection Input 6 Default States	Off	Off
Teleprotection Input 7 Default States	Off	Off
Teleprotection Input 8 Default States	Off	Off
Teleprotection Input 9 Default States	Off	Off
Teleprotection Input 10 Default States	Off	Off
Teleprotection Input 11 Default States	Off	Off
Teleprotection Input 12 Default States	Off	Off
Teleprotection Input 13 Default States	Off	Off
Teleprotection Input 14 Default States	Off	Off
Teleprotection Input 15 Default States	Off	Off
Teleprotection Input 16 Default States	Off	Off

The following setting is available for all 16 teleprotection inputs on channels 1 and 2.

Teleprotection Input 1 Default States

Range: Off, On, Latest/Off, Latest/On

Default: Off

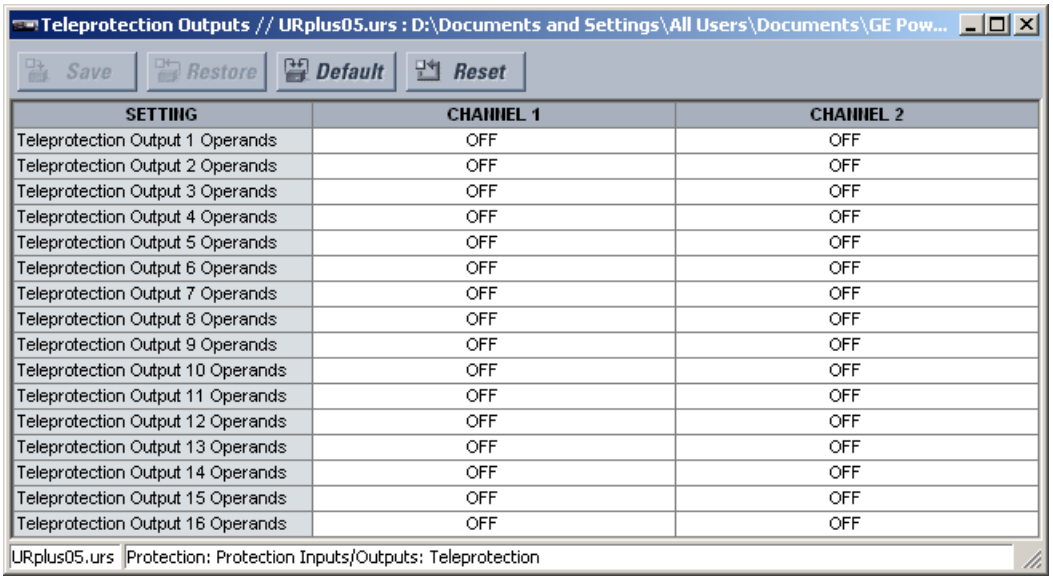
Programming this setting to "On" defaults the input to logic 1 when the channel fails. A value of "Off" defaults the input to logic 0 when the channel fails.

The "Latest/On" and "Latest/Off" values freeze the input in case of lost communications. If the latest state is not known, such as after relay power-up but before the first communication exchange, then the input defaults to logic 1 for "Latest/On" and logic 0 for "Latest/Off".

Teleprotection output settings

Select the **Settings > Protection > Protection Inputs/Outputs > Teleprotection > Teleprotection Outputs** menu item to open the teleprotection outputs configuration window.

Figure 133: Teleprotection outputs configuration settings



SETTING	CHANNEL 1	CHANNEL 2
Teleprotection Output 1 Operands	OFF	OFF
Teleprotection Output 2 Operands	OFF	OFF
Teleprotection Output 3 Operands	OFF	OFF
Teleprotection Output 4 Operands	OFF	OFF
Teleprotection Output 5 Operands	OFF	OFF
Teleprotection Output 6 Operands	OFF	OFF
Teleprotection Output 7 Operands	OFF	OFF
Teleprotection Output 8 Operands	OFF	OFF
Teleprotection Output 9 Operands	OFF	OFF
Teleprotection Output 10 Operands	OFF	OFF
Teleprotection Output 11 Operands	OFF	OFF
Teleprotection Output 12 Operands	OFF	OFF
Teleprotection Output 13 Operands	OFF	OFF
Teleprotection Output 14 Operands	OFF	OFF
Teleprotection Output 15 Operands	OFF	OFF
Teleprotection Output 16 Operands	OFF	OFF

The following setting is available for all 16 teleprotection inputs on channels 1 and 2.

Teleprotection Output 1 Operands

Range: any FlexLogic operand

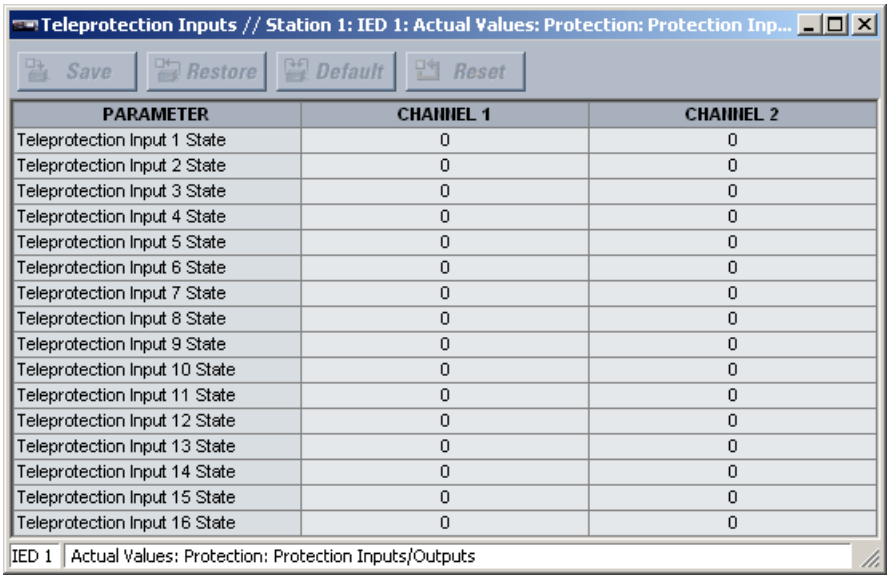
Default: Off

Processing of the teleprotection inputs and outputs is dependent on the number of communication channels and terminals. On two-terminal two-channel systems, they are processed continuously on each channel and mapped separately per channel. Therefore, to achieve redundancy, the user must assign the same operand on both channels (teleprotection outputs at the sending end or corresponding teleprotection inputs at the receiving end). On three-terminal two-channel systems, redundancy is achieved by programming signal re-transmittal in the case of channel failure between any pair of UR^{Plus}-series devices.

Teleprotection input states

Select the **Actual Values > Protection > Protection Inputs/Outputs > Teleprotection Inputs** menu item to open the teleprotection inputs states window.

Figure 134: Teleprotection input states



PARAMETER	CHANNEL 1	CHANNEL 2
Teleprotection Input 1 State	0	0
Teleprotection Input 2 State	0	0
Teleprotection Input 3 State	0	0
Teleprotection Input 4 State	0	0
Teleprotection Input 5 State	0	0
Teleprotection Input 6 State	0	0
Teleprotection Input 7 State	0	0
Teleprotection Input 8 State	0	0
Teleprotection Input 9 State	0	0
Teleprotection Input 10 State	0	0
Teleprotection Input 11 State	0	0
Teleprotection Input 12 State	0	0
Teleprotection Input 13 State	0	0
Teleprotection Input 14 State	0	0
Teleprotection Input 15 State	0	0
Teleprotection Input 16 State	0	0

The following actual value is available for all 16 teleprotection inputs on channels 1 and 2.

Teleprotection Input 1 State

Range: Off, On, Latest/On, Latest/Off

This actual value displays the state of the teleprotection input on channels 1 and 2.

The "Latest/On" and "Latest/Off" values freeze the input in case of lost communications. If the latest state is not known, such as after relay power-up but before the first communication exchange, then the input defaults to logic 1 for "Latest/On" and logic 0 for "Latest/Off".

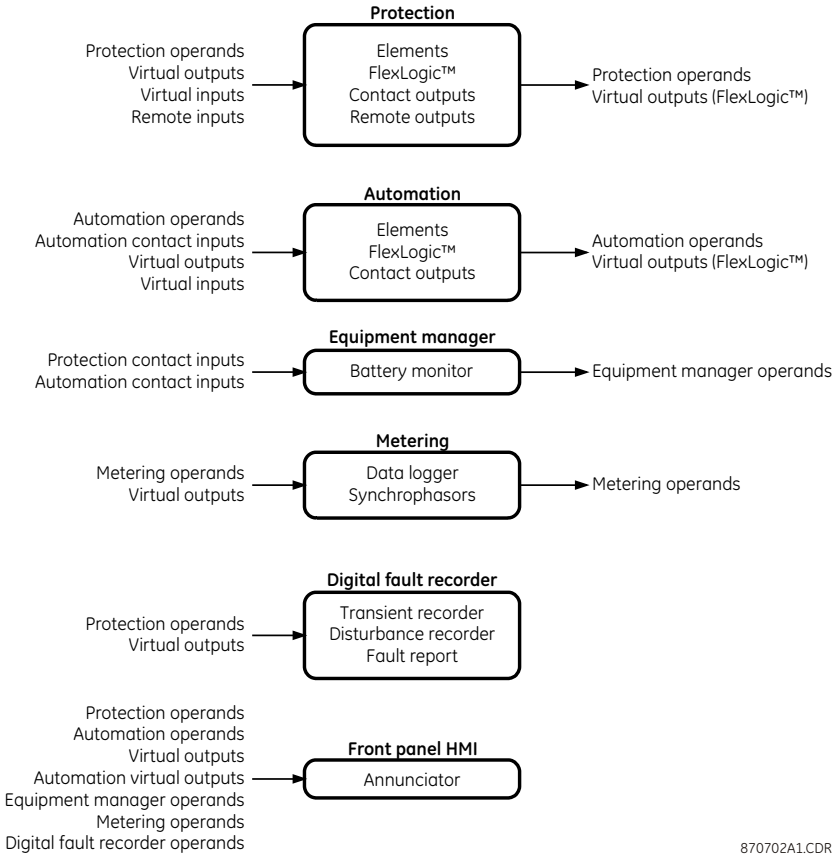
Using shared operands in protection

The EnerVista UR^{Plus} Setup software groups the C90^{Plus} system into the following seven primary functions. Each function has its own setting parameters and each generates its own outputs in the form of operands.

- Communications
- Protection
- Automation.
- Digital fault recorder (DFR)
- Metering
- Equipment manager
- Self-tests
- Front panel interface (HMI)

However, it is often desirable for an output from an element within one function can be available to an element within another function. For instance, it may be useful for the digital fault recorder to record the output operands of any protection element. Consequently a fixed, predetermined set of operands is available as to each function, as shown.

Figure 135: Default operand list by function



The content of each operand list is dependent on the selected order code.

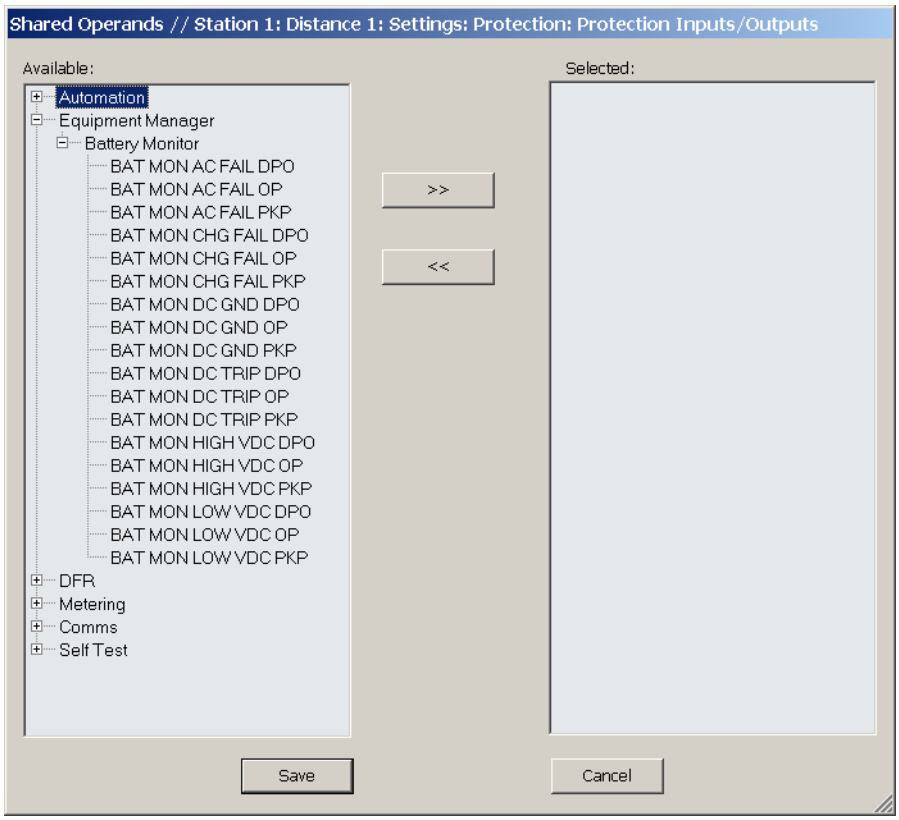
The shared operands functionality expands upon this system. With this feature, an output from any element can be assigned as a shared operand within the EnerVista UR^{Plus} Setup software. These signals can then be assigned as inputs to other functions.

For example, assume that the GND TOC1 OP protection operand is required as a signal within the automation function. This operand would then be assigned as a shared operand, and would subsequently become available to the automation function. A total of 64 operands can be assigned as shared operands within each function.

Shared protection operands

Select the **Settings > Protection > Protection Inputs/Outputs > Shared Operands** menu item to select the shared protection FlexLogic operands.

Figure 136: Shared operands configuration window

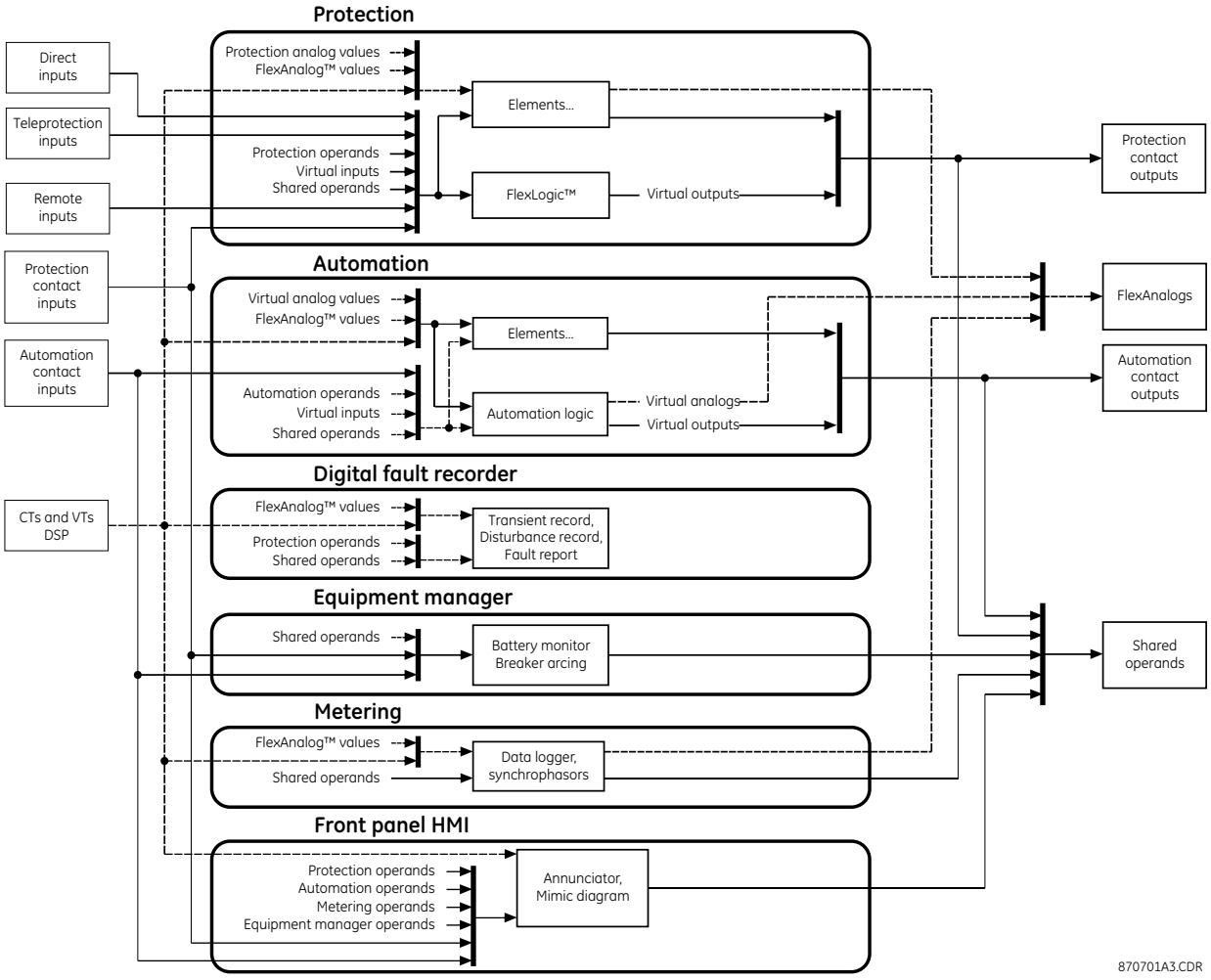


The left side of this screen displays all C90^{Plus} operands that are available to the protection function as shared operands. Select any operands from the other five primary features by clicking on the **>>** button. Operands can be de-assigned as shared operands by pressing the **<<** button.

Protection FlexLogic

The arrangement of internal digital logic in the C90^{Plus} combines fixed and user-programmable parameters. The logic upon which individual features are designed is fixed, and all other logic, from digital input signals through elements or combinations of elements to digital outputs, is variable. The user has complete control of all variable logic through FlexLogic. In general, the system receives analog and digital inputs which it uses to produce analog and digital outputs. The major sub-systems of a generic UR^{Plus}-series device involved in this process are shown here.

Figure 137: UR^{Plus}-series architecture overview



The states of all digital signals used in the C90^{Plus} are represented by flags (or FlexLogic operands, which are described later in this section). A logic 1 state is represented by a *set* flag. Any external contact change-of-state can be used to block an element from operating, as an input to a control feature in a FlexLogic equation, or to operate a contact output. The state of the contact input can be displayed locally or viewed remotely via the communications facilities provided. If a simple scheme where a contact input is used to block an element is desired, this selection is made when programming the element. This capability also applies to the other features that set flags: elements, virtual inputs, remote inputs, schemes, and human operators.

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

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

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

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

A FlexLogic equation consists of parameters that are either operands or operators. Operands have a logic state of 1 or 0. Operators provide a defined function, such as an AND gate or a timer. Each equation defines the combinations of parameters to be used to set a virtual output flag. Evaluation of an equation results in either a logic 1 state (=ON, flag set) or logic 0 state (=OFF, 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 characteristics of the different types of operands are tabulated as follows.

Table 17: Protection FlexLogic operand types

Type	State	Example	Characteristics (input is logic 1 or "on" if...)
Contact input	On	CONT IP1 ON	Voltage is presently applied to the input (external contact closed)
	Off	CONT IP1 OFF	Voltage is presently not applied to the input (external contact open)
Contact output	Voltage on	CONT OP1 VON	Voltage exists across the contact
	Voltage off	CONT OP1 VOFF	Voltage does not exist across the contact
	Current on	CONT OP1 ION	Current is flowing through the contact
	Current off	CONT OP1 IOFF	Current is not flowing through the contact
Digital counter	Greater than	COUNTER 1 HI	The number of pulses counted is above the set number
	Equal to	COUNTER 1 EQL	The number of pulses counted is equal to the set number
	Less than	COUNTER 1 LO	The number of pulses counted is below the set number
Direct input	On	DIRECT INPUT 1 ON	The direct input is presently in the ON state
Element (analog)	Pickup	PHASE TOC1 PKP	The tested parameter is presently above the pickup setting of an element which responds to rising values or below the pickup setting of an element which responds to falling values
	Dropout	PHASE TOC1 DPO	This operand is the logical inverse of the pickup 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 ELEM 1 PKP	The output operand is at logic 1
	Dropout	DIG ELEM 1 DPO	This operand is the logical inverse of the pickup operand
	Operate	DIG ELEM 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
Remote input	On	REMOTE IN 1 ON	The remote input is presently in the on state
Virtual input	On	VIRT IP 1 ON	The virtual input is presently in the on state
Virtual output	On	VIRT OP 1 ON	The virtual input is presently in the on state

Protection FlexLogic gates and operators

The table summarizes characteristics of logic gates used in protection FlexLogic equations.

Table 18: Protection FlexLogic gate characteristics

Gate	Inputs	Output is logic 1 if...
NOT	1	the input is logic 0
OR	2 to 16	any input is logic 1
AND	2 to 16	all inputs are logic 1
NOR	2 to 16	all inputs are logic 0
NAND	2 to 16	any input is logic 0
XOR	2	only one input is logic 1

The following operators are available for use in protection FlexLogic equations.

Table 19: Protection FlexLogic operators

Type	Syntax	Description	Operation
Editor	INSERT	Insert a parameter in the equation list	---
	DELETE	Delete a parameter from an equation list	---
End	END	The first END operator signifies the last entry in the FlexLogic equation	---
One shots	POSITIVE ONE SHOT	One shot that corresponds 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 are a maximum of 64 one shots.
	NEGATIVE ONE SHOT	One shot that corresponds to a negative-going edge	
	DUAL ONE SHOT	One shot that responds to both the positive and negative-going edges	
Logic gates	NOT	A logical NOT gate	Operates on the previous parameter
	AND(*n*)	An *n*-input AND gate, *n* = 1 to 16	Operates on the previous *n* parameters
	OR(n)	An *n*-input OR gate, *n* = 1 to 16	Operates on the previous *n* parameters
	NOR(*n*)	An *n*-input NOR gate, *n* = 1 to 16	Operates on the previous *n* parameters
	NAND(*n*)	An *n*-input NAND gate, *n* = 1 to 16	Operates on the previous *n* parameters
	XOR(2)	A two-input exclusive OR gate	Operates on the previous 2 parameters
	LATCH(S,R)	Latch (set, reset), reset-dominant	Operates on the previous 2 parameters. The parameter preceding LATCH(S,R) is the reset input. The parameter preceding the reset input is the set input.
Timers	TIMER *n*	Timer set with the settings programmed for FlexLogic timer *n*, where *n* = 1 to 32	The timer is started by the preceding parameter. The output of the timer is TIMER #.
Assign outputs	VIRT OP *n*	Assigns the previous FlexLogic parameter to virtual output *n*, where *n* = 1 to 96	The virtual output is set by the preceding parameter

FlexLogic rules

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

1. Logic operands must precede the logic operator that uses the operands as inputs.
2. Logic 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.

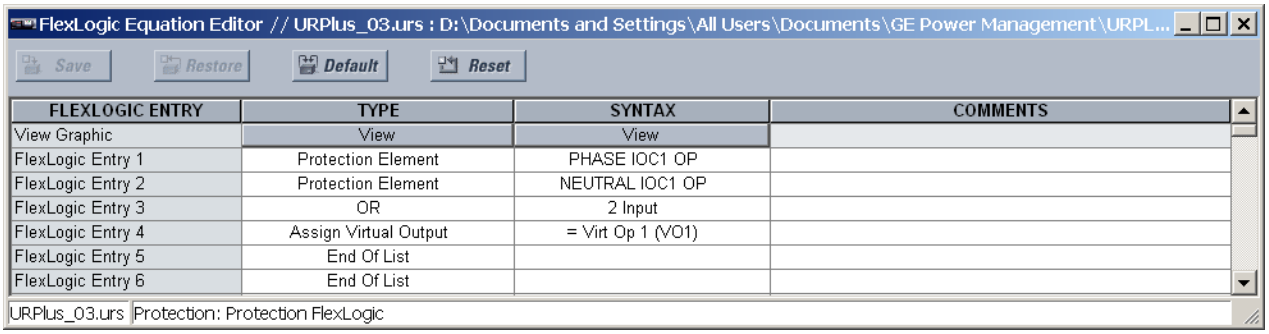
3. Assigning the output of a logic operator to a virtual output terminates the equation.
4. A timer operator (for example TIMER 1) or virtual output assignment (for example, = Virt Op 1) can only be used once. If this rule is broken, a syntax error is declared.

Protection FlexLogic equation editor

A protection FlexLogic equation can contain up to 512 entries, including the END operator. If a disabled element is selected as a FlexLogic entry, the associated state flag is never asserted (set to logic 1).

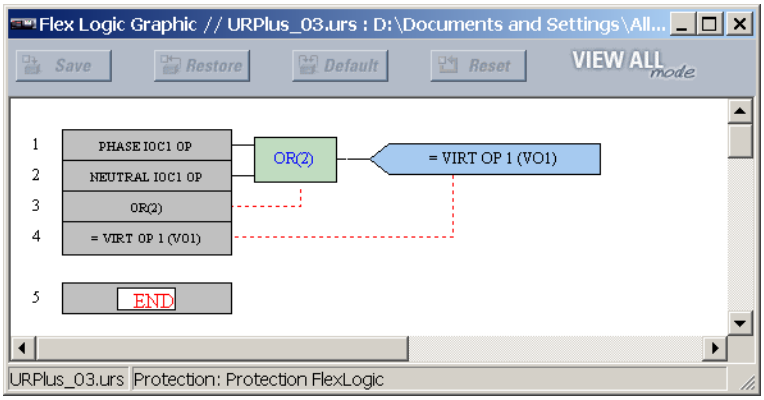
Select the **Settings > Protection > Protection FlexLogic > FlexLogic Equation Editor** menu item to open the protection FlexLogic equation editor window.

Figure 138: Protection FlexLogic configuration settings



A graphical representation of the protection FlexLogic can be displayed by clicking on the **View** button at the top of the equation.

Figure 139: Typical protection FlexLogic display

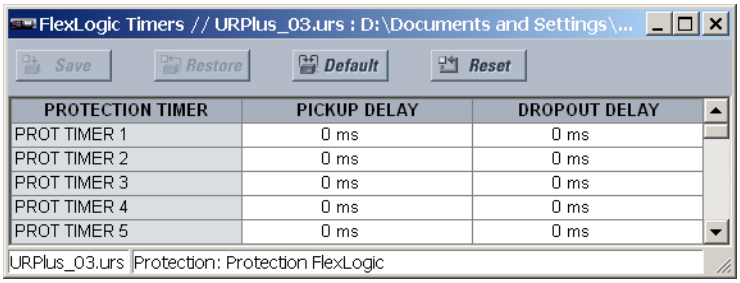


Protection FlexLogic timers

There are 32 identical protection FlexLogic timers available. These timers can be used as operators in FlexLogic equations.

Select the **Settings > Protection > Protection FlexLogic > FlexLogic Timers** menu item to open the protection FlexLogic timers configuration window.

Figure 140: Protection FlexLogic timers configuration settings



The following settings are available for each protection FlexLogic timer.

Pickup Delay

Range: 0 to 3600000000 ms in steps of 1
Default: 0

This setting specifies the time delay to pickup. If a pickup delay is not required, set this value to "0".

Dropout Delay

Range: 0 to 3600000000 ms in steps of 1
Default: 0

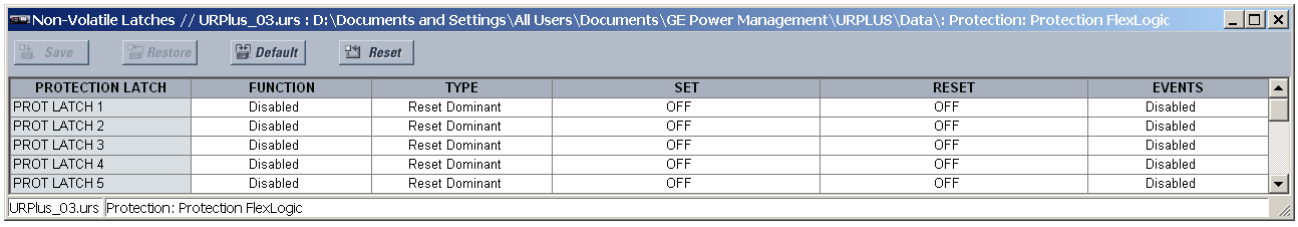
This setting specifies the time delay to dropout. If a dropout delay is not required, set this value to "0".

Non-volatile latches

The non-volatile latches provide a permanent logical flag that is stored safely and will not reset upon reboot after the relay is powered down. Typical applications include sustaining operator commands or permanently block relay functions, such as autoreclose, until a deliberate interface action resets the latch. There are 16 non-volatile latches available for use in protection schemes.

Select the **Settings > Protection > Protection FlexLogic > Non-Volatile Latches** menu item to open the non-volatile latches configuration window.

Figure 141: Non-volatile latches configuration settings



The following settings are available for the protection non-volatile latches.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the corresponding protection non-volatile latch.

Type

Range: Reset Dominant, Set Dominant
Default: Reset Dominant

This setting selects the non-volatile latch as set-dominant or reset-dominant.

Set

Range: any FlexLogic operand or shared operand
Default: OFF

If the operand assigned to this setting is asserted, the non-volatile latch is set.

Reset

Range: any FlexLogic operand or shared operand
Default: OFF

If the operand assigned to this setting is asserted, the non-volatile latch is reset.

Events

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the logging of non-volatile latch events in the sequence of events recorder.

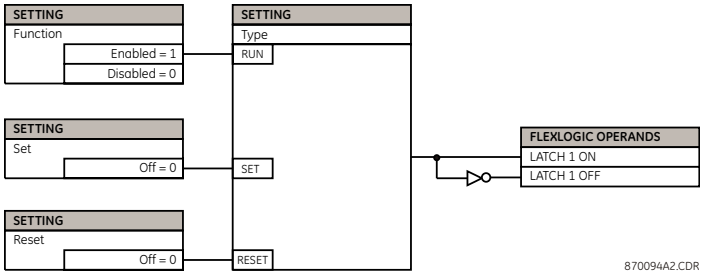
The following table summarizes the operation of the non-volatile latches.

Table 20: Non-volatile latch operation table

Type	Latch operation			
	Set	**Reset**	**On**	**Off**
Reset-dominant	ON	OFF	ON	OFF
	OFF	OFF	Previous state	Previous state
	ON	ON	OFF	ON
	OFF	ON	OFF	ON
Set-dominant	ON	OFF	ON	OFF
	ON	ON	ON	OFF
	OFF	OFF	Previous state	Previous state
	OFF	ON	OFF	ON

The figure shows the logic diagram for protection non-volatile latches.

Figure 142: Non-volatile latches scheme logic



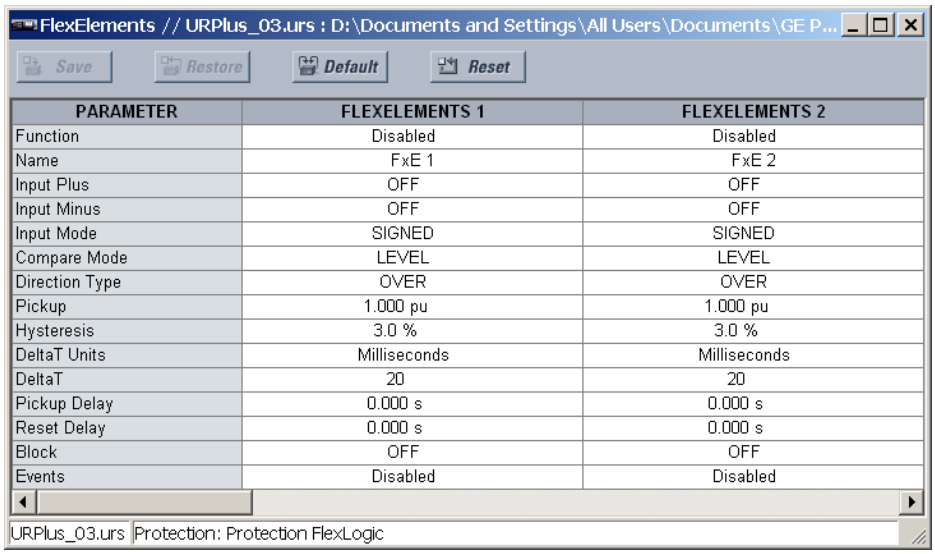
Protection FlexElements

A FlexElement is a universal comparator that can be used to monitor any analog actual value calculated by the relay or a net difference between any two analog actual values of the same type. The effective operating signal can be treated as a signed number or an absolute value. The output from a FlexElement can also be used for further logic processing. A total of eight FlexElements are dedicated for the protection system.

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

Select the **Settings > Protection > Protection FlexLogic > FlexElements** menu item to open the protection FlexElements configuration window.

Figure 143: Protection FlexElements configuration settings



PARAMETER	FLEXELEMENTS 1	FLEXELEMENTS 2
Function	Disabled	Disabled
Name	FxE 1	FxE 2
Input Plus	OFF	OFF
Input Minus	OFF	OFF
Input Mode	SIGNED	SIGNED
Compare Mode	LEVEL	LEVEL
Direction Type	OVER	OVER
Pickup	1.000 pu	1.000 pu
Hysteresis	3.0 %	3.0 %
DeltaT Units	Milliseconds	Milliseconds
DeltaT	20	20
Pickup Delay	0.000 s	0.000 s
Reset Delay	0.000 s	0.000 s
Block	OFF	OFF
Events	Disabled	Disabled

The following settings are available for each protection FlexElement.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the corresponding FlexElement.

Name

Range: up to 6 alphanumeric characters
Default: FxE 1

An alphanumeric identifier can be assigned to a FlexElement for diagnostic, setting, and event recording purposes. The default "FxE 1" text that appears in event records and logic operands are replaced by the text programmed in this setting.

Input Plus

Range: any analog actual value parameter or OFF
Default: OFF

This setting specifies the first (non-inverted) input to the FlexElement. A value of zero is assumed as the input if this setting is "OFF". For proper operation of the element, at least one input must be selected. Otherwise, the element does not assert its output operands.

Input Minus

Range: any analog actual value parameter or OFF
Default: OFF

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

Input Mode

Range: Signed, Absolute

Default: Signed

If this setting value is “Signed”, then the FlexElement responds directly to the differential signal. If this setting value is “Absolute”, then the FlexElement responds to the absolute value of the differential signal. Sample applications for the absolute input mode include monitoring the angular difference between two phasors with a symmetrical limit angle in both directions, monitoring power regardless of its direction, or monitoring a trend regardless of whether the signal increases of decreases.

Compare Mode

Range: Level, Delta

Default: Level

This setting specifies how the element responds to its operating signal. If this setting value is “Level”, the element responds directly to its operating signal (as defined by the **Input Plus**, Input Minus, and **Input Mode** settings). If this setting value if “Delta”, the element responds to the rate of change of its operating signal (as defined by the **Delta T** and **Delta T Units** settings).

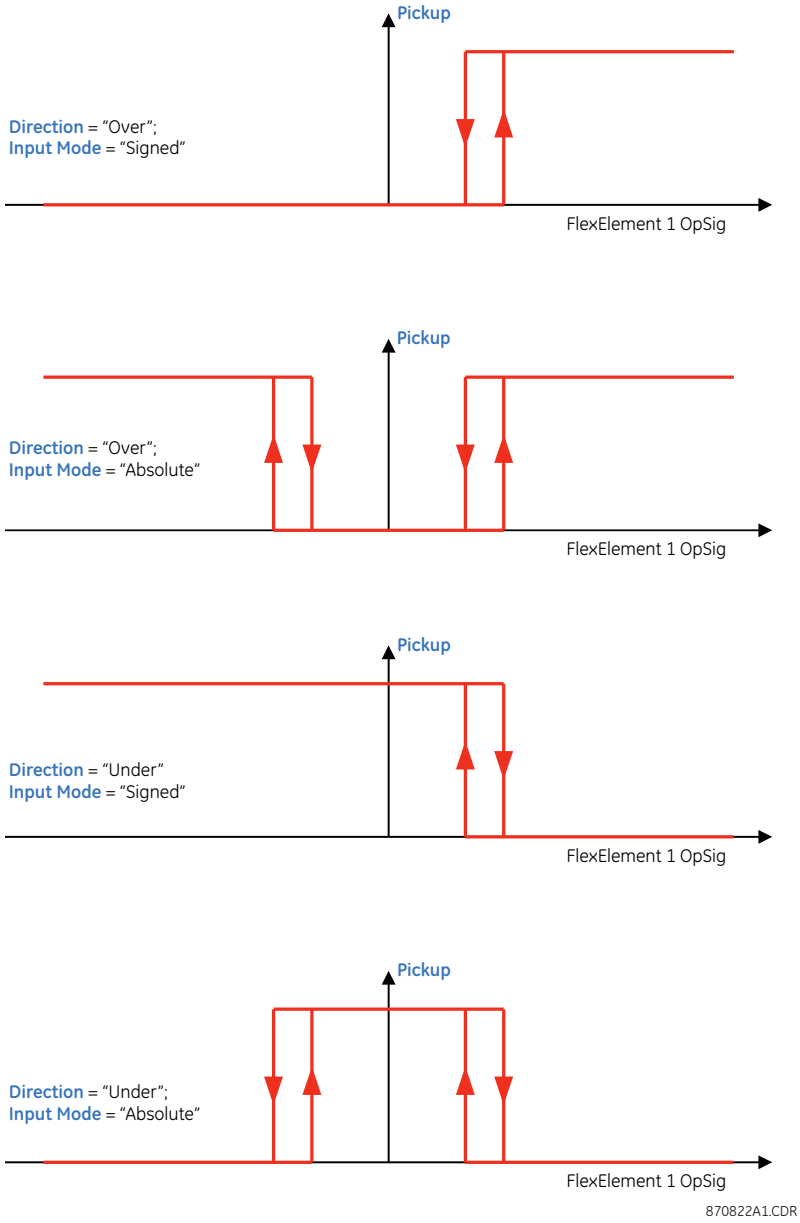
Direction Type

Range: Over, Under

Default: Over

This setting enables the relay to respond to either high or low values of the operating signal.

Figure 144: Relationship of input mode and direction settings



Pickup

Range: –90.000 to 90.000 pu in steps of 0.001
Default: 1.000 pu

This setting specifies the operating threshold for the effective operating signal of the FlexElement. If the **Direction Type** setting is "Over", the element picks up when the operating signal exceeds the value specified here. If the **Direction Type** setting is "Under", the element picks up when the operating signal falls below the value specified here.

This setting is entered in per-unit values using the following definitions of the base units.

Table 21: Protection FlexElement pickup per-unit base units

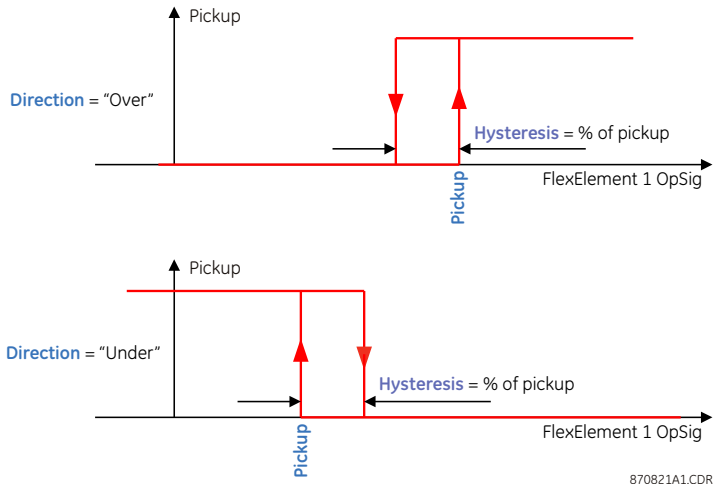
Element	Base unit
Frequency	1 Hz
Power factor	1.00
Source current	Maximum nominal primary RMS value of the +IN and –IN inputs
Source power	Maximum value of the product of the voltage and current base values for the +IN and –IN inputs.
Source voltage	Maximum nominal primary RMS value of the +IN and –IN inputs.

Hysteresis

Range: 0.1 to 50.0% in steps of 0.1
Default: 3.0%

This setting controls the element pickup and dropout relation by specifying the width of the hysteresis loop as a percentage of the pickup value. Both the operating signal and the pickup threshold can be negative, facilitating applications such as reverse power alarm protection. The FlexElement can be programmed to work with all analog actual values measured by the relay.

Figure 145: Direction, pickup, and hysteresis relation



Delta T Units

Range: milliseconds, seconds, minutes
Default: milliseconds

This setting specifies the time unit for the **Delta T** setting. It is applicable only in the delta comparison mode.

Delta T

Range: 20 to 86400 in steps of 1
Default: 20

This setting specifies duration of the time interval for the rate of change mode of operation. It is applicable only in the delta comparison mode.

Pickup Delay

Range: 0.000 to 65.535 seconds in steps of 0.001
Default: 0.000 seconds

This setting specifies the pickup delay of the FlexElement

Reset Delay

Range: 0.000 to 65.535 seconds in steps of 0.001
Default: 0.000 seconds

This setting specifies the reset delay of the FlexElement.

Block

Range: any FlexLogic operand or shared operand
Default: Off

Assertion of the operand assigned to this setting blocks operation of the FlexElement.

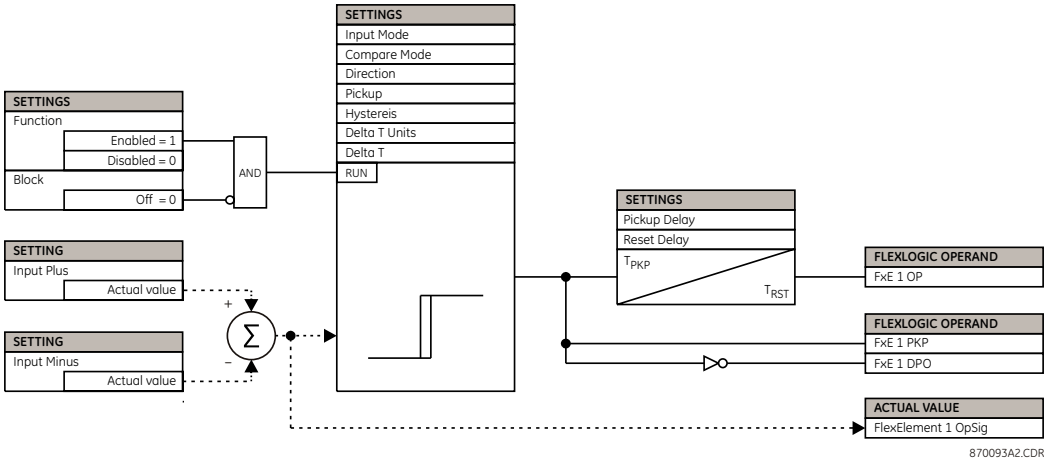
Events

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the logging of FlexElement events in the sequence of events recorder.

The figure shows the logic diagram for FlexElements.

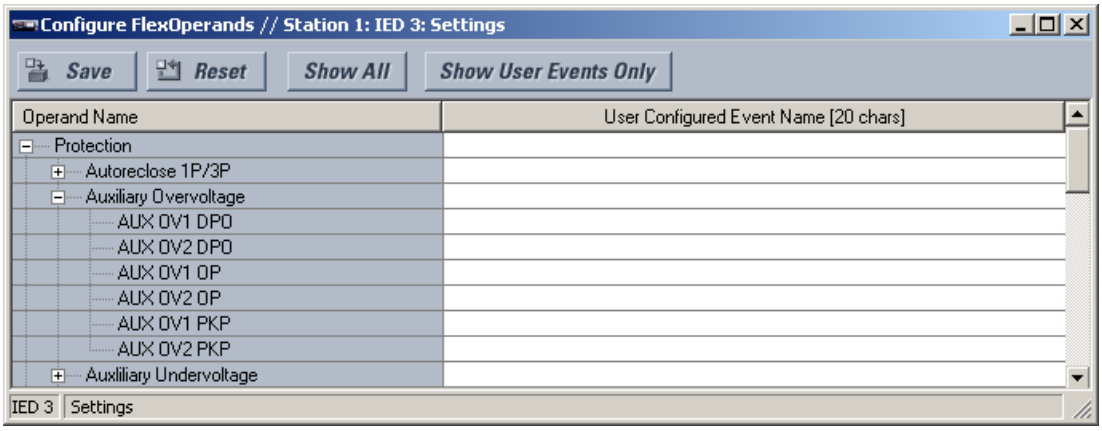
Figure 146: Protection FlexElements scheme logic



Customizing the protection FlexLogic operands

Select the **Settings > Configure FlexOperands** menu item to open the user-configurable operands window.

Figure 147: User-configurable protection FlexLogic operands window



The left side of this screen displays all operands that are currently available to the C90^{Plus}. The protection FlexLogic operands are displayed by selecting the **Protection** tree item. Each operand can be renamed with a user-specified value to provide additional information or match specific applications.

User Configured Event Name

Range: up to 20 alphanumeric characters

Default: ---

Each available protection FlexLogic operand can be renamed to a user-specified value. This feature allows users to rename operands to allow for clearer identification or to match specific applications. The new operand name appears in protection and automation logic, in settings that take operands as their value, and in event reports.

Protection FlexLogic operands

The following protection FlexLogic operands are available for the C90^{Plus}. They are listed alphabetically by operand syntax. Some operands can be renamed within their settings window, including the names of breakers, contact inputs, virtual inputs, and virtual outputs. All operands can also be assigned user-defined names through the **Settings > Configure FlexOperands** menu item.

Autoreclose operands

AR 1-P RIP	Asserted when a single-pole autoreclose is in progress.
AR 3-P/1 RIP	Asserted when a three-pole autoreclose is in progress via dead time 1.
AR 3-P/2 RIP	Asserted when a three-pole autoreclose is in progress via dead time 2.
AR 3-P/3 RIP	Asserted when a three-pole autoreclose is in progress via dead time 3.
AR 3-P/4 RIP	Asserted when a three-pole autoreclose is in progress via dead time 4.
AR BKR1 BLK	Asserted when reclosure of breaker 1 is blocked.
AR BKR2 BLK	Asserted when reclosure of breaker 2 is blocked.
AR CLOSE BKR1	Asserted when a close breaker 1 signal is issued.
AR CLOSE BKR2	Asserted when a close breaker 2 signal is issued.
AR DISABLED	Asserted when the autoreclose element is disabled.
AR ENABLED	Asserted when the autoreclose element is enabled.
AR FORCE 3-P TRIP	Asserted when a trip is forced to a three-phase trip.
AR INCOMPLETE SEQ	Asserted when a the incomplete sequence timer times out.
AR LO	Asserted when the autoreclose element is in the lockout state.
AR RESET	Asserted when the autoreclose element has been reset manually or by the reset timer.
AR RIP	Asserted when the autoreclose element is in the reclose-in-progress state.
AR SHOT CNT > 0	Asserted when the first close breaker signal has been issued.
AR SHOT CNT = 1	Asserted when the shot count is equal to 1.
AR SHOT CNT = 2	Asserted when the shot count is equal to 2.
AR SHOT CNT = 3	Asserted when the shot count is equal to 3.
AR SHOT CNT = 4	Asserted when the shot count is equal to 4.
AR ZONE 1 EXTENT	Asserted when the zone 1 distance function is be set to the extended over-reach value.

Auxiliary overvoltage operands

AUX OV1 DPO ..... Asserted when the auxiliary overvoltage element drops out.

AUX OV1 OP ..... Asserted when the auxiliary overvoltage element operates.

AUX OV1 PKP ..... Asserted when the auxiliary overvoltage element picks up.

Auxiliary undervoltage operands

AUX UV1 DPO ..... Asserted when the auxiliary undervoltage element drops out.

AUX UV1 OP ..... Asserted when the auxiliary undervoltage element operates.

AUX UV1 PKP ..... Asserted when the auxiliary undervoltage element picks up.

Breaker configuration operands

BKR1 ANY POLE OPEN ..... Asserted when at least one pole of breaker 1 is open.

BKR1 BAD STATE ..... Asserted when the normally open and normally closed breaker indications disagree.

BKR1 CLOSE CMD ..... Asserted when close command is executed on breaker 1.

BKR1 CLOSED ..... Asserted when breaker 1 is closed.

BKR1 DISCREPANCY ..... Asserted when the three poles of the breaker disagree (that is, when they are not all opened or all closed).

BKR1 INTERMED ..... Asserted when the breaker is in transition between the opened and closed states.

BKR1 ONE POLE OPEN ..... Asserted when only one pole of breaker 1 is open.

BKR1 OPEN CMD ..... Asserted when an open command has been executed on breaker 1.

BKR1 OPENED ..... Asserted when breaker 1 is opened.

BKR1 SUBST CLOSED ..... Asserted when the status of breaker 1 has been substituted with a closed indication.

BKR1 SUBST ON ..... Asserted when breaker status substitution is enabled.

BKR1 SUBST OPENED ..... Asserted when the status of the breaker has been substituted with an opened indication.

BKR1 TRIP CMD A ..... Asserted when a close command is executed on pole A of breaker 1.

BKR1 TRIP CMD B ..... Asserted when a close command is executed on pole B of breaker 1.

BKR1 TRIP CMD C ..... Asserted when a close command is executed on pole C of breaker 1.

BKR1A BAD STATE ..... Asserted when the normally open and normally closed breaker indications disagree for pole A of breaker 1.

BKR1A CLOSED ..... Asserted when breaker 1 pole A is closed.

BKR1A INTERMED ..... Asserted when breaker 1 pole A is in transition between the opened and closed states.

BKR1A OPENED ..... Asserted when breaker 1 pole A is opened.

BKR1B BAD STATE ..... Asserted when the normally open and normally closed breaker indications disagree for pole B of breaker 1.

BKR1B CLOSED ..... Asserted when breaker 1 pole B is closed.

BKR1B INTERMED ..... Asserted when breaker 1 pole B is in transition between the opened and closed states.

BKR1B OPENED ..... Asserted when breaker 1 pole B is opened.

BKR1C BAD STATE ..... Asserted when the normally open and normally closed breaker indications disagree for pole C of breaker 1.

BKR1C CLOSED ..... Asserted when breaker 1 pole C is closed.

BKR1C INTERMED ..... Asserted when breaker 1 pole C is in transition between the opened and closed states.

BKR1C OPENED ..... Asserted when breaker 1 pole C is opened.

BKR2 ..... The operands listed above are also available for breaker 2.

Breaker failure operands

BKR FAIL 1 RETRIP ..... Asserted upon a breaker failure 1 three-pole trip.

BKR FAIL 1 RETRIPA ..... Asserted when breaker failure 1 re-trips on phase A (single-pole schemes only).

BKR FAIL 1 RETRIPB ..... Asserted when breaker failure 1 re-trips on phase B (single-pole schemes only).

BKR FAIL 1 RETRIPC ..... Asserted when breaker failure 1 re-trips on phase C (single-pole schemes only).

BKR FAIL 1 T1 OP ..... Asserted when the breaker failure 1 timer 1 operates.

BKR FAIL 1 T2 OP ..... Asserted when the breaker failure 1 timer 2 operates.

BKR FAIL 1 T3 OP ..... Asserted when the breaker failure 1 timer 3 operates.

BKR FAIL 1 TRIP OP ..... Asserted when breaker failure 1 trip has operated.

BKR FAIL 2 ..... The same set of operands listed above are available for the breaker failure 2 element.

Breaker flashover operands

BKR 1 FLSHOVR DPO ..... Asserted when breaker 1 flashover drops out.

BKR 1 FLSHOVR DPO A ..... Asserted when breaker 1 flashover drops out for phase A.

BKR 1 FLSHOVR DPO B ..... Asserted when breaker 1 flashover drops out for phase B.

BKR 1 FLSHOVR DPO C ..... Asserted when breaker 1 flashover drops out for phase C.

BKR 1 FLSHOVR OP ..... Asserted when breaker 1 flashover operates.

BKR 1 FLSHOVR OP A ..... Asserted when breaker 1 flashover operates for phase A.

BKR 1 FLSHOVR OP B ..... Asserted when breaker 1 flashover operates for phase B.

BKR 1 FLSHOVR OP C ..... Asserted when breaker 1 flashover operates for phase C.

BKR 1 FLSHOVR PKP ..... Asserted when breaker 1 flashover picks up.

BKR 1 FLSHOVR PKP A ..... Asserted when breaker 1 flashover picks up for phase A.

BKR 1 FLSHOVR PKP B ..... Asserted when breaker 1 flashover picks up for phase B.

BKR 1 FLSHOVR PKP C ..... Asserted when breaker 1 flashover picks up for phase C.

BKR 2 FLSHOVR ..... The operands listed above are available for the breaker flashover 2 element.

Protection contact input operands

CONTACT IP 1 ON ..... Asserted when the field contact connected to contact input 1 is closed.

CONTACT IP 1 OFF ..... Asserted when the field contact connected to contact input 1 is opened.

CONTACT IP 1 TROUBLE OP ..... Asserted when there is an internal or external problem with contact input 1.

CONTACT IP 1 TROUBLE DPO ..... Asserted when there are no problems with contact input 1.

CONTACT IP 2 to *40* ..... The operands listed above are available for the contact inputs 2 through 40.

Digital counter operands

COUNTER 1 EQL ..... Asserted when the output of digital counter 1 is equal to the comparison value.

COUNTER 1 HI ..... Asserted when the output of digital counter 1 is greater than the comparison value.

COUNTER 1 LO ..... Asserted when the output of digital counter 1 is less than the comparison value.

COUNTER 2 to 8..... The operands listed above are also available for digital counters 2 through 8.

FlexMatrix operands

FLXMAT 1 DPO..... Asserted when FlexMatrix 1 drops out.

FLXMAT 1 OP..... Asserted when FlexMatrix 1 operates.

FLXMAT 1 PKP..... Asserted when FlexMatrix 1 picks up.

FLXMAT 2 to 8..... The operands listed above are also available for FlexMatrix elements 2 through 8.

FlexElement™ operands

FXE 1 DPO..... Asserted when protection FlexElement™ 1 drops out.

FXE 1 OP..... Asserted when protection FlexElement™ 1 operates.

FXE 1 PKP..... Asserted when protection FlexElement™ 1 picks up.

FXE 2 to 8..... The operands listed above are also available for protection FlexElements™ 2 through 8.

Ground instantaneous overcurrent operands

GROUND IOC1 DPO..... Asserted when ground instantaneous overcurrent 1 drops out.

GROUND IOC1 OP..... Asserted when ground instantaneous overcurrent 1 operates.

GROUND IOC1 PKP..... Asserted when ground instantaneous overcurrent 1 picks up.

GROUND IOC2 to 12..... The operands listed above are also available for ground instantaneous overcurrent elements 2 through 12.

Ground time overcurrent operands

GROUND TOC1 DPO..... Asserted when ground time overcurrent 1 drops out.

GROUND TOC1 OP..... Asserted when ground time overcurrent 1 operates.

GROUND TOC1 PKP..... Asserted when ground time overcurrent 1 picks up.

GROUND TOC2 to 6..... The operands listed above are also available for ground time overcurrent elements 2 through 6.

Non-volatile latch operands

LATCH 1 OFF..... Asserted when non-volatile latch 1 is off (logic 0).

LATCH 1 ON..... Asserted when non-volatile latch 1 is on (logic 1).

LATCH 2 to 16..... The operands listed above are also available for non-volatile latches 2 to 16.

Neutral directional overcurrent operands

NTRL DIR OC1 FWD..... Asserted when the neutral directional overcurrent 1 element forward mode operates.

NTRL DIR OC1 REV..... Asserted when the neutral directional overcurrent 1 element reverse mode operates.

NTRL DIR OC2 FWD..... Asserted when the neutral directional overcurrent 2 element forward mode operates.

NTRL DIR OC2 REV..... Asserted when the neutral directional overcurrent 2 element reverse mode operates.

Negative-sequence instantaneous overcurrent operands

NEG SEQ IOC1 DPO..... Asserted when the negative-sequence instantaneous overcurrent 1 element drops out.

NEG SEQ IOC1 OP..... Asserted when the negative-sequence instantaneous overcurrent 1 element operates.

NEG SEQ IOC1 PKP..... Asserted when the negative-sequence instantaneous overcurrent 1 element picks up.

NEG SEQ IOC2 ..... The operands listed above are also available for negative-sequence instantaneous overcurrent 2.

Negative-sequence overvoltage operands

NEG SEQ OV DPO ..... Asserted when the negative-sequence overvoltage element drops out.

NEG SEQ OV OP ..... Asserted when the negative-sequence overvoltage element operates.

NEG SEQ OV PKP ..... Asserted when the negative-sequence overvoltage element has picks up.

Negative-sequence time overcurrent operands

NEG SEQ TOC1 DPO ..... Asserted when the negative-sequence time overcurrent 1 element drops out.

NEG SEQ TOC1 OP ..... Asserted when the negative-sequence time overcurrent 1 element operates.

NEG SEQ TOC1 PKP ..... Asserted when the negative-sequence time overcurrent 1 element picks up.

NEG SEQ TOC2 ..... The operands listed above are also available for negative-sequence time overcurrent 2.

Neutral instantaneous overcurrent operands

NEUTRAL IOC1 DPO ..... Asserted when the neutral instantaneous overcurrent 1 element drops out.

NEUTRAL IOC1 OP ..... Asserted when the neutral instantaneous overcurrent 1 element operates.

NEUTRAL IOC1 PKP ..... Asserted when the neutral instantaneous overcurrent 1 element picks up.

NEUTRAL IOC2 to 12 ..... The operands listed above are also available for neutral instantaneous overcurrent 2 through 12.

Neutral overvoltage operands

NEUTRAL OV1 DPO ..... Asserted when the neutral overvoltage 1 element drops out.

NEUTRAL OV1 OP ..... Asserted when the neutral overvoltage 1 element operates.

NEUTRAL OV1 PKP ..... Asserted when the neutral overvoltage 1 element picks up.

NEUTRAL OV2 to 3 ..... The operands listed above are also available for neutral overvoltage 2 and 3.

Neutral time overcurrent operands

NEUTRAL TOC1 DPO ..... Asserted when the neutral time overcurrent 1 element drops out.

NEUTRAL TOC1 OP ..... Asserted when the neutral time overcurrent 1 element operates.

NEUTRAL TOC1 PKP ..... Asserted when the neutral time overcurrent 1 element picks up.

NEUTRAL TOC 2 to 6 ..... The operands listed above are also available for neutral time overcurrent 2 through 6.

Neutral directional overcurrent operands

NTRL DIR OC1 FWD ..... Asserted when the neutral directional overcurrent 1 element forward mode operates.

NTRL DIR OC1 REV ..... Asserted when the neutral directional overcurrent 1 element reverse mode operates.

NTRL DIR OC2 FWD ..... Asserted when the neutral directional overcurrent 2 element forward mode operates.

NTRL DIR OC2 REV — Asserted when the neutral directional overcurrent 2 element reverse mode operates.

Phase directional overcurrent operands

PH DIR1 BLK — Asserted when the phase directional overcurrent 1 element is blocked.

PH DIR1 BLK A — Asserted when the phase directional overcurrent 1 element is blocked in phase A.

PH DIR1 BLK B — Asserted when the phase directional overcurrent 1 element is blocked in phase B.

PH DIR1 BLK C — Asserted when the phase directional overcurrent 1 element is blocked in phase C.

PH DIR 2 — Same set of operands as shown above for the phase directional overcurrent 2 element.

Phase instantaneous overcurrent operands

PHASE IOC1 DPO — Asserted when at least one phase of the phase instantaneous overcurrent 1 element drops out.

PHASE IOC1 DPO A — Asserted when phase A of the phase instantaneous overcurrent 1 element drops out.

PHASE IOC1 DPO B — Asserted when phase B of the phase instantaneous overcurrent 1 element drops out.

PHASE IOC1 DPO C — Asserted when phase C of the phase instantaneous overcurrent 1 element drops out.

PHASE IOC1 OP — Asserted when at least one phase of the phase instantaneous overcurrent 1 element operates.

PHASE IOC1 OP A — Asserted when phase A of the phase instantaneous overcurrent 1 element operates.

PHASE IOC1 OP B — Asserted when phase B of the phase instantaneous overcurrent 1 element operates.

PHASE IOC1 OP C — Asserted when phase C of the phase instantaneous overcurrent 1 element operates.

PHASE IOC1 PKP — Asserted when at least one phase of the phase instantaneous overcurrent 1 element picks up.

PHASE IOC1 PKP A — Asserted when phase A of the phase instantaneous overcurrent 1 element picks up.

PHASE IOC1 PKP B — Asserted when phase B of the phase instantaneous overcurrent 1 element picks up.

PHASE IOC1 PKP C — Asserted when phase C of the phase instantaneous overcurrent 1 element picks up.

PHASE IOC2 to 12 — Same set of operands as shown above for the phase instantaneous overcurrent elements 2 through 12.

Phase overvoltage operands

PHASE OV1 DPO — Asserted when at least one phase of the phase overvoltage 1 element drops out.

PHASE OV1 DPO A — Asserted when phase A of the phase overvoltage 1 element drops out.

PHASE OV1 DPO B — Asserted when phase B of the phase overvoltage 1 element drops out.

PHASE OV1 DPO C — Asserted when phase C of the phase overvoltage 1 element drops out.

PHASE OV1 OP — Asserted when at least one phase of the phase overvoltage 1 element operates.

PHASE OV1 OP A ..... Asserted when phase A of the phase overvoltage 1 element operates.

PHASE OV1 OP B ..... Asserted when phase B of the phase overvoltage 1 element operates.

PHASE OV1 OP C ..... Asserted when phase C of the phase overvoltage 1 element operates.

PHASE OV1 PKP ..... Asserted when at least one phase of the phase overvoltage 1 element picks up.

PHASE OV1 PKP A ..... Asserted when phase A of the phase overvoltage 1 element picks up.

PHASE OV1 PKP B ..... Asserted when phase B of the phase overvoltage 1 element picks up.

PHASE OV1 PKP C ..... Asserted when phase C of the phase overvoltage 1 element picks up.

PHASE OV2 ..... Same set of operands as shown above for the phase overvoltage 2 element.

Phase time overcurrent operands

PHASE TOC1 DPO ..... Asserted when at least one phase of the phase time overcurrent 1 element drops out.

PHASE TOC1 DPO A ..... Asserted when phase A of the phase time overcurrent 1 element drops out.

PHASE TOC1 DPO B ..... Asserted when phase B of the phase time overcurrent 1 element drops out.

PHASE TOC1 DPO C ..... Asserted when phase C of the phase time overcurrent 1 element drops out.

PHASE TOC1 OP ..... Asserted when at least one phase of the phase time overcurrent 1 element operates.

PHASE TOC1 OP A ..... Asserted when phase A of the phase time overcurrent 1 element operates.

PHASE TOC1 OP B ..... Asserted when phase B of the phase time overcurrent 1 element operates.

PHASE TOC1 OP C ..... Asserted when phase C of the phase time overcurrent 1 element operates.

PHASE TOC1 PKP ..... Asserted when at least one phase of the phase time overcurrent 1 element picks up.

PHASE TOC1 PKP A ..... Asserted when phase A of the phase time overcurrent 1 element picks up.

PHASE TOC1 PKP B ..... Asserted when phase B of the phase time overcurrent 1 element picks up.

PHASE TOC1 PKP C ..... Asserted when phase C of the phase time overcurrent 1 element picks up.

PHASE TOC2 to 6 ..... Same set of operands as shown above for the phase time overcurrent elements 2 through 6.

Phase overvoltage operands

PHASE OV1 DPO ..... Asserted when at least one phase of the phase overvoltage 1 element drops out.

PHASE OV1 DPO A ..... Asserted when phase A of the phase overvoltage 1 element drops out.

PHASE OV1 DPO B ..... Asserted when phase B of the phase overvoltage 1 element drops out.

PHASE OV1 DPO C ..... Asserted when phase C of the phase overvoltage 1 element drops out.

PHASE OV1 OP ..... Asserted when at least one phase of the phase overvoltage 1 element operates.

PHASE OV1 OP A ..... Asserted when phase A of the phase overvoltage 1 element operates.

PHASE OV1 OP B ..... Asserted when phase B of the phase overvoltage 1 element operates.

PHASE OV1 OP C ..... Asserted when phase C of the phase overvoltage 1 element operates.

PHASE OV1 PKP ..... Asserted when at least one phase of the phase overvoltage 1 element picks up.

PHASE OV1 PKP A ..... Asserted when phase A of the phase overvoltage 1 element picks up.

PHASE OV1 PKP B ..... Asserted when phase B of the phase overvoltage 1 element picks up.

PHASE OV1 PKP C ..... Asserted when phase C of the phase overvoltage 1 element picks up.

PHASE OV2 ..... Same set of operands as shown above for the phase overvoltage 2 element.

Phase undervoltage operands

PHASE UV1 DPO ..... Asserted when at least one phase of the phase undervoltage 1 element drops out.

PHASE UV1 DPO A ..... Asserted when phase A of the phase undervoltage 1 element drops out.

PHASE UV1 DPO B ..... Asserted when phase B of the phase undervoltage 1 element drops out.

PHASE UV1 DPO C ..... Asserted when phase C of the phase undervoltage 1 element drops out.

PHASE UV1 OP ..... Asserted when at least one phase of the phase undervoltage 1 element operates.

PHASE UV1 OP A ..... Asserted when phase A of the phase undervoltage 1 element operates.

PHASE UV1 OP B ..... Asserted when phase B of the phase undervoltage 1 element operates.

PHASE UV1 OP C ..... Asserted when phase C of the phase undervoltage 1 element operates.

PHASE UV1 PKP ..... Asserted when at least one phase of the phase undervoltage 1 element picks up.

PHASE UV1 PKP A ..... Asserted when phase A of the phase undervoltage 1 element picks up.

PHASE UV1 PKP B ..... Asserted when phase B of the phase undervoltage 1 element picks up.

PHASE UV1 PKP C ..... Asserted when phase C of the phase undervoltage 1 element picks up.

PHASE UV2 ..... Same set of operands as shown above for the phase undervoltage 2 element.

Setting group operands

SETTING GROUP ACT 1 ..... Asserted when setting group 1 is active.

SETTING GROUP ACT 2 ..... Asserted when setting group 2 is active.

SETTING GROUP ACT 3 ..... Asserted when setting group 3 is active.

SETTING GROUP ACT 4 ..... Asserted when setting group 4 is active.
SETTING GROUP ACT 5 ..... Asserted when setting group 5 is active.
SETTING GROUP ACT 6 ..... Asserted when setting group 6 is active.

Disturbance detector operands

SRC1 50DD OP ..... Asserted when the disturbance detector for source 1 operates.
SRC2 50DD OP ..... Asserted when the disturbance detector for source 2 operates.
SRC3 50DD OP ..... Asserted when the disturbance detector for source 3 operates.

Voltage transformer fuse failure (VTFF) operands

SRC1 VTFF DPO ..... Asserted when the VT fuse failure detector for source 1 drops out.
SRC1 VTFF OP ..... Asserted when the VT fuse failure detector for source 1 operates.
SRC1 VTFF VOL LOSS ..... Asserted when the VT fuse failure detector for source 1 loses voltage signals (V_2 is less than 15% and V_1 is less than 5% of nominal).
SRC2 to SRC3 ..... The set of operands shown above are available VT fuse failure elements for sources 2 through 3.

Protection FlexAnalog parameters

The following protection FlexAnalog parameters (analog operands) are available for the C90^{Plus}. They are listed alphabetically by operand syntax.

Setting group analog operand

Active Setting Group ..... The currently active setting group

Digital counter analog operands

Digital Counter 1 Value ..... Actual value of digital counter 1
Digital Counter 2 Value ..... Actual value of digital counter 2
Digital Counter 3 Value ..... Actual value of digital counter 3
Digital Counter 4 Value ..... Actual value of digital counter 4
Digital Counter 5 Value ..... Actual value of digital counter 5
Digital Counter 6 Value ..... Actual value of digital counter 6
Digital Counter 7 Value ..... Actual value of digital counter 7
Digital Counter 8 Value ..... Actual value of digital counter 8

FlexElement™ analog operands

FlexElement 1 Value ..... Metered value for FlexElement 1
FlexElement 2 Value ..... Metered value for FlexElement 2
FlexElement 3 Value ..... Metered value for FlexElement 3
FlexElement 4 Value ..... Metered value for FlexElement 4
FlexElement 5 Value ..... Metered value for FlexElement 5
FlexElement 6 Value ..... Metered value for FlexElement 6
FlexElement 7 Value ..... Metered value for FlexElement 7
FlexElement 8 Value ..... Metered value for FlexElement 8
FlexElement 9 Value ..... Metered value for FlexElement 9
FlexElement 10 Value ..... Metered value for FlexElement 10
FlexElement 11 Value ..... Metered value for FlexElement 11
FlexElement 12 Value ..... Metered value for FlexElement 12

FlexElement 13 Value ..... Metered value for FlexElement 13
FlexElement 14 Value ..... Metered value for FlexElement 14
FlexElement 15 Value ..... Metered value for FlexElement 15
FlexElement 16 Value ..... Metered value for FlexElement 16

Small signal oscillation detection analog operands

SSOD 1 Input Counter ..... Small signal oscillation detector 1 input counter value
SSOD 1 Input Time ..... Small signal oscillation detector 1 input time value
SSOD 1 Mag ..... Small signal oscillation detector 1 magnitude value
SSOD 2 Input Counter ..... Small signal oscillation detector 2 input counter value
SSOD 2 Input Time ..... Small signal oscillation detector 2 input time value
SSOD 2 Mag ..... Small signal oscillation detector 2 magnitude value
SSOD 3 Input Counter ..... Small signal oscillation detector 3 input counter value
SSOD 3 Input Time ..... Small signal oscillation detector 3 input time value
SSOD 3 Mag ..... Small signal oscillation detector 3 magnitude value
SSOD 4 Input Counter ..... Small signal oscillation detector 4 input counter value
SSOD 4 Input Time ..... Small signal oscillation detector 4 input time value
SSOD 4 Mag ..... Small signal oscillation detector 4 magnitude value
SSOD 5 Input Counter ..... Small signal oscillation detector 5 input counter value
SSOD 5 Input Time ..... Small signal oscillation detector 5 input time value
SSOD 5 Mag ..... Small signal oscillation detector 5 magnitude value

C90Plus Controller

Chapter 8: Automation

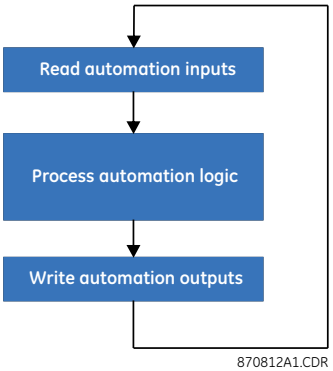
This section outlines how to program the C90Plus automation features.

Automation controller overview

The C90Plus automation controller allows the user to easily implement a variety of custom automation schemes. The controller can access both digital and analog inputs and outputs. Operations carried out on digital inputs and outputs are referred to as logical operations, whereas operations carried out on analog inputs and outputs are referred to as math operations. Digital inputs and outputs include physical inputs and outputs residing locally in the C90Plus, remote inputs and outputs originating in external devices, and outputs generated by internal, hard-coded functions. The results of processing inputs and outputs are stored locally in the form of virtual inputs and outputs. These can, in turn, be assigned to drive contact outputs, annunciator indications, or be used as inputs to internal, hard-coded functions. They are also available via communications to external devices or master programs.

All inputs are read at the beginning of the automation scan, then the logic is processed. After logic processing, the outputs are written. The C90Plus automation scan rate is 50 ms. A total of 4096 lines can be programmed in the automation controller.

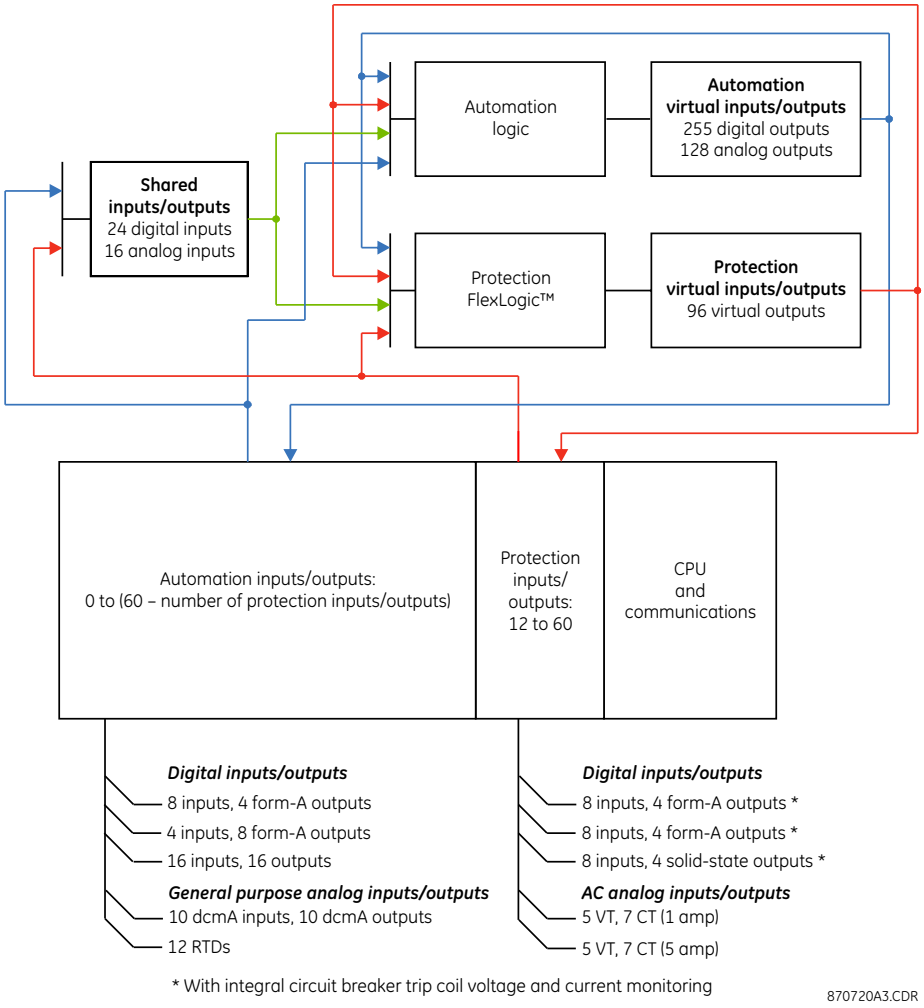
Figure 1: Automation scan



Input and output structure

The figure shows the input and output structure of the C90^{Plus}. Three groupings of inputs and outputs are defined: physical, shared, and virtual, with digital and analog types within each grouping.

Figure 2: Input and output structure



The digital inputs and outputs have the following characteristics.

- Physical inputs and outputs: The C90^{Plus} can accommodate a maximum of five input/output modules.
- Shared inputs and outputs: These are internal registers that are accessible to both the protection and automation functions. This allows protection physical inputs to be passed to the automation function and *vice-versa*.
- Virtual inputs and outputs: A total of 96 points are available in the controller for storage of the intermediate or final results of logic processing (defined as virtual digital outputs).

The analog inputs and outputs have the following characteristics.

- Physical inputs: These are derived from analog input cards designed to measure process variables produced by transducers.
- Shared inputs and outputs: These are internal registers that are accessible to both the protection and automation functions. This allows protection physical inputs to be passed to the automation function and *vice-versa*. The C90^{Plus} can store a total of 64

shared operands. This allows the automation function access to a large variety of analog measurements resident in the protection functions.

- Virtual inputs and outputs: A total of 64 points are available in the controller for storage of the intermediate of final results of math processing (defined as virtual analog outputs).

Breakers

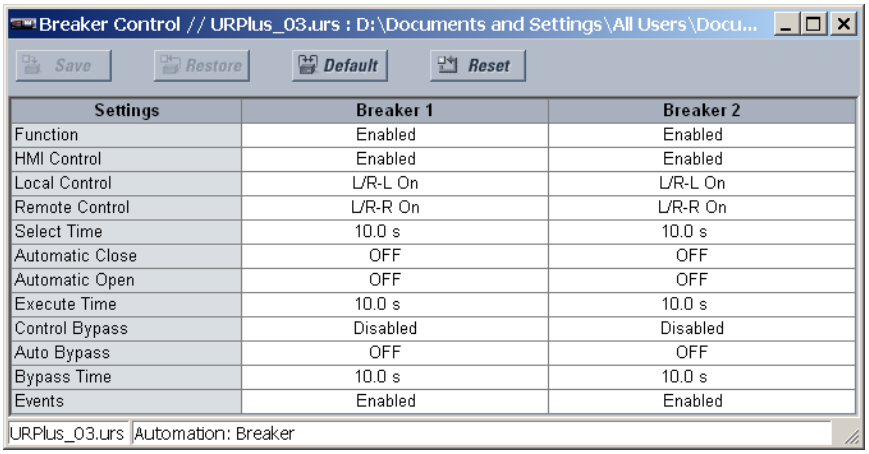
This section describes the breaker control and breaker interlocking features for each of the 6 available breakers.

Breaker control

The breaker control element contains the auxiliary logic for control of circuit breakers required for SCADA and for the front panel interface. The control function incorporates select-before-operate. Selection is required before a control action is permitted. Selecting a device inhibits service to other clients. Selection is also inhibited if an operation is in progress. The logic permits interlocking to be bypassed if required.

Select the **Settings > Automation > Breaker > Breaker Control** menu item to open the breaker control configuration window.

Figure 3: Breaker control configuration settings window



Settings	Breaker 1	Breaker 2
Function	Enabled	Enabled
HMI Control	Enabled	Enabled
Local Control	L/R-L On	L/R-L On
Remote Control	L/R-R On	L/R-R On
Select Time	10.0 s	10.0 s
Automatic Close	OFF	OFF
Automatic Open	OFF	OFF
Execute Time	10.0 s	10.0 s
Control Bypass	Disabled	Disabled
Auto Bypass	OFF	OFF
Bypass Time	10.0 s	10.0 s
Events	Enabled	Enabled

The following settings are available for each breaker.

Function

Range: Enabled, Disabled

Default: Enabled

This setting enables or disables breaker control.

HMI Control

Range: Enabled, Disabled

Default: Enabled

This setting enables breaker control through the front panel interface and populates the front panel display with breaker control soft-keys.

Local Control

Range: any automation logic operand or shared operand
Default: L/R-L On

When the operand assigned to this setting is asserted, control is enabled from the front panel interface. This setting is normally assigned to the local status of a local/remote switch. If continuous local control is required, this setting can be programmed as "On".

Remote Control

Range: any automation logic operand or shared operand
Default: L/R-R On

When the operand assigned to this setting is asserted, control is enabled from SCADA. This setting is normally assigned to the remote status of a local/remote switch. If continuous remote control is required, this setting can be programmed as "On".

Select Time

Range: 0.00 to 30.00 seconds in steps of 0.01
Default: 10.00 seconds

This setting specifies the maximum permissible time from selection of the breaker and a control action.

Automatic Close

Range: any automation logic operand or shared operand
Default: OFF

This setting is used to close the device from an automatic control scheme.

Automatic Open

Range: any automation logic operand or shared operand
Default: OFF

This setting is used to open the device from an automatic control scheme.

Execute Time

Range: 0.0 to 10.0 seconds in steps of 0.1
Default: 10.0 seconds

This setting specifies the duration of the open and close commands used to control the breaker.

Control Bypass

Range: Enabled, Disabled
Default: Disabled

When enabled, this setting allows the interlocking to be bypassed from local or remote control.

NOTICE

Non-interlocked control can result in equipment damage.

Automation Bypass

Range: any automation logic operand or shared operand
Default: OFF

When the operand assigned to this setting is asserted, interlocking is bypassed.

NOTICE

Non-interlocked control can result in equipment damage.

Bypass Time

Range: 0.0 to 30.0 seconds in steps of 0.1

Default: 10.0 seconds

This setting specifies the time window during which non-interlocked control can occur once bypass has been selected.

The following figures provide the breaker control logic.

Figure 4: Breaker control logic, sheet 1 of 3

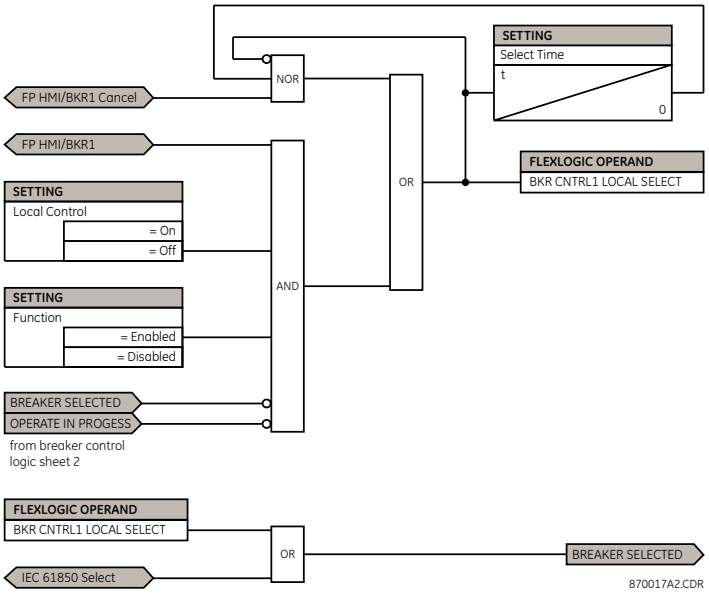


Figure 5: Breaker control logic, sheet 2 of 3

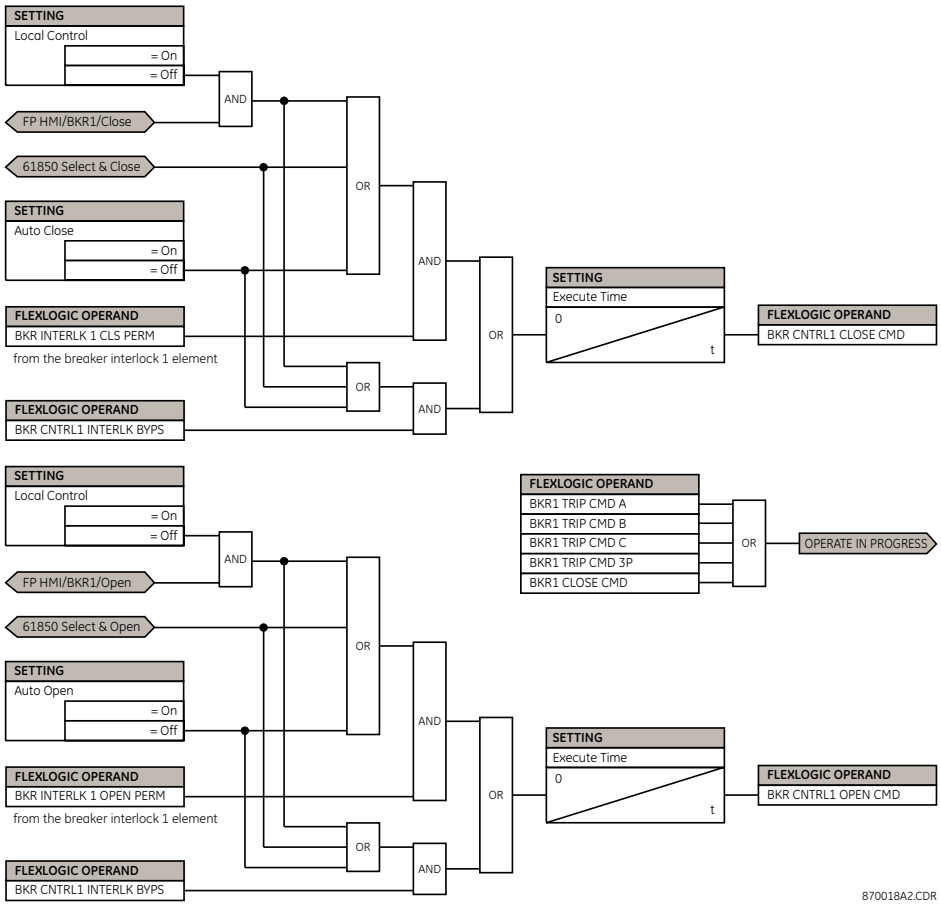
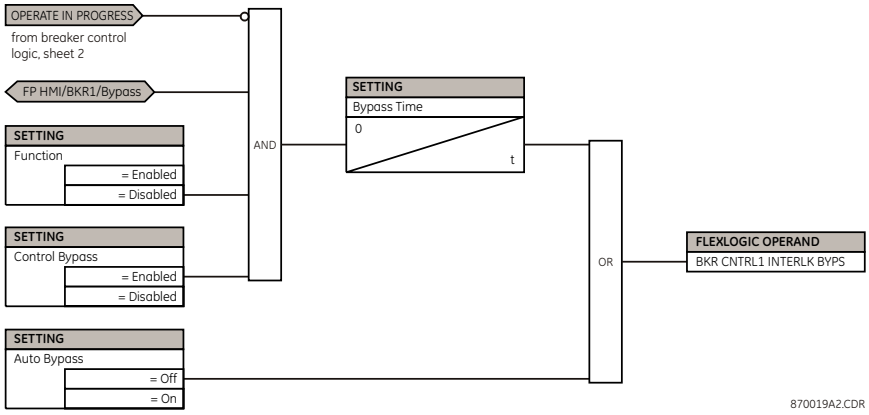


Figure 6: Breaker control logic, sheet 3 of 3

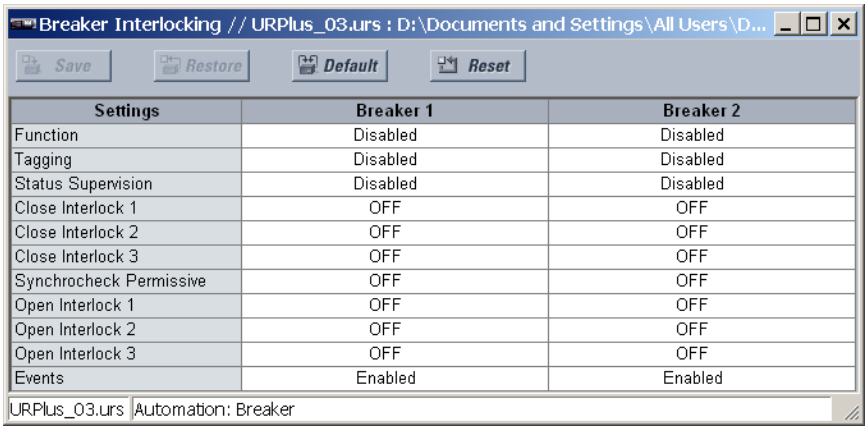


Breaker interlocking

The breaker interlocking element contains the auxiliary logic for interlocking of circuit breakers. Up to three inputs can be assigned for interlocking the open and close controls. An input is also available for supervision by a synchrocheck element. The breaker may also be tagged through the front panel interface or through SCADA. Opening and closing of a tagged device is inhibited in logic.

Select the **Settings > Automation > Breaker > Breaker Interlocking** menu item to open the breaker interlocking configuration window.

Figure 7: Breaker interlocking configuration settings



Settings	Breaker 1	Breaker 2
Function	Disabled	Disabled
Tagging	Disabled	Disabled
Status Supervision	Disabled	Disabled
Close Interlock 1	OFF	OFF
Close Interlock 2	OFF	OFF
Close Interlock 3	OFF	OFF
Synchrocheck Permissive	OFF	OFF
Open Interlock 1	OFF	OFF
Open Interlock 2	OFF	OFF
Open Interlock 3	OFF	OFF
Events	Enabled	Enabled

The following settings are available for each breaker interlocking element.

Function

Range: Enabled, Disabled

Default: Disabled

This setting enables the breaker position indications and control logic. If disabled, all outputs and front panel indications are switched off.

Tagging

Range: Enabled, Disabled

Default: Disabled

When enabled, tagging control is enabled and a TAG/UNTAG soft-key is displayed on the front panel interface. When a breaker is tagged both local and remote control of the device is inhibited.

Status Supervision

Range: Enabled, Disabled

Default: Disabled

When enabled, control of the breaker is supervised by its breaker status. An open command cannot be sent to a breaker that currently indicates open and a close command cannot be sent to a breaker that indicates closed.

Close Interlock 1, Close Interlock 2, Close Interlock 3

Range: any automation logic operand or shared operand

Default: OFF

Closing of the device is inhibited if any of the operands assigned to these settings are asserted.

Synchrocheck Permissive

Range: any automation logic operand or shared operand

Default: SYNC 1 SYNC OP

This setting is used to supervise closing of the breaker by a synchrocheck element. If synchrocheck is not required, this setting should be selected as “ON”.

Open Interlock 1, Open Interlock 2, Open Interlock 3

Range: any automation logic operand or shared operand

Default: Off

Opening of the device is inhibited if any of the operands assigned to these settings are asserted.

Events

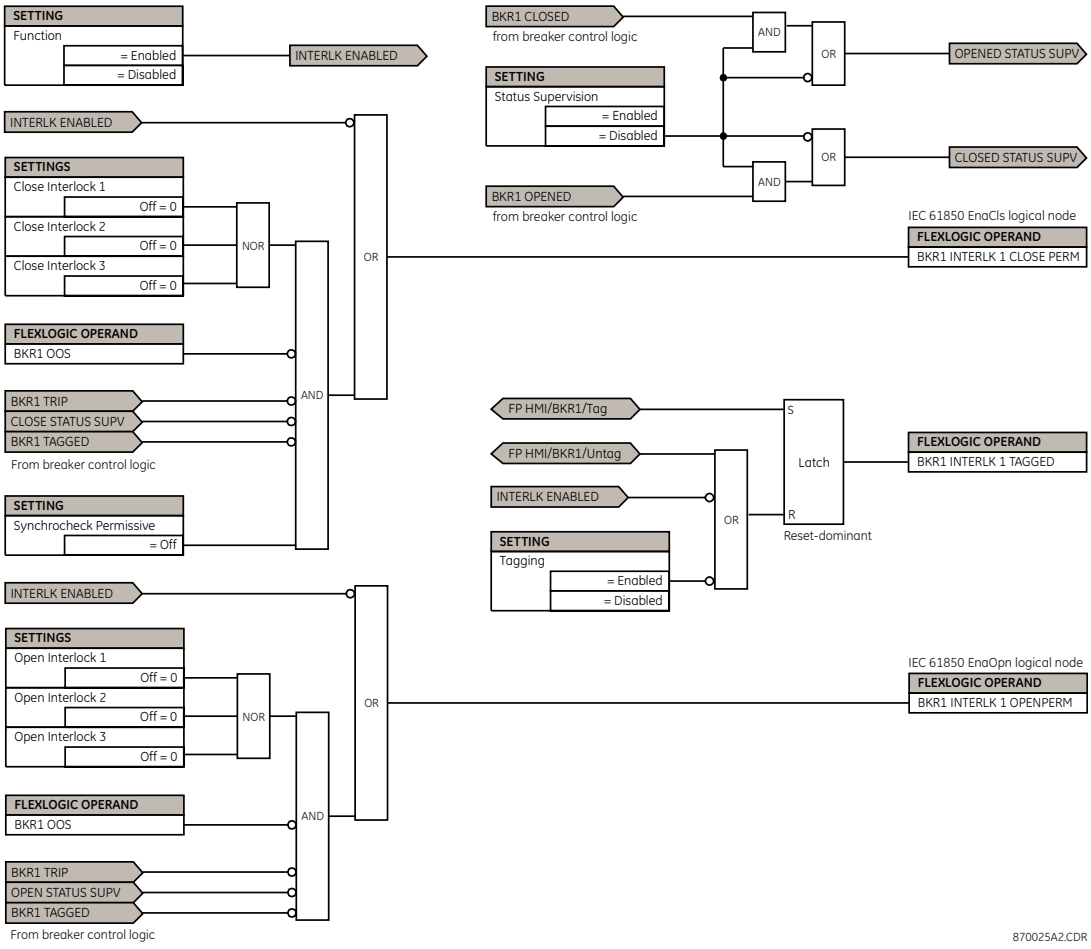
Range: Enabled, Disabled

Default: Enabled

The setting enables or disables the logging of breaker interlocking events in the sequence of events recorder.

The figure shows the breaker interlocking logic.

Figure 8: Breaker interlocking logic



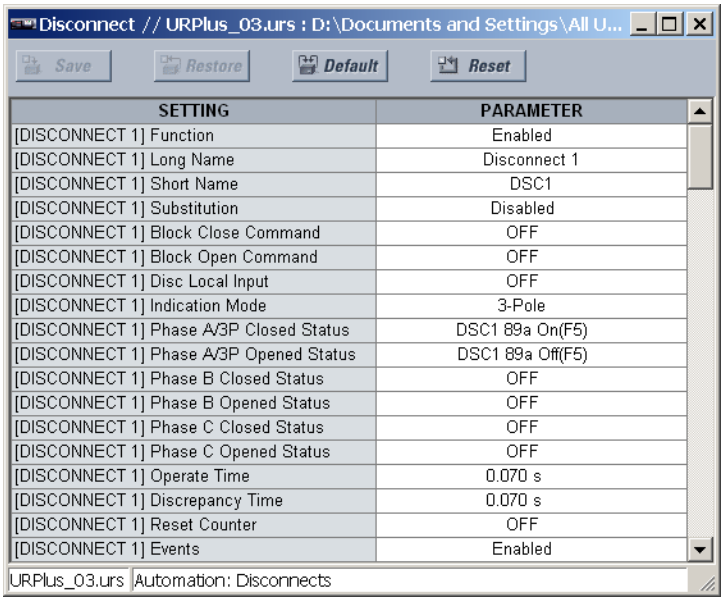
Disconnects

The disconnect element contains the auxiliary logic for status and serves as the interface for opening and closing of the disconnect from protection and automation functions. The logic also permits a manual substitution of the position indication. There are 30 disconnect elements available in the C90^{Plus}.

Disconnect configuration

Select the **Settings > Automation > Disconnects > Disconnect Configuration** menu item to open the disconnect control configuration window.

Figure 9: Disconnect configuration settings



The following settings are available for each disconnect.

Function

Range: Enabled, Disabled
Default: Enabled

This setting enables the disconnect position indications and control logic. If disabled, all outputs and front panel indications are switched off.

Long Name

Range: up to 12 alphanumeric characters
Default: DISCONNECT 1

This setting identifies the primary device for control confirmations on the front panel interface and in the event record.

Short Name

Range: up to 6 alphanumeric characters
Default: DSC1

This setting identifies the primary device soft-keys and indications on the front panel interface.

Substitution

Range: Enabled, Disabled
Default: Disabled

If this setting is "Enabled", the position indication of the disconnect can be substituted with a manually entered value.

Block Close Command

Range: any automation logic operand or shared operand
Default: OFF

Assertion of the operand assigned to this setting prevents the disconnect from closing.

Block Open Command

Range: any automation logic operand or shared operand
Default: OFF

Assertion of the operand assigned to this setting prevents the disconnect from opening.

Disconnect Local Input

Range: any automation logic operand or shared operand
Default: OFF

Closing or opening of the disconnect through the disconnect interlock element is inhibited if the operand assigned to this setting is asserted.

Indication Mode

Range: 3-Pole, 1-Pole
Default: 3-Pole

If the "3-Pole" value is selected, the disconnect indications are derived from a single status input (or pair of status inputs). If the "1-Pole" value is selected, the disconnect indications are derived from three status inputs (or pairs of status inputs).

Phase A/3P Closed Status

Range: any automation logic operand or shared operand
Default: Off

The operand assigned to this setting is used to derive the three-pole or phase A circuit disconnect position indication from a normally-opened (52a) status input.

Phase A/3P Opened Status

Range: any automation logic operand or shared operand
Default: DSC2 89a On(K10)

The operand assigned to this setting is used to derive the three-pole or phase A circuit disconnect position indication from a normally-closed (52b) status input. If unavailable, the closed status input can be inverted to provide this signal.

Phase B Closed Status

Range: any automation logic operand or shared operand
Default: DSC2 89a Off(K10)

The operand assigned to this setting is used to derive the phase B disconnect position indication from a normally-opened (52a) status input. This setting is not required if the **Indication Mode** is "1-Pole".

Phase B Opened Status

Range: any automation logic operand or shared operand
Default: Off

The operand assigned to this setting is used to derive the phase B disconnect position indication from a normally-closed (52b) status input. If unavailable, the closed status input can be inverted to provide this signal. This setting is not required if the **Indication Mode** is "1-Pole".

Phase C Opened Status

Range: any automation logic operand or shared operand
Default: Off

The operand assigned to this setting is used to derive the phase C disconnect position indication from a normally-opened (52a) status input. This setting is not required if the **Indication Mode** is "1-Pole".

Phase C Closed Status

Range: any automation logic operand or shared operand
Default: Off

The operand assigned to this setting is used to derive the phase C disconnect position indication from a normally-closed (52b) status input. If unavailable, the closed status input can be inverted to provide this signal. This setting is not required if the **Indication Mode** is "1-Pole".

Operate Time

Range: 0.000 to 2.000 seconds in steps of 0.001

Default: 0.070 seconds

This setting specifies a timer that is asserted when both the normally open and normally closed disconnect indications are reset. When the timer expires, a bad status is indicated for the disconnect. Set the time to be equal to the normal operating time for the disconnect.

Discrepancy Time

Range: 0.000 to 2.000 seconds in steps of 0.001

Default: 0.070 seconds

This setting specifies a timer that is asserted when the three disconnect poles are not all opened or not all closed. Set the time to be greater than the longest expected time for which the three disconnect poles disagree.

Reset Counter

Range: any automation logic operand or shared operand

Default: Off

Assertion of the operand assigned to this setting resets the disconnect operation counters.

Events

Range: Enabled, Disabled

Default: Enabled

This setting enables and disables the logging of circuit disconnect events in the sequence of events recorder.

The figures show the disconnect 1 configuration logic. The logic is identical for each available disconnect.

Figure 10: Disconnect scheme logic, sheet 1 of 4

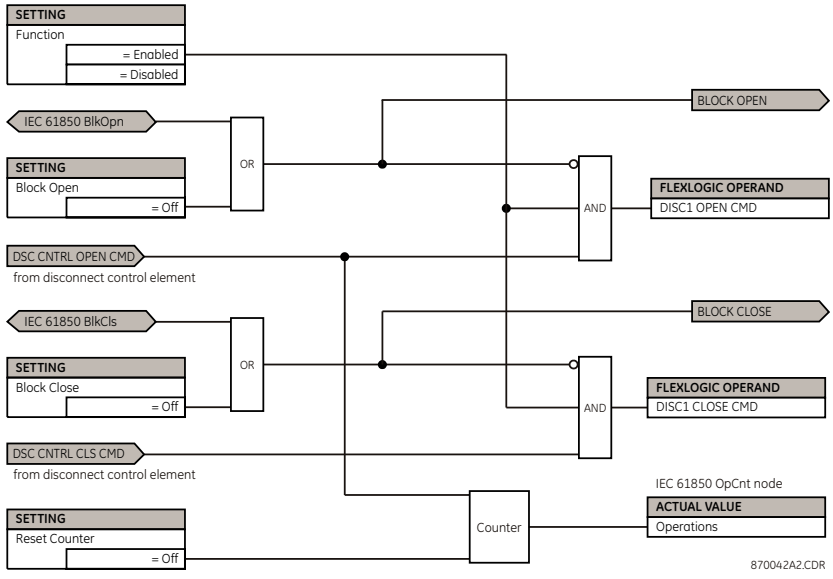


Figure 11: Disconnect scheme logic, sheet 2 of 4

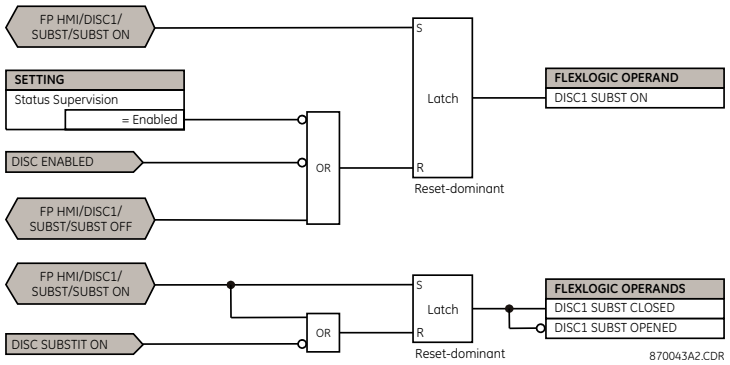


Figure 12: Disconnect scheme logic, sheet 3 of 4

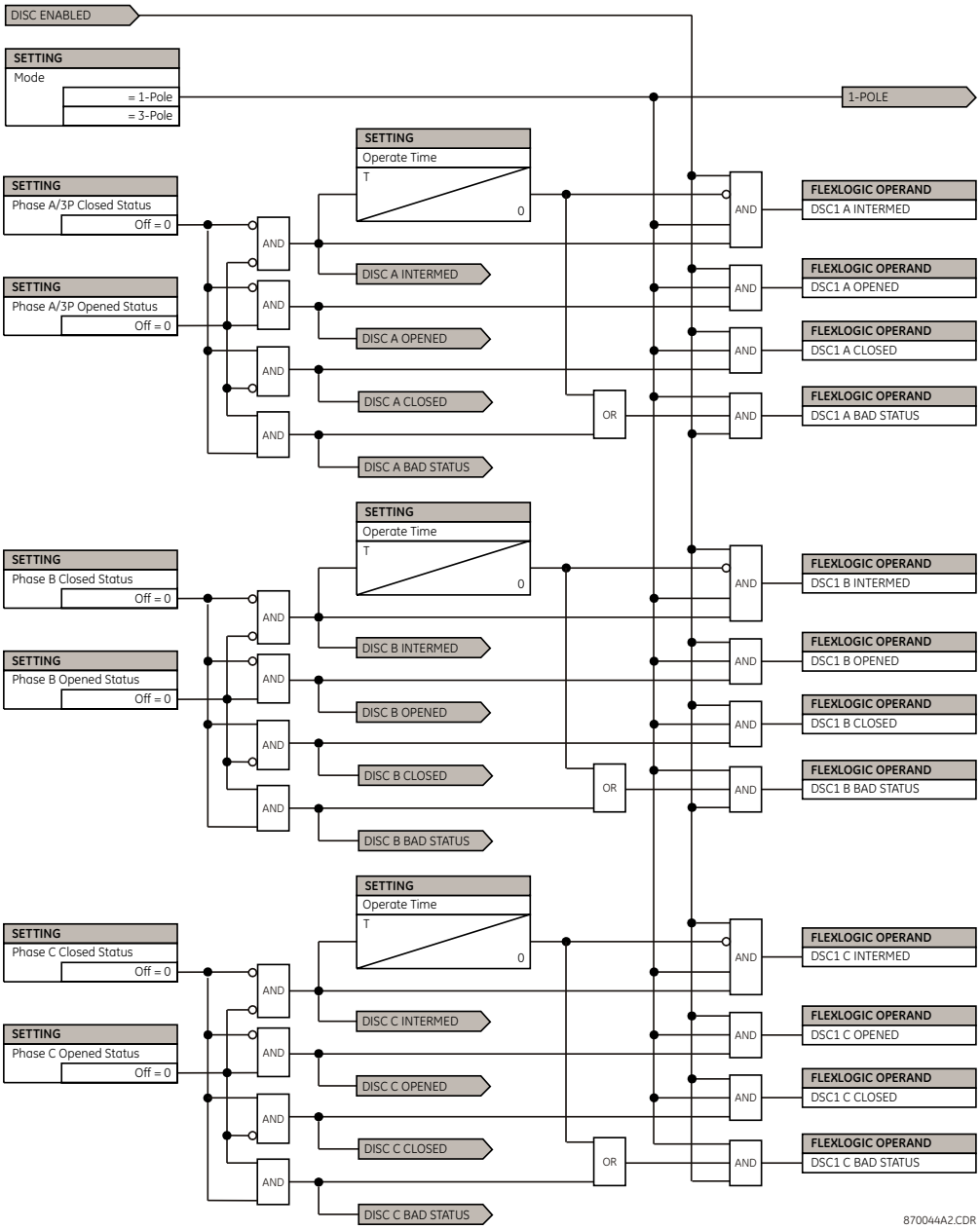
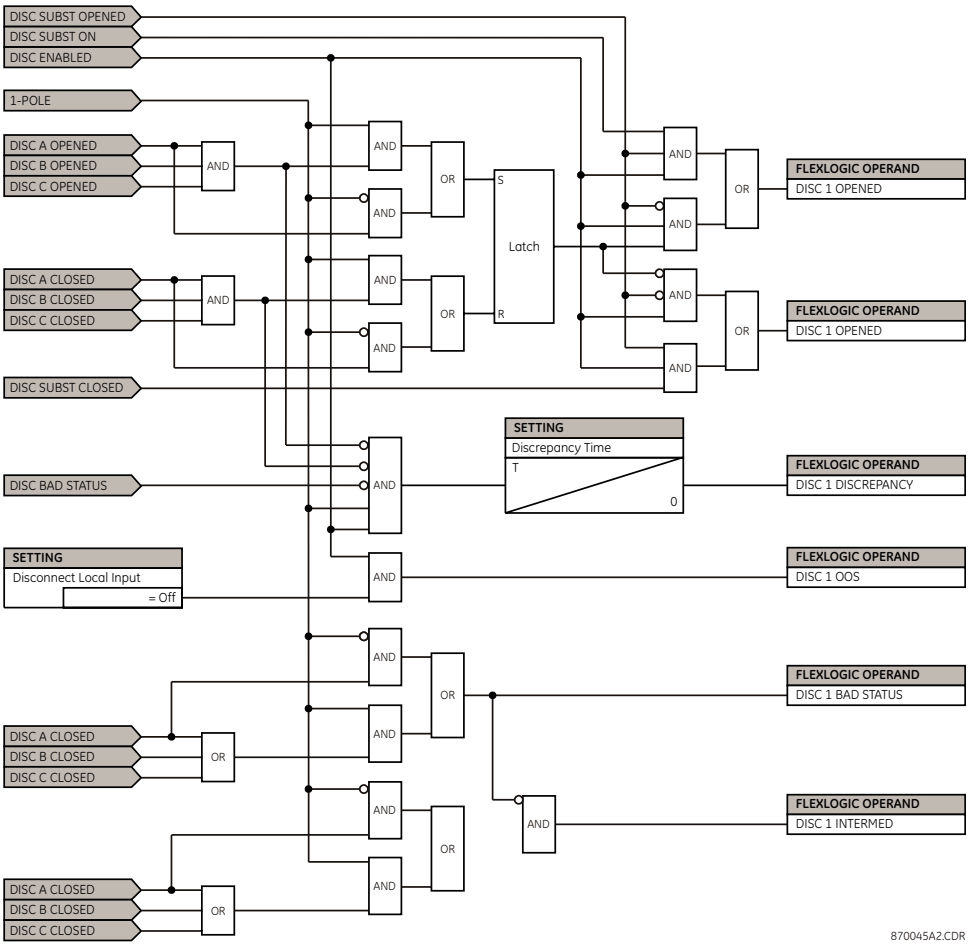


Figure 13: Disconnect scheme logic, sheet 4 of 4

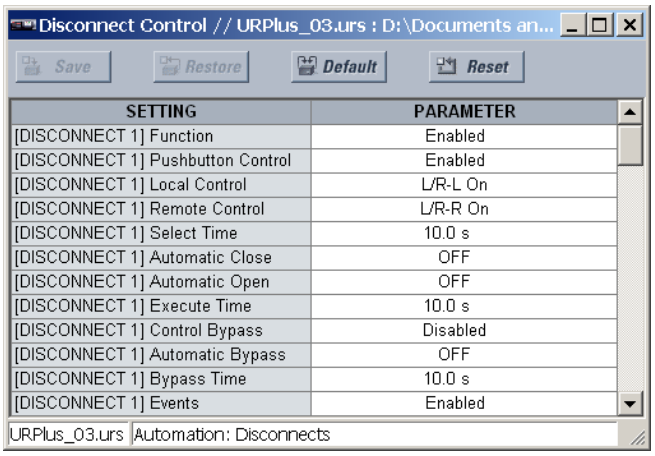


Disconnect control

The disconnect control element contains the auxiliary logic for control of circuit breakers required for SCADA and the front panel interface. The control function incorporates select-before-operate functionality. Selection is required before a control action is permitted. Selecting a device inhibits service to other clients. Selection is also inhibited if an operation is in-progress. The logic permits interlocking to be bypassed if required.

Select the **Settings > Automation > Disconnects > Disconnect Control** menu item to open the disconnect control configuration window.

Figure 14: Disconnect control configuration settings



The following settings are available for each disconnect.

Function

Range: Enabled, Disabled
Default: Enabled

This setting enables and disables the disconnect control feature.

Pushbutton Control

Range: Enabled, Disabled
Default: Enabled

This setting enables control of the device via the front panel and populates the front panel interface with control soft-keys.

Local Control

Range: any automation logic operand or shared operand
Default: L/R-L On

When the operand assigned to this setting is asserted, control is permitted from the front panel interface. This setting is normally assigned to the local status of a local/remote switch. If continuous local control is required, this input may be switched to on.

Remote Control

Range: any automation logic operand or shared operand
Default: L/R-R On

When the operand assigned to this setting is asserted, remote control is permitted from SCADA. This setting is normally assigned to the remote status of a local/remote switch. If continuous remote control is required, this input may be switched to on.

Select Time

Range: 0.0 to 30.0 seconds in steps of 0.1
Default: 10.0 seconds

This setting specifies the maximum permissible time from selection of the disconnect and a control action.

Automatic Close

Range: any automation logic operand or shared operand
Default: OFF

The operand assigned to this setting is used to close the device from an automatic control scheme.

Automatic Open

Range: any automation logic operand or shared operand
Default: OFF

The operand assigned to this setting is used to open the device from an automatic control scheme.

Execute Time

Range: 0.0 to 10.0 seconds in steps of 0.1
Default: 10.0 seconds

This setting specifies the duration of the open and close commands used to control the disconnect.

Control Bypass

Range: Enabled, Disabled
Default: Disabled

When enabled, this setting allows the interlocking to be bypassed from local or remote control.

NOTICE

Non-interlocked control can result in equipment damage.

Automatic Bypass

Range: any automation logic operand or shared operand
Default: OFF

When the operand assigned to this setting is asserted, interlocking is bypassed.

NOTICE

Non-interlocked control can result in equipment damage.

Bypass Time

Range: 0.0 to 30.0 seconds in steps of 0.1
Default: 10.0 seconds

This setting specifies the time window during which non-interlocked control can occur once bypass has been selected.

Events

Range: Enabled, Disabled
Default: Enabled

This setting enables and disables the logging of disconnect control events in the sequence of events recorder.

The figures show the disconnect control logic. The logic is identical for all available disconnects.

Figure 15: Disconnect control logic, sheet 1 of 3

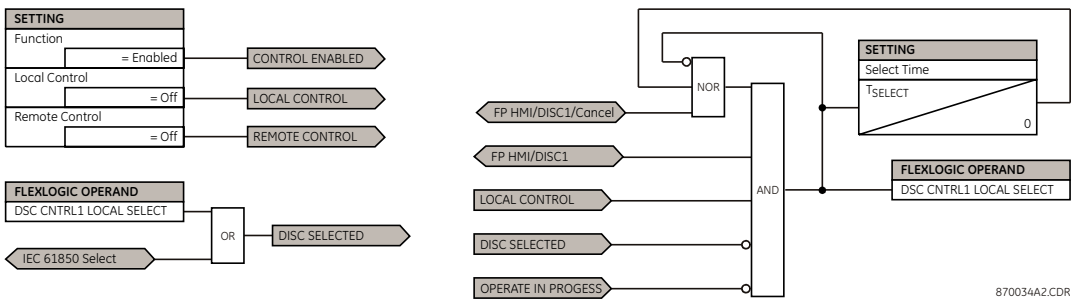


Figure 16: Disconnect control logic, sheet 2 of 3

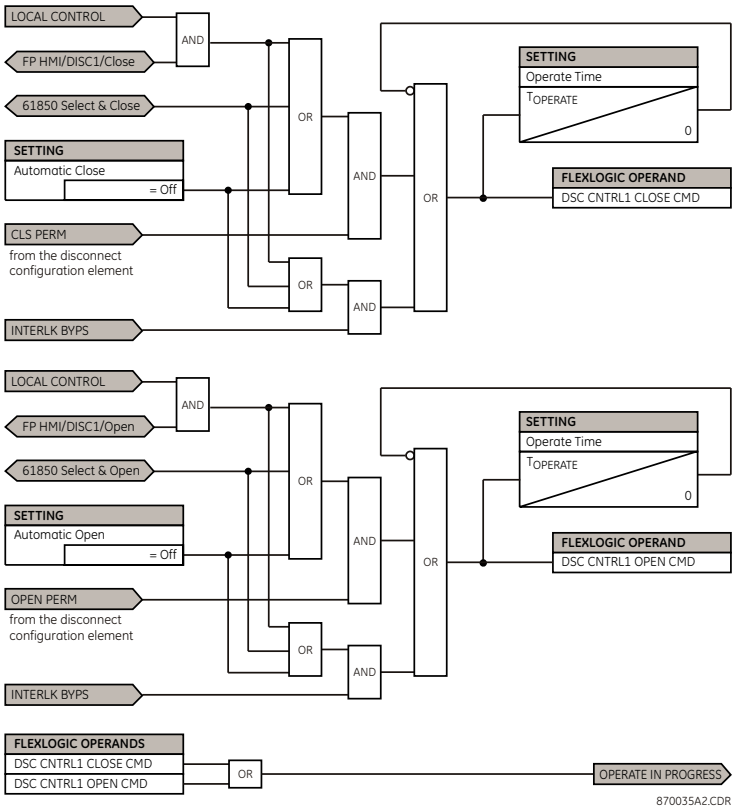
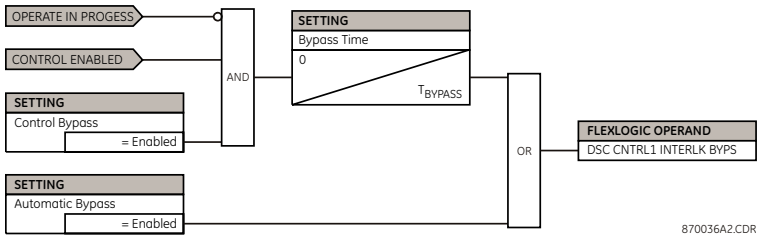


Figure 17: Disconnect control logic, sheet 3 of 3

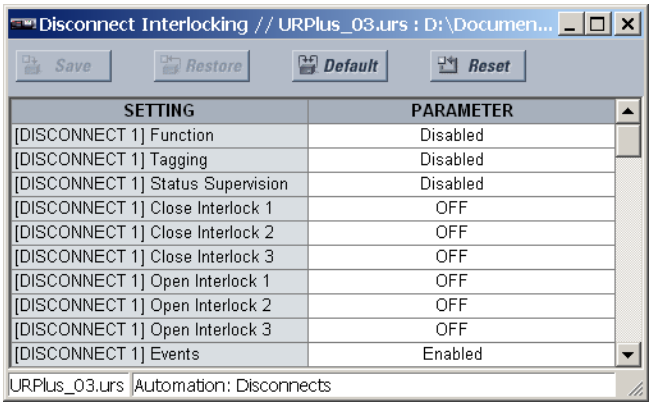


Disconnect interlocking

The disconnect interlocking element contains the auxiliary logic for interlocking of disconnects. Up to three inputs can be assigned for interlocking the open and close controls. An input is also available for supervision by a synchrocheck element. The disconnect may also be tagged through the front panel interface or through SCADA. Opening and closing of a tagged device is inhibited in logic.

Select the **Settings > Automation > Disconnects > Disconnect Interlocking** menu item to open the disconnect control configuration window.

Figure 18: Disconnect interlocking configuration settings



The following settings are available for each disconnect.

Function

Range: Enabled, Disabled

Default: Disabled

This setting enables the disconnect position indications and control logic. If "Disabled", all outputs and front panel indications are switched off.

Tagging

Range: Enabled, Disabled

Default: Disabled

When this setting is "Enabled", tagging control is enabled and a TAG/UNTAG soft-key is populated on the front panel interface. When a disconnect is tagged, both local and remote control of the device is inhibited.

Status Supervision

Range: Enabled, Disabled

Default: Disabled

When this setting is "Enabled", control of the disconnect is supervised by its disconnect status. An open command cannot be sent to a disconnect that currently indicates open and a close command cannot be sent to a disconnect that indicates closed.

Close Interlock 1, Close Interlock 2, Close Interlock 3

Range: any automation logic operand or shared operand

Default: OFF

If any of the operands assigned to these settings are asserted, closing of the device is inhibited.

Open Interlock 1, Open Interlock 2, Open Interlock 3

Range: any automation logic operand or shared operand

Default: OFF

If any of the operands assigned to these settings are asserted, opening of the device is inhibited.

Events

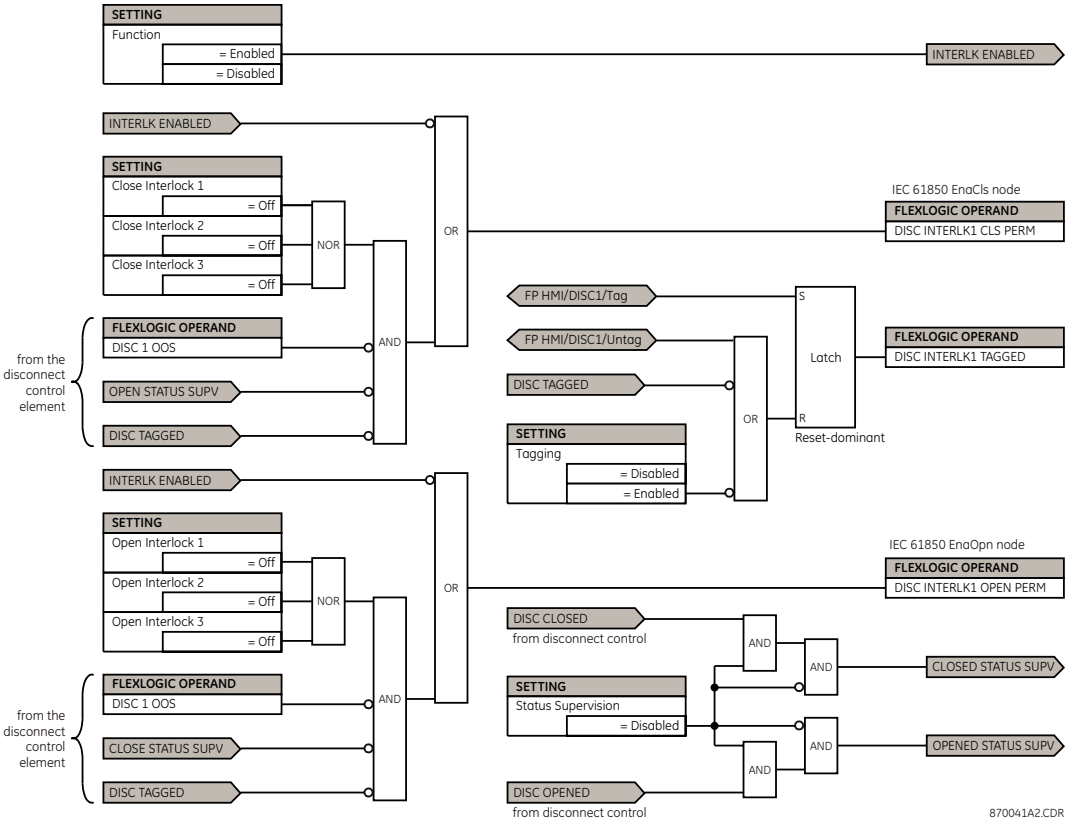
Range: Enabled, Disabled

Default: Enabled

This setting enables and disables the logging of disconnect interlocking events in the sequence of events recorder.

The figure shows the disconnect interlocking logic. The logic is identical for all available disconnects.

Figure 19: Disconnect interlocking logic



Automation control

This section outlines the control elements used for automation.

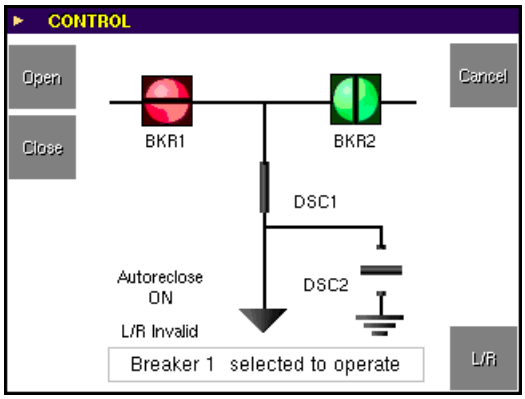
Front panel status and control

There can be a maximum of 6 breakers and 30 disconnect switches (referred to as devices) plus autoreclose and local-remote status and control. All devices have a short name setting and a full name setting. The short name is used to designate the device and the associated select pushbutton.

The top-level control screen presents the status of each enabled breaker and disconnect. The status of the local-remote function and the autoreclose function is shown if these functions are enabled. All devices are displayed in grey.

If the pushbutton control setting is enabled for a device or function, then the pushbutton on the front panel interface is assigned as shown in the example below. A device that does not have pushbutton control enabled does not have a pushbutton on this screen.

Figure 20: Device selected to operate



A confirmation message is displayed using the full name for the device to be controlled. If no buttons are pressed, the control action is canceled in after the select time timer expires. The control action can be cancelled by pushing the CANCEL key. Pressing the OPEN or CLOSE keys initiates an open or close control action for the selected device.

If control bypass has been enabled, a BYPASS key will be displayed. Press this button to bypass the interlocking logic for the device permitting non-interlocked control of this device. When bypassed, control remains active for a single control operation, until the bypass time timer expires, or the cancel button is pressed.

NOTICE

Non-interlocked control can result in equipment damage.

If tagging has been enabled, a TAG key also be displays. When the TAG key is operated, a small "T" is displayed next to the device. The open and close operations are inhibited on a tagged device. When a device is tagged, the TAG button changes to UNTAG.

If substitution is enabled, the SUBST key displays, When the SUBST key is operated, a new screen is presented that allows the user to enable or disable substitution. Once substitution has been enabled, a small "S" is displayed next to the device. The user can now manually change the indication of the device using the SUBST OPENED and SUBST CLOSED keys.

Figure 21: Breaker 1 tagged

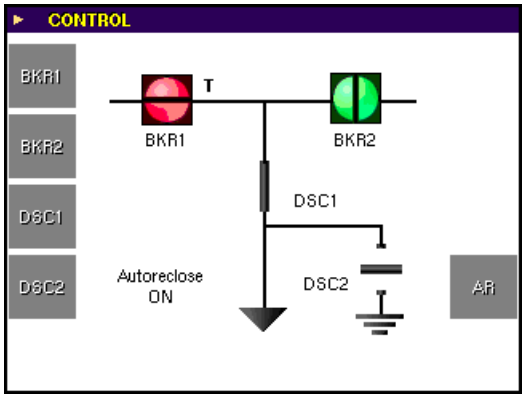
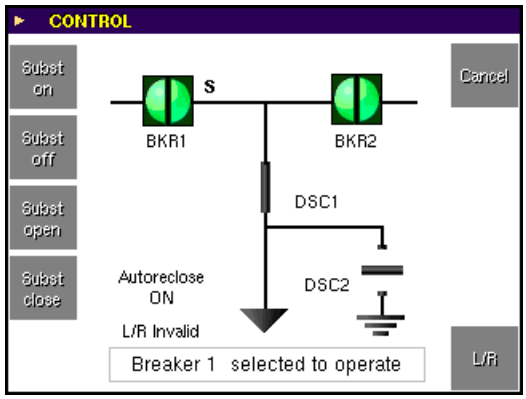
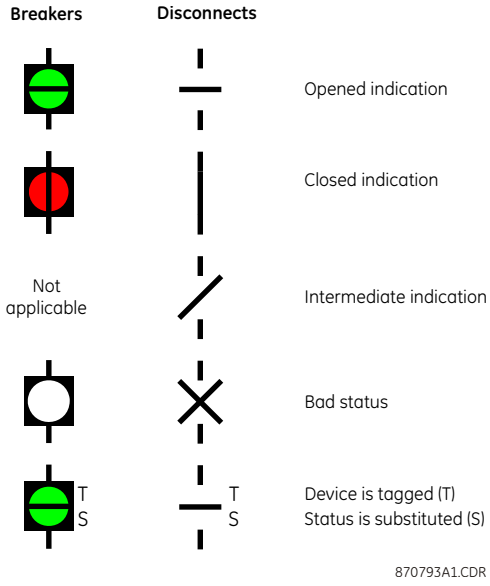


Figure 22: Breaker 1 status substituted



The following indications are provided for breakers and disconnects.

Figure 23: Front panel indicators for breakers and disconnects

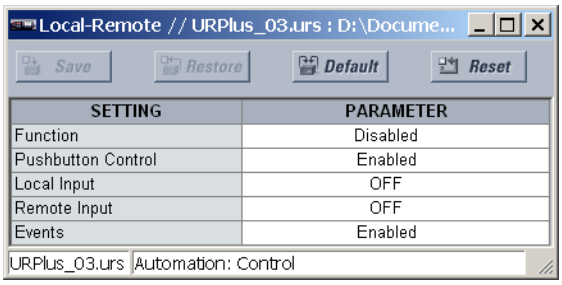


Local-remote control scheme

The local-remote control scheme is used to define the current location for operator control of power system devices (for example, breakers, disconnects, etc.). The function accepts inputs from the front panel interface or from an external source. The automation logic outputs (L/R-L On and L/R-R On) are assigned as inputs to the breaker and disconnect elements. The position of the latch is stored in non-volatile memory.

Select the **Settings > Automation > Control > Local-Remote** menu item to open the local-remote control scheme configuration window.

Figure 24: Local-remote control configuration settings



The following settings are available for the local-remote control scheme.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the local-remote control scheme automation logic and front panel indications.

Pushbutton Control

Range: Enabled, Disabled
Default: Enabled

This setting enables local-remote control selection via the front panel interface and populates the front panel display with control soft-keys.

Local Input

Range: any automation logic operand or shared operand
Default: OFF

When the operand assigned to this setting is asserted, the local-remote latch is set to local. This setting is normally used in cases where the local-remote selection is derived from an external switch or from a central location.

Remote Input

Range: any automation logic operand or shared operand
Default: OFF

When the operand assigned to this setting is asserted, the local-remote latch is set to remote. This setting is normally used in cases where the local-remote selection is derived from an external switch or from a central location.

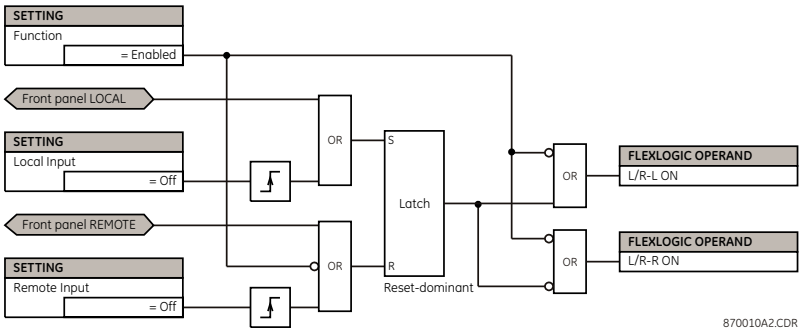
Events

Range: Enabled, Disabled
Default: Enabled

This settings enables and disables the recording of local-remote control scheme events in the sequence of events recorder.

The figure shows the logic diagram for the local-remote control scheme.

Figure 25: Local-remote control scheme logic



Synchrocheck

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

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

Synchrocheck verifies that the voltages (V_1 and V_2) on the two sides of the supervised circuit breaker are within set limits of magnitude, angle and frequency differences. The time that the two voltages remain within the admissible angle difference is determined by the setting of the phase angle difference $\Delta\Phi$ and the frequency difference ΔF (slip frequency). It can be defined as the time it would take the voltage phasor V_1 or V_2 to traverse an angle equal to $2 \times \Delta\Phi$ at a frequency equal to the frequency difference ΔF. This time can be calculated by

$$T = \frac{1}{\frac{360°}{2 \times \Delta\phi} \times \Delta F} \qquad \textbf{Eq. 1}$$

where $\Delta\Phi$ represents the phase angle difference in degrees and ΔF represents the frequency difference in hertz.

For example, for default values of $\Delta\Phi = 30°$ and $\Delta F = 0.1$ Hz, the time the angle between the two voltages is less than the set value is

$$T = \frac{1}{\frac{360°}{2 \times \Delta\Phi} \times \Delta F} = \frac{1}{\frac{360°}{2 \times 30°} \times 0.1\,\text{Hz}} = 1.66 \text{ sec.} \qquad \textbf{Eq. 2}$$

If one or both sources are de-energized, the synchrocheck programming can allow for closing of the circuit breaker using undervoltage control to bypass the synchrocheck measurements (via the dead source function).

Using the synchrocheck function

The selected sources for synchrocheck inputs V_1 and V_2 (which must not be the same source) may include both a three-phase and an auxiliary voltage. The relay automatically selects the specific voltages to be used by the synchrocheck element in accordance with the following table.

Table 1: Voltages used by the synchrocheck element

V_1 or V_2 (source *Y*)	V_2 or V_1 (source *Z*)	Auto-selected combination		Auto-selected voltage
		Source *Y*	Source *Z*	
Phase VTs and auxiliary VT	Phase VTs and auxiliary VT	Phase	Phase	V_{AB}
Phase VTs and auxiliary VT	Phase VT	Phase	Phase	V_{AB}
Phase VT	Phase VT	Phase	Phase	V_{AB}
Phase VT and auxiliary VT	Auxiliary VT	Phase	Auxiliary	V_{aux} (as set for source *Z*)
Auxiliary VT	Auxiliary VT	Auxiliary	Auxiliary	V_{aux} (as set for selected sources)

The voltages V_1 and V_2 are automatically matched so the corresponding voltages from the two sources are used to measure conditions. A phase-to-phase voltage is used if available in both sources. If one or both of the sources have only an auxiliary voltage, then this voltage is used.

For example, if an auxiliary voltage is programmed to V_{AG}, the synchrocheck element automatically selects V_{AG} from the other source. If the comparison is required on a specific voltage, the user can externally connect that specific voltage to auxiliary voltage terminals and then use this auxiliary voltage to check the synchronism conditions.

If using a single CT/VT module with both phase voltages and an auxiliary voltage, ensure that only the auxiliary voltage is programmed in one of the sources used for synchrocheck.

NOTE

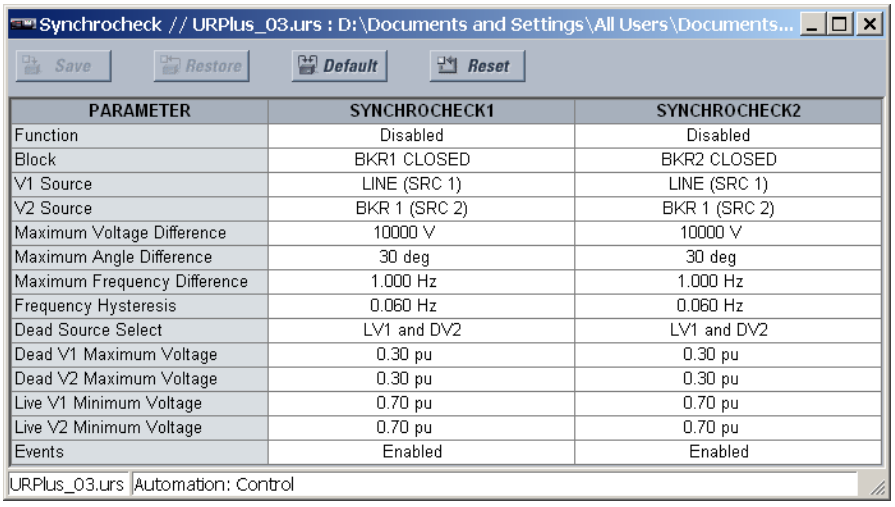
Exception: synchronism cannot be checked between delta-connected phase VTs and a wye-connected auxiliary voltage.

The C90^{Plus} measures frequency and volts per hertz from an input on a given source with priorities as established by the configuration of input channels to the source. The relay uses the phase channel of a three-phase set of voltages if programmed as part of that source. The relay uses the auxiliary voltage channel only if that channel is programmed as part of the source and a three-phase set is not.

Synchrocheck settings

Select the **Settings > Automation > Control > Synchrocheck** menu item to open the synchrocheck configuration window.

Figure 26: Synchrocheck configuration settings



PARAMETER	SYNCHROCHECK1	SYNCHROCHECK2
Function	Disabled	Disabled
Block	BKR1 CLOSED	BKR2 CLOSED
V1 Source	LINE (SRC 1)	LINE (SRC 1)
V2 Source	BKR 1 (SRC 2)	BKR 1 (SRC 2)
Maximum Voltage Difference	10000 V	10000 V
Maximum Angle Difference	30 deg	30 deg
Maximum Frequency Difference	1.000 Hz	1.000 Hz
Frequency Hysteresis	0.060 Hz	0.060 Hz
Dead Source Select	LV1 and DV2	LV1 and DV2
Dead V1 Maximum Voltage	0.30 pu	0.30 pu
Dead V2 Maximum Voltage	0.30 pu	0.30 pu
Live V1 Minimum Voltage	0.70 pu	0.70 pu
Live V2 Minimum Voltage	0.70 pu	0.70 pu
Events	Enabled	Enabled

The following settings are available for each synchrocheck element. The default values outlined are for the synchrocheck 1 element.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables the synchrocheck position indications and control logic. If disabled, all synchrocheck outputs and front panel indications are switched off.

Block

Range: any automation logic operand or shared operand
Default: BKR1 CLOSED

Assertion of the operand assigned to this setting blocks operation of the synchrocheck element.

V1 Source

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)
Default: LINE (SRC 1)

This setting selects the source for the V_1 voltage.

V2 Source

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)
Default: BKR 1 (SRC 2)

This setting selects the source for the V_2 voltage.

Maximum Voltage Difference

Range: 0 to 400000 volts in steps of 1
Default: 10000 volts

This setting specifies the maximum primary voltage difference (in volts) between the two sources. A primary voltage magnitude difference between the two input voltages less than this value is within the permissible limit for synchronism.

Maximum Angle Difference

Range: 0 to 100° in steps of 1
Default: 30°

This setting specifies the maximum angular difference (in degrees) between the two sources. An angular difference between the two input voltage phasors less than this value is within the permissible limit for synchronism.

Maximum Frequency Difference

Range: 0.00 to 2.00 Hz in steps of 0.01
Default: 1.00 Hz

This setting selects the maximum frequency difference (in hertz) between the two sources. A frequency difference between the two input voltage systems below this value is within the permissible limit for synchronism.

Frequency Hysteresis

Range: 0.00 to 0.10 Hz in steps of 0.01
Default: 0.06 Hz

This setting specifies the required hysteresis for the maximum frequency difference condition. The condition becomes satisfied when the frequency difference is less than the value specified by the **Maximum Frequency Difference** setting. Once the synchrocheck element has operated, the frequency difference must increase above the sum of this setting and the Maximum Frequency Difference setting to drop out (assuming the other two conditions, voltage and angle, remain satisfied).

Dead Source Select

Range: None, LV1 and DV2, DV1 and LV2, DV1 or DV2, DV1 Xor DV2, DV1 and DV2
Default: LV1 and DV2

This setting selects the combination of dead and live sources that bypass the synchronism check function and permit the breaker to be closed when one or both of the two voltages (V_1 and V_2) are below the maximum voltage threshold. A dead or live source is declared by monitoring the voltage level. Six options are available:

- "None" — The dead source function is disabled
- "LV1 and DV2" — Live V_1 and dead V_2
- "DV1 and LV2" — Dead V_1 and live V_2
- "DV1 or DV2" — Dead V_1 or dead V_2
- "DV1 Xor DV2" — Dead V_1 exclusive-or dead V_2 (one source is dead and the other is live)
- "DV1 and DV2" — Dead V_1 and dead V_2

Dead V1 Maximum Voltage

Range: 0.00 to 1.25 pu in steps of 0.01
Default: 0.30 pu

This setting specifies a maximum voltage magnitude for V_1 in per-unit values. At values less than this magnitude, the V_1 voltage input that is used for synchrocheck is considered dead or de-energized.

Dead V2 Maximum Voltage

Range: 0.00 to 1.25 pu in steps of 0.01
Default: 0.30 pu

This setting specifies a maximum voltage magnitude for V_2 in per-unit values. At values less than this magnitude, the V_2 voltage input that is used for synchrocheck is considered dead or de-energized.

Live V1 Minimum Voltage

Range: 0.00 to 1.25 pu in steps of 0.01
Default: 0.70 pu

This setting specifies a minimum voltage magnitude for V_1 in per-unit values. At values greater than this magnitude, the V_1 voltage input that is used for synchrocheck is considered live or energized.

Live V2 Minimum Voltage

Range: 0.00 to 1.25 pu in steps of 0.01
Default: 0.70 pu

This setting specifies a minimum voltage magnitude for V_2 in per-unit values. At values greater than this magnitude, the V_2 voltage input that is used for synchrocheck is considered live or energized.

Events

Range: Enabled, Disabled
Default: Enabled

This setting enables and disables the logging of synchrocheck events in the sequence of events recorder.

The figures show the logic for the synchrocheck element.

Figure 27: Synchrocheck scheme logic, sheet 1 of 2

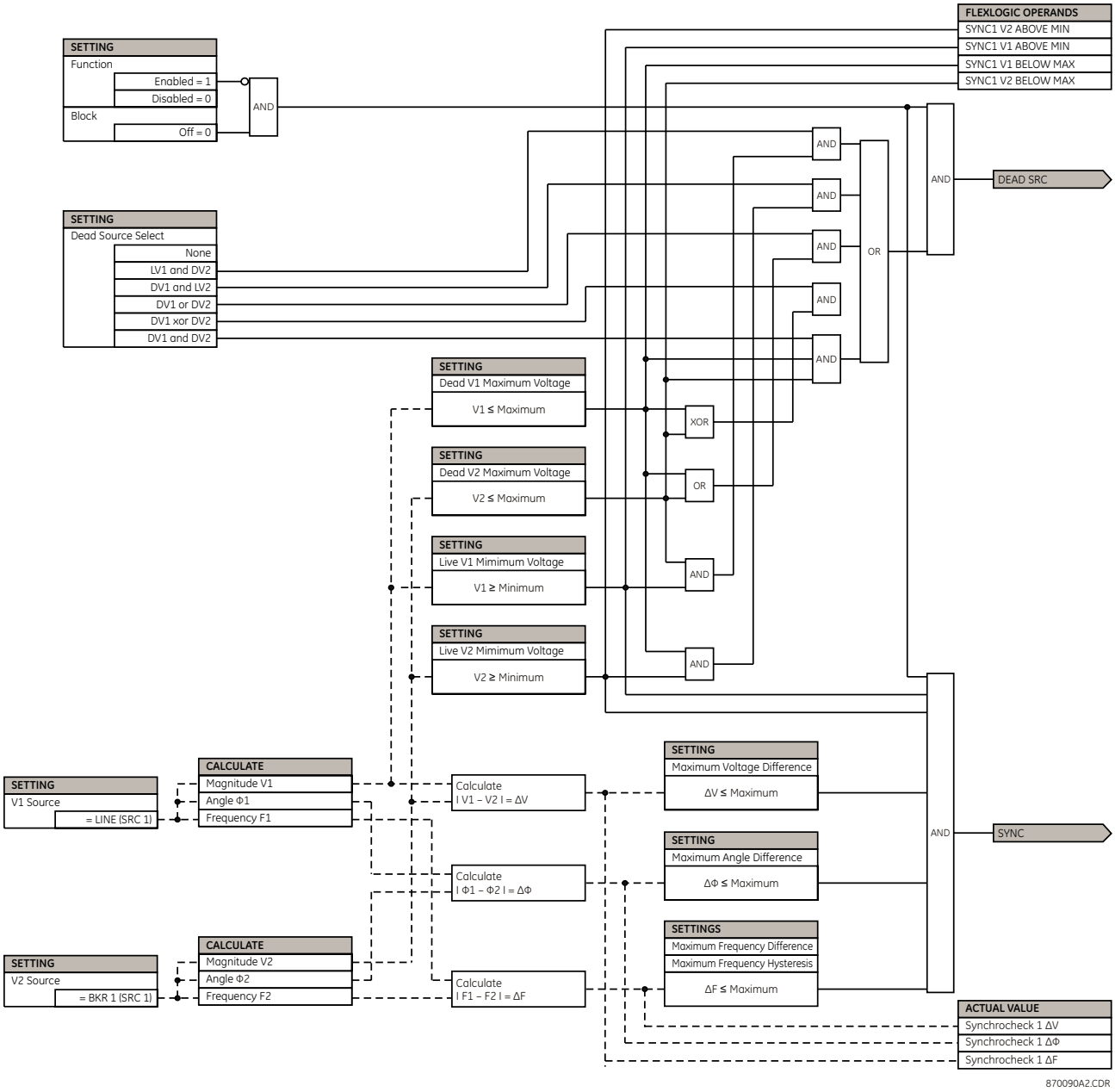
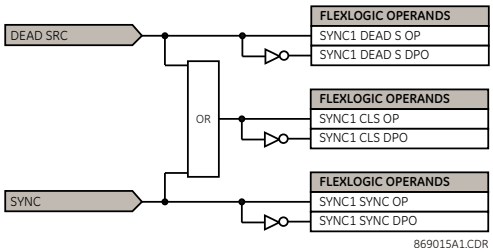


Figure 28: Synchrocheck scheme logic, sheet 2 of 2



Selector switch

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

Selector switch operation

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

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

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

Figure 29: Time-out mode

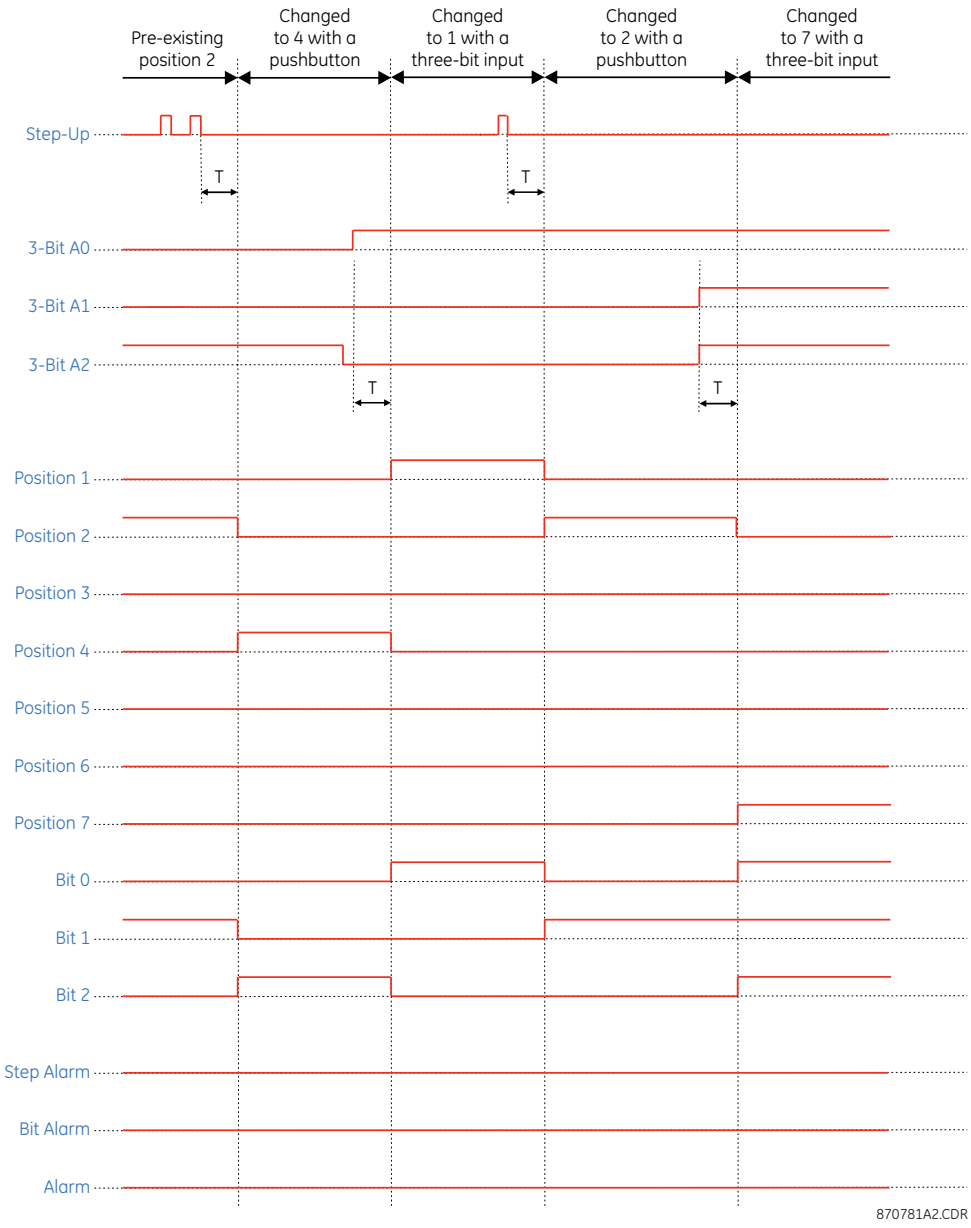
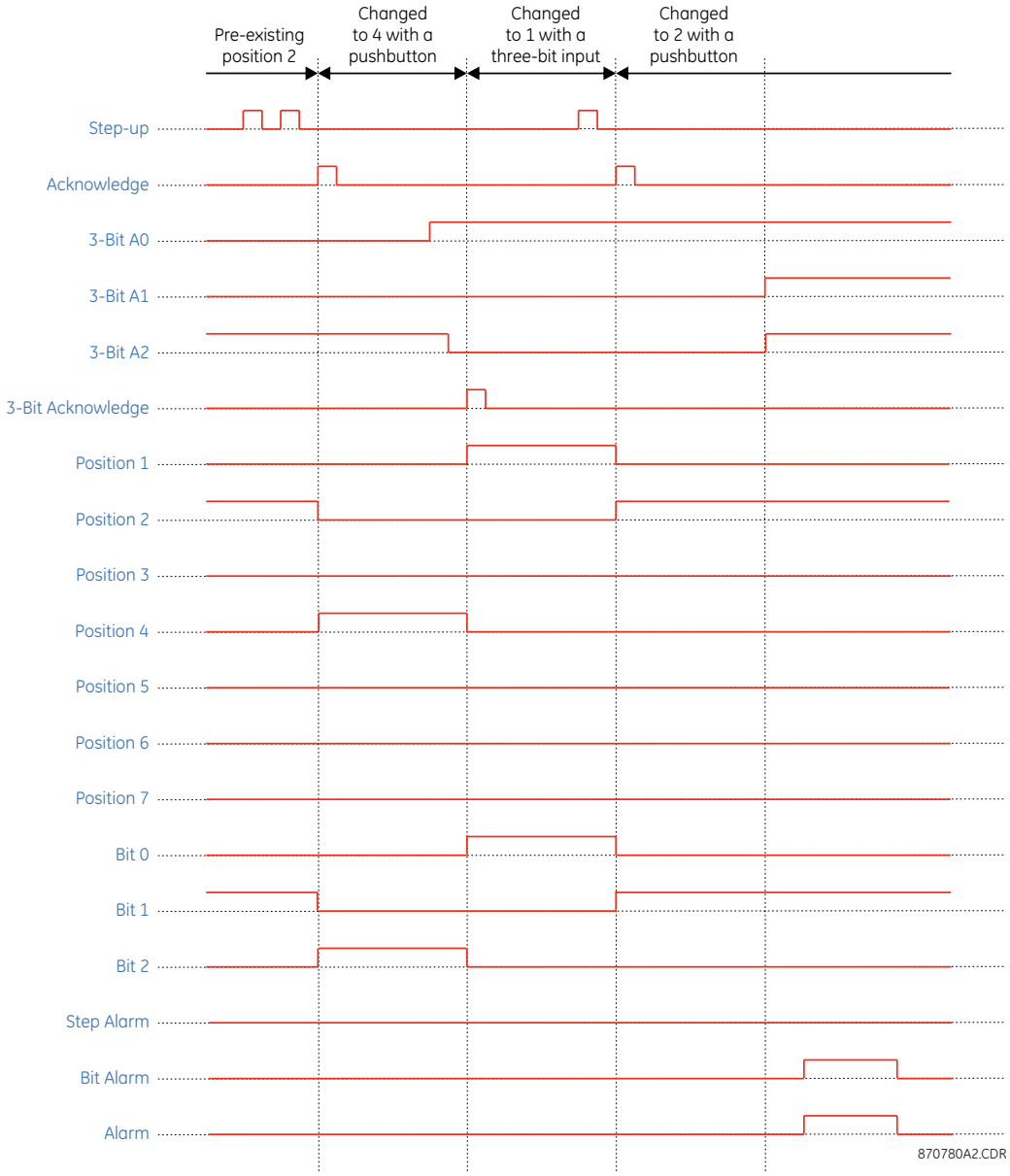


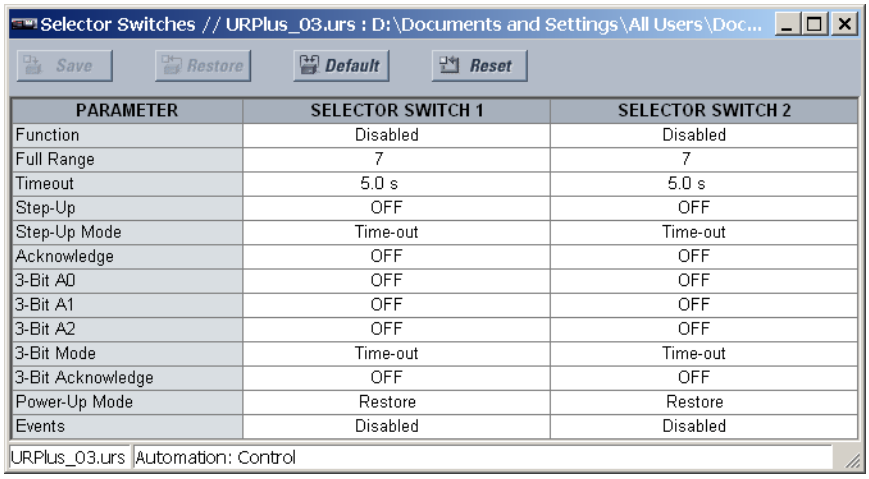
Figure 30: Acknowledge mode



Selector switch settings

Select the **Settings > Automation > Control > Selector Switches** menu item to open the selector switch configuration window.

Figure 31: Selector switch configuration settings



PARAMETER	SELECTOR SWITCH 1	SELECTOR SWITCH 2
Function	Disabled	Disabled
Full Range	7	7
Timeout	5.0 s	5.0 s
Step-Up	OFF	OFF
Step-Up Mode	Time-out	Time-out
Acknowledge	OFF	OFF
3-Bit A0	OFF	OFF
3-Bit A1	OFF	OFF
3-Bit A2	OFF	OFF
3-Bit Mode	Time-out	Time-out
3-Bit Acknowledge	OFF	OFF
Power-Up Mode	Restore	Restore
Events	Disabled	Disabled

The following settings are available for each selector switch.

Function

Range: Enabled, Disabled

Default: Disabled

This setting enables and disables the selector switch.

Full Range

Range: 1 to 7 in steps of 1

Default: 7

This setting specifies the upper position of the selector switch. When stepping up through available positions of the selector, the upper position wraps up to the lower position (position 1). When using a direct three-bit control word for programming the selector to a desired position, the change takes place only if the control word is within the range of 1 to the full range. If the control word is outside the range, an alarm is established by activating the SELECTOR ALARM operand for 3 seconds.

Timeout

Range: 3.0 to 60.0 seconds in steps of 0.1

Default: 5.0 seconds

This setting specifies the time-out period for the selector. This value is used by the relay in two ways. When the **Step-Up Mode** is "Time-out", the setting specifies the required period of inactivity of the control input after which the pre-selected position is automatically applied. When the **Step-Up Mode** is "Acknowledge", the setting specifies the period of time for the acknowledging input to appear. The timer is re-started by any activity of the control input. The acknowledging input must come before this timer expires; otherwise, the change does not take place and an alarm is set.

Step-Up

Range: any automation logic operand or shared operand

Default: OFF

This setting selects a control input for the selector switch. The switch is shifted to a new position at each rising edge of this signal. The position changes incrementally, wrapping up from the last (the **Full Range** value) to the first (position 1). Consecutive pulses of this control operand must not occur faster than every 50 ms. After each rising edge of the assigned operand, the time-out timer is restarted. The pre-selected position is applied after the selector times out (time-out mode), or when the acknowledging signal appears before the element times out (acknowledge mode). Typically, a user-programmable pushbutton is configured as the stepping up control input.

Step-Up Mode

Range: Time-out, Acknowledge

Default: Time-out

This setting defines the selector mode of operation. When set to "Time-out", the selector will change its position after a pre-defined period of inactivity at the control input. The change is automatic and does not require any explicit confirmation of the intent to change the selector's position. When set to "Acknowledge", the selector changes its position only after the intent is confirmed through a separate acknowledging signal. If the acknowledging signal does not appear within a pre-defined period of time, the selector does not accept the change and an alarm is established by setting the SELECTOR STP ALARM output FlexLogic operand for 3 seconds.

To activate a selector switch via the front panel, this setting should select the corresponding pushbutton operand (for example, PUSHBUTTON 1 ON). Note that this operand will only be asserted if the corresponding pushbutton element has been enabled

Acknowledge

Range: any automation logic operand or shared operand

Default: OFF

This setting selects an acknowledging input for the stepping up control input. The pre-selected position is applied on the rising edge of the assigned operand. This setting is active only under the acknowledge mode of operation. The acknowledging signal must appear within the time defined by the **Timeout** setting after the last activity of the control input. A user-programmable pushbutton is typically configured as the acknowledging input.

3-Bit A0, 3-Bit A1, 3-Bit A2

Range: any automation logic operand or shared operand

Default: OFF

These settings specify a three-bit control input of the selector. The three-bit control word pre-selects the position using the following encoding convention.

Table 2: Selector switch three-bit control word

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

The rest position (0, 0, 0) does not generate an action and is intended for situations when the device generating the three-bit control word is having a problem. When in time-out mode, the pre-selected position is applied in the time specified (in seconds) by the **Timeout** setting after the last activity of the three-bit input. When in acknowledge mode, the pre-selected position is applied on the rising edge of the acknowledging input specified by the **3-Bit Acknowledge** setting.

The stepping up control input (selected by the **Step-Up** setting) and the three-bit control inputs (A0, A1, and A2) lock-out mutually. Once the stepping up sequence is initiated, the three-bit control input is inactive; once the three-bit control sequence is initiated, the stepping up input is inactive.

3-Bit Mode

Range: Time-out, Acknowledge
Default: Time-out

This setting selects the selector mode of operation. When set to "Time-out", the selector changes its position after a pre-defined period of inactivity at the control input. The change is automatic and does not require explicit confirmation to change the selector position. When set to "Acknowledge", the selector changes its position only after confirmation through a separate acknowledging signal. If the acknowledging signal does not appear within a pre-defined period of time, the selector rejects the change and an alarm established by invoking the SELECTOR BIT ALARM FlexLogic operand for 3 seconds.

3-Bit Acknowledge

Range: any automation logic operand or shared operand
Default: OFF

This setting selects an acknowledging input for the three-bit control input. The pre-selected position is applied on the rising edge of the assigned operand. This setting is active only under the acknowledge mode of operation. The acknowledging signal must appear within the time defined by the **Timeout** setting after the last activity of the three-bit control inputs. Note that the stepping up control input and three-bit control input have independent acknowledging signals (the SELECTOR 1 ACK and SELECTOR 1 3BIT ACK operands, accordingly).

Power-Up Mode

Range: Restore, Synchronize, Sync/Restore
Default: Restore

This setting selects the selector switch behavior on power up of the relay.

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

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

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

Events

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the logging of selector switch events in the sequence of events recorder. If enabled, the following events are logged.

Selector switch events

SELECTOR 1 POS 1..... Selector 1 changed its position to 1.
SELECTOR 1 POS 2..... Selector 1 changed its position to 2.
SELECTOR 1 POS 3..... Selector 1 changed its position to 3.
SELECTOR 1 POS 4..... Selector 1 changed its position to 4.

SELECTOR 1 POS 5 ..... Selector 1 changed its position to 5.

SELECTOR 1 POS 6 ..... Selector 1 changed its position to 6.

SELECTOR 1 POS 7 ..... Selector 1 changed its position to 7.

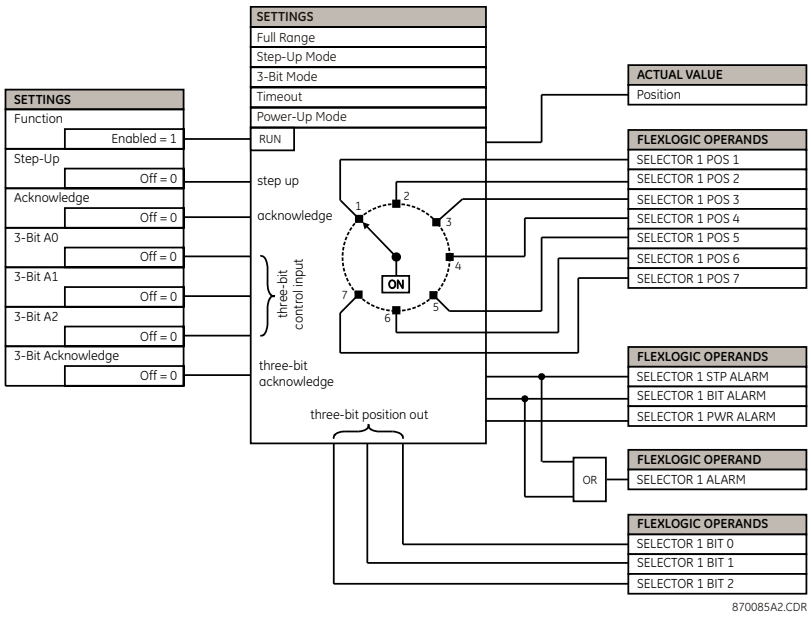
SELECTOR 1 STP ALARM The selector position pre-selected via the stepping up control input has not been confirmed before the time out.

SELECTOR 1 BIT ALARM The selector position pre-selected via the three-bit control input has not been confirmed before the time out.

SELECTOR 2 ..... The set of events shown above are available for selector switch 2.

The figure shows the logic diagram for the selector switch.

Figure 32: Selector switch logic



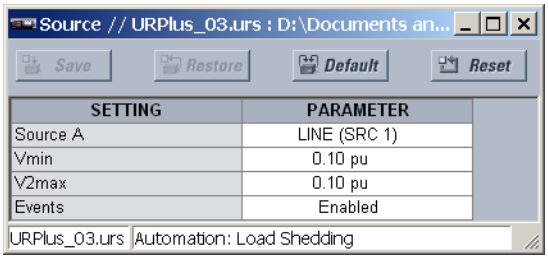
Load shedding

Multiple stages of underfrequency, undervoltage, and frequency rate of change elements can be used to initiate load shedding or remedial actions schemes. These elements can also initiate frequency-based load restoration schemes during lack of generation in the network or due to sudden load drops. The advanced automation capabilities of the C90^{Plus} allow flexible special protection schemes, advanced load shedding schemes, and load restoration schemes to be built.

Load shedding source

Select the **Settings > Automation > Load Shedding > Source** menu item to open the load shedding sources configuration window.

Figure 33: Load shedding source configuration window



The settings specify the characteristics of the source used for the load shedding functions (underfrequency, undervoltage, and frequency rate of change). The following settings are available.

Source A

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)
Default: LINE (SRC 1)

This setting selects the source to use for the load shedding functions (underfrequency, undervoltage, and frequency rate of change).

Minimum Voltage

Range: 0.00 to 1.25 pu in steps of 0.01
Default: 0.10 pu

This setting specifies the minimum phase-to-phase voltage required on all three phases for operation of the load shedding feature. That is, if any phase-to-phase voltage is less than the value specified by this setting, the LS SOURCE INVALID operand operates after 100 ms and all load shedding elements are then blocked. If this setting is programmed to zero, then its logic is effectively ignored and LS SOURCE INVALID operand is not asserted because of any level of phase-to-phase voltage, including zero.

Maximum V_2

Range: 0.05 to 1.25 pu in steps of 0.01
Default: 0.10 pu

This setting specifies the maximum level of negative-sequence voltage permitted for operation of the load shedding elements. If the negative-sequence voltage reaches or exceeds the values specified by the **Minimum Voltage** setting, then the LS SOURCE INVALID operand will operate after 100 ms and all load shedding elements will then be blocked.

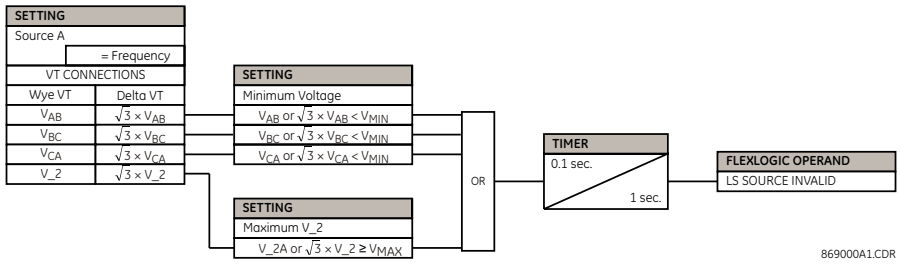
Events

Range: Disabled, Enabled
Default: Enabled

This setting enables and disables the logging of load shedding source events in the sequence of events recorder.

The figure is the load shedding source logic diagram.

Figure 34: Load shedding source logic

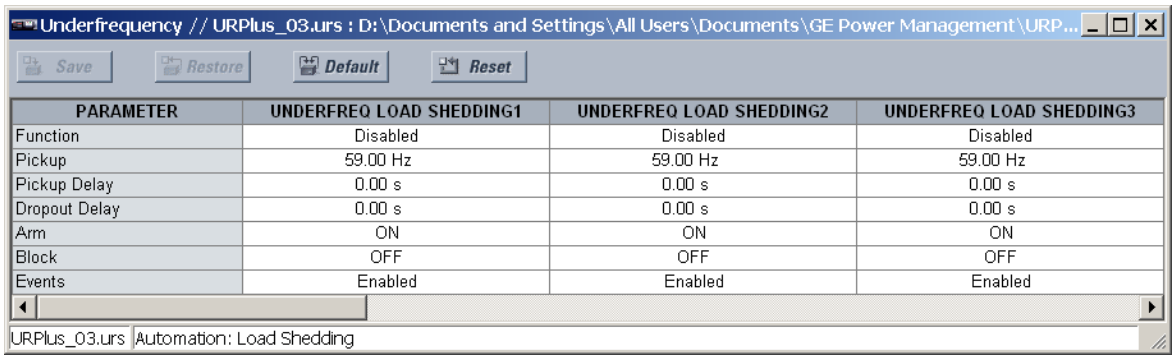


Underfrequency load shedding

There are ten (10) underfrequency load shedding elements.

Select the **Settings > Automation > Load Shedding > Underfrequency** menu item to open the underfrequency load shedding configuration window.

Figure 35: Underfrequency load shedding configuration window



PARAMETER	UNDERFREQ LOAD SHEDDING1	UNDERFREQ LOAD SHEDDING2	UNDERFREQ LOAD SHEDDING3
Function	Disabled	Disabled	Disabled
Pickup	59.00 Hz	59.00 Hz	59.00 Hz
Pickup Delay	0.00 s	0.00 s	0.00 s
Dropout Delay	0.00 s	0.00 s	0.00 s
Arm	ON	ON	ON
Block	OFF	OFF	OFF
Events	Enabled	Enabled	Enabled

The following settings are available for each underfrequency load shedding element.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the underfrequency load shedding function.

Pickup

Range: 45.00 to 65.00 Hz in steps of 0.01
Default: 59.00 Hz

This setting specifies the pickup level for the underfrequency load shedding element. For example, if the system frequency is 60 Hz and load shedding is required at 59.5 Hz, the setting will be 59.50 Hz.

Pickup Delay

Range: 0.00 to 99.99 seconds in steps of 0.01
Default: 0.00 seconds

This setting specifies a time delay on pickup for the duration between the pickup and operate output states of the underfrequency load shedding element.

Dropout Delay

Range: 0.00 to 99.99 seconds in steps of 0.01
Default: 0.00 seconds

This setting specifies a time delay on dropout for the duration between the operate output state and the return to logic 0 after the input transits outside the defined pickup range.

Arm

Range: any automation logic operand or shared operand
Default: ON

Assertion of the operand assigned to this setting arms the underfrequency load shedding element.

Block

Range: any automation logic operand or shared operand
Default: OFF

Assertion of the operand assigned to this setting blocks operation of the underfrequency load shedding element.

Events

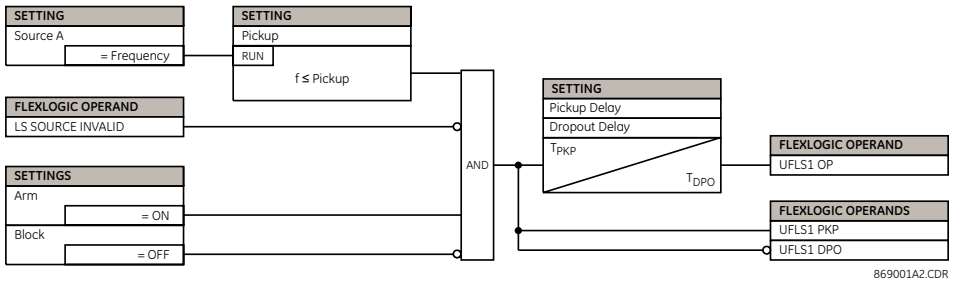
Range: Enabled, Disabled

Default: Enabled

This setting enables and disables the logging of underfrequency load shedding events in the sequence of events recorder.

The figure is the logic diagram for the underfrequency load shedding function.

Figure 36: Underfrequency load shedding logic

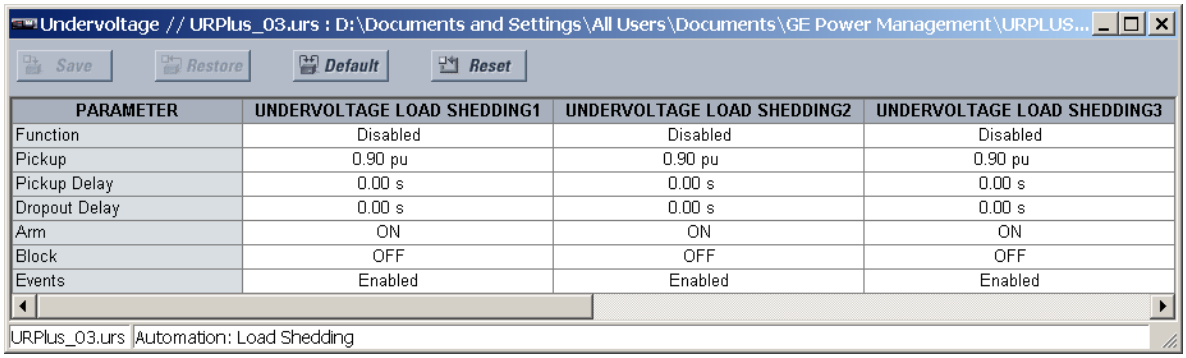


Undervoltage load shedding

There are six undervoltage load shedding elements.

Select the **Settings > Automation > Load Shedding > Undervoltage** menu item to open the undervoltage load shedding configuration window.

Figure 37: Undervoltage load shedding configuration window



PARAMETER	UNDERVOLTAGE LOAD SHEDDING1	UNDERVOLTAGE LOAD SHEDDING2	UNDERVOLTAGE LOAD SHEDDING3
Function	Disabled	Disabled	Disabled
Pickup	0.90 pu	0.90 pu	0.90 pu
Pickup Delay	0.00 s	0.00 s	0.00 s
Dropout Delay	0.00 s	0.00 s	0.00 s
Arm	ON	ON	ON
Block	OFF	OFF	OFF
Events	Enabled	Enabled	Enabled

The following settings are available for each undervoltage load shedding element.

Function

Range: Enabled, Disabled

Default: Disabled

This setting enables and disables the undervoltage load shedding function.

Pickup

Range: 0.10 to 1.25 pu in steps of 0.01

Default: 0.90 pu

This setting specifies the pickup level for the undervoltage load shedding element.

Pickup Delay

Range: 0.00 to 99.99 seconds in steps of 0.01

Default: 0.00 seconds

This setting specifies a time delay on pickup for the duration between the pickup and operate output states of the undervoltage load shedding element.

Dropout Delay

Range: 0.00 to 99.99 seconds in steps of 0.01
Default: 0.00 seconds

This setting specifies a time delay on dropout for the duration between the operate output state and the return to logic 0 after the input transits outside the defined pickup range.

Arm

Range: any automation logic operand or shared operand
Default: ON

Assertion of the operand assigned to this setting arms the undervoltage load shedding element.

Block

Range: any automation logic operand or shared operand
Default: OFF

Assertion of the operand assigned to this setting blocks operation of the undervoltage load shedding element.

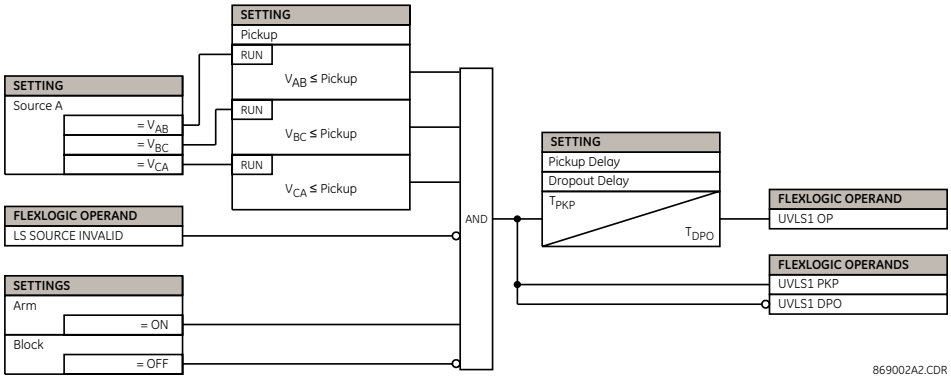
Events

Range: Enabled, Disabled
Default: Enabled

This setting enables and disables the logging of undervoltage load shedding events in the sequence of events recorder.

The figure is the logic diagram for the undervoltage load shedding function.

Figure 38: Undervoltage load shedding logic

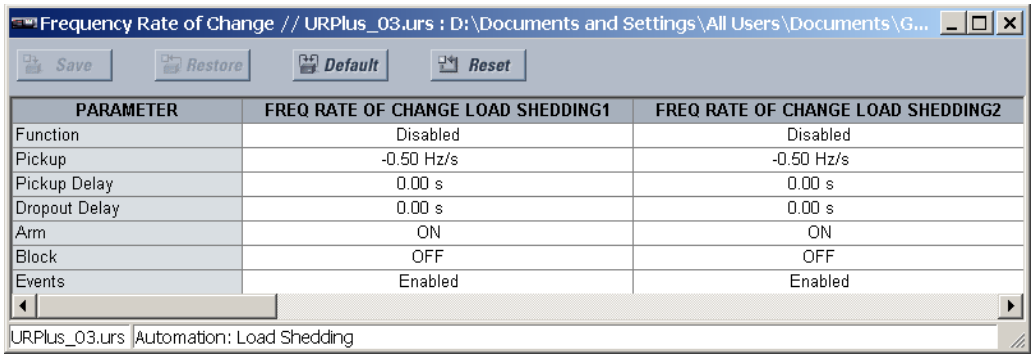


Frequency rate of change load shedding

There are four frequency rate of change load shedding elements.

Select the **Settings > Automation > Load Shedding > Frequency Rate of Change** menu item to open the frequency rate of change load shedding configuration window.

Figure 39: Frequency rate of change load shedding configuration window



The following settings are available for each frequency rate of change load shedding element.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the frequency rate of change load shedding function.

Pickup

Range: –15.00 to –0.10 Hz/second in steps of 0.01
Default: –0.50 Hz/second

This setting specifies the pickup level for the frequency rate of change load shedding element.

Pickup Delay

Range: 0.00 to 99.99 seconds in steps of 0.01
Default: 0.00 seconds

This setting specifies a time delay on pickup for the duration between the pickup and operate output states of the frequency rate of change load shedding element.

Dropout Delay

Range: 0.00 to 99.99 seconds in steps of 0.01
Default: 0.00 seconds

This setting specifies a time delay on dropout for the duration between the operate output state and the return to logic 0 after the input transits outside the defined pickup range.

Arm

Range: any automation logic operand or shared operand
Default: ON

Assertion of the operand assigned to this setting arms the frequency rate of change load shedding element.

Block

Range: any automation logic operand or shared operand
Default: OFF

Assertion of the operand assigned to this setting blocks operation of the frequency rate of change load shedding element.

Events

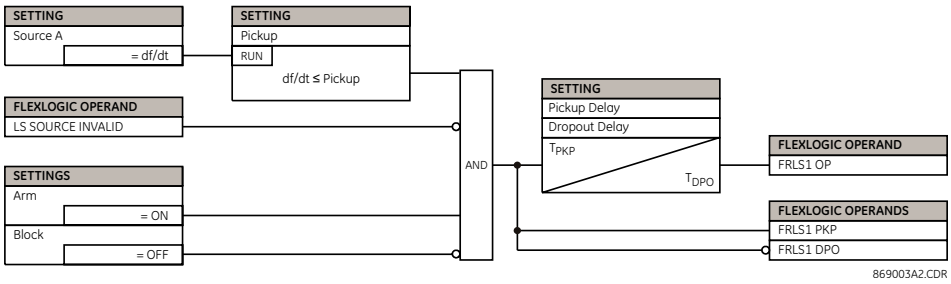
Range: Enabled, Disabled

Default: Enabled

This setting enables and disables the logging of frequency rate of change load shedding events in the sequence of events recorder.

The figure is the logic diagram for the frequency rate of change load shedding function.

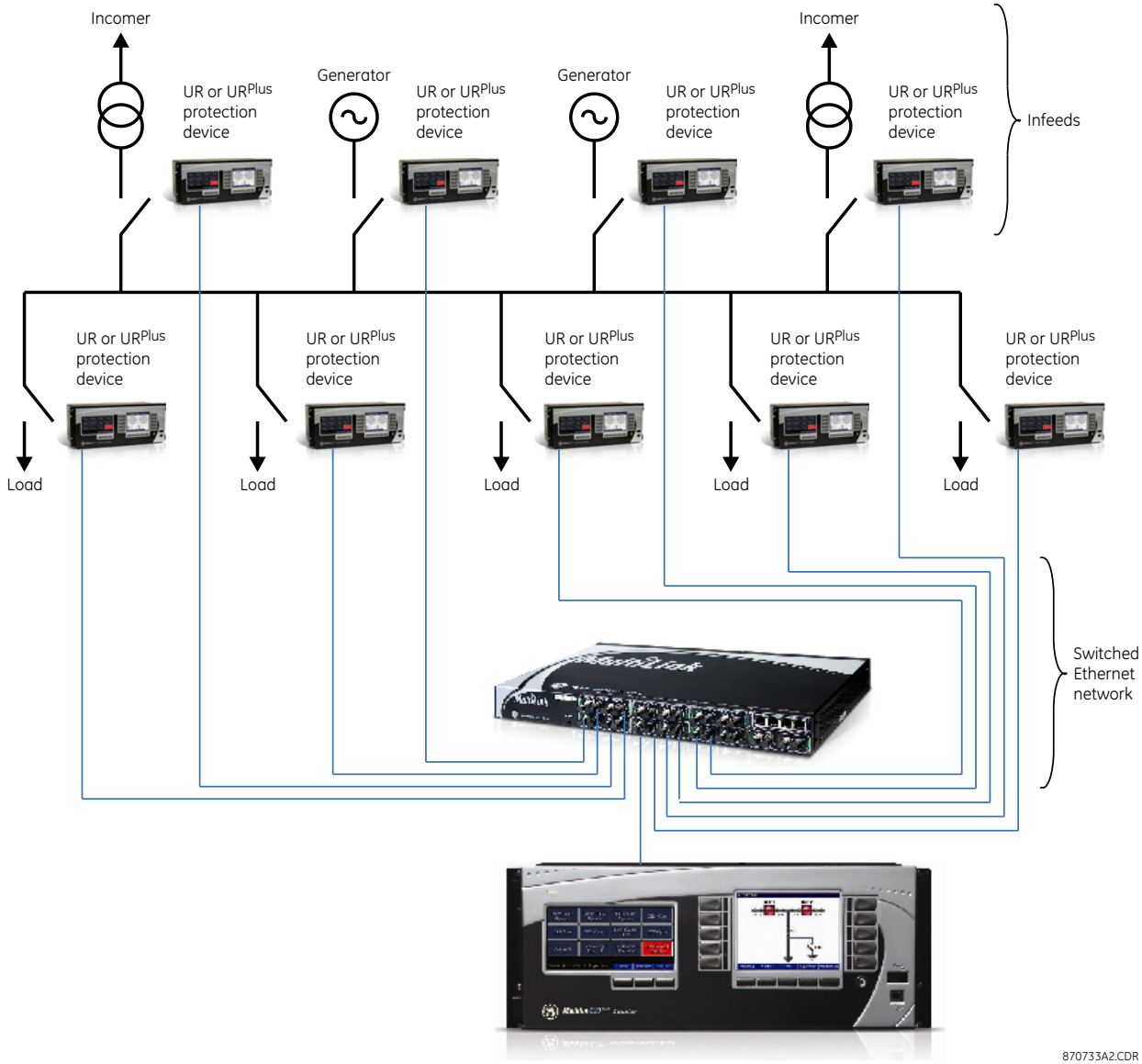
Figure 40: Frequency rate of change load shedding logic



Fast load shedding

Fast load shedding is a remedial action scheme that in a contingency initiates shedding of loads as required to preserve system load/generation balance, thereby avoiding complete system collapse. A contingency here is the loss of one or more infeeds (local generators or of incomers from the grid). Unlike undervoltage, underfrequency or frequency rate of change load shedding schemes, fast load shedding schemes can initiate load shedding before the system frequency or system voltage declines, which in many cases is essential for maintaining system stability.

Figure 41: Representative system with fast load shedding



The representative system shown above is used to explain the operation of fast load shedding at a high level. The main features of an industrial campus electrical power distribution system are represented. The distribution system is supplied by infeeds: a collection of incomers from the grid transmission system and local generators. The distribution system in turn supplies a large number of individual loads, a few of which are shown. The local generators may be used to maintain operation of some or all of the campus processes in the event of loss of grid incomers and separation from the grid. Local generators may also be used to make more efficient use of fuel required for process heat (for example, co-generation), thus reducing the amount of energy purchased from the grid. In some cases, local generation may be sold to the grid for profit. The number of local generators actually connected and the amount of power each generates varies over time. This can be the result of the availability of the local generators, the present cost of grid energy, and the present demand of the manufacturing process load.

The physics of electrical systems forces the sum of the real power generated by local generation and the real power imported from the grid to precisely equal the sum of the real power consumed by the loads plus the amount of real power if any exported to the

grid, at all times and at every instant. If a local generator is tripped, or a grid incomer is lost, the physics forces additional power to be drawn from the remaining grid incomers and local generators to match the load. Increased power flow through an incomer can overload it, causing it to trip and leading to cascading tripping and total collapse of the distribution system. Increased power flow out of a generator can cause it to slow, and if the prime mover cannot provide additional mechanical power rapidly enough, lead to frequency collapse of the campus distribution system.

Fast load shedding prevents such system collapse by shedding the number of loads required to respect the amount of power that remaining infeeds can safely supply. Less critical loads are shed so that more critical loads are maintained, and the manufacturing process suffers the minimum impact possible.

Introduction to the fast load shed controller

The C90^{Plus} fast load shed (FLS) element can be used either as a fast load shed controller or as an aggregator. A fast load shed controller (FLSC) is the device that makes the final load shedding decisions in real time. An aggregator is a device that combines load information from multiple end devices into a single message, to extend the number of loads an FLSC can control. An end device for the purposes described here is an IED that monitors, controls, and typically protects the infeeds and sheddable loads, as well as interfaces with a controller/aggregator to the process equipment.

An FLSC is configured to shed load groups in the event of a contingency according to a set of priorities or trip masks. For the purposes described here a contingency is the loss of any one or more infeeds. A load group is a number of individual loads that are treated by the fast load shedding scheme as a single unit, allowing the FLSC to handle thousands of individual loads with a manageable number of settings. Priorities are numbers assigned to each load group, used when the FLSC is in adaptive mode to instruct the FLSC on the relative importance of the load groups. A trip mask is a scenario setting used when the FLSC is in static mode specifying which load groups to shed for the associated scenario. A scenario is a specific contingency, the presence of which is calculated by FlexLogic in the FLSC using the infeed offline status values and perhaps other information. An example of a scenario is incomer T1 going offline while generator G1 is out of service.

The priorities/trip masks may contain permanent setting values, or an external computer can be set up to continuously adjust the priorities/trip mask as required by changing process needs.

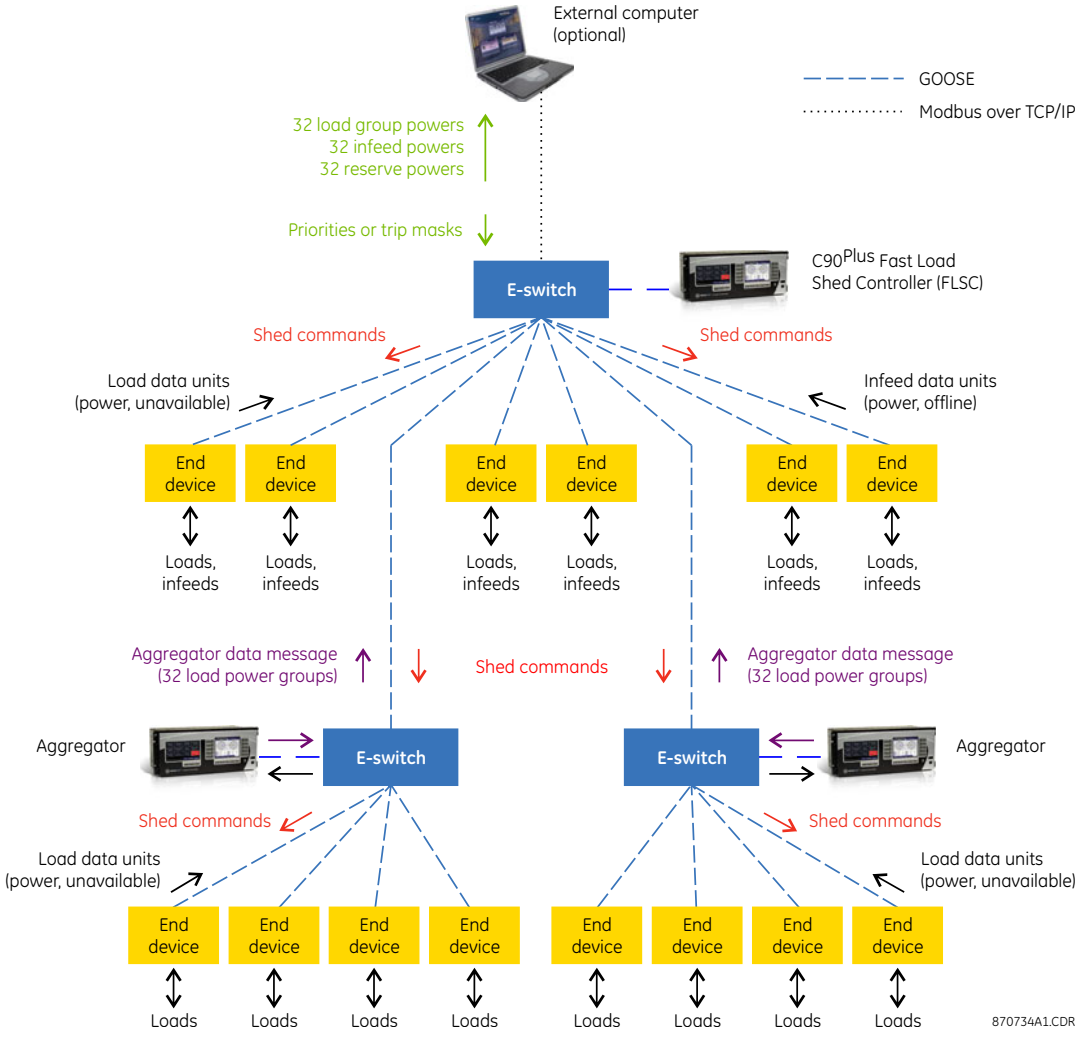
The FLSC is informed of present system power flows and of contingencies via data messages received from end devices, aggregators, or both. The information received by an FLSC or by an aggregator in a data message about a load, an infeed or an aggregator is referred to as a data unit. Based on settings, on the information in data units, and on the present priorities or trip masks values, the controller generates shed requests indicating which load groups are required to be shed by the end devices. The shed requests are transmitted to the end devices in a shed command message; the end devices do the actual shedding. Data messages and shed commands are per the IEC 61850-8-1 GOOSE specification, and so the C90^{Plus} FLS element may be used with many types of IEDs that support the protocol, including GE Digital Energy's UR-series, UR^{Plus}-series, and F650 protection systems.

The FLSC receives load and infeed information from up to a combined total of 64 end devices and aggregators, plus 6 local loads and infeeds. Each aggregator receives information from up to a total of 64 loads and aggregators, plus 6 local loads and infeeds. Thus it is possible to have an installation with 12 infeeds, 18 loads, and 40 aggregators, each aggregator with 64 loads, all this supporting a total of 12 infeeds and $40 \times 64 + 18 = 2578$ sheddable loads.

FLS scheme communications

End devices send to an FLSC or an aggregator six data units in a single data message. Not all of the data units in a data message need be used. Infeed data units contain the measured real power flowing out of the infeed and the offline status of the infeed. Change of offline status from "Off" to "On" is indication of the loss or eminent loss of that infeed; that is, a contingency. Load data units contain the measured real power flowing into the load and the unavailability status of the load for fast load shedding. Loads with unavailability status of "On" are not included when calculating the amount of sheddable load there is at present in a load group. It is possible for a data message to contain both infeed and load data units. Data messages with infeed data units should be sent directly to the FLSC.

Figure 42: FLS scheme communications



Aggregators send to the FLSC (or conceivably to another higher level aggregator) a single data message. Aggregator data messages contain 32 load group powers. Each load group power is the sum of the powers of the load data units that are available for shedding and are aggregated by that aggregator to that load group.

The FLSC sends back down to the end devices an individual shed request operand for each of the load groups used by the application, typically all in a single shed command GOOSE. The shed commands are sent directly to all end devices via the switched network.

The up to 64 data messages an FLSC or aggregator can receive are completely independent of the other GOOSE facilities provided by the C90^{Plus}. These other GOOSE receive facilities can continue to be used for other purposes. However, in the FLSC, one of the platform's configurable GOOSE transmit messages is typically used to transmit shed commands. In aggregators, one of the platform's configurable GOOSE transmit messages is typically used to transmit aggregator data messages.

UR-series end devices must use a configurable GOOSE to publish data messages for each six of its infeed or load data units. Data messages with infeed data units should use fast configurable GOOSE messages for fastest contingency detection at the FLSC. UR-series end devices interfacing to infeeds must also use a configurable GOOSE to subscribe to shed commands.

End device data messages

Both the FLSC and the aggregator expect the data messages from end devices to be composed in a particular manner. The infeed and load data messages are formatted as follows.

- The message must be compliant with IEC 61850-8-1 specifications for GOOSE messages.
- The destination MAC address must match the FLSC/aggregator's FLS MAC Address setting value.
- The GOOSE ID (goID) must match the FLSC/aggregator's FLS goID setting value, but with a suffix containing the data unit numbers of the data units in this message. Aggregator messages, which have power information for all data units, have as a suffix the letter "A". See the FLS element settings section for formatting information. Each data unit input to a given FLSC/aggregator must have a unique and valid data unit number, or undesirable behavior results.
- The first member of the data message dataset must be a Boolean, herein referred to as toggle. Its value is ignored by the FLSC/aggregator. It is intended that in UR-series end devices its value be toggled at the intended data unit update rate to force re-transmission in UR-series end devices using fast GOOSE messages, as UR-series fast GOOSE only transmits on change of state of a Boolean member. A Boolean must be present here even when the end device is not a UR-series device.
- The remaining dataset members in an infeed or load data message must be six pairs, each pair a Boolean followed by a FLOAT32. Each pair is the information in a data unit. For infeed data units, the Boolean is the offline status of the infeed, and the FLOAT32 is the measured infeed power. For load data units, the Boolean is the unavailability for shedding status, and the FLOAT32 is the measured load power. The unit of all powers is watts. There must be six pairs even if the end device publishes fewer than six actual data units; the values of unused pairs at the end of the dataset are ignored on receipt. Both the Boolean and FLOAT32 must be present in each pair, even where the power is not actually measured.

For UR-series end devices, data messages with infeed data units should use one of the two fast GOOSE messages for fastest contingency detection. Use of the aggressive retransmission curve setting value should be considered.

The following figures show a possible UR-series end device data message configuration with three load data units: 8, 2 and 17. Note that dataset members 8 through 13 are not used by the aggregator/FLSC, but are nevertheless filled in with attributes of valid logical nodes, in this case repeats of the third load data unit's attributes.

Figure 43: Possible load UR-series end device data message configuration

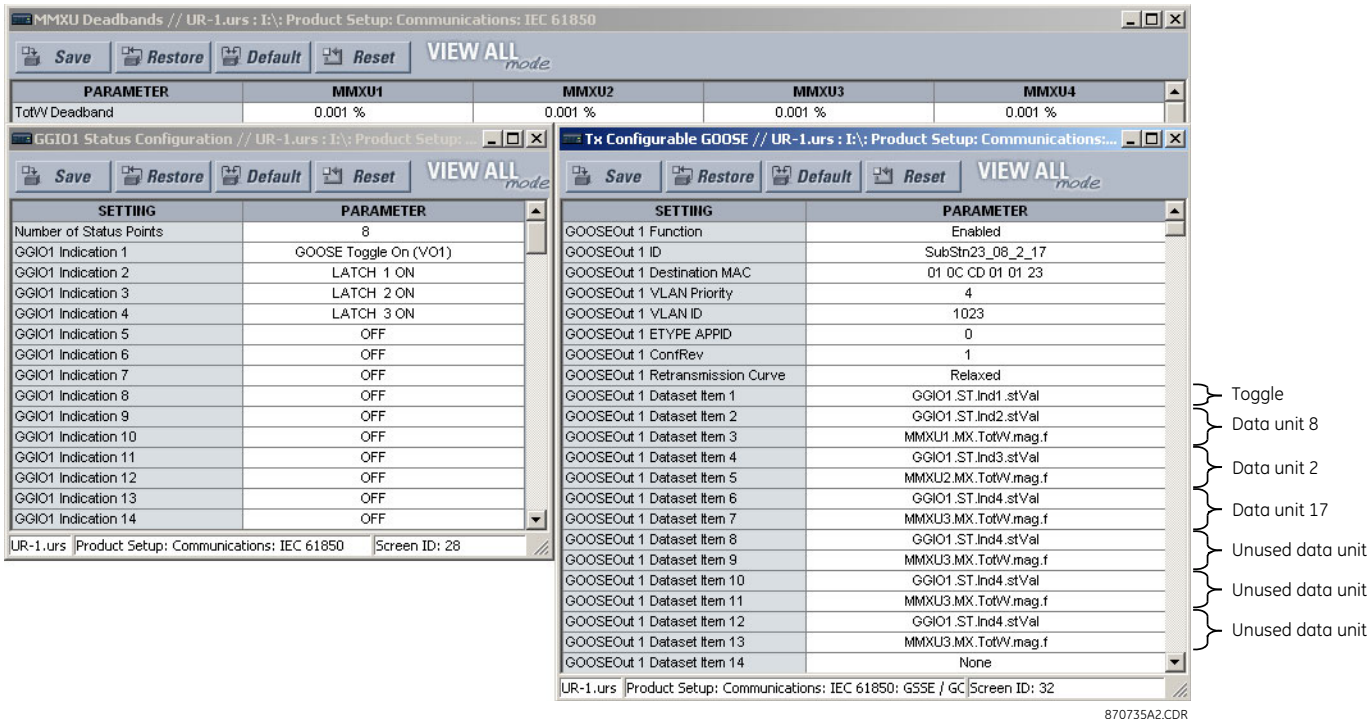
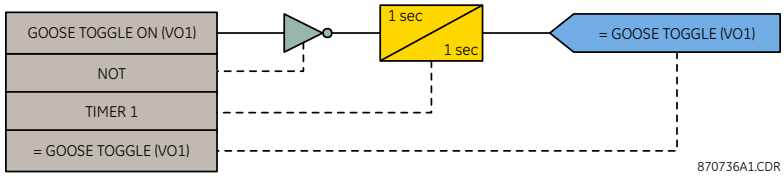


Figure 44: UR-series fast GOOSE toggle logic for 1 second toggle interval

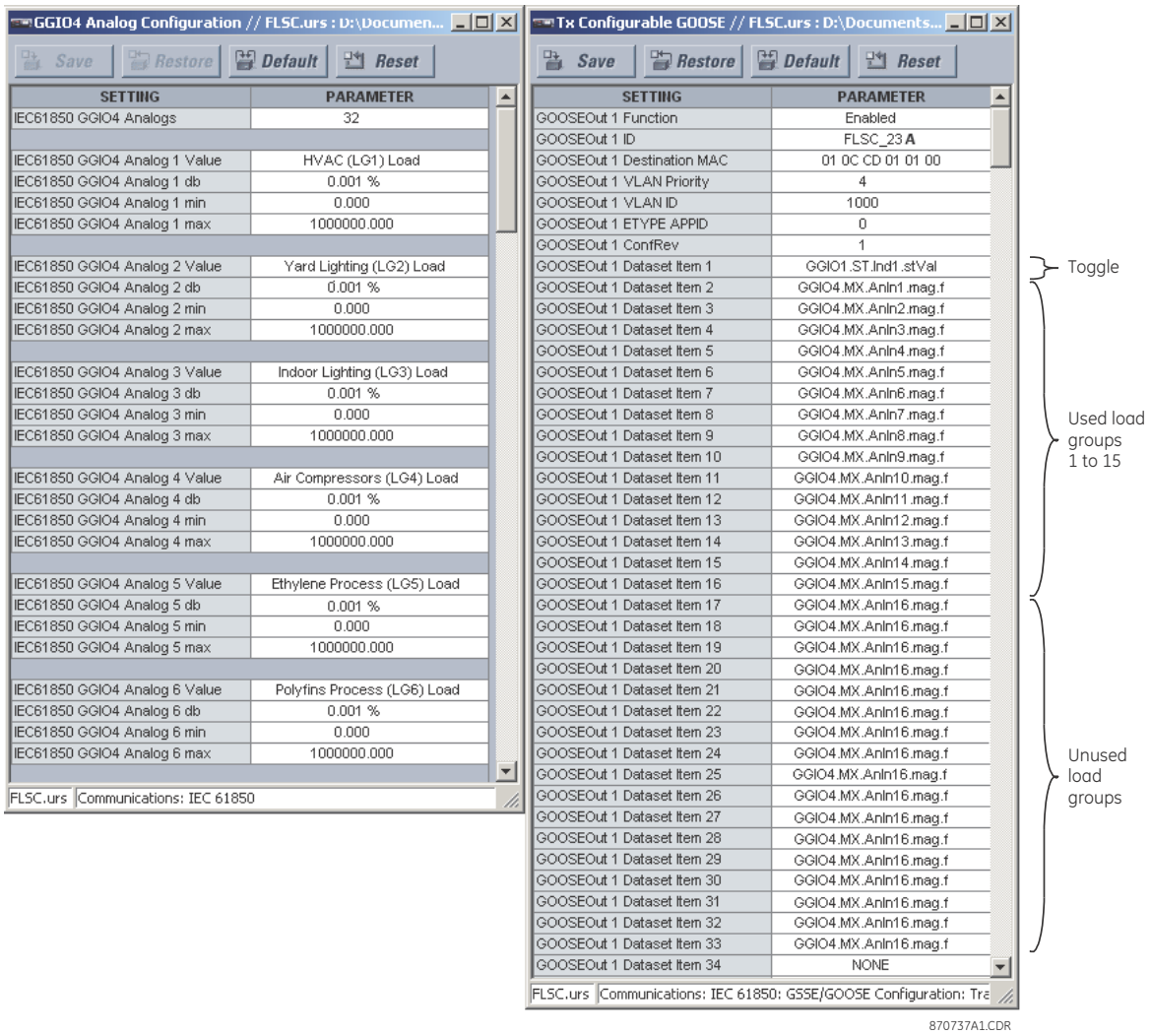


Aggregator data messages

Both the FLSC and the aggregators expect the aggregator data messages from aggregators to be composed with destination MAC address, GOOSE ID and first member (Toggle) as load/infeed data messages. Aggregator message dataset however must follow Toggle with 32 FLOAT32 members; that is, the content of one aggregator data unit. The value of the first of these FLOAT32 members must be the load aggregated by this aggregator for the first load group, the next FLOAT32 member the aggregated load of the second load group, and so on. All 32 FLOAT32 members must be present even if not all 32 load groups are used by the application.

The following figure shows a possible aggregator message configuration in application where only load groups 1 through 15 are used. The unused dataset members are populated with references to “Anln16”, which is mapped to an unused load group, and thus have zero values.

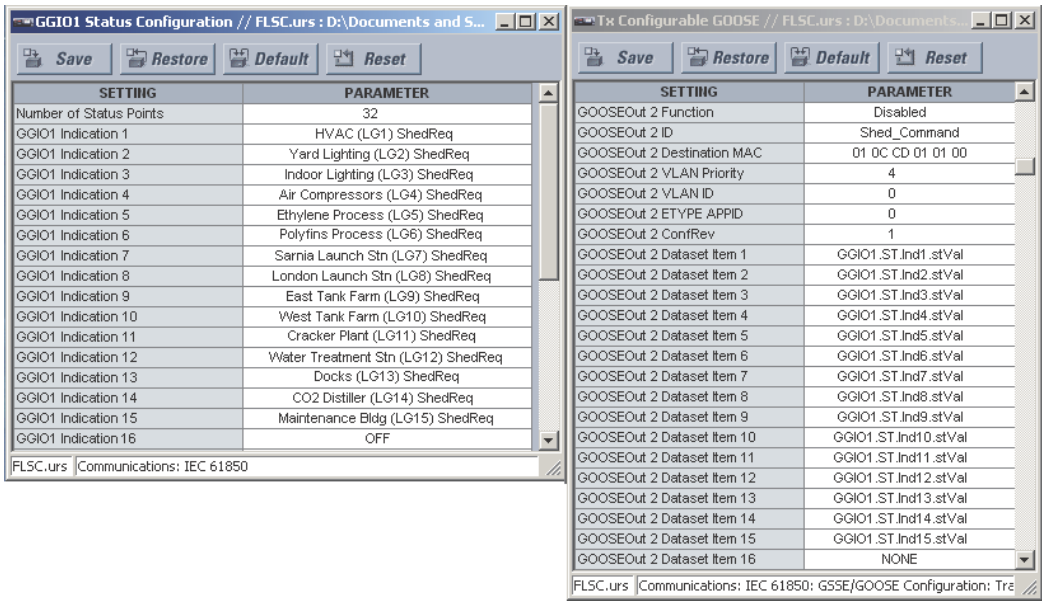
Figure 45: Possible aggregator data message configuration



Shed commands

Shed commands are created by the FLSC using a configurable GOOSE and GGIO1. They may be constructed in different ways. The following figure shows one possibility: in an application wherein only the first 15 of the 32 load groups are used. Any shed command structure that gets the shed requests to their destinations in a timely manner is acceptable.

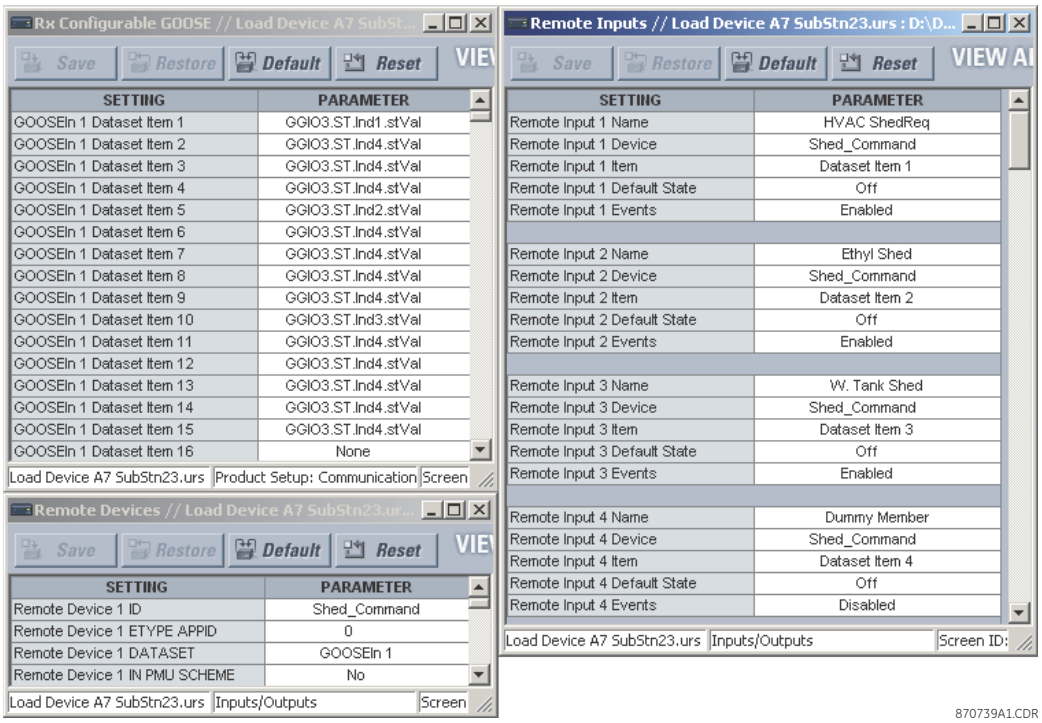
Figure 46: Example configuration for publishing shed commands



870738A1.CDR

The receiving end device must be configured to extract from the shed command the shed requests of the load groups to which its loads are assigned, and to trip any of its loads that have their shed request bit "On" and the unavailable for shedding status "Off". The following figure shows the configuration of a UR-series end device that interfaces three loads assigned to load groups 1, 5 and 10. Not shown here are settings that result in shedding the three loads when operands RI1, RI2, and RI3 ("GGIO3.ST.ind1.stVal", "GGIO3.ST.ind2.stVal", and "GGIO3.ST.ind3.stVal") become on. All shed requests present in the shed command must be configured to some Boolean, so here the unused shed requests are configured to "GGIO3.ST.ind4.stVal".

Figure 47: Example UR-series end device configuration for shed command subscription



Data message monitoring

The FLS element maintains a "timeAllowedtoLive" timer for each of the data units. This timer is reset to the "timeAllowedtoLive" value received in each data message containing that data unit. Should this timer ever time out, indicating loss of connection, the data unit's Comms Trbl and status operands are set to "On", and the data unit power value is set to zero. The FLSC uses the values of the Comms Trbl operands to prevent the loss of connection and the resulting change of offline status to "On" from initiating a contingency. The local data units, which do not use communications, do not have Comms Trbl operands.

An FLS Comms Trbl operand is set On while the Comms Trbl operand of any enabled data unit is On. This or the individual data unit Comms Trbl operands may be used to annunciate FLS scheme trouble conditions, and perhaps even to block the FLSC.

Fast load shed algorithm

The fast load shedding controller (FLSC) can operate in either static mode or adaptive mode. In the static mode, the shed requests required for each scenario (the trip masks) are either fixed and pre-configured within the FLSC, or are continuously pre-calculated and downloaded to the FLSC by an external computer system; the FLSC issues the scenario's shed requests should the scenario occur. In the adaptive mode, the FLSC moment-by-moment calculates the amount of load shedding required (that is, the load shed order) for the present situation, and issues shed requests as required to meet the load shed order and the present load group priorities.

In either mode, the FLSC continuously calculates the load available for shedding in each load group as: the sum of the power of all data units that are mapped to the load group and have unavailability for shedding status "Off", plus the sum of the corresponding power values of all aggregator data units.

Using the power values of data units mapped to infeeds and various infeed settings, the FLS element estimates the amount of additional power (that is, reserve power) each infeed can deliver in event of a contingency. Depending on the settings, the estimation can be either based on the infeed being able to immediately jump to its maximum power, or its increase being some fraction of its present power.

The steady-state value of the load, infeed and reserve is estimated using the average of each of these quantities over a 10 second period that does not include the most recent 2 seconds. These steady-state values are latched (frozen) when a contingency is first declared, and the latched values used till the contingency is over and the power system is assumed to have reached a new steady-state. This is done as the aim of the FLSC is to achieve a steady-state load/infeed balance, and instantaneous measurement values leading up to and during the contingency may contain unsustainable transients. For instance, should an incomer open at the utility's end, and the FLSC see its power zero when the offline status becomes "On", the estimate of power lost would be none were instantaneous power measurements used.

A contingency is declared in adaptive mode when any infeed is lost and in static mode when any of the programmed scenarios occurs. An infeed is deemed lost when its offline status transitions from "Off" to "On", other than due to loss of communications. A scenario is deemed to have occurred when its scenario operand transitions from "Off" to "On".

Both the infeed lost condition and the scenario occurred condition are latched till the end of the contingency. Each time an infeed is initially lost or a scenario initially occurs, the contingency timer is triggered or re-triggered. The contingency lasts till the contingency timer finally times-out. The contingency timer has a dropout setting intended to be set long enough that on time-out the power system ought to be in a new stable state.

A load shed order value is continuously calculated as the sum of the stead-state values of all lost infeed powers, less the sum of the steady-state reserves of all infeeds not lost. The load shed order is the amount of load shedding required to restore the load/infeed balance. A load shed order value less than zero indicates no shedding is required.

$$P_{shed} = \begin{cases} 0, & \text{if contingency timer is Off} \\ \sum_{\text{all } i} \begin{cases} +P_I[i] \text{ if } Lost[i] \\ -P_R[i] \text{ if not } Lost[i] \end{cases}, & \text{otherwise} \end{cases}$$

Eq. 3

where

- P_{shed} is the load shed order
- P_I [i] is the steady-state infeed power of infeed i
- P_R [i] is the steady-state reserve power of infeed i
- $Lost$[i] is the lost status of infeed i

When in the adaptive mode, in each protection pass sufficient shed request operands are set and latched such that the sum of the latched steady-state load group load values just exceed the load shed order. Load groups with lower priorities are shed in preference to load groups with higher priorities. Load groups with priority zero are not used. Load groups having the same priority are all shed when any needs to be shed.

Should a second infeed be lost (that is, should there be a multiple or evolving contingency) the above calculations will result in the load shed order increasing, and in general the number of shed requests also increasing.

Note that this algorithm does not need to monitor non-sheddable loads. However, all infeeds whose loss can cause a significant power imbalance or that can supply significant reserve should be monitored.

When in the static mode, in each protection pass each load group's shed request operand is set and latched when one of the 32 scenario operands is On and the bit in that scenario's trip mask corresponding to that load group is a one. The scenario operand values are calculated by user configured FlexLogic. Each scenario's trip mask has 32 bits, one for

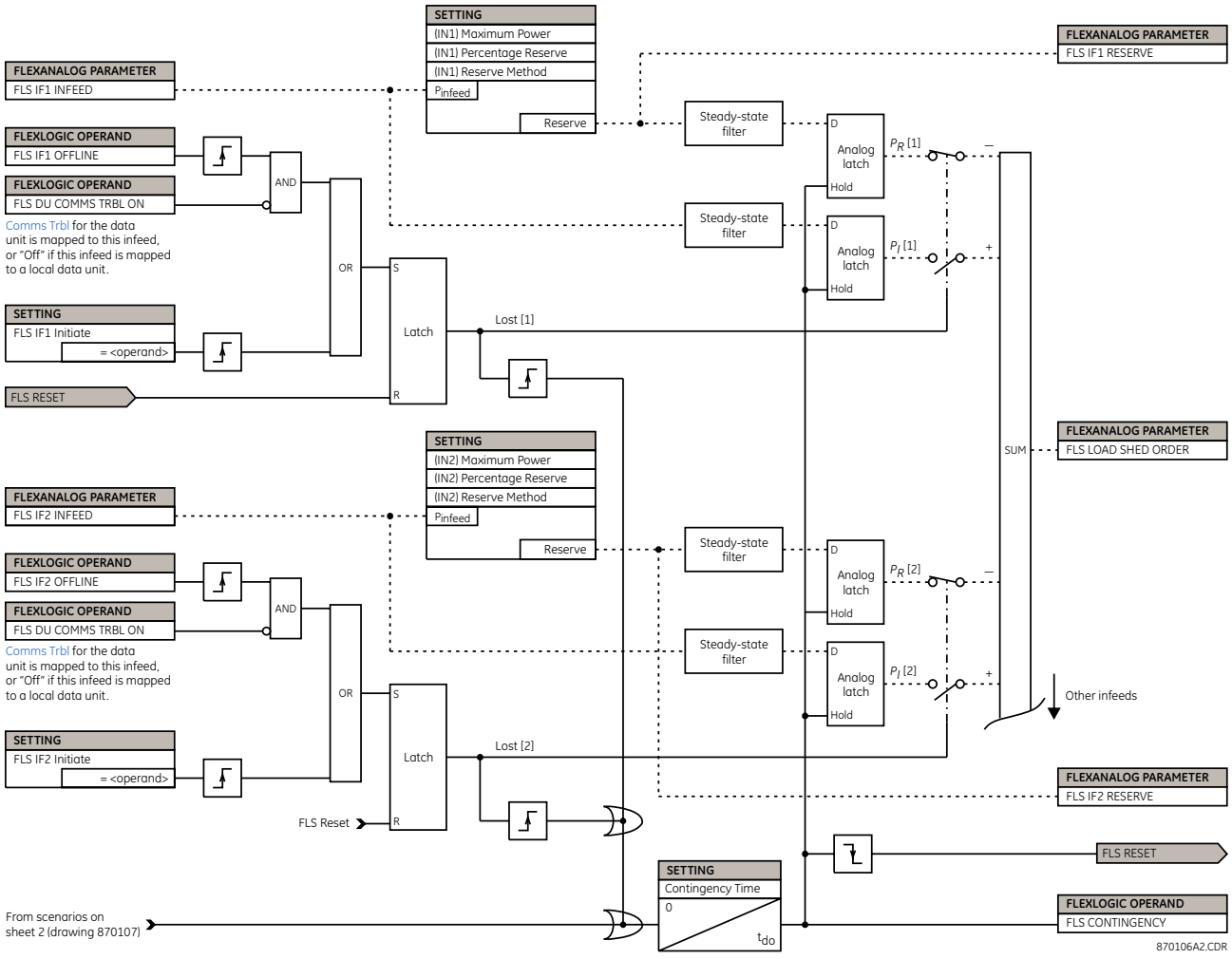
each load group. An external computer system is typically responsible for ensuring the trip masks have the appropriate values pre-contingency, although the trip masks may also be set manually through the EnerVista software.

In either mode, the shed requests are sent to the end devices in the shed command GOOSE messages described earlier, and the end devices shed the loads in the requested load groups. When no new infeeds have been lost and no new scenarios detected for some time (that is, when the contingency timer expires), the above-mentioned latches are reset, terminating the shed requests.

Note that change requests for priorities and trip masks and for their writable actual values received during a contingency are not implemented till the contingency is over. This is as an update initiated before the contingency began may arrive during the contingency. In this case implementing the update would result in both the shedding called for in the pre-update settings and the shedding called for in the updated settings being requested, possibly producing more load shedding than appropriate.

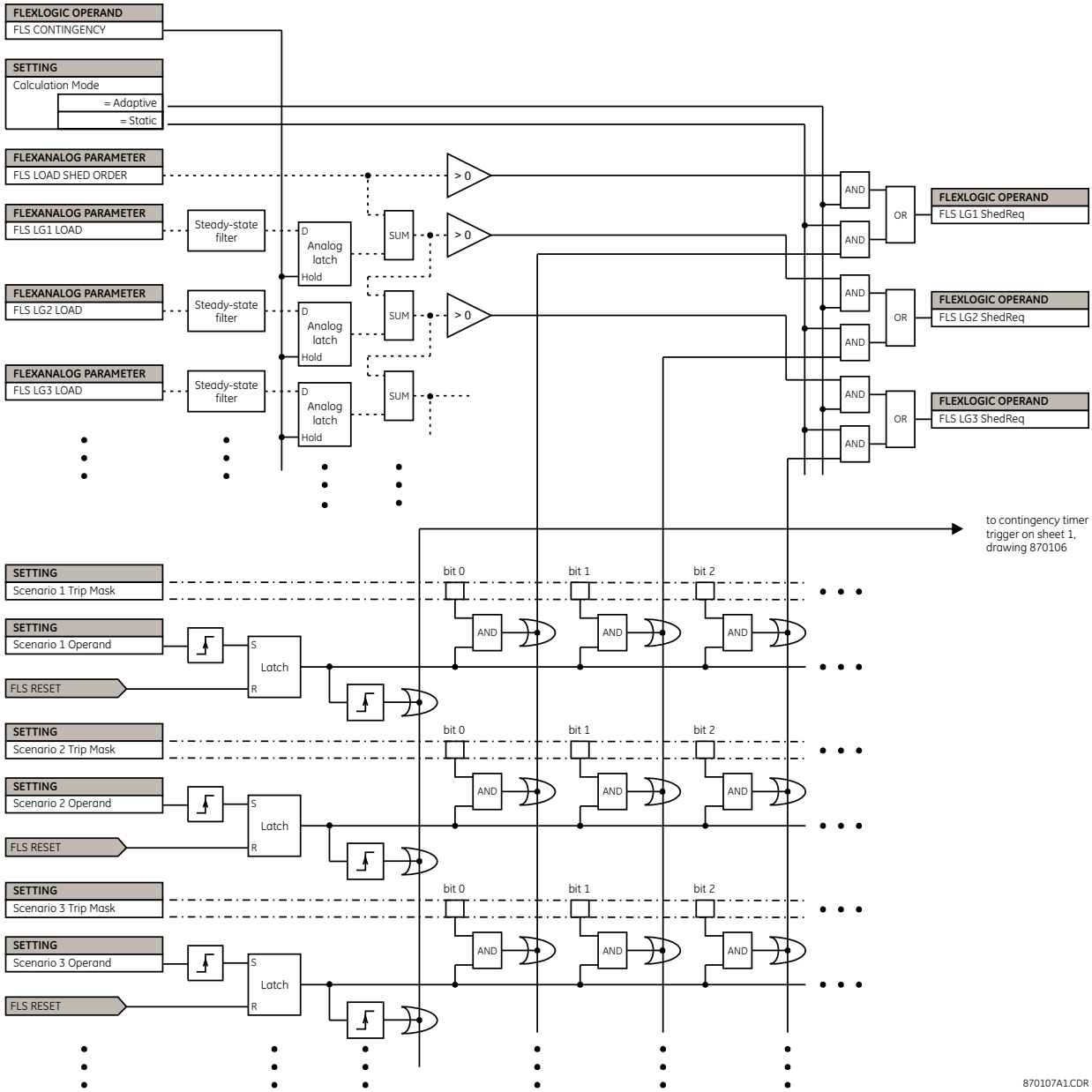
The logic diagram illustrating the adaptive mode load shed order development for infeeds 1 and 2 is shown below. The development logic for other infeeds is similar. The logic shown is for when LG1 has the lowest priority, followed by LG2, then LG3. The actual logic dynamically arranges the chain in priority order.

Figure 48: :Adaptive mode load shed order development example for infeeds 1 and 2



The following figure is the logic diagram illustrating the static mode load shed request development for load groups 1, 2, and 3.

Figure 49: Static mode load shed request development example for load groups 1 to 3



Fast load shed settings

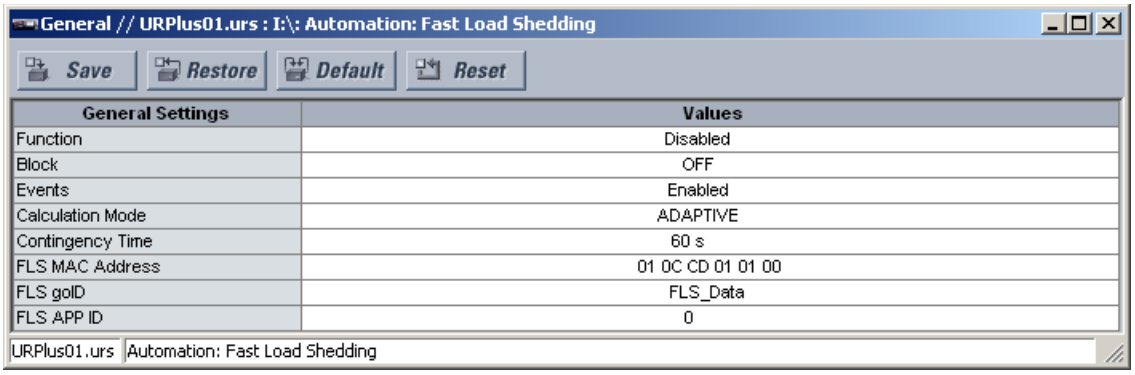
The fast load shed (FLS) element settings are divided into sets: general settings affecting overall operation, data unit settings, infeed settings, load group settings, and scenario settings.

General fast load shedding settings

The general fast load shedding settings include settings for the GOOSE header, settings to select calculation mode and contingency time, settings to enable and to block shedding, and a setting to enable changes of state to be recorded by the events recorder.

Select the **Settings > Automation > Fast Load Shedding > General** menu item to open the general fast load shedding settings configuration window.

Figure 50: General fast load shedding settings



The following general settings are available for fast load shedding.

Function

Range: Disabled, Enabled

Default: Disabled

This setting enables and disables the fast load shedding (FLS) element. When set to "Disabled", the fast load shed logic and analog output operands are forced "Off" or zero. When this setting is changed to "Enabled", the fast load shedding controller (FLSC) is blocked for an additional 16 seconds.

Block

Range: any automation logic operand or shared operand

Default: OFF

This setting selects an operand to control the fast load shedding (FLS) element block feature. When the selected operand is "ON", the infeed and contingency latches are held reset, and the contingency timer is held reset. Thus the shed request operands are held in the "Off" state. Otherwise, the FLS element operands continue to be updated normally. This setting may be used with appropriate automation or protection logic to block the FLS scheme via operator control and/or automatically disarm the FLS scheme following a contingency until manually rearmed. This setting may also be used to block the scheme when critical data messages are interrupted.

This setting is not available when the C90^{Plus} order code specifies aggregator only functionality. In this case, the fast load shedding element behaves as if the setting value is "ON".

Events

Range: Enabled, Disabled

Default: Enabled

When this setting is "Enabled", every "Off" to "On" change of state of each fast load shedding logic operand is logged in the event record.

Calculation Mode

Range: Adaptive, Static, Aggregator

Default: Adaptive

When set to "Adaptive", the fast load shedding element on its own calculates and issues shed requests based on the amount of infeed power lost, the amount of reserve power remaining, the power available for shedding in each load group, and load group priorities.

When set to "Static", trip masks specify for each scenario the shed requests to be issued on occurrence of the scenario. Scenarios are defined using protection or automation logic within the C90^{Plus}.

When set to "Aggregator", the shed request operands are forced "Off" and the contingency timer is held reset. Otherwise, the fast load shedding (FLS) operands continue to be updated normally. This mode is for FLS elements used as aggregators.

When this setting's value is changed from or to "Aggregator", the fast load shedding controller is blocked for 16 seconds.

This setting is not available when the C90^{Plus} order code specifies aggregator only functionality. In this case, the fast load shedding element behaves as if the setting value is "Aggregator".

Contingency Time

Range: 20 to 1000 seconds in steps of 1
Default: 60 seconds

This setting specifies the amount of time following the detection of a contingency until the contingency is deemed to be complete and a new steady state is to be deemed to be in effect.

This setting is not available when the C90^{Plus} order code specifies aggregator only functionality.

FLS MAC Address

Range: 01-0C-CD-01-00-00 through 01-0C-CD-01-01-FF
Default: 01-0C-CD-01-01-00

This setting specifies the multicast destination MAC address of all data messages used by this element. Each C90^{Plus} fast load shedding element should have a multicast address unique to its site.

FLS goID

Range: up to 65 ASCII characters
Default: FLS_Data

This setting specifies the first part of goID fields of all data messages accepted by this element. Each C90^{Plus} fast load shedding (FLS) element must have a first part unique to its site. The data message publisher must make the second part of the goID field specify the data unit numbers of the data units in the data message. The second part must immediately follow the last character matching the **FLS goID** setting.

For an infeed or load data unit, the second part of the goID is the data unit numbers in the order the data units appear in the dataset, with each data unit number prefixed by an underscore character. For example, if the **FLS goID** setting is set to "SubStn23" and a data message contains data units 9, 31, and 20 in that sequence, then the data message publisher must set the goID value to be "SubStn23_9_31_20".

For an aggregator data unit, which can be the only data unit in a data message, the second part of the goID is the aggregator data unit number preceded by an underscore and followed by the upper case character "A". For example, if the FLS goID setting is set to "SubStn23", and a data message contains an aggregator data unit for data unit number 64, then the data message publisher must set the goID value to be "SubStn23_64A".

FLS APPID

Range: 0 to 16383 in steps of 1
Default: 0

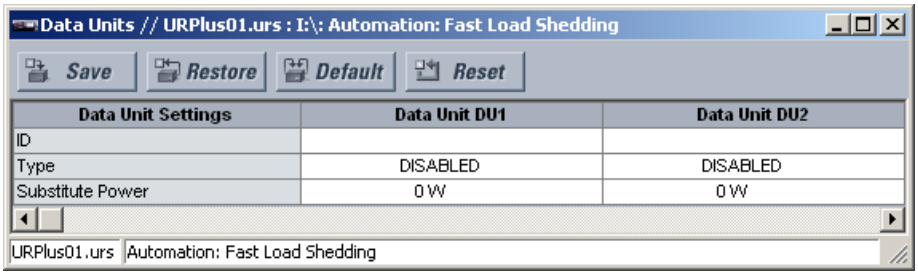
This setting identifies the application identification field value of fast load shedding messages to be received. It must match the corresponding settings on the sending device for a data message to be accepted. IEC 61850-8-1 states that a unique, source-orientated GOOSE APPID within a system is strongly recommended, and that the default value is reserved to indicate lack of configuration.

Fast load shedding data unit settings

The data unit settings include settings for naming, describing, and substituting values for each of the 64 data units. A data unit is either an infeed offline/power pair from an end unit, a load unavailable/power pair from an end unit, or a set of load group powers from an aggregator.

Select the **Settings > Automation > Fast Load Shedding > Data Units** menu item to open the fast load shedding data unit settings configuration window.

Figure 51: Fast load shedding data units configuration window



The following settings are available for each of the 64 fast load shedding data units.

ID

Range: up to 20 alphanumeric characters
Default: <empty>

The text entered for this setting appears in fast load shed reports where the data unit is referenced. Typically, the text will be the name of the power system element that the data measures (for example, "Maint. Bldg. HVAC").

Type

Range: Disabled, Infeed 1, Infeed 2, Infeed 3,..., Infeed 32, Load Group 1, Load Group 2, Load Group 3..., Load Group 32, Aggregator
Default: Disabled

The value of this setting is used in determining the type and meaning of the data message members.

If set to "Disabled", the data unit power, status and Comms Trbl operands are set to "Off" and zero. Any data unit values received are ignored.

If set to one of "Infeed 1" to "Infeed 32", the data unit values received determine the offline status value and measured power value of the selected infeed. An infeed is not allowed to have more than one data unit or local data unit. When the C90^{Plus} order code specifies aggregator only functionality, the "Infeed 1" to "Infeed 32" values are not allowed.

If set to one of "Load Group 1" to "Load Group 32", the data unit values received determine the unavailability for shedding status value and measured power values of the selected load data unit. A load group may have multiple load data units.

If set to "Aggregator", the values of the 32 measured power values in the data unit are summed into the corresponding 32 load groups measured power values.

Data messages that have dataset structure not matching the requirements of the value of this setting are ignored. Such results in the Comms Trbl operand becoming "On".

When this setting is changed, the fast load shedding controller is blocked for 16 seconds.

Substitute Power

Range: –999,999.9 to 999,999.9 kW in steps of 0.1
Default: 0.0 kW

The setting specifies the default value of the associated writable actual value along with the setting value itself. For infeed and load data units (when the writable actual value is non-zero for infeed and load data units) the value is used in place of the received power

value. For load data units, a writable actual value less than zero causes the value zero to be used in place of the received power value. This feature may be used to enter manually or via an external computer system an infeed or load power value where the power is not actually measured by the end device. The fast load shedding controller will use a zero power value when offline status or unavailability for shedding status is "On" even if the substitute power writable actual value is non-zero.

A DCS/SCADA system may be used to adjust the substitute power value from time-to-time to meet changing process conditions. To facilitate this, the FLSC actually uses in its algorithms a writable actual value whose value is initialized from the setting. The DCS/SCADA may overwrite the writable actual value repeatedly without wearing out the non-volatile settings flash memory. The substitute power writable actual values are in a contiguous block of Modbus registers to facilitate mass updating.

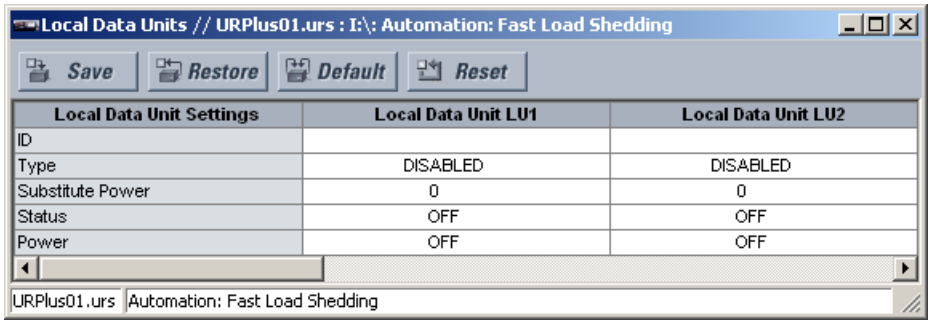
For aggregator data units, this setting and its writable actual value have no function.

Fast load shedding local data unit settings

The local data unit settings include settings for naming, describing, selecting value origin operands, and substituting values for each of the six local data units. A local data unit is either an infeed offline/power pair, or a load unavailable/power pair, where the values are in either case from local operands.

Select the **Settings > Automation > Fast Load Shedding > Local Data Units** menu item to open the fast load shedding local data unit settings configuration window.

Figure 52: Fast load shedding local data units configuration window



The following settings are available for each of the 6 fast load shedding local data units.

ID

Range: up to 20 alphanumeric characters

Default: <empty>

The text entered for this setting appears in fast load shed reports where the local data unit is referenced. Typically, the text will be the name of the power system element that the data measures (for example, "Generator G1").

Type

Range: Disabled, Infeed 1, Infeed 2, Infeed 3,..., Infeed 32, Load Group 1, Local Group 2, Local Group 3,..., Local Group 32

Default: Disabled

The value of this setting is used in determining the type or meaning of the status and power members.

If set to "Disabled", the local data unit power and status operand are set to "Off" and zero, and the operands selected by the power and status settings ignored.

If set to one of "Infeed 1" through "Infeed 32", the values of the operands selected by the power and status settings determine the offline status value and measured power value of the selected infeed. An infeed is not allowed to have more than one data unit or local data unit. When the C90^{Plus} order code specifies aggregator only functionality, the "Infeed 1" through "Infeed 32" values are not allowed.

If set to one of "Local Group 1" through "Local Group 32", the values of the operands selected by the power and status settings determine the unavailability for shedding status value and measured power values of the selected load data unit. A load group may have multiple load data units.

When this setting value is changed, the fast load shedding controller is blocked for 16 seconds.

Substitute Power

Range: –999,999.9 to 999,999.9 kW in steps of 0.1

Default: 0.0 kW

This settings specifies the default value of the associated writable actual value along with the setting value itself. When the value of the writable actual value is non-zero, its value is used in place of the value of the operand selected by the power setting for infeed and load local data units. For load data units, a writable actual value less than zero causes the value zero to be used in place of the received power value. This feature may be used to enter manually or via an external computer system an infeed or load power value where the power is not actually measured locally. The fast load shedding controller will use a zero power value when the value of the operand selected by the status setting is "On" even if the substitute power setting value is non-zero.

A DCS/SCADA system may be used to adjust the substitute power value from time-to-time to meet changing process conditions. To facilitate this, the FLSC actually uses in its algorithms a writable actual value whose value is initialized from the setting. The DCS/SCADA may overwrite the writable actual value repeatedly without wearing out the non-volatile settings flash memory. The local substitute power writable actual values are in a contiguous block of Modbus registers to facilitate mass updating.

Status

Range: any automation logic operand or shared operand

Default: OFF

This setting selects an operand whose value is used as the Boolean value of a local data unit. The value is interpreted as the infeed offline status when its local data unit type setting value is any infeed. The value is interpreted as the unavailability for shedding status when its local data unit type setting value is any load.

The local data unit is disabled while this setting is "ON" or "OFF".

Power

Range: any FlexAnalog parameter

Default: OFF

This setting selects a FlexAnalog paramter (analog operand) whose value is used as the measured power value of a local data unit. The value is interpreted as measured infeed power when its local data type setting value is any infeed. The value is interpreted as measured load power when its local data unit type setting value is any load.

Fast load shedding infeed settings

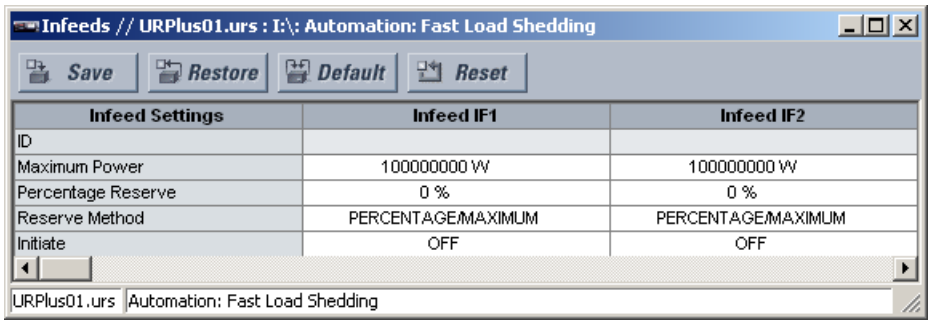
The fast load shedding element also has settings for determining the reserve power of each of the 32 infeeds. Note that the ID setting of the data unit or local data unit mapped to an infeed is used as the infeed ID. If no data unit or local data unit is mapped, the infeed ID is blank



The infeed settings are not available when the C90^{Plus} order code specifies aggregator only functionality.

Select the **Settings > Automation > Fast Load Shedding > Infeeds** menu item to open the fast load shedding infeed settings configuration window.

Figure 53: Fast load shedding infeeds configuration window



The following settings and actual values are available for each of the 32 fast load shedding infeeds.

ID

Range: up to 20 alphanumeric characters

This text shown in this read-only actual value field reflects the local or remote data unit ID assigned to the infeed through the corresponding **Type** settings. Typically, the text displayed will be the name of the power system element that the data measures (for example, "Generator G1").

Maximum Power

Range: 0.0 to 999999.9 kW in steps of 0.1

Default: 100000 kW

This setting specifies the maximum power that the infeed can deliver to the system. For an incomer, this may be its emergency short time rating. Where the **Reserve Method** setting is "Maximum" or "Percentage/Maximum", its value is used in the estimation of the reserve power available from the infeed. When using either of these methods, the received infeed power value should not exceed this setting value.

Percentage Reserve

Range: 0 to 100% in steps of 1

Default: 0%

This setting specifies the amount of power expressed as a percentage of the present power the infeed can deliver to the system in a timely manner in the event of a contingency. For example, thermal generators in general cannot be manoeuvred quickly. They may not be able to reach their maximum power rating in time to stabilize the system, but can in a timely manner increase their output by some lesser amount. Where the **Reserve Method** setting is "Percentage" or "Percentage/Maximum", this setting value is used in the estimation of the reserve power available from the infeed.

Reserve Method

Range: Maximum, Percentage, Percentage/Maximum

Default: Percentage/Maximum

If the value of this setting is "Maximum", the reserve power available from the infeed is calculated as the **Maximum Power** setting value less the present infeed power value, or zero if the infeed power is greater than the maximum power setting. This setting is intended for infeeds that can quickly increase power up to some maximum no matter the pre-contingency power, such as incomers from the grid limited by a transformer emergency rating. Signed arithmetic is used: if pre-contingency the infeed was exporting (that is, negative power), then the reserve calculated will be greater than the maximum power setting.

If the value of this setting is "Percentage", the reserve power available from the infeed is calculated as the **Percentage Power** setting value multiplied by the present infeed power value, or zero if the infeed power is less than zero.

If the value of this setting is "Percentage/Maximum", the reserve power available from the infeed is calculated as the least of the other two methods. This setting value is intended for infeeds that when at low power cannot quickly increase power to the maximum, due to for instance prime mover manoeuvring speed limitations.

If the Comms Trbl operand of the data unit mapped to this infeed is "On", or the infeed is offline, then the reserve power is zero no matter the method setting. In no case is the calculated reserve less than zero.

Initiate

Range: any automation logic operand or shared operand

Default: OFF

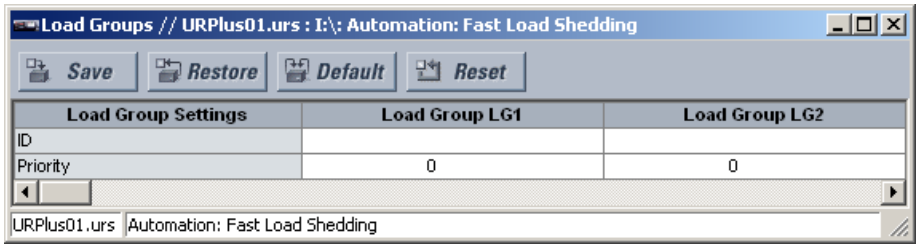
This setting selects an operand that provides a means alternate to the data unit or local data unit status to declare the infeed offline. When the selected operand transitions from "OFF" to "ON", a contingency is initiated as shown in the logic diagram.

Fast load shedding load group settings

The fast load shedding element also has settings for naming and priority for each of the 32 load groups.

Select the **Settings > Automation > Fast Load Shedding > Load Groups** menu item to open the fast load shedding load group settings configuration window.

Figure 54: Fast load shedding load group configuration window



The following settings are available for each of the 32 fast load shedding load groups.

ID

Range: up to 20 alphanumeric characters

Default: <empty>

The text entered for this setting appears in fast load shed reports where the load group is referenced. Typically, the text will describe the loads grouped (for example, "Site 5 Non-critical").

Priority

Range: 0 to 128 in steps of 1

Default: 0

This setting specifies the default value of the associated writable actual value along with the setting value itself. The writable actual value is only used by the fast load shedding controller (FLSC) in the adaptive mode. In the adaptive mode, the writable actual value specifies a priority for the load group. A load group with priority zero is considered not available for shedding. Otherwise, a load group with lower priority (where 128 is the lowest priority) are shed in preference to a load group with higher priority (where 1 is the highest priority). Load groups with the same priority are all shed when any needs to be shed. More priority values than load groups are provided to facilitate adjusting priorities.

A DCS/SCADA system may be used to adjust the priority value from time-to-time to meet changing process conditions. To facilitate this, the FLSC actually uses in its algorithms a writable actual value whose value is initialized from the setting. The DCS/SCADA may overwrite the writable actual value repeatedly without wearing out the non-volatile settings flash memory. The priority writable actual value is in a contiguous block of Modbus registers to facilitate mass updating.

When any priority setting is changed, all priority writable actual values are forced to the priority setting values.

Note that priority setting value changes and fast load shedding writable actual value changes are not accepted while the contingency timer is active. This is to prevent undesired shed requests that might otherwise occur as a result of two different load shed priority values being used for the same contingency.

This setting is not available when the C90^{Plus} order code specifies aggregator only functionality.

Fast load shedding scenario settings

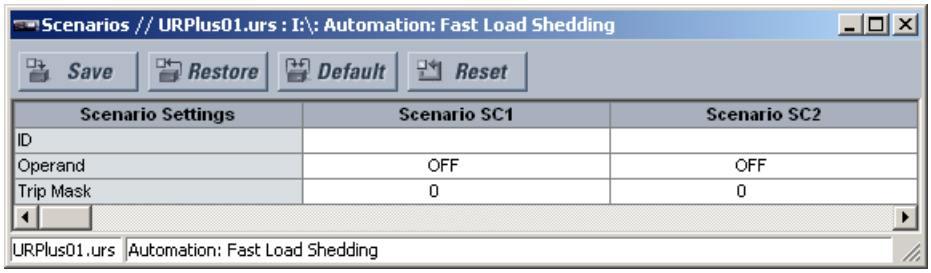
The scenario settings include settings for each scenario selecting the operand that activates when the scenario occurs, and the trip mask setting that identifies the load group shed requests to issue for that scenario. These settings are only used by the fast load shedding controller when in the static mode. These setting values are described below in detail.

NOTE

The scenario settings are not available when the C90^{Plus} order code specifies aggregator only functionality.

Select the **Settings > Automation > Fast Load Shedding > Scenarios** menu item to open the fast load shedding scenario settings configuration window.

Figure 55: Fast load shedding scenario configuration window



The following settings are available for each of the 32 fast load shedding scenarios.

ID

Range: up to 20 alphanumeric characters

Default: <empty>

The text entered here appears in fast load shed reports where the scenario is referenced. Typically, the text will describe the scenario (for example, “Loss of T1+G1”).

Operand

Range: any automation logic operand or shared operand

Default: OFF

The selected operand should become “On” or pulse “On” when the corresponding scenario occurs. Protection logic is typically used to produce the operand. The logic does not need to latch or stretch the “On” signal, as the fast load shedding element latches the rising edge internally until the contingency timer expires.

It is recommended that the scenario operand (typically a virtual output) be given a descriptive ID and its events enabled so that the scenario is also recorded in the event record.

Trip Mask

Range: any 32-bit bitstring

Default: 0x0000 0000

The setting value is interpreted as a bitstring, wherein each bit corresponds to a particular load group. The least significant bit corresponds to load group 1, the most significant bit to load group 32. When the operand selected for a particular scenario activates, the fast load shedding element activates the shed request for each load group that has its bit in that scenario's trip mask set to 1.

A DCS/SCADA system may adjust the trip mask value from time-to-time to meet changing process conditions. To facilitate this, the fast load shedding controller actually uses in its algorithms a writable actual value whose value is initialized from the setting. The DCS/SCADA may overwrite the writable actual value repeatedly without wearing out the non-volatile settings flash memory. The trip mask writable actual values are in a contiguous block of Modbus registers to facilitate mass updating.

When any trip mask setting is changed, all trip mask writable actual values are forced to the trip mask setting values.

Note that trip mask setting value changes and fast load shedding writable actual value changes are not accepted while the contingency timer is active. This is to prevent undesired shed requests that might otherwise occur as a result of two different load shed trip mask patterns being used for the same contingency.

Automation inputs and outputs

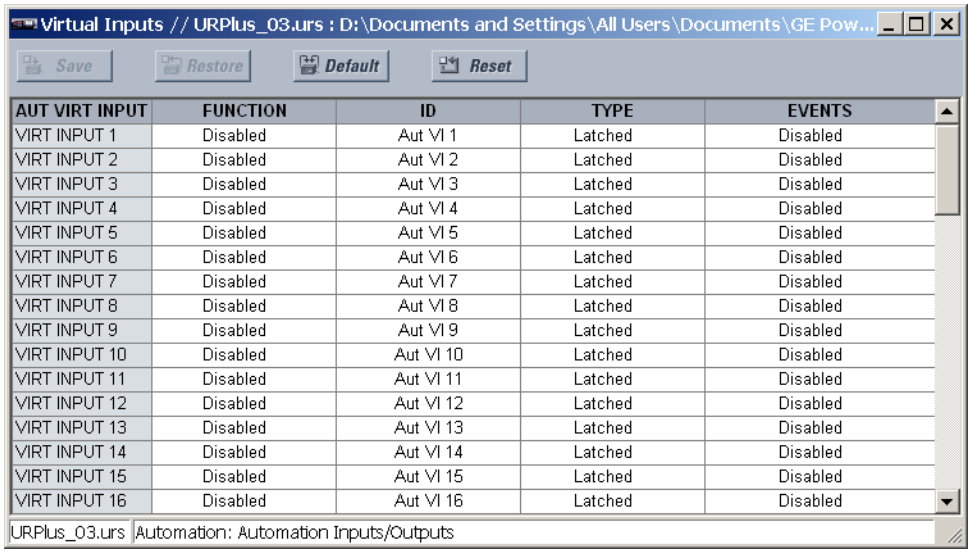
Three groupings of automation inputs and outputs are defined: physical (contacts), shared, and virtual. Within these three groupings there are two types: analog and digital.

Automation virtual inputs

There are 128 virtual inputs that can be individually programmed to respond to input signals from the front panel interface and communications protocols. All virtual input operands are defaulted to off (logic 0) unless the appropriate input signal is received.

Select the **Settings > Automation > Automation Inputs/Outputs > Virtual Inputs** menu item to access the virtual input configuration settings.

Figure 56: Automation virtual inputs configuration settings



AUT VIRT INPUT	FUNCTION	ID	TYPE	EVENTS
VIRT INPUT 1	Disabled	Aut VI 1	Latched	Disabled
VIRT INPUT 2	Disabled	Aut VI 2	Latched	Disabled
VIRT INPUT 3	Disabled	Aut VI 3	Latched	Disabled
VIRT INPUT 4	Disabled	Aut VI 4	Latched	Disabled
VIRT INPUT 5	Disabled	Aut VI 5	Latched	Disabled
VIRT INPUT 6	Disabled	Aut VI 6	Latched	Disabled
VIRT INPUT 7	Disabled	Aut VI 7	Latched	Disabled
VIRT INPUT 8	Disabled	Aut VI 8	Latched	Disabled
VIRT INPUT 9	Disabled	Aut VI 9	Latched	Disabled
VIRT INPUT 10	Disabled	Aut VI 10	Latched	Disabled
VIRT INPUT 11	Disabled	Aut VI 11	Latched	Disabled
VIRT INPUT 12	Disabled	Aut VI 12	Latched	Disabled
VIRT INPUT 13	Disabled	Aut VI 13	Latched	Disabled
VIRT INPUT 14	Disabled	Aut VI 14	Latched	Disabled
VIRT INPUT 15	Disabled	Aut VI 15	Latched	Disabled
VIRT INPUT 16	Disabled	Aut VI 16	Latched	Disabled

The following settings are available for each automation virtual input. The default values outlined are for virtual input 1.

Function

Range: Enabled, Disabled

Default: Disabled

If this setting is "Disabled", the virtual input is forced to off (logic 0) regardless of any attempt to alter the input. If set to "Enabled", the input operates as shown on the logic diagram and generates output logic operands in response to received input signals and the applied settings.

ID

Range: up to 12 alphanumeric characters

Default: Aut VI 1

This setting specifies an identifier that can be assigned to each virtual input.

Type

Range: Self-Reset, Latched

Default: Latched

There are two types of operation: self-reset and latched. If this settings is "Self-Reset", the output operand is asserted (logic 1) for only one evaluation of the automation logic equations and then return to 0 when the input signal transits from off to on. If set to "Latched", the virtual input sets the state of the output operand to the same state as the most recent received input.

NOTE

The self-reset operating mode generates an output operand for a single evaluation of the automation logic equations. If the operand is to be used anywhere other than internally in an automation logic equation, it likely has to be lengthened in time. An automation logic timer with a delayed reset can perform this function.

Events

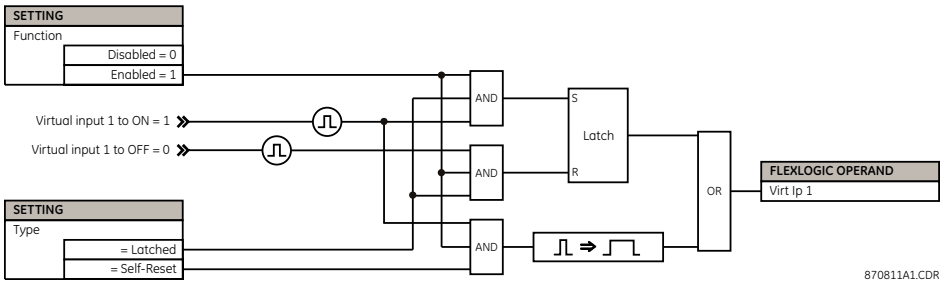
Range: Enabled, Disabled

Default: Disabled

If this setting is "Enabled", every change in the automation virtual input state triggers an event in the sequence of events recorder.

The figure shows the automation virtual input logic. The logic is identical for all automation virtual inputs.

Figure 57: Automation virtual input logic

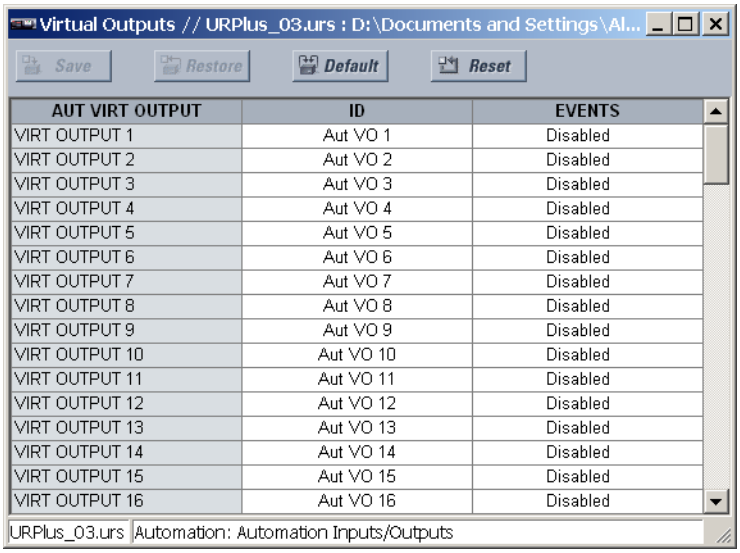


Automation virtual outputs

There are 255 virtual outputs that can be assigned via automation logic. Virtual outputs are resolved in each pass through the evaluation of the automation logic equations.

Select the **Settings > Automation > Automation Inputs/Outputs > Virtual Outputs** menu item to access the automation virtual output configuration settings.

Figure 58: Automation virtual output settings



AUT VIRT OUTPUT	ID	EVENTS
VIRT OUTPUT 1	Aut VO 1	Disabled
VIRT OUTPUT 2	Aut VO 2	Disabled
VIRT OUTPUT 3	Aut VO 3	Disabled
VIRT OUTPUT 4	Aut VO 4	Disabled
VIRT OUTPUT 5	Aut VO 5	Disabled
VIRT OUTPUT 6	Aut VO 6	Disabled
VIRT OUTPUT 7	Aut VO 7	Disabled
VIRT OUTPUT 8	Aut VO 8	Disabled
VIRT OUTPUT 9	Aut VO 9	Disabled
VIRT OUTPUT 10	Aut VO 10	Disabled
VIRT OUTPUT 11	Aut VO 11	Disabled
VIRT OUTPUT 12	Aut VO 12	Disabled
VIRT OUTPUT 13	Aut VO 13	Disabled
VIRT OUTPUT 14	Aut VO 14	Disabled
VIRT OUTPUT 15	Aut VO 15	Disabled
VIRT OUTPUT 16	Aut VO 16	Disabled

The following settings are available for each automation virtual output. If not assigned, the virtual output is forced to off (logic 0).

ID

Range: up to 12 alphanumeric characters
Default: Aut VO 1

This setting specifies an identifier that may be assigned to each automation virtual output.

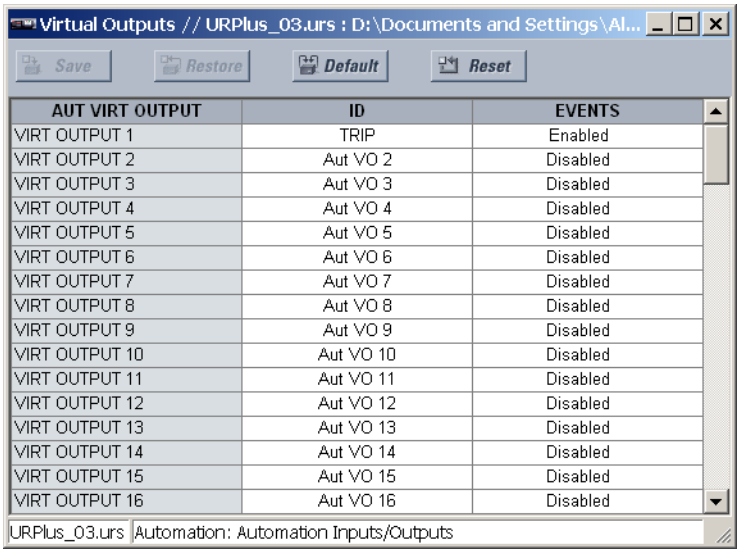
Events

Range: Enabled, Disabled
Default: Disabled

If this setting is "Enabled", every change in the automation virtual output state triggers an event in the sequence of events recorder.

For example, if automation virtual output 1 is the trip signal from automation logic and the trip relay is used to signal events, the settings are be programmed as follows.

Figure 59: Automation virtual output programming example



Contact input and output default assignment

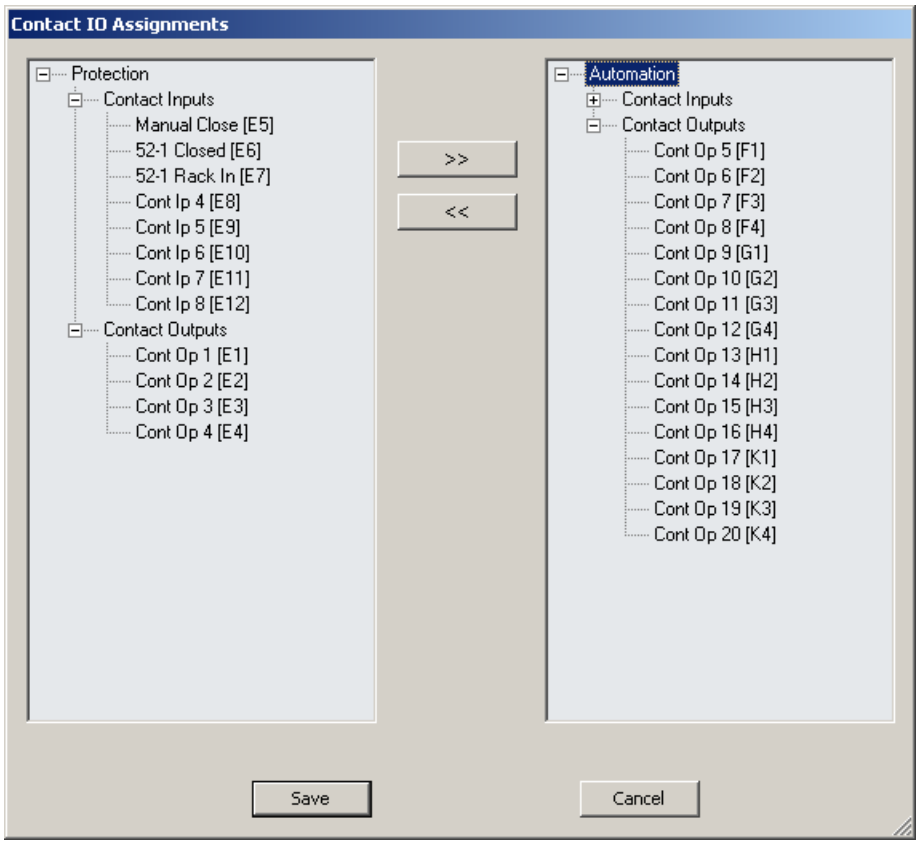
When a new settings file is created, the available contacts are automatically assigned to the protection or automation functions according to the following convention:

- First I/O module → protection
- All subsequent I/O modules → automation

For example, if a C90^{Plus} is configured with contact input/output cards in slots E, F, and G, then the inputs and outputs associated with slot E are assigned to protection and the inputs and outputs associated with slots F and G are assigned to automation.

These default assignments may be changed to match the requirements of the application. This is done by right-clicking on the setting filename and choosing the menu **Manage Settings File > I/O Assignments** menu item. The following window displays.

Figure 60: Contact input and output assignments



All available contact inputs and output can be reassigned using the **>>** and **<<** buttons.

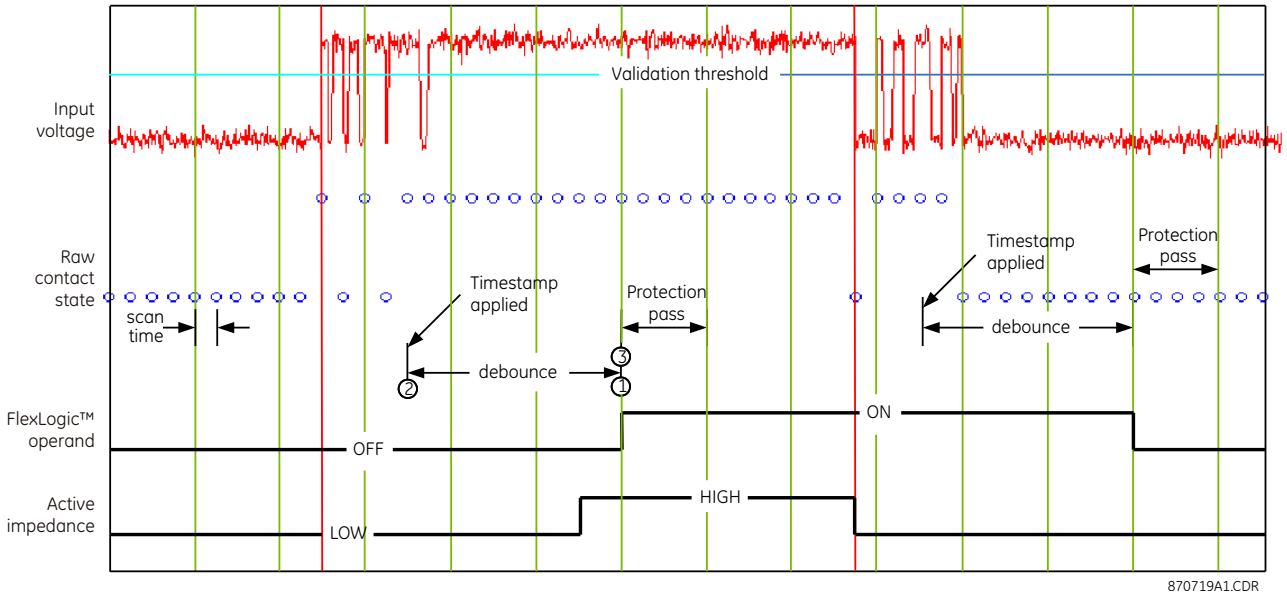
Contact input configuration

The C90^{Plus} can monitor the status of up to 115 field contacts. Each input can be wetted from the C90^{Plus} 48 volt auxiliary supply or from an external power supply. Each digital input has a dedicated delay timer for filtering of contact bouncing. The C90^{Plus} can also detect an oscillating input via the chatter feature. Each contact input active impedance circuitry to provide security against false turn-on of an input due to excessive stray capacitance of field wiring.

A raw status is scanned synchronously for all contact inputs at the rate of 0.25 ms as shown below. A new contact input state must be maintained for a user-programmable debounce time for the C90^{Plus} to validate the new contact state. The debounce time is set at 2.0 ms in the figure below; as such, the eighth sample validates the change of state (mark 1 in the figure below). Once validated (de-bounced), the automation contact input asserts a corresponding automation operand and logs an event (if event logging is enabled).

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 2 in the figure).

Figure 61: Automation contact input debouncing mechanism and time-stamping



Automation equations and timers, are executed at the automation scan rate. The automation operand reflecting the debounced state of the contact is updated at the automation pass following the validation (mark 3 in the figure). The update is performed at the beginning of the 1 ms scanning pass so all automation functions and equations are fed with the updated states of the contact inputs.

The automation operand response time to the contact input change is equal to the debounce time setting plus a maximum of one protection pass. 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 0.25 ms scan rate, the time resolution for the contact input is less than 1 ms.

For example, sixteen protection passes per cycle on a 60 Hz system correspond to an protection pass every 1.04 ms. With a contact debounce time setting of 3.0 ms, the automation operand assertion time limits are: 3.0 + 0.0 = 3.0 ms and 3.0 + 1.04 = 4.04 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 ms accuracy using the time of the first scan corresponding to the new state. Therefore, the time stamp reflects a change in the DC voltage across the digital input terminals that was not accidental as it was subsequently validated using the debounce timer. Keep in mind that the associated automation operand is asserted or de-asserted later, after validating the change. The debounce algorithm is symmetrical: the same procedure and debounce time are used to filter the OFF-ON and ON-OFF transitions.

The active impedance feature controls the input impedance presented to the system according to the current state of the input. When the contact input circuitry initially detects a voltage increase, it draws 10 mA of current. If the state change is due to a transient coupled through the stray capacitance of the field wiring, then the high current sink charges the capacitance causing the transient to rapidly decay. If voltage increase is due to a state change of the field contact, then the increased current has no impact on the input voltage, and the state change is validated. Once the input has been declared to be on, the input circuitry reduces the current drawn to 1 mA to minimize the power dissipated by the input.

When the input detects a voltage decrease, the input circuitry draws 10 mA of current. If the voltage decrease is due to a state change then the voltage quickly decreases, speeding up the recognition of the reset of the field contact by quickly discharging any input capacitance.

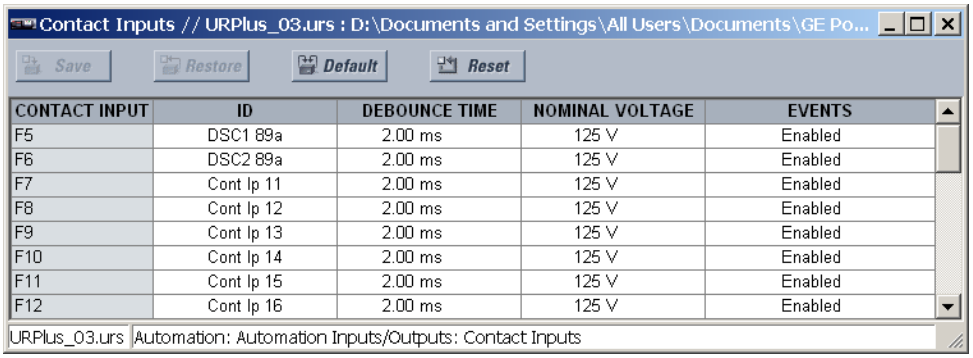
NOTE

The contact input update time is 1 ms. However, depending on where the contact input status change is triggered within a 1 ms window, the worst-case contact input recognition time is 2 ms.

Contact input settings

Select the **Settings > Automation > Automation Inputs/Outputs > Contact Inputs > Contact Inputs** menu item to access the automation contact input configuration settings.

Figure 62: Automation contact input configuration settings



CONTACT INPUT	ID	DEBOUNCE TIME	NOMINAL VOLTAGE	EVENTS
F5	DSC1 89a	2.00 ms	125 V	Enabled
F6	DSC2 89a	2.00 ms	125 V	Enabled
F7	Cont Ip 11	2.00 ms	125 V	Enabled
F8	Cont Ip 12	2.00 ms	125 V	Enabled
F9	Cont Ip 13	2.00 ms	125 V	Enabled
F10	Cont Ip 14	2.00 ms	125 V	Enabled
F11	Cont Ip 15	2.00 ms	125 V	Enabled
F12	Cont Ip 16	2.00 ms	125 V	Enabled

The contact inputs menu contains configuration settings for each input. Upon startup, the relay processor determines (from an assessment of the installed modules) which contact inputs are available and then displays settings for only those inputs. The following settings are available for each contact input.

ID

Range: up to 12 alphanumeric characters
Default: Cont Ip 1

An alphanumeric identifier can be assigned to a contact input for diagnostic, setting, and event recording purposes. The "CONTACT IP 1" text in event records and automation logic operands are replaced by the text programmed in this setting.

Debounce Time

Range: 1.50 to 16.00 ms in steps of 0.25
Default: 2.00 ms

This setting defines the time required for the contact to overcome contact bouncing conditions. As this time differs for different contact types and manufacturers, program it as a maximum contact debounce time (per manufacturer specifications) plus additional margin to ensure proper operation.

Nominal Voltage

Range: 24 to 250 volts in steps of 1
Default: 125 volts

This setting specifies the range required to validate a closed contact input. This range is fixed at 70 to 130% of this setting value, with an absolute minimum of 20 volts and an absolute maximum of 285 volts.

Table 3: Nominal voltage setting for typical battery voltages

Nominal voltage	Validation threshold
24 V	20 V
48 V	33.6 V
125 V	87.5 V
250 V	175 V

Events

Range: Enabled, Disabled

Default: Enabled

If this setting is "Enabled", every change in the contact input state triggers an event in the event recorder.

Contact input chatter detection

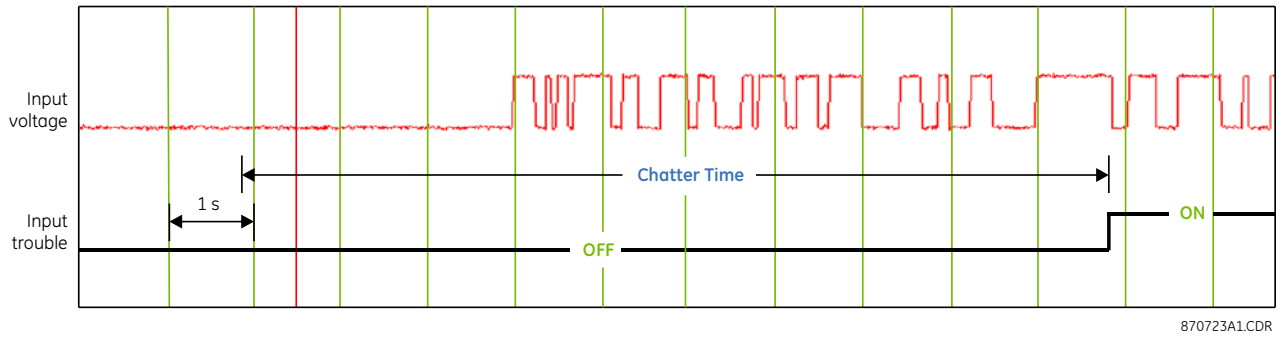
The C90^{Plus} has a chatter detection feature. When enabled, the IED monitors the number of state changes that occur within a set duration. If this value exceeds a set value, then a trouble condition is declared for the input and the CONTACT INPUT TROUBLE operand is asserted.

The input trouble alarm impacts relay functionality as follows:

- Automation logic operands — Operand state is blocked
- DNP 3.0 communications — Reporting of the input is blocked
- IEC 60870-5-104 communications — Reporting of the input is blocked
- IEC 61850 GSSE and IEC 61850 GOOSE — Reporting of the input is blocked
- Sequence of events recorder — Reporting of the input is blocked

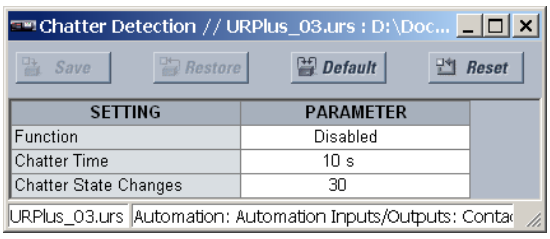
The trouble condition resets if the input undergoes no state changes for a duration equal to twice the chatter time setting.

Figure 63: Chatter detection example



Select the **Settings > Automation > Automation Inputs/Outputs > Contact Inputs > Chatter Detection** menu item to access the contact input chatter detection settings.

Figure 64: Contact input chatter detection configuration



The following settings are applied to all available protection and automation contact inputs.

Function

Range: Enabled, Disabled

Default: Disabled

This setting enables and disables the chatter detection feature.

Chatter Time

Range: 1 to 100 seconds in steps of 1

Default: 10 seconds

This setting specifies the time window that the relay contacts are monitored for contact input state changes.

Chatter State Changes

Range: 10 to 100 in steps of 1

Default: 30

This setting specifies the number of state changes that must occur in the time window defined by the **Chatter Time** setting before issuing the trouble operand.

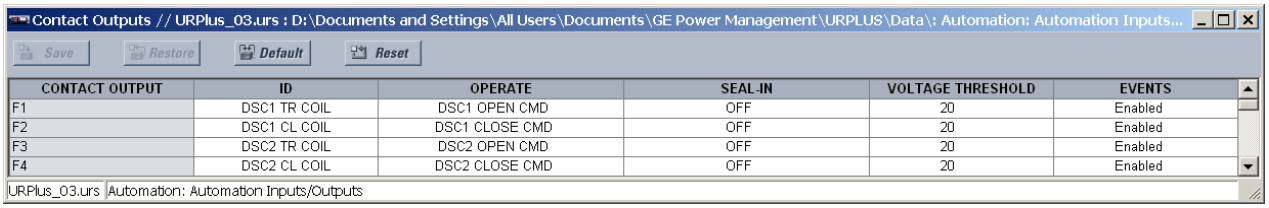
Since chatter detection is a hardware diagnostic, a trouble indication is logged regardless of the **Events** setting being enabled or disabled for a particular input.

Contact outputs

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 presents the settings for only these outputs.

Select the **Settings > Automation > Automation Inputs/Outputs > Contact Outputs** menu item to access the contact output configuration settings.

Figure 65: Automation contact output configuration settings



The settings for contact output 1 are used as an example. These settings are available for all contact outputs.

ID

Range: up to 12 alphanumeric characters

Default: Cont Op 1

This setting specifies an alphanumeric identifier for the contact output.

Operate

Range: any automation logic operand or shared operand

Default: OFF

This setting selects an operand (virtual output, element state, contact input, or virtual input) that operates the contact output when asserted.

Seal-In

Range: any automation logic operand or shared operand

Default: OFF

This setting selects an operand (virtual output, element state, contact input, or virtual input) that seals-in the contact output when asserted.

Voltage Threshold

Range: 20 to 250 volts in steps of 1

Default: 20

This setting specifies determines the level at which the Contact Op 1 VOn and Contact Op 1 VOff operands function. It is only shown for contact outputs that have monitoring.

Events

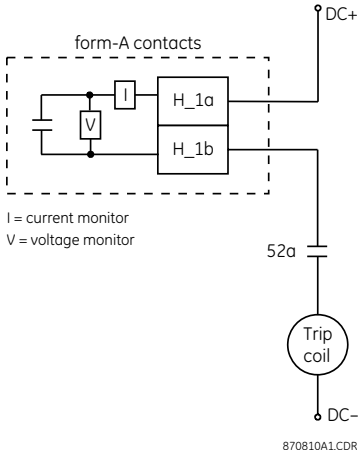
Range: Enabled, Disabled

Default: Enabled

If this setting is "Enabled", every change in the contact output state triggers an event in the event recorder.

For example, consider a trip circuit current being monitored by providing a current threshold detector in series with some form-A contacts as shown.

Figure 66: Trip circuit monitoring example

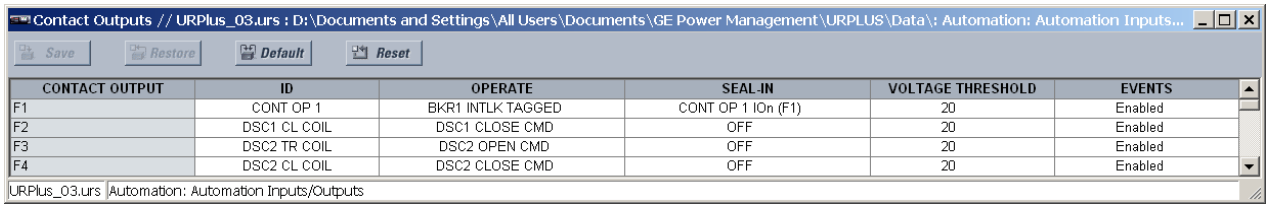


The name of the automation logic operand set by the monitor consists of the contact output identifier followed by the name of the flag. For example, using the default identifiers, we could have Cont Op 1 IOn and Cont Op 1 VOn.

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. However, 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 referred to as a *trip seal-in* scheme.

This trip seal-in scheme can be realized in the C90^{Plus} by using the Cont Op 1 IOn automation logic operand to seal-in the contact output as follows.

Figure 67: Trip seal-in scheme settings

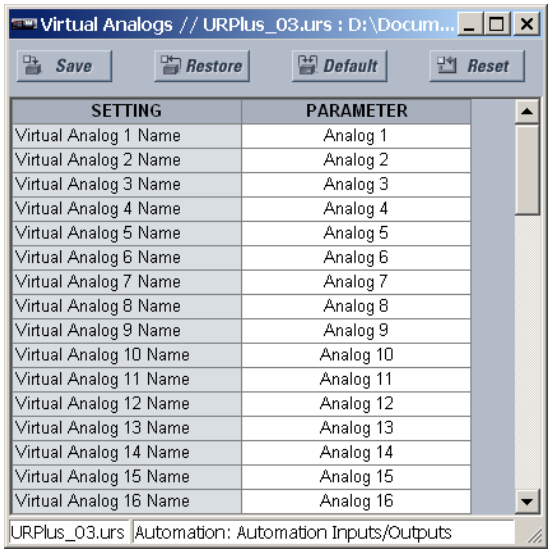


Virtual analog outputs

There are 128 virtual analog outputs that can be assigned via automation logic. Virtual analog outputs are resolved in each pass through the evaluation of the automation logic equations.

Select the **Settings > Automation > Automation Inputs/Outputs > Virtual Analogs** menu item to access the virtual analog output configuration settings.

Figure 68: Virtual analog output configuration settings



The following setting is available, with that for virtual analog output 1 outlined. The settings are identical for all virtual analog outputs.

Virtual Analog 1 Name

Range: up to 12 alphanumeric characters

Default: Analog 1

This setting specifies an identifier for virtual analog output 1. This value is included in the actual values and also is used to reference output to features designed to measure this of parameter.

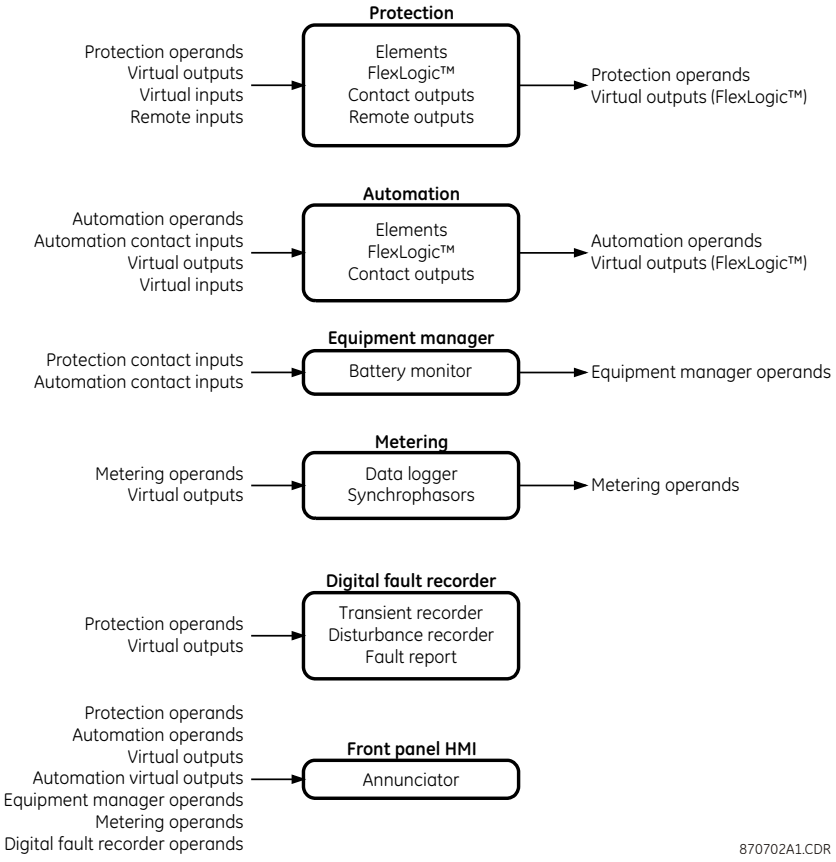
Using shared operands in automation

The EnerVista UR^{Plus} Setup software groups the C90^{Plus} system into the following seven primary functions. Each function has its own setting parameters and each generates its own outputs in the form of operands.

- Communications
- Protection
- Automation.
- Digital fault recorder (DFR)
- Metering
- Equipment manager
- Self-tests
- Front panel interface (HMI)

However, it is often desirable for an output from an element within one function can be available to an element within another function. For instance, it may be useful for the digital fault recorder to record the output operands of any protection element. Consequently a fixed, predetermined set of operands is available as to each function, as shown.

Figure 69: Default operand list by function



The content of each operand list is dependent on the selected order code.

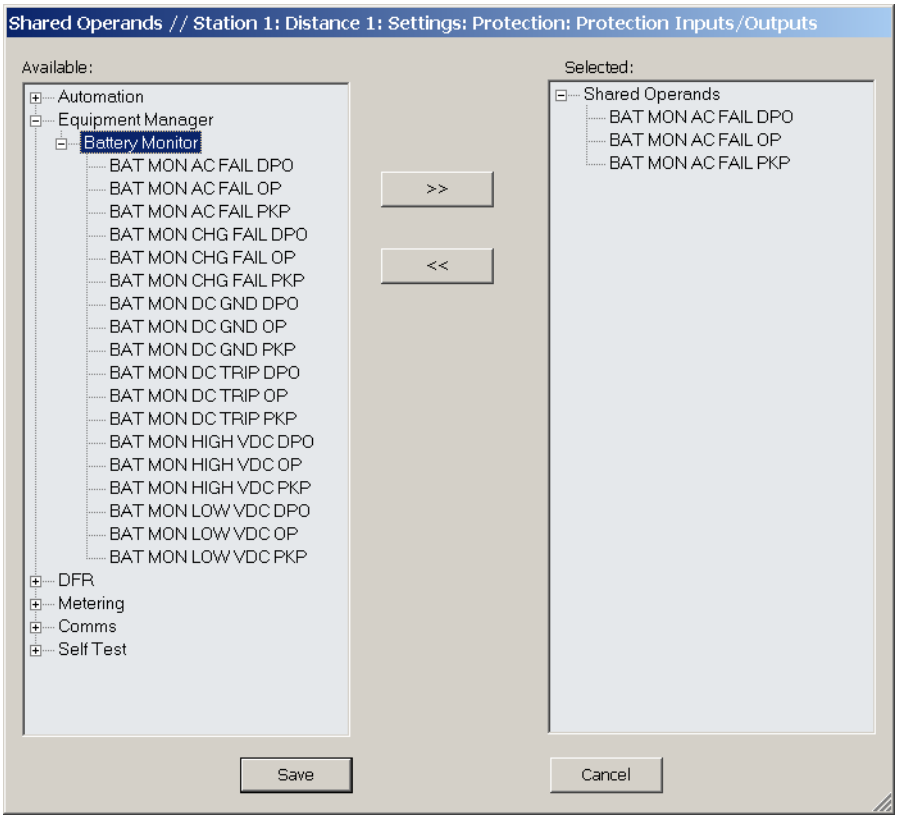
The shared operands functionality expands upon this system. With this feature, an output from any element can be assigned as a shared operand within the EnerVista UR^{Plus} Setup software. These signals can then be assigned as inputs to other functions.

For example, assume that the GND TOC1 OP protection operand is required as a signal within the automation function. This operand would then be assigned as a shared operand, and would subsequently become available to the automation function. A total of 64 operands can be assigned as shared operands within each function.

Shared automation operands

Select the **Settings > Automation > Automation Inputs/Outputs > Shared Operands** menu item to select the shared automation logic operands.

Figure 70: Shared operands configuration window

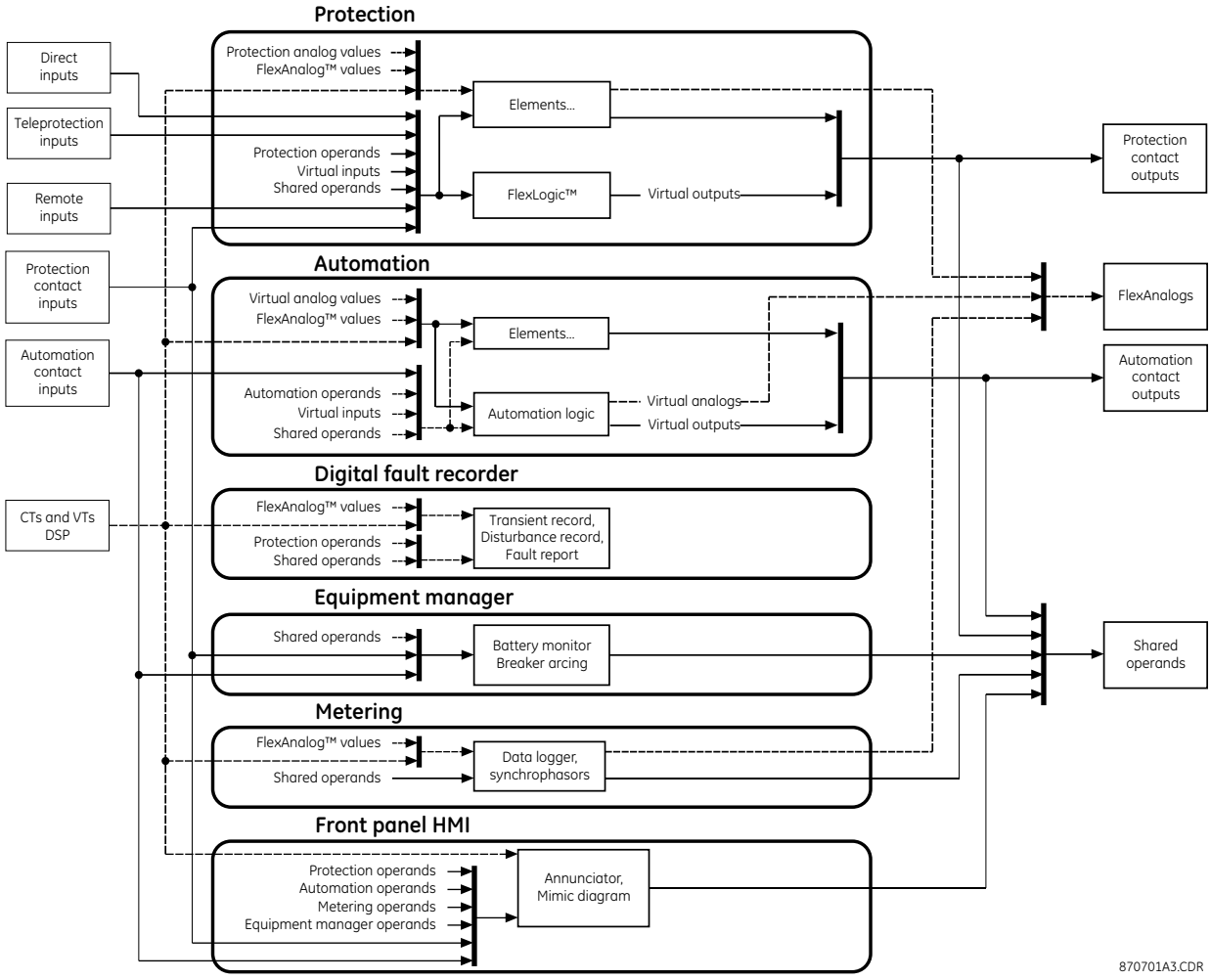


The left side of this screen displays all C90^{Plus} operands that are available to the automation function as shared operands. Select any operands from the other five primary features by clicking the **>>** button. Operands can be de-assigned as shared operands by pressing the **<<** button.

Automation logic

The C90^{Plus} internal digital logic combines fixed and user-programmable parameters. The logic upon which individual features are designed is fixed, and all other logic, from digital input signals through elements or combinations of elements to digital outputs, is variable. The user has complete control of all variable logic through automation logic. In general, the system receives digital inputs that it uses to produce digital outputs and analog inputs that it uses to produce analog outputs. The figure shows the major sub-systems of a generic UR^{Plus}-series relay involved in this process.

Figure 71: UR^{Plus}-series architecture overview



The states of all digital signals used in the C90^{Plus} are represented by flags (or automation logic operands, described later in this section). A logic 1 state 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 an automation logic equation, or to operate a contact output. The state of the contact input can be displayed locally or viewed remotely via the communications facilities provided. If a simple scheme where a contact input is used to block an element is desired, this selection is made when programming the element. This capability also applies to the other features that set flags: elements, virtual inputs, remote inputs, schemes, and human operators.

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

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

An automation logic 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 logic 1 (=ON, flag set) or logic 0 (=OFF, flag not set). Each equation is evaluated at the automation scan rate.

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 characteristics of the different types of operands are tabulated as follows.

Table 4: Automation logic operand types

Type	State	Example	Characteristics (input is logic 1 or "on" if...)
Digital input	On	DIG IP1 ON	Voltage is presently applied to the input (external contact closed)
	Off	DIG IP1 OFF	Voltage is presently not applied to the input (external contact open)
Digital output	Voltage on	DIG OP1 VON	Voltage exists across the contact
	Voltage off	DIG OP1 VOFF	Voltage does not exist across the contact
	Current on	DIG OP1 ION	Current is flowing through the contact
	Current off	CONT OP1 IOFF	Current is not flowing through the contact
Digital counter	Greater than	COUNTER 1 HI	The number of pulses counted is above the set number
	Equal to	COUNTER 1 EQL	The number of pulses counted is equal to the set number
	Less than	COUNTER 1 LO	The number of pulses counted is below the set number
Direct input	On	DIRECT INPUT 1 ON	The direct input is presently in the ON state
Element	Pickup	DIG ELEM 1 PKP	The output operand is at logic 1
	Dropout	DIG ELEM 1 DPO	This operand is the logical inverse of the pickup operand
	Operate	DIG ELEM 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
Remote input	On	REMOTE IN 1 ON	The remote input is presently in the on state
Virtual input	On	VIRT IP 1 ON	The virtual input is presently in the on state
Virtual output	On	VIRT OP 1 ON	The virtual output is presently in the on state

Automation operators

The following operators are available for the creation of automation logic:

- One-shots
- Boolean operators and latches
- Math operators
- Virtual outputs
- Comparators
- Timers

Unlike earlier versions of the C90^{Plus}, automation timers are implemented like gates or latches and not through the specific setting menus.

The following sections provide detail on these operators.

About automation one-shots

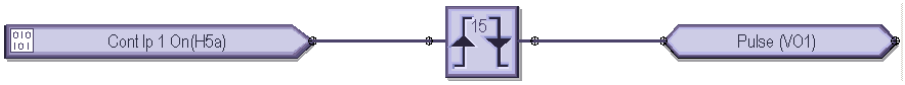
The automation one-shot syntax is shown in the following table.

Table 5: Automation logic one shots

Syntax	Description
POSITIVE ONE SHOT	One shot that responds to a positive-going edge
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

A *one-shot* accepts any digital input or the output of any logical operator. Its output asserts for one scan following a transition of its input. A negative one-shot operates on a falling edge of its input, and a positive one-shot operates on a rising edge of its input. A dual one-shot operates on a rising edge or falling edge of its input. A total of 64 one-shots are available in the C90^{Plus} automation controller.

Figure 72: One-shot used in automation logic



About Boolean operators and latches

The Boolean logic and latch syntax is shown in the following table.

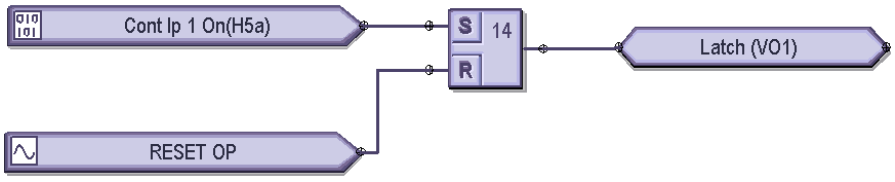
Table 6: Automation logic Boolean operators and latches

Syntax	Description	Output is ON if...
NOT	Logical NOT gate. Operates on the previous operand.	the input is logic 0
OR(2) to OR(16)	Logical OR gates. Operate on the previous 2 to 16 operands.	any input is logic 1
AND(2) to AND(16)	Logical AND gates. Operates on the previous 2 to 16 operands.	all inputs are logic 1
NOR(2) to NOR(16)	Logical NOR gates. Operates on the previous 2 to 16 operands.	all inputs are logic 0
NAND(2) to NAND(16)	Logical NAND gates. Operates on the previous 2 to 16 operands.	any input is logic 0
XOR(2)	Logical exclusive OR gate. Operates on the previous two operands.	only one input is logic 1
LATCH (S,R)	Reset-dominant latch. The operand preceding LATCH(S,R) is the reset input. The operand preceding the reset input is the set input.	there is a positive transition on the set input

Boolean operators perform Boolean logic operations on any digital input or the output of any preceding logical operator. The output of a logic operator may be used in further logic processing. The final output of a sequence of logic operations is stored as a virtual digital output (VDO). The logic operators available in the automation controller are tabulated as follows.

A *latch* is asserted on a positive transition of its set input and retains this state until the positive transition of its reset input. A latch accepts any digital input or the output of any logical operator to either of its inputs. A total of 256 latches are available in the C90^{Plus} automation controller.

Figure 73: Latch used in automation logic



Automation math operators

The automation logic math syntax is shown in the following table. Operators shown with the (a, b) suffix operate on two operands, whereas the others operate on one operand.

Table 7: Automation math operators

Syntax	Description
ABS	Return the absolute value of the previous operand
ACOS	Return the arccosine value of the previous operand
ADD (a, b)	Add the previous 2 operands
ASIN	Return the arcsine value of the previous operand
ATAN	Return the arctangent value of the previous operand
ATAN2 (a, b)	Return the arctangent value of the first operand divided by the second operand, with a range of –180 to 180°
CEIL	Return the smallest integer greater than or equal to the operand
COS	Return the cosine value of the previous operand
DIV(a, b)	Divide the first operand by the second operand
EXP	Return the power of *e* (the base of natural logarithms) value of the previous operand
FLOOR	Return the largest integer less than or equal to the operand
FMOD (a, b)	Return the remainder of the first operand divided by the second operand
IMAG (a,b)	Return the imaginary value of the previous two operands, where the first operand is the magnitude and the second operand is the angle
LOG	Return the natural logarithm (base *e*) value of the previous operand
LOG10	Return the base 10 logarithm value of the previous operand
MAG (a, b)	Return magnitude of the previous two operands, where the first operand is the real value the second operand is the imaginary value
MUL (a, b)	Multiply the previous two operands
NEG	Multiply the previous operand by –1
POW (a, b)	Raise the first operand to a power of the second operand
REAL (a, b)	Return real value of the previous two operands, where the first operand is the magnitude and the second operand is the angle
SIN	Return the sine value of the previous operand
SQRT	Return the square root of the previous operand
SUB (a ,b)	Subtract the second operand from the first operand
TAN	Return the tangent value of the previous operand

The automation controller can perform *math* operations on any analog input, any numerical constant, or the output of a preceding math operator. The final output of a sequence of math operations is stored as a virtual analog output (VAO). Numerical constants are IEEE 32-bit floating-point values and are fixed during operation of the controller. The math operators available in the automation controller are tabulated as follows.

Any analog input or the result of any math operation can be assigned to a FlexElement, which is a general purpose analog comparator. A FlexElements compare a single input with a threshold value or can compare two inputs. The output from a FlexElement can be used for further logic processing. A total of 16 FlexElements are dedicated for the automation controller.

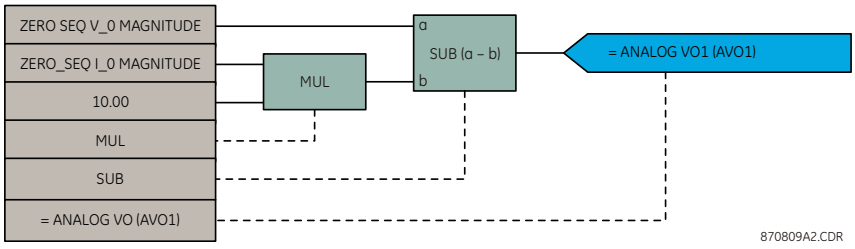
All math calculations are carried out using 32-bit IEEE floating-point numbers as defined by IEEE 754-185. This format has a range of -3.402823×10^{38} to 3.402823×10^{38}.

Consider the following math calculation.

$$\text{Analog VO1} = |V_0| - |I_0| \times 10.000 \qquad \textbf{Eq. 4}$$

The following figure is the automation logic diagram for this example.

Figure 74: Math example



When using programming language, it is a best practice to initialize a variable before using it within a program. The same principle applies to using virtual analog values in automation logic. For example, if we want an automation logic equation of the form AVO1 + SRC 4 Ig RMS = AVO3, then the result of AVO3 depends of the previous value of the AVO1 (this can any value between −∞ and +∞). As a result, the AVO3 value is indeterministic. In this case, a better approach is to initialize virtual analog output 1 as follows:

```
AVO1 = 20    // initialize virtual analog output 1 to 20
AVO1 + SRC4 Ig RMS = AVO3    // add an offset of 20 to the Ig RMS
```

About automation virtual outputs

The automation virtual output syntax is shown in the following table.

Table 8: Automation virtual output operators

Syntax	Description
VDO(1) to VDO(96)	Assigns the previous automation logic operand to the corresponding automation virtual digital output
VAO1 to VAO64	Assigns the previous automation logic operand to the corresponding automation virtual analog output

About automation comparators

Automation comparators have two inputs that are denoted "+" and "−". Each inputs be assigned to a FlexAnalog value or an analog constant. There are six types of comparators in automation logic.

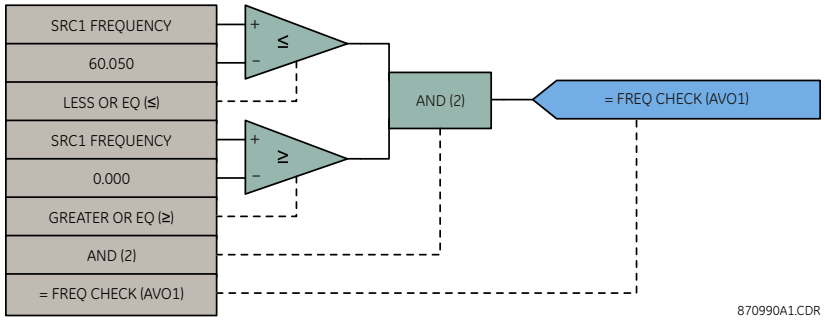
- Greater than (>)
- Less than (<)
- Equal to (=)
- Not equal to (≠)

- Greater than or equal to (≥)
- Less than or equal to (≤)

The output of the comparator is logic 1 if the inputs satisfy the condition of the particular comparator. Otherwise, the output is logic 0. The comparator output can be used as an input to Boolean logic or be assigned to an automation virtual output (AVO).

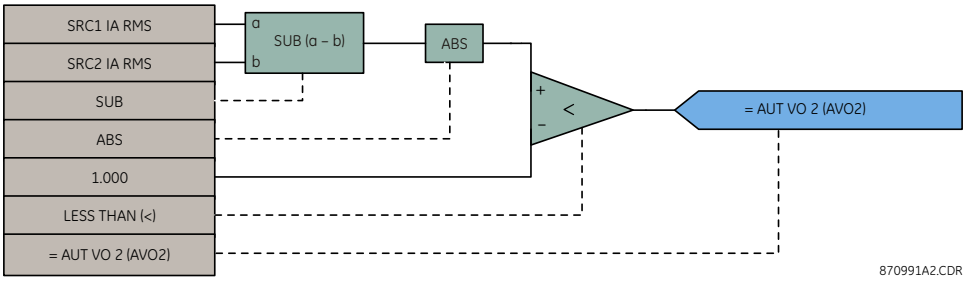
The following automation logic uses the greater than or equal to and the less than or equal to comparators to test that a value is within a specified range.

Figure 75: Using comparators to verify a value is within a specified range



The following automation logic uses the less than comparator to check if two values are approximately equal.

Figure 76: Using comparators to verify approximate equivalence



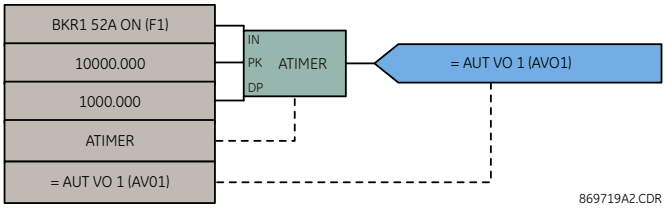
About automation timers

Unlike earlier versions of the C90^{Plus}, automation timers are implemented like gates or latches and not through the specific setting menus. Automation timers have the following syntax: TIMER (IN, PKP, DPO).

A *timer* accepts any digital input or the output of any logical operator as its IN parameter. The timer output asserts when its input is asserted for a time equal to or greater than the PKP parameter. Likewise, the timer output resets when its input has been reset for a time equal to or greater than its DPO parameter.

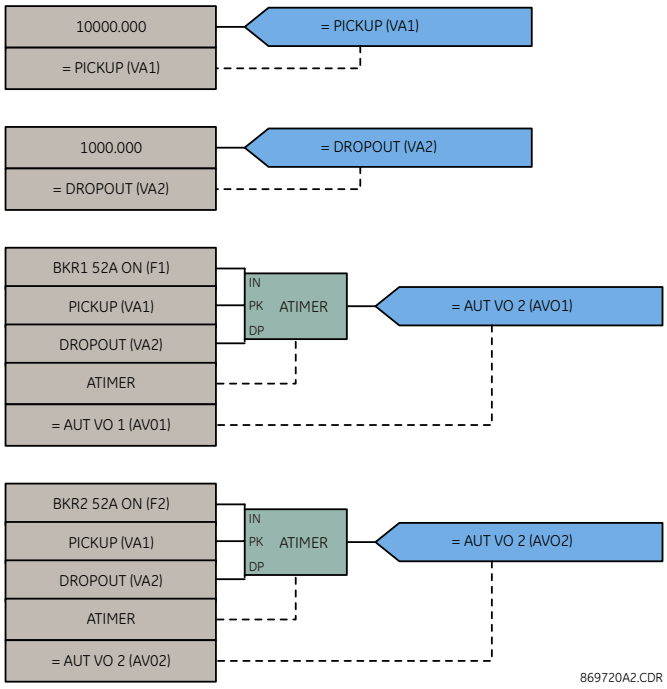
For example, the following logic produces an output that picks up 10 seconds after contact input F1 closes and drops out 1 second after the contact opens.

Figure 77: Using an automation timer



Virtual analogs can also be assigned to control the pickup and dropout of timers. In the following example, two virtual analogs are used to define the pickup and dropout of two different timers.

Figure 78: Using virtual analogs to control automation timers

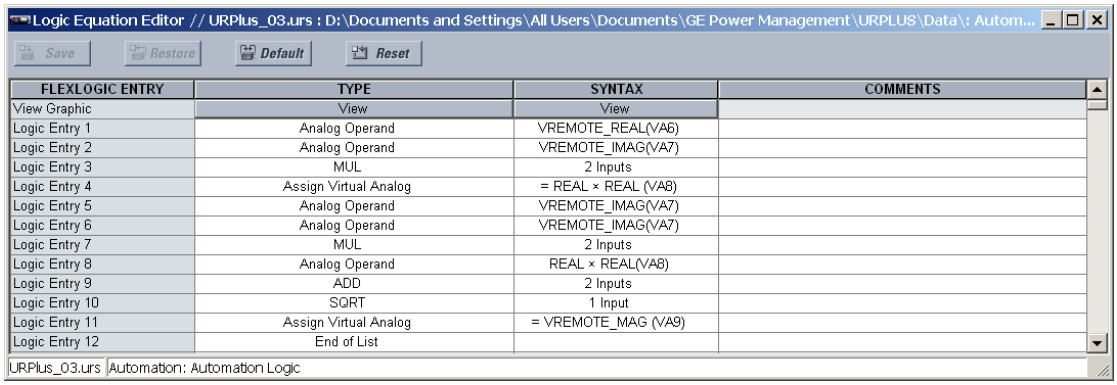


Automation logic equation editor

An automation logic equation can contain up to 4096 entries, including the END operator. If a disabled element is selected as an automation logic entry, the associated state flag is never asserted (set to logic 1).

Select the **Settings > Automation > Automation FlexLogic > FlexLogic Equation Editor** menu item to open the automation logic equation editor window.

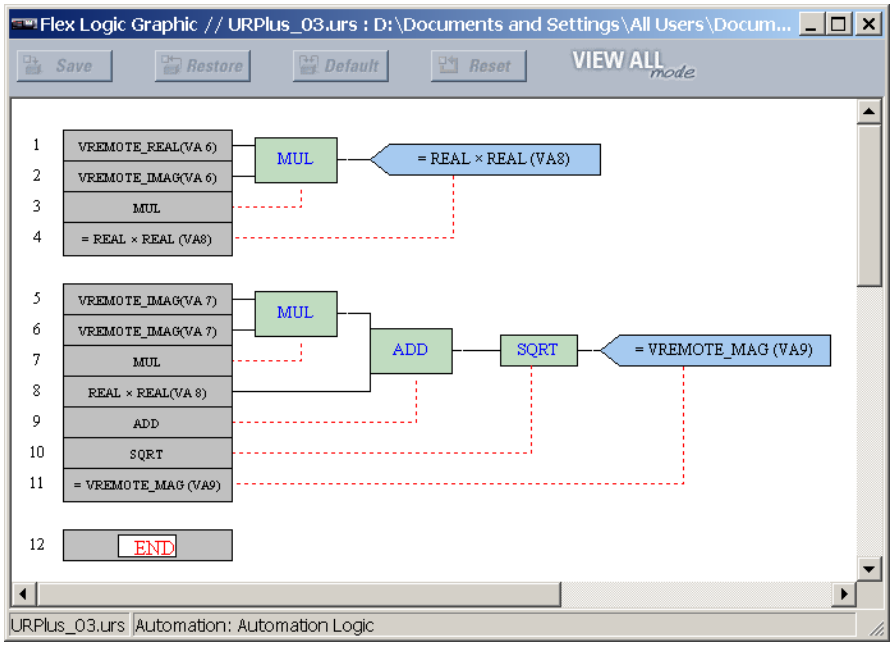
Figure 79: Automation logic configuration settings



FLEXLOGIC ENTRY	TYPE	SYNTAX	COMMENTS
View Graphic	View	View	
Logic Entry 1	Analog Operand	VREMOTE_REAL(VA6)	
Logic Entry 2	Analog Operand	VREMOTE_IMAG(VA7)	
Logic Entry 3	MUL	2 Inputs	
Logic Entry 4	Assign Virtual Analog	= REAL × REAL (VA8)	
Logic Entry 5	Analog Operand	VREMOTE_IMAG(VA7)	
Logic Entry 6	Analog Operand	VREMOTE_IMAG(VA7)	
Logic Entry 7	MUL	2 Inputs	
Logic Entry 8	Analog Operand	REAL × REAL(VA8)	
Logic Entry 9	ADD	2 Inputs	
Logic Entry 10	SQRT	1 Input	
Logic Entry 11	Assign Virtual Analog	= VREMOTE_MAG (VA9)	
Logic Entry 12	End of List		

A graphical representation of the automation logic can be displayed by clicking the **View** button at the top of the equation.

Figure 80: Typical automation logic display



Automation logic rules

When forming an automation logic equation, the sequence in the linear array of parameters must follow these general rules.

1. There are two types of operators: logic operators and math operators.
2. Logic operands must precede the logic operator that uses the operands as inputs.
3. Logic 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.
4. Assigning the output of a logic operator to a virtual output terminates the equation.
5. A timer operator (for example Aut Timer 1) or virtual output assignment (for example, = Virt Op 1) may only be used once. If this rule is broken, a syntax error is declared.
6. Math operands must precede the math operator that uses the operands as inputs.
7. Math operators have only one output. The output of a math operator must be used to create a virtual analog if it is to be used as an input to two or more operators.
8. Assigning the output of a math operator to a virtual analog terminates the equation.

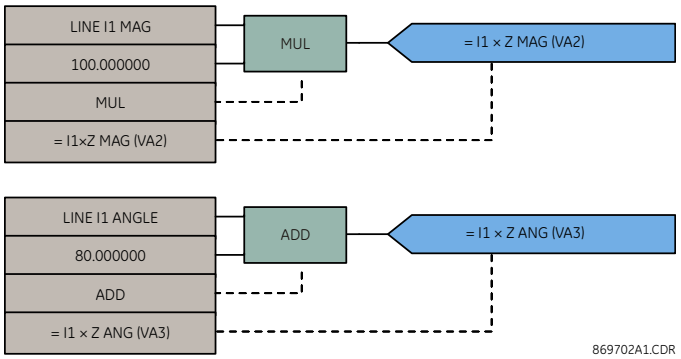
Automation logic programming example

The following automation logic programming example illustrates the implementation of a voltage regulation scheme with line drop compensation. In this scheme, the C90^{Plus} measures the local end positive-sequence voltage and calculates the remote end positive-sequence line voltage (the load center voltage) to compensate for the voltage drop on the line.

In this example, the line positive-sequence impedance is 100.0 primary ohms at 80° and the PT ratio is 1000:1. The difference between the remote end voltage and the setting voltage (69.9 volts secondary = 69900 volts primary) is assigned to the virtual analog 1 value and named DELTA_V (note that all analog quantities in the automation logic are primary values). The automation logic includes a voltage reduction command represented by virtual input 1 and named V_REDUCT. If voltage reduction is enabled, then the setpoint voltage is reduced by 5%.

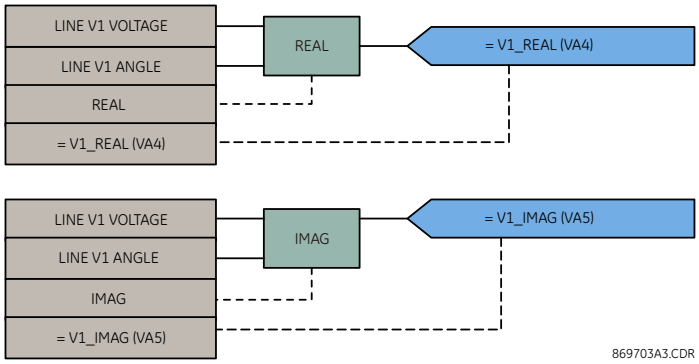
The following logic calculates the magnitude and angle of $I_1 \times Z$ and assigns these results to virtual analog 2 and virtual analog 3, respectively.

Figure 81: Magnitude and angle calculation logic for $I_1 \times Z$



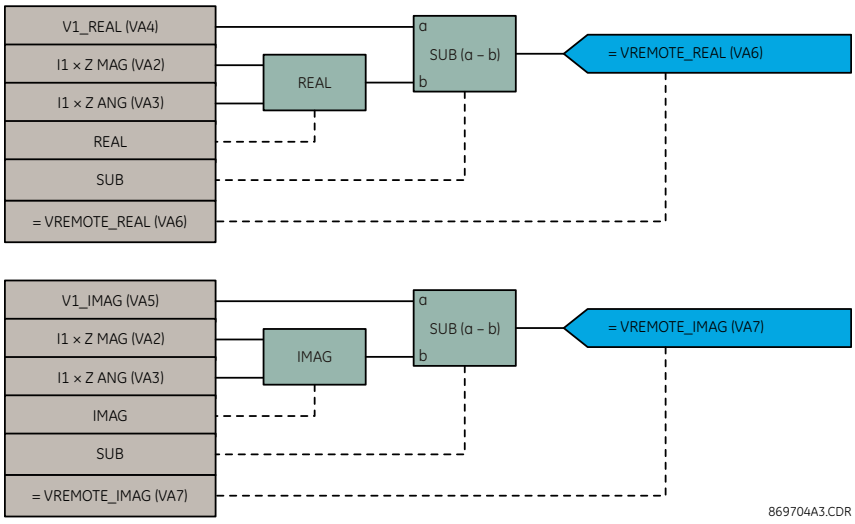
The following logic calculates the real and imaginary parts of the local positive-sequence voltage and assigns these results to virtual analog 4 and virtual analog 5, respectively.

Figure 82: Real and imaginary component calculation logic for local voltage



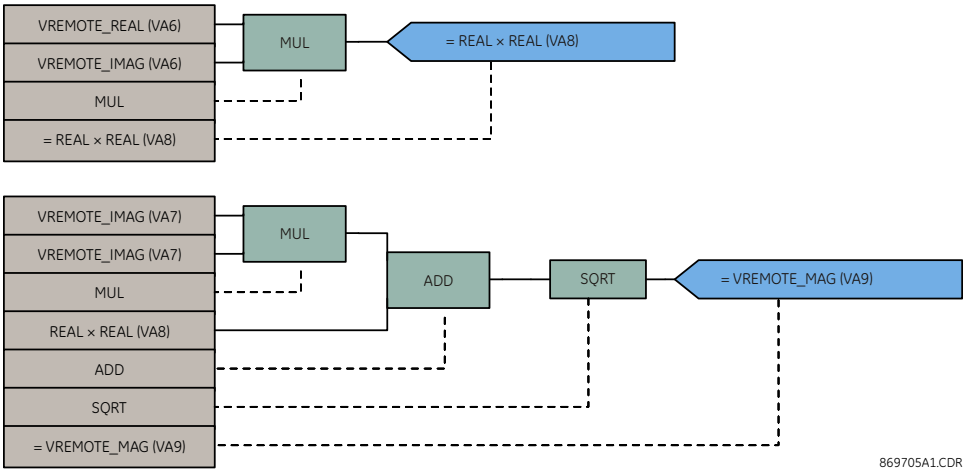
Next, the real and imaginary components of the remote voltage is calculated and assigned to virtual analog 6 and virtual analog 7, respectively.

Figure 83: Real and imaginary component calculation logic for remote voltage



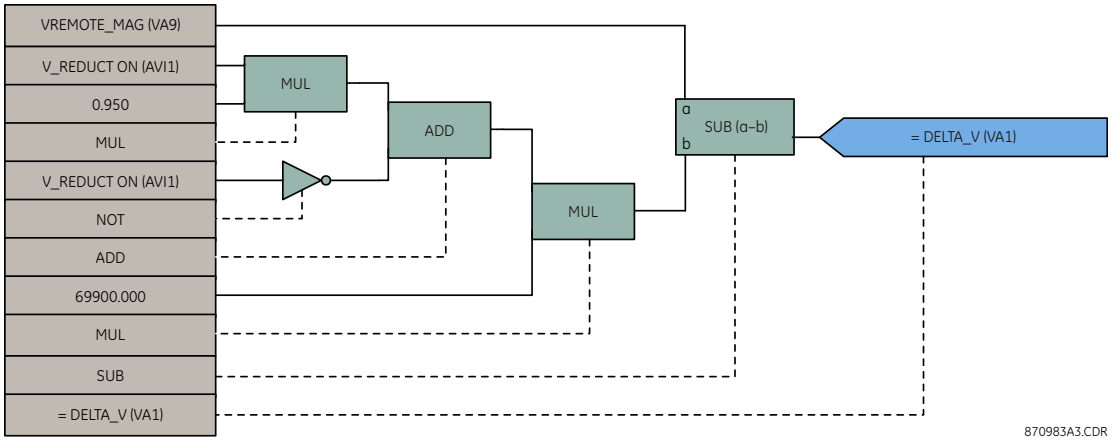
The magnitude of the remote voltage is calculated next and assigned to virtual analog 9. Note that virtual analog 8 is used as an intermediate value in the automation logic.

Figure 84: Remote voltage magnitude calculation logic



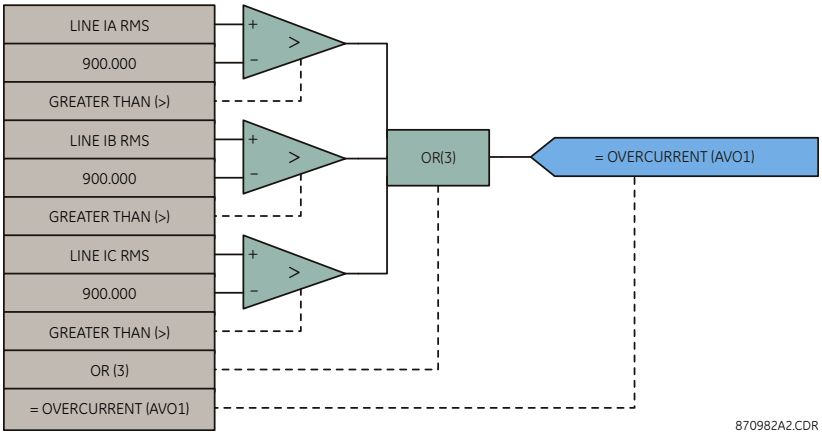
Now that the remote voltage magnitude has been calculated, the following logic calculates the voltage difference between this and the setting voltage.

Figure 85: Voltage difference automation logic



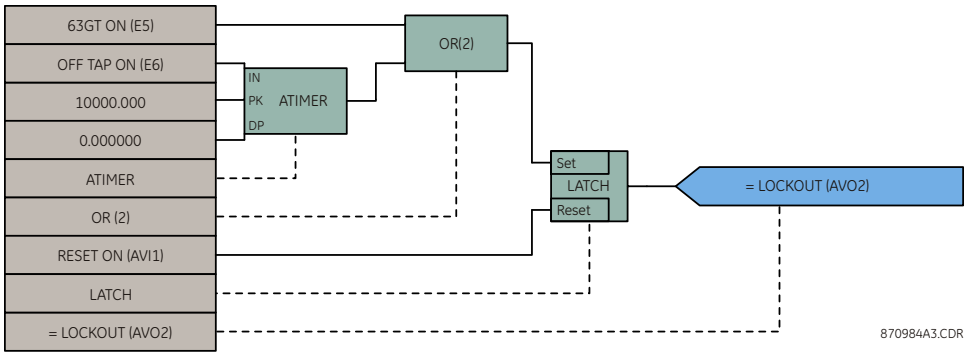
The current on each phase is checked to ensure that it is less than the maximum allowable for a tap changer operation.

Figure 86: Overcurrent check automation logic



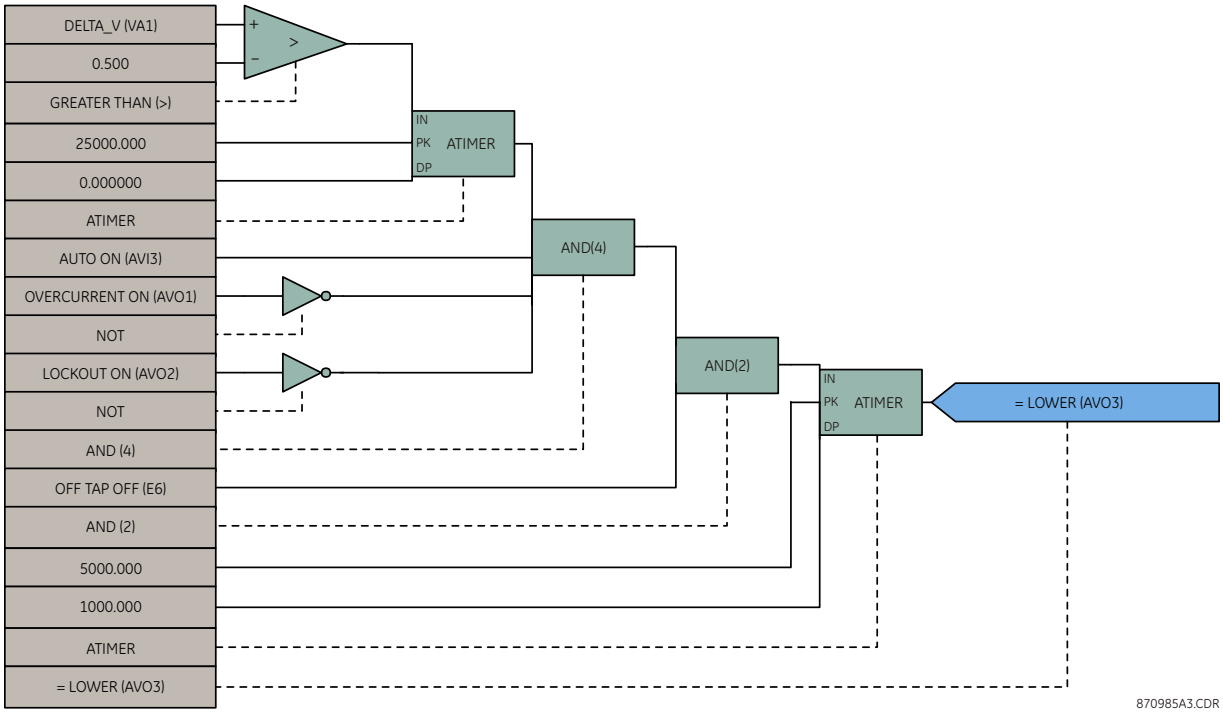
A lockout is implemented with the following logic. The lockout is asserted if the tap changer gas trip contact is picked up (63GT). The lockout is also asserted if the tap changer remains between taps for more than ten seconds. The lockout is latched until manually reset.

Figure 87: Lockout automation logic



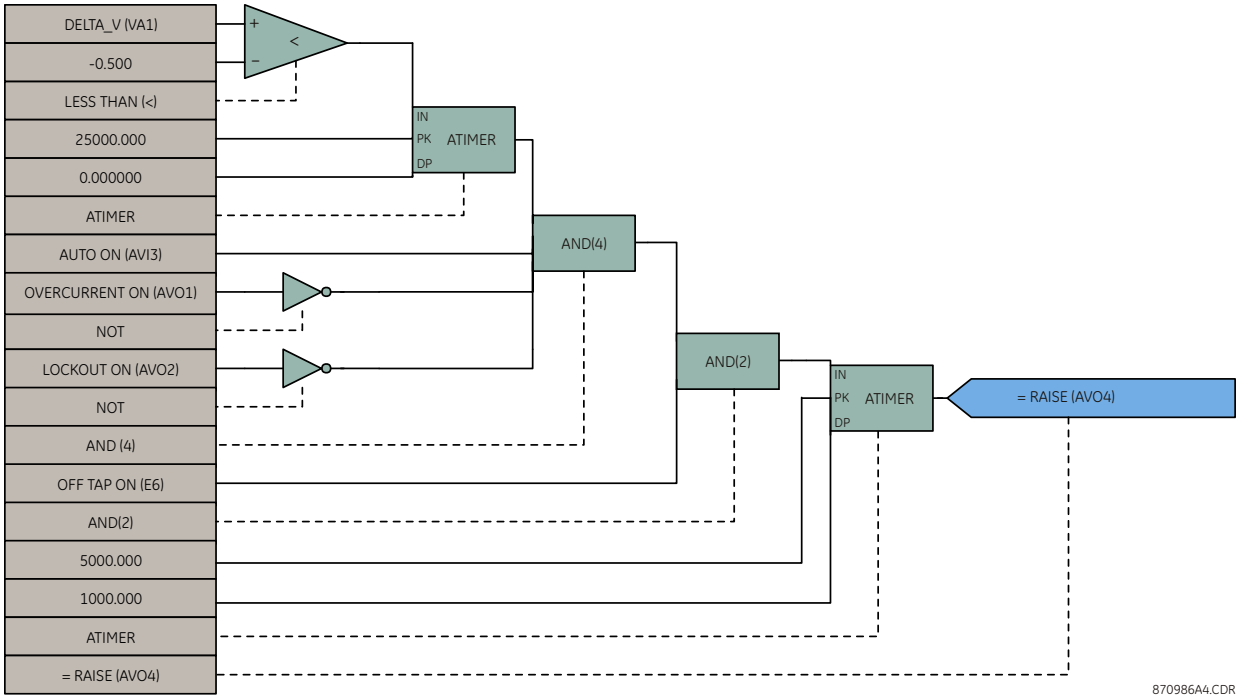
When DELTA_V is greater than 0.5 volts for more than 30 seconds (the sum of timers 2 and 3), the tap changer control is in auto mode, no overcurrent condition exists, and there is no lockout, then a LOWER command is issued via analog virtual output 4. If the voltage remains high, then subsequent LOWER commands are issued at five second intervals.

Figure 88: Lower command automation logic



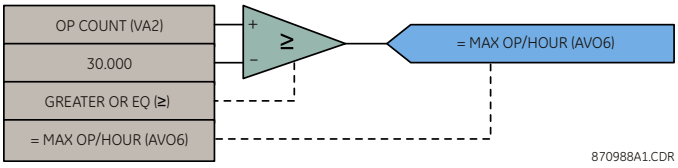
When DELTA_V is less than –0.5 volts for more than 30 seconds (the sum of timers 2 and 3), the tap changer control is in auto mode, no overcurrent condition exists, and there is no lockout, then a RAISE command is issued. If the voltage remains low, then subsequent RAISE commands are issued at five second intervals.

Figure 89: Raise command automation logic



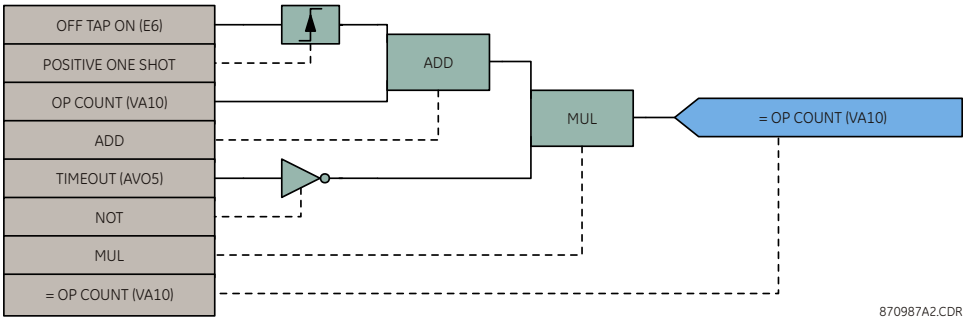
The following automation logic detects excessive tap changer operations. First, a TIMEOUT signal is created that produces a one second pulse once an hour.

Figure 90: Timeout signal automation logic



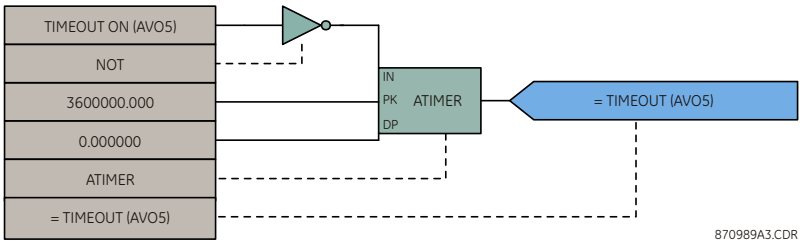
A counter is then implemented to accumulate the number of operations (indicated by the OFF TAP signal). The value of OP COUNT is reset to zero by the TIMEOUT signal once per hour.

Figure 91: Operation counter automation logic



If the number of operations is equal to or greater than the maximum number of permitted operations (30 in this example), then a MAX OP/HOUR alarm is declared.

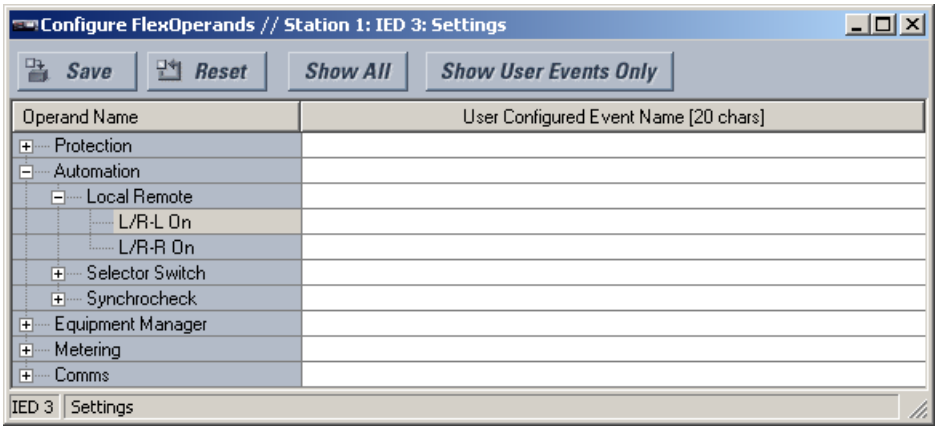
Figure 92: Maximum operations per hour alarm automation logic



Customizing the automation logic operands

Select the **Settings > Configure FlexOperands** menu item to open the user-configurable operands window.

Figure 93: User-configurable automation logic operands window



The left side of this screen displays all operands that are currently available to the C90^{Plus}. The automation logic operands are displayed by selecting the **Automation** tree item. Each operand can be renamed with a user-specified value to provide additional information or match specific applications.

User Configured Event Name

Range: up to 20 alphanumeric characters

Default: ---

Each available automation operand can be renamed to a user-specified value. This feature allows users to rename operands to allow for clearer identification or to match specific applications. The new operand name appears in protection and automation logic, in settings that take operands as their value, and in event reports.

Automation logic operands

The following automation logic operands are available for the C90^{Plus}. They are listed alphabetically by operand syntax. Some operands can be re-named by the user. These include the names of breakers, contact inputs, and virtual outputs. The default names are indicated in the lists below.

Automation virtual output operands

Aut VO 1 ON ..... Asserted when automation virtual output 1 is in the ON state (logic 1).

Aut VO 2 to 255 ..... The operands listed above are available for the automation virtual outputs 2 through 255. These operands will reflect the programmed names for the automation virtual outputs.

Breaker control operands

BKR CNTRL1 CLOSE CMD ..... Asserted when a close command is issued on breaker 1 from breaker control.

BKR CNTRL1 INTERLCK BYPS ..... Asserted when interlocking is bypassed for breaker 1.

BKR CNTRL1 OPEN CMD ..... Asserted when an open command is issued on breaker 1 from breaker control.

BKR CNTRL2 ..... The operands listed above are also available for all breakers.

Breaker interlocking operands

BKR INTERLK1 CLS PERM ..... Asserted when all conditions have been satisfied for closing breaker 1.

BKR INTERLK1 OPEN PERM ..... Asserted when all conditions have been satisfied for opening breaker 1.

BKR INTERLK1 TAGGED ..... Asserted when a tag is applied to breaker 1.

BKR INTERLK2 ..... The operands listed above are available all breaker interlocking elements.

Automation contact input operands

Cont Ip 1 OFF ..... Asserted when the field contact connected to contact input 1 is opened.

Cont Ip 1 ON ..... Asserted when the field contact connected to contact input 1 is closed.

Cont Ip 1 TRB OFF ..... Asserted when there are no problems with contact input 1.

Cont Ip 1 TRB ON ..... Asserted when there is an internal or external problem with contact input 1.

Cont Ip 2 to 40 ..... The operands listed above are available for automation contact inputs 2 through 40. These operands will reflect the programmed names for the automation contact inputs.

Automation contact output operands

Cont Op 1 IOff ..... Asserted when contact output 1 with current monitoring is opened.

Cont Op 1 IOn ..... Asserted when contact output 1 with current monitoring is closed.

Cont Op 1 VOff ..... Asserted when contact output 1 with voltage monitoring is opened.

Cont Op 1 VOn ..... Asserted when contact output 1 with voltage monitoring is closed.

Cont Op 2 to 40 ..... The operands listed above are available for automation contract outputs 2 through 40. These operands will reflect the programmed names for the automation contact outputs.

Disconnect control operands

DISC CNTRL1 CLOSE CMD ..... Asserted when disconnect 1 is closed.

DISC CNTRL1 INTERLCK BYPS ..... Asserted when interlocking has been bypassed for disconnect 1.

DISC CNTRL1 LOCAL SELECT ..... Asserted when disconnect 1 has been selected from the front panel HMI.

DISC CNTRL1 OPEN CMD ..... Asserted when disconnect 1 is open.

DISC CNTRL1 REMOTE SELECT ..... Asserted when disconnect 1 has been selected from SCADA.

DISC CNTRL2 ..... The operands listed above are available all disconnects.

Disconnect interlock operands

DISC INTERLK1 CLS PERM ..... Asserted when all conditions have been satisfied for closing disconnect 1.

DISC INTERLK1 OPEN PERM ..... Asserted when all conditions have been satisfied for opening disconnect 1.

DISC INTERLK1 TAGGED ..... Asserted when a tag is applied to disconnect 1.

DISC INTERLK2 ..... The operands listed above are available all disconnect interlocking elements.

Disconnect configuration operands

DISC1 ANY POLE OPEN ..... Asserted when at least one pole of disconnect 1 is open.

DISC1 BAD STATE ..... Asserted when the normally open and normally closed disconnect indications disagree.

DISC1 CLOSE CMD ..... Asserted when a close command has been executed on disconnect 1.

DISC1 CLOSED ..... Asserted when disconnect 1 has been closed.

DISC1 DISCREPANCY ..... Asserted when the three poles of the disconnect disagree (that is, when they are not all opened or all closed).

DISC1 INTERMED ..... Asserted when the disconnect is in transition between the opened and closed states.

DISC1 ONE POLE OPEN ..... Asserted when only one pole of disconnect 1 is open

DISC1 OPEN CMD ..... Asserted when an open command is executed on disconnect 1.

DISC1 OPENED ..... Asserted when disconnect 1 is opened.

DISC1 SUBST CLOSED ..... Asserted when the status of disconnect 1 has been substituted with a closed indication.

DISC1 SUBST ON ..... Asserted when disconnect status substitution is enabled for disconnect 1.

DISC1 SUBST OPENED ..... Asserted when the status of disconnect 1 has been substituted with an opened indication.

DISC1A BAD STATE ..... Asserted when the normally open and normally closed breaker indications disagree for pole A of disconnect 1.

DISC1A CLOSED ..... Asserted when disconnect 1 pole A is closed.

DISC1A INTERMED ..... Asserted when breaker 1 pole A is in transition between the opened and closed states.

DISC1A OPENED ..... Asserted when disconnect 1 pole A is opened.

DISC1B BAD STATE ..... Asserted when the normally open and normally closed breaker indications disagree for pole B of disconnect 1.

DISC1B CLOSED ..... Asserted when disconnect 1 pole B is closed.

DISC1B INTERMED ..... Asserted when breaker 1 pole B is in transition between the opened and closed states.

DISC1B OPENED ..... Asserted when disconnect 1 pole B is opened.

DISC1C BAD STATE ..... Asserted when the normally open and normally closed breaker indications disagree for pole C of disconnect 1.

DISC1C CLOSED ..... Asserted when disconnect 1 pole C is closed.

DISC1C INTERMED ..... Asserted when breaker 1 pole C is in transition between the opened and closed states.

DISC1C OPENED ..... Asserted when disconnect 1 pole C is opened.

DISC2 ..... The operands listed above are available for all disconnects.

Fast load shedding operands

FLS ANY SHEDREQ OFF ..... Asserted when there is no shed request.

FLS ANY SHEDREQ ON ..... Asserted when there are one or more shed requests.

FLS COMMS TRBL OFF ..... Asserted when all enabled data unit Comms Trbl operands are off.

FLS COMMS TRBL ON ..... Asserted when one ore more enabled data unit Comms Trbl operands are on.

FLS CONTINGENCY OFF: Asserted when the contingency timer is not active.

FLS CONTINGENCY ON: Asserted when the contingency timer is active.

FLS DU1 COMMS TRBL ON: Asserted when the data unit is enabled but valid data messages are not being received.

FLS DU1 STATUS ON: Asserted when the data unit offline status or unavailability for shedding status is being received with value on, when communications are lost, and when the data unit is not disabled. This value is undefined for aggregator data units.

FLS D2...: The fast load shedding data unit operands listed above are also available for data units 2 through 64.

FLS IF1...32 OFFLINE: Asserted when the mapped data unit or local data unit status is on.

FLS IF2...: The fast load shedding infeed operand listed above is also available for infeeds 2 through 32.

FLS LG1 SHEDREQ ON: Asserted when the fast load shedding element is requesting the loads in the load group be shed.

FLS LG2...: The fast load shedding load group operand listed above is also available for load groups 2 through 32.

FLS LU1 STATUS ON: Asserted when the value of the operand selected by the local data unit status setting is on and the local data unit is not disabled.

FLS LU2...: The fast load shedding local data unit operand listed above is also available for local data units 2 through 6.

Frequency rate of change load shedding operands

FRLS1 DPO: Asserted when the frequency rate of change load shedding 1 element drops out.

FRLS1 OP: Asserted when the frequency rate of change load shedding 1 element operates.

FRLS1 PKP: Asserted when the frequency rate of change load shedding 1 element picks up.

FRLS2...: The operands listed above are also available for the frequency rate of change load shedding 2 to 4 elements.

Local-remote control scheme operands

L/R L ON: Asserted while the local control scheme is enabled.

L/R R ON: Asserted while the remote control scheme is enabled.

Selector switch operands

SELECTOR 1 ALARM: Asserted when the position of selector 1 has been pre-selected but not acknowledged.

SELECTOR 1 BIT 0: Represents the first bit of the three-bit word encoding position of selector 1.

SELECTOR 1 BIT 1: Represents the second bit of the three-bit word encoding position of selector 1.

SELECTOR 1 BIT 2: Represents the third bit of the three-bit word encoding position of selector 1.

SELECTOR 1 BIT ALARM: Asserted when the position of selector 1 has been pre-selected with the three-bit control input but not acknowledged.

SELECTOR 1 POS 1: Asserted when selector switch 1 is in position 1.

SELECTOR 1 POS 2: Asserted when selector switch 1 is in position 2.

SELECTOR 1 POS 3: Asserted when selector switch 1 is in position 3.

SELECTOR 1 POS 4: Asserted when selector switch 1 is in position 4.

SELECTOR 1 POS 5: Asserted when selector switch 1 is in position 5.

SELECTOR 1 POS 6: Asserted when selector switch 1 is in position 6.

SELECTOR 1 POS 7: Asserted when selector switch 1 is in position 7.

SELECTOR 1 PWR ALARM: Asserted when the position of selector switch 1 is undetermined or restored from memory when the relay powers up and synchronizes to the three-bit input.

SELECTOR 1 STP ALARM: Asserted when the position of selector 1 has been pre-selected with the stepping up control input but not acknowledged.

SELECTOR 2...: The same set of operands shown above are available for selector switch 2.

Small signal oscillation detection operands

SSOD 1 ALARM: Asserted when the small signal oscillation detector 1 alarm picks up.

SSOD 1 FAIL: Asserted when the small signal oscillation detector 1 is not receiving valid data from programmed inputs for at least 10 seconds.

SSOD 1 INT: Asserted during the small signal oscillation detector 1 interval.

SSOD1 TRIP: Asserted when the small signal oscillation detector 1 trip picks up.

SSOID2: The same set of operands shown above are available for small signal oscillation detector 2

Synchrocheck operands

SYNC 1 CLS DPO: Asserted when the synchrocheck 1 close has dropped out.

SYNC 1 CLS OP: Asserted when the synchrocheck 1 close has operated.

SYNC 1 DEAD S DPO: Asserted when the synchrocheck 1 dead source has dropped out.

SYNC 1 DEAD S OP: Asserted when the synchrocheck 1 dead source has operated.

SYNC 1 SYNC DPO: Asserted when the synchrocheck 1 has dropped out while in synchronization.

SYNC 1 SYNC OP: Asserted when the synchrocheck 1 has operated while in synchronization.

SYNC 1 V1 ABOVE MIN: Asserted when the synchrocheck 1 V_1 value is above the minimum live voltage.

SYNC 1 V1 BELOW MAX: Asserted when the synchrocheck 1 V_1 value is below the maximum dead voltage.

SYNC 1 V2 ABOVE MIN: Asserted when the synchrocheck 1 V_2 value is above the minimum live voltage.

SYNC 1 V2 BELOW MAX: Asserted when the synchrocheck 1 V_2 value is below the maximum dead voltage.

SYNC 2...: The set of operands shown above are available for synchrocheck 2.

Underfrequency load shedding operands

UFLS1 DPO: Asserted when the underfrequency load shedding 1 element drops out.

UFLS1 OP: Asserted when the underfrequency load shedding 1 element operates.

UFLS1 PKP: Asserted when the underfrequency load shedding 1 element picks up.

UFLS2...: The operands listed above are also available for the underfrequency load shedding 2 to 6 elements.

Undervoltage load shedding operands

UVLS1 DPO ..... Asserted when the undervoltage load shedding 1 element drops out.

UVLS1 OP ..... Asserted when the undervoltage load shedding 1 element operates.

UVLS1 PKP ..... Asserted when the undervoltage load shedding 1 element picks up.

UVLS2... ..... The operands listed above are also available for the undervoltage load shedding 2 to 6 elements.

Automation FlexAnalog parameters

The following automation FlexAnalog parameters (analog operands) are available for the C90^{Plus}. They are listed alphabetically by operand syntax.

Fast load shedding analog operands

FLS DU 1 Power ..... Fast load shedding data unit 1 power value

FLS IF 1 Infeed ..... Fast load shedding infeed 1 power value

FLS IF 1 Reserve ..... Fast load shedding infeed 1 percentage reserve value

FLS LG 1 Load ..... Fast load shedding load group 1 load value

FLS Load Shed Order ..... Fast load shedding load shed order value

FLS LU 1 Power ..... Fast load shedding local data unit 1 power value

FLS S 1 Arming ..... Fast load shedding scenario 1 arming value

FLS Total Avbl Load ..... Fast load shedding total available load value

FLS Total Infeed ..... Fast load shedding total infeed power value

FLS Total Reserve ..... Fast load shedding total percentage reserve value

Load shedding analog operands

Load Shed df/dt 1 ..... Metered frequency rate of change load shedding 1 value

Load Shed dv/dt 1 ..... Metered voltage rate of change load shedding 1 value

Load Shed df/dt 2... ..... The parameters above are available for the frequency rate of change load shedding 2 through 4 elements

Load Shed dv/dt 2... ..... The parameters above are available for the voltage rate of change load shedding 2 through 6 elements

Synchrocheck analog operands

Synchchk 1 Delta V ..... Metered voltage difference for the synchrocheck 1 element

Synchchk 1 Delta F ..... Metered frequency difference for the synchrocheck 1 element

Synchchk 1 Delta Phs ..... Metered phase difference for the synchrocheck 1 element

Synchchk 2 Delta V ..... Metered voltage difference for the synchrocheck 2 element

Synchchk 2 Delta F ..... Metered frequency difference for the synchrocheck 2 element

Synchchk 2 Delta Phs ..... Metered phase difference for the synchrocheck 2 element

C90Plus Controller

Chapter 9: Equipment manager

A program for equipment monitoring can result in extended equipment life, improved system reliability, and increased equipment availability. Furthermore, effective equipment monitoring allows maintenance to be targeted towards the equipment in the greatest need. The C90Plus provides a variety of measurements and alarms that can be used to monitor the condition of the DC battery.

Overview of the equipment manager

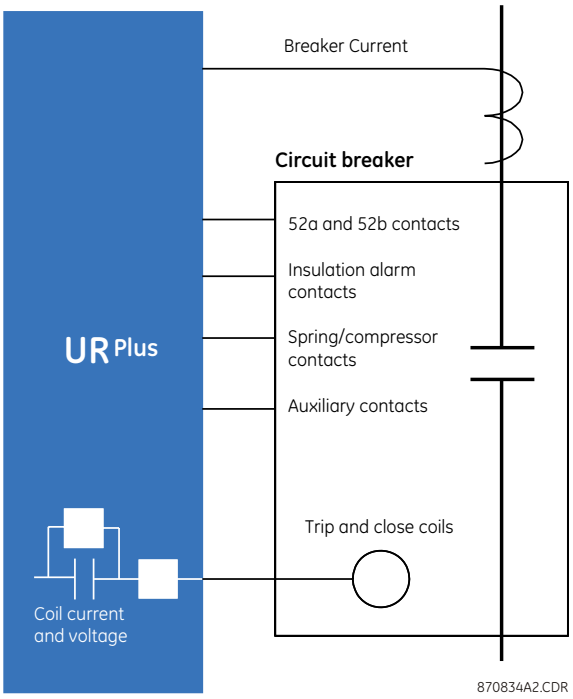
The C90Plus equipment manager is broken down into six functions according to the specific equipment sub-system.

- Breaker arcing (supported in C90Plus)
- Breaker timing
- Coil signature
- Breaker insulation
- Breaker auxiliaries
- Battery monitor (supported in C90Plus)



Only the battery monitor and breaker arcing features are supported in the current version of the C90Plus.

Figure 1: Equipment manager block diagram



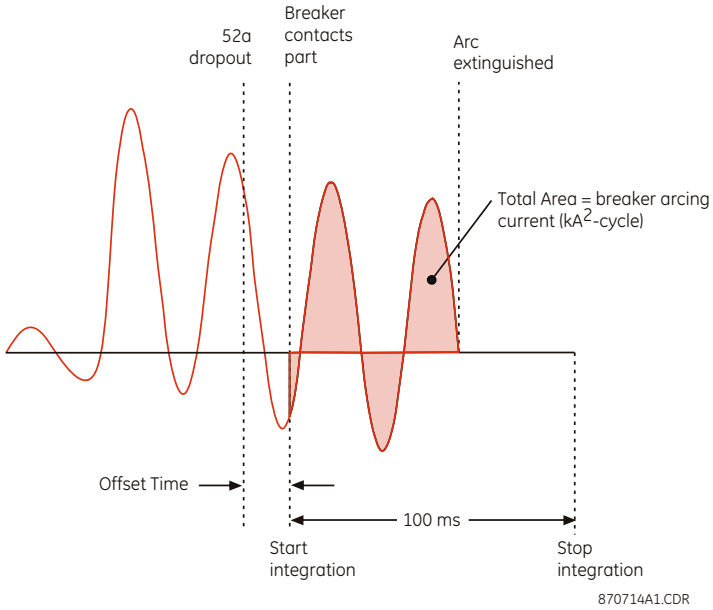
Breaker management

This section describes the breaker management features of the equipment manager.

Circuit breaker arcing

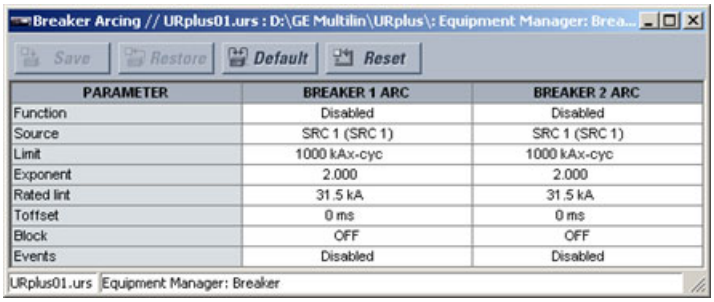
The breaker arcing function provides indications of the condition of the circuit breaker interrupter. The primary function is measurement of accumulated contact wear. This is accomplished by integrating the current passing through the breaker during interruption. The function compares the accumulated arcing current with manufacturer data to provide an indication that the breaker requires maintenance. The function also measures the total clearing time, and the maximum interrupted current. This latter value is compared with manufacturer data to determine if the interrupt rating of the breaker has been exceeded.

Figure 2: Breaker arcing current measurement



Select the **Settings > Equipment Manager > Breaker > Breaker Arcing** menu item to open the breaker arcing current configuration window.

Figure 3: Breaker arcing current configuration settings



PARAMETER	BREAKER 1 ARC	BREAKER 2 ARC
Function	Disabled	Disabled
Source	SRC 1 (SRC 1)	SRC 1 (SRC 1)
Limit	1000 kAx-cyc	1000 kAx-cyc
Exponent	2.000	2.000
Rated Int	31.5 kA	31.5 kA
Toffset	0 ms	0 ms
Block	OFF	OFF
Events	Disabled	Disabled

The following settings are available for each breaker arcing current element.

Function

Range: Enabled, Disabled
Default: Disabled

This settings enables or disables the breaker arcing current function.

Source

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)
Default: LINE (SRC 1)

This setting selects the signal source for the breaker arcing current element.

Limit

Range: 0 to 50000 kA^2-cycle in steps of 1
Default: 1000 kA^2-cycle

This setting specifies the limit of the accumulated current arcing time for maintenance.

Exponent

Range: 1.000 to 5.000 in steps of 0.001
Default: 2.000

This setting specifies the accumulated breaker wear is proportional to the following equation,

$$\sum I^x t \qquad \textbf{Eq. 1}$$

where *x* is the arcing exponent. The typical value for the arcing exponent is 2.

Interruption Rating

Range: 0.0 to 100.0 kA in steps of 0.1
Default: 31.5 kA

This setting specifies the maximum symmetrical interruption rating of the circuit breaker.

Arcing Time Offset

Range: 0 to 50 ms in steps of 1
Default: 0 ms

This setting specifies the time difference between the dropout of the 52a auxiliary contact and the parting of the circuit breaker contacts (measured from a circuit breaker timing diagram).

Block

Range: any equipment manager operand or shared operand
Default: OFF

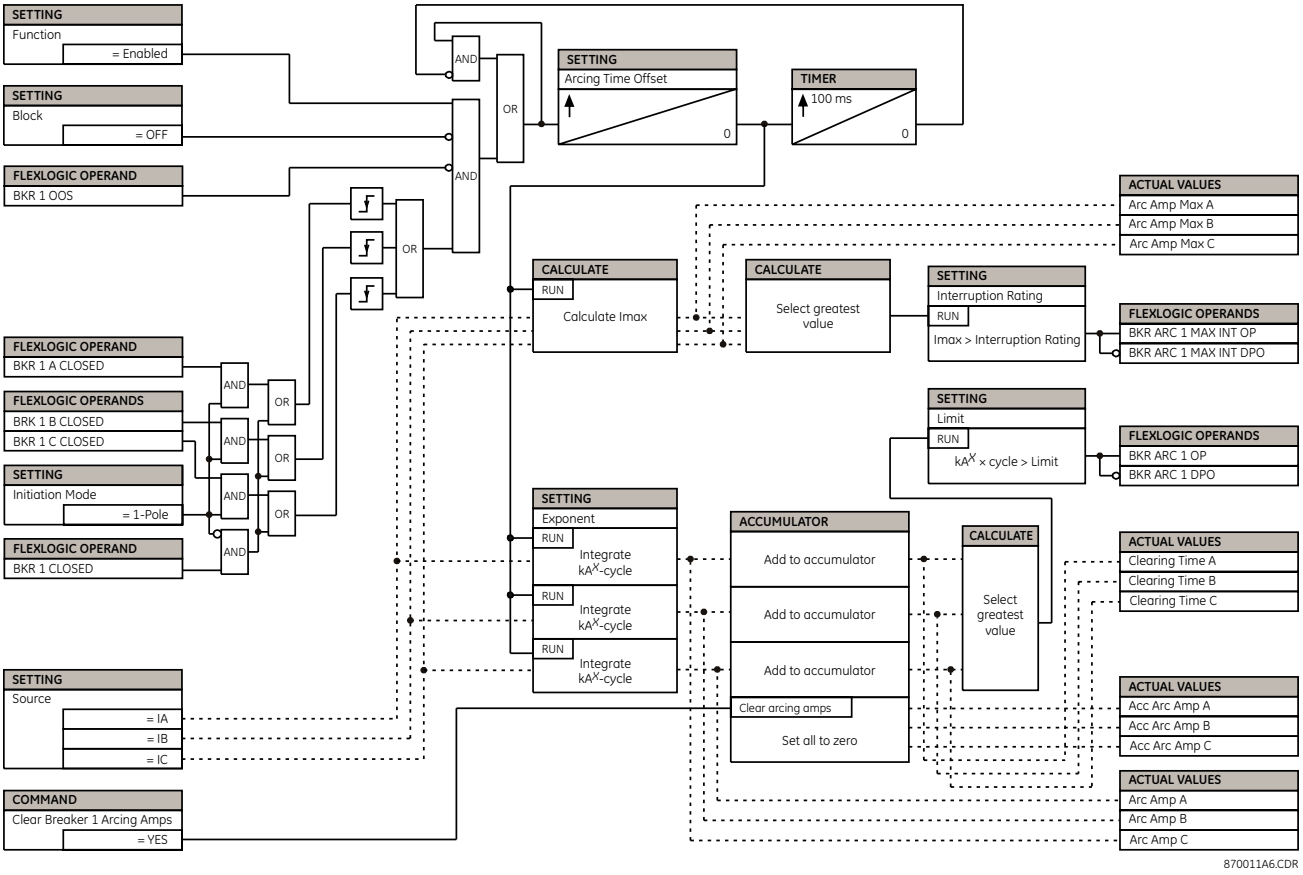
Assertion of the operand assigned to this setting blocks operation of the circuit breaker arcing element.

Events

Range: Enabled, Disabled
Default: Disabled

This setting enables or disables the recording of breaker arcing current events in the sequence of events record.

Figure 4: Breaker arcing current logic



Battery monitor

The battery monitor function monitors the health of the DC battery system. It provides an analog indication of the current DC voltage derived from a contact input wired between the positive and negative rails of the battery system. This signal is used to generate high and low DC voltage alarms. This function also monitors and conditions the auxiliary alarm contacts from the battery charger.

Indications and wiring

The following indications and alarms are provided for the battery monitor function.

Battery monitor alarms and indications

BATTERY VOLTAGE..... Displays the present value of the battery voltage.

HIGH DC VOLTAGE..... Indicates the battery DC voltage is greater than the maximum setting value.

LOW DC VOLTAGE..... Indicates the battery DC voltage is less than the minimum setting value.

SUPPLY FAIL..... Indicates the AC supply to the battery charger has failed.

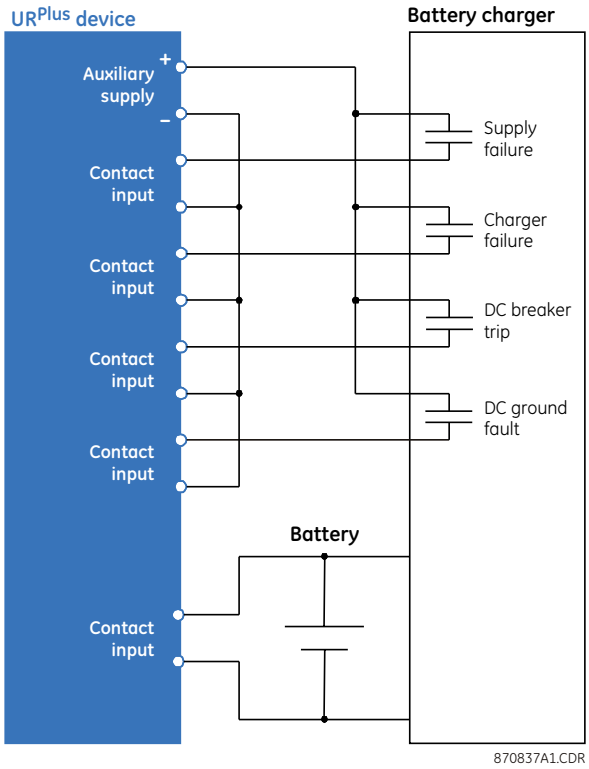
CHARGER FAIL..... Indicates the battery charger has failed.

BREAKER TRIP..... Indicates a DC distribution breaker has operated.

DC GND FLT..... Indicates a battery DC ground fault.

The figure shows typical wiring for the battery monitor element.

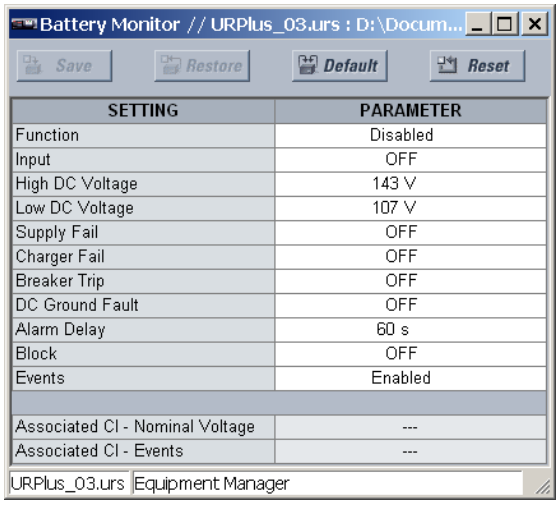
Figure 5: Battery monitor wiring diagram



Battery monitor settings

Select the **Settings > Equipment Manager > Battery Monitor** menu item to open the battery monitor configuration window.

Figure 6: Battery monitor configuration settings



The following settings are available.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the battery monitor element.

Input

Range: any contact input or OFF
Default: OFF

This setting specifies the contact input used to monitor the battery voltage.

High DC Volts

Range: 38 to 275 volts in steps of 1
Default: 143 volts

This setting is used to detect battery overcharging. This can result in loss of life, loss of electrolyte, and thermal runaway. Set this setting above the expected voltage during an equalization charge.

Low DC Volts

Range: 38 to 275 volts in steps of 1
Default: 107 volts

This setting is used to detect battery undercharging, which can lead to reduced cell capacity and sulfation. An undervoltage condition will also occur due to a charger failure.

Supply Fail

Range: any equipment manager operand or shared operand
Default: OFF

This setting selects the input connected to the AC supply failure contact.

Charger Fail

Range: any equipment manager operand or shared operand
Default: OFF

This setting selects the input connected to the charger critical failure contact.

Breaker Trip

Range: any equipment manager operand or shared operand
Default: OFF

This setting selects the input connected to the DC distribution breaker trip contact.

DC Ground Fault

Range: any equipment manager operand or shared operand
Default: OFF

This setting selects the input connected to the DC ground fault contact.

Alarm Delay

Range: 2 to 300 seconds in steps of 1
Default: 60 seconds

This setting specifies the time required for a field contact to be asserted before the corresponding alarm is declared.

Block

Range: any equipment manager operand or shared operand
Default: OFF

Assertion of the operand assigned to this setting blocks operation of the battery monitor element.

Events

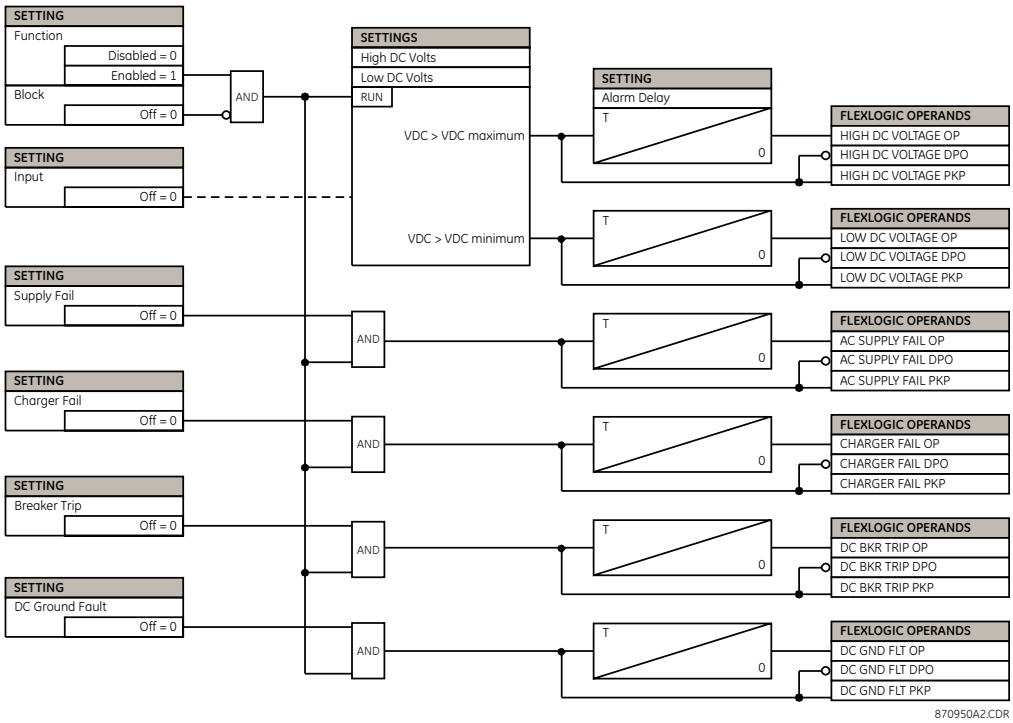
Range: Enabled, Disabled

Default: Enabled

This setting enables and disables the logging of battery monitoring events in the sequence of events recorder.

The figure shows the battery monitoring logic diagram.

Figure 7: Battery monitor scheme logic



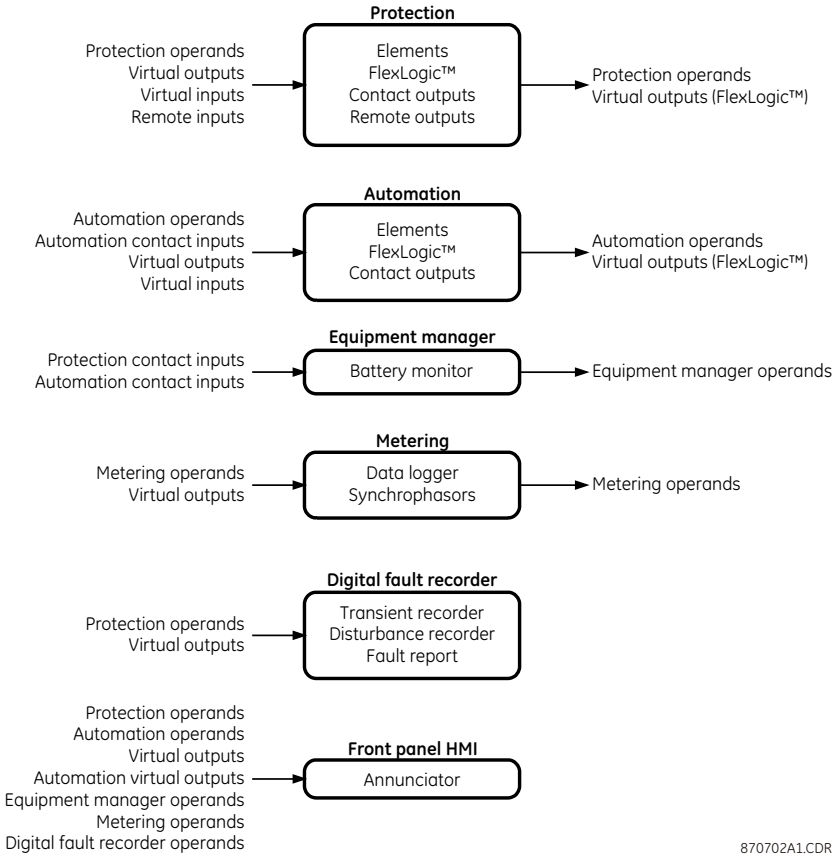
Using shared operands in the equipment manager

The EnerVista UR^{Plus} Setup software groups the C90^{Plus} system into the following seven primary functions. Each function has its own setting parameters and each generates its own outputs in the form of operands.

- Communications
- Protection
- Automation.
- Digital fault recorder (DFR)
- Metering
- Equipment manager
- Self-tests
- Front panel interface (HMI)

However, it is often desirable for an output from an element within one function can be available to an element within another function. For instance, it may be useful for the digital fault recorder to record the output operands of any protection element. Consequently a fixed, predetermined set of operands is available as to each function, as shown.

Figure 8: Default operand list by function



The content of each operand list is dependent on the selected order code.

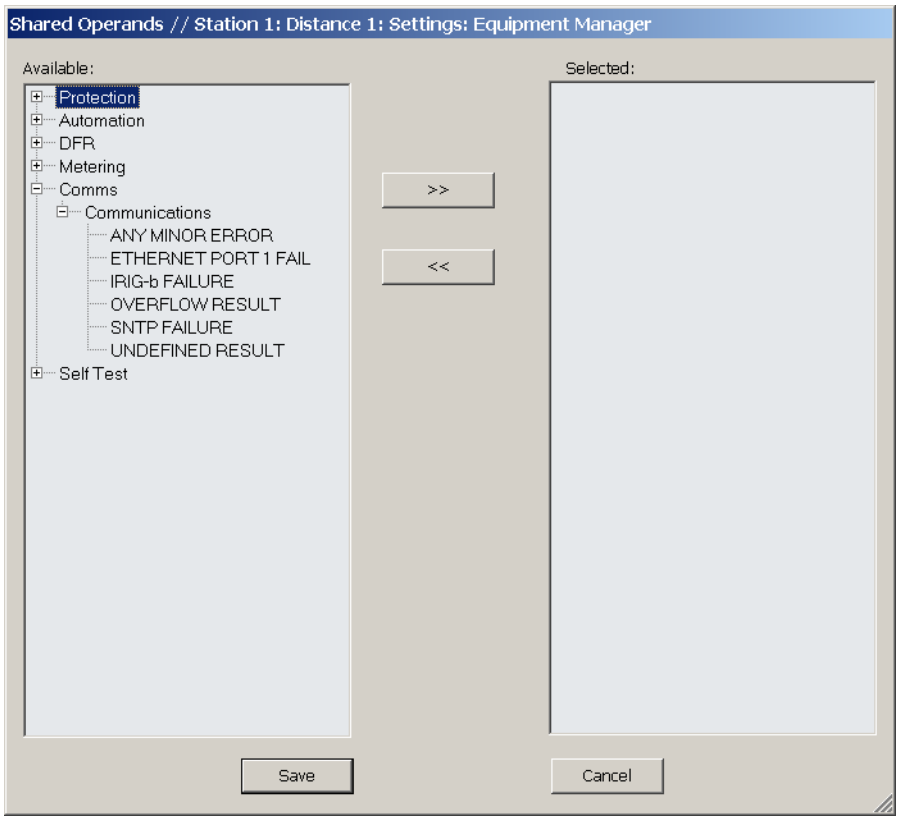
The shared operands functionality expands upon this system. With this feature, an output from any element can be assigned as a shared operand within the EnerVista UR^{Plus} Setup software. These signals can then be assigned as inputs to other functions.

For example, assume that the GND TOC1 OP protection operand is required as a signal within the automation function. This operand would then be assigned as a shared operand, and would subsequently become available to the automation function. A total of 64 operands can be assigned as shared operands within each function.

Shared equipment manager operands

Select the **Settings > Equipment Manager > Shared Operands** menu item to select the shared equipment manager operands.

Figure 9: Shared operands configuration window

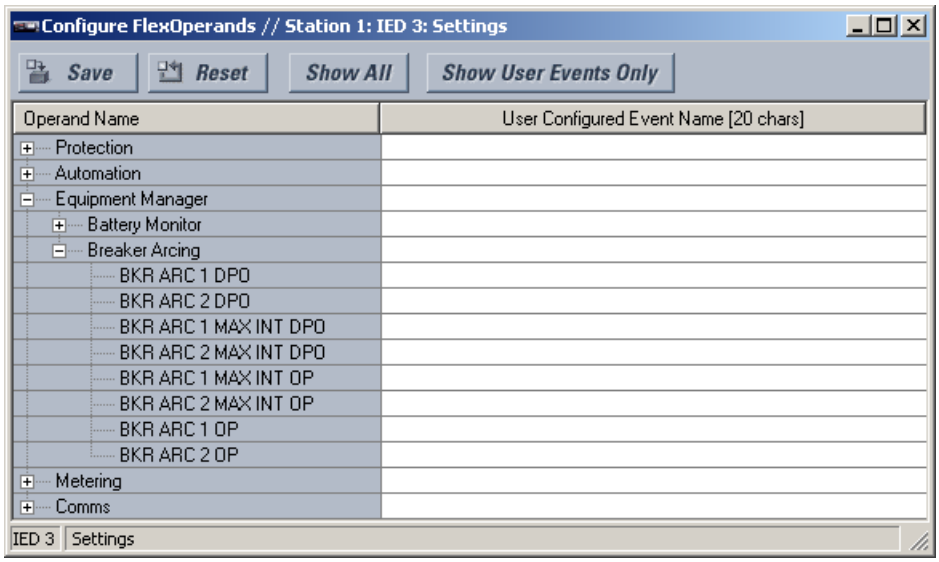


The left side of this screen displays all C90^{Plus} operands that are available to the equipment manager function as shared operands. Select any operands from the other five primary features by clicking the **>>** button. Operands can be de-assigned as shared operands by clicking the **<<** button.

Customizing the equipment manager logic operands

Select the **Settings > Configure FlexOperands** menu item to open the user-configurable operands window.

Figure 10: User-configurable equipment manager logic operands window



The left side of this screen displays all operands that are currently available to the C90^{Plus}. The equipment manager logic operands are displayed by selecting the **Equipment Manager** tree item. Each operand can be renamed with a user-specified value to provide additional information or match specific applications.

User Configured Event Name

Range: up to 20 alphanumeric characters

Default: ---

Each available equipment manager operand can be renamed to a user-specified value. This feature allows users to rename operands to allow for clearer identification or to match specific applications. The new operand name appears in protection and automation logic, in settings that take operands as their value, and in event reports.

Equipment manager operands

The following equipment manager operands are available for the C90^{Plus}. They are listed alphabetically by operand syntax. If wanted, these operands can be assigned user-defined names through the **Settings > Configure FlexOperands** menu item.

Battery monitor operands

BAT MON AC FAIL DPO ..... Asserted when the AC supply failure monitor drops out.

BAT MON AC FAIL OP ..... Asserted when the AC supply failure monitor operates.

BAT MON AC FAIL PKP ..... Asserted when the AC supply failure monitor picks up.

BAT MON CHG FAIL DPO ..... Asserted when the battery charger failure monitor drops out.

BAT MON CHG FAIL OP ..... Asserted when the battery charger failure monitor operates.

BAT MON CHG FAIL PKP ..... Asserted when the battery charger failure monitor picks up.

BAT MON DC GND DPO ..... Asserted when the DC ground fault monitor drops out.

BAT MON DC GND OP ..... Asserted when the DC ground fault monitor operates.

BAT MON DC GND PKP ..... Asserted when the DC ground fault monitor picks up.

BAT MON DC TRIP DPO ..... Asserted when the DC distribution breaker monitor drops out.

BAT MON DC TRIP OP ..... Asserted when the DC distribution breaker monitor operates.

BAT MON DC TRIP PKP ..... Asserted when the DC distribution breaker monitor picks up.

BAT MON HIGH VDC DPO ..... Asserted when the battery high DC voltage monitor drops out.

BAT MON HIGH VDC OP ..... Asserted when the battery high DC voltage monitor operates.

BAT MON HIGH VDC PKP ..... Asserted when the battery high DC voltage monitor picks up.
BAT MON LOW VDC DPO ..... Asserted when the battery low DC voltage monitor drops out.
BAT MON LOW VDC OP ..... Asserted when the battery low DC voltage monitor operates.
BAT MON LOW VDC PKP ..... Asserted when the battery low DC voltage monitor picks up.

Breaker arcing current operands

BKR ARC 1 DPO ..... Asserted when breaker arcing 1 element drops out.
BKR ARC 1 MAX IN DPO ..... Asserted when the maximum symmetrical interruption of the breaker arcing 1 element drops out.
BKR ARC 1 MAX IN OP ..... Asserted when the maximum symmetrical interruption of the breaker arcing 1 element operates.
BKR ARC 1 OP ..... Asserted when breaker arcing 1 element operates.
BKR ARC 2 ..... The operands listed above are available for the breaker arcing 2 element.

Equipment manager FlexAnalog parameters

The following equipment manager FlexAnalog parameters (analog operands) are available for the C90^{Plus}. They are listed alphabetically by operand syntax.

Battery monitor analog operand

Battery Voltage ..... Metered battery voltage for the battery monitoring feature

Breaker arcing analog operands

Bkr 1 Arc Amp A ..... Metered phase A arcing current for breaker 1
Bkr 1 Arc Amp B ..... Metered phase B arcing current for breaker 1
Bkr 1 Arc Amp C ..... Metered phase C arcing current for breaker 1
Bkr 1 Op Time A ..... Metered phase A operating time for breaker 1
Bkr 1 Op Time B ..... Metered phase B operating time for breaker 1
Bkr 1 Op Time C ..... Metered phase C operating time for breaker 1
Bkr 1 Op Time ..... Metered three-phase operating time for breaker 1
Bkr 2 Arc Amp A ..... Metered phase A arcing current for breaker 2
Bkr 2 Arc Amp B ..... Metered phase B arcing current for breaker 2
Bkr 2 Arc Amp C ..... Metered phase C arcing current for breaker 2
Bkr 2 Op Time A ..... Metered phase A operating time for breaker 2
Bkr 2 Op Time B ..... Metered phase B operating time for breaker 2
Bkr 2 Op Time C ..... Metered phase C operating time for breaker 2
Bkr 2 Op Time ..... Metered three-phase operating time for breaker 2

C90Plus Controller

Chapter 10: Digital fault recorder

The digital fault recorder (DFR) captures detailed information regarding abnormal occurrences in the power system. The information captured by the DFR is stored in the C90Plus in non-volatile memory and can be accessed through the front panel interface. The DFR consists of the following four functions:

- A sequence of events recorder that provides a time-stamped record of the operation of breakers, protection elements, and alarms. The recording of events is enabled on a per-element basis.
- A fault report that records fault type, magnitude and duration of the fault, and the response of protection functions
- A transient recorder that records analog and digital signals for short duration events at a high resolution
- A disturbance recorder that records analog and digital signals for long duration events, such as power swings and voltage sags, at a resolution of one sample per cycle

Sequence of events recorder

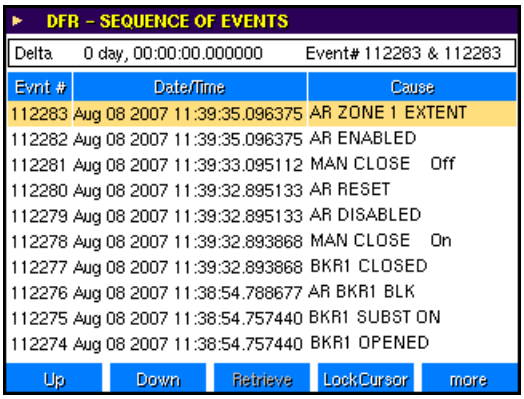
This event recorder provides a time-stamped record of state changes of signals monitored by the C90Plus. These signals include the state of circuit breakers and disconnect switches, external alarms and indications, and any of the internal functions of the IED. The C90Plus can store a total of 8192 events. Once this memory is filled, the oldest events are overwritten.

Most C90Plus elements contain an **Events** setting. When this setting is enabled, state changes for FlexLogic operands associated with the element are written to the sequence of events recorder. If this setting is disabled then state changes for the element are not recorded.

Front panel operation

The sequence of events record can be accessed from the front panel through the digital fault recorder (DFR) page. Using the navigations keys, the user can scroll or page through the events list. Two cursors are provided for measurement of the time difference between events.

Figure 1: Example sequence of events record



Fault report

The C90^{Plus} device supports one fault report and an associated fault locator. The signal source and trigger condition, as well as the characteristics of the line or feeder, are entered in the fault report configuration settings.

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

- Fault report number
- Device identification, programmed by the user
- Firmware revision of the relay
- Date and time of trigger
- Cause of trip
- Line and feeder identification via the name of a configured signal source
- Active protection setting group at the time of trigger
- Pre-fault current and voltage phasors (two cycles before 50DD disturbance associated with fault report source)
- Fault current and voltage phasors (once cycle after the trigger)
- Elements operated at the time of triggering
- Events: nine before the trigger and seven after the trigger

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

Front panel indications

The digital fault reporter summary screen provides an indication that the fault report is ready to capture data and has memory available. In protected mode, the **Ready to Capture** indication is green when all of the following conditions hold:

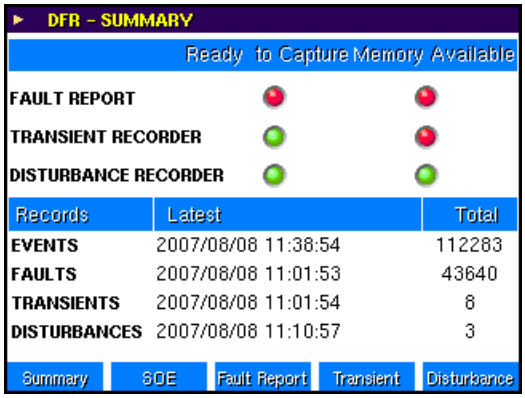
- The fault report feature is enabled
- The source for the fault report is properly configured
- The block trigger input is not asserted
- Memory is available
- A record capture is not currently in progress

Otherwise the indication is red. In automatic overwrite mode, the **Ready to Capture** indication is green when all of the following conditions hold:

- The fault report feature is enabled
- The source for the fault report is properly configured
- The block trigger input is not asserted
- A record capture is not currently in progress

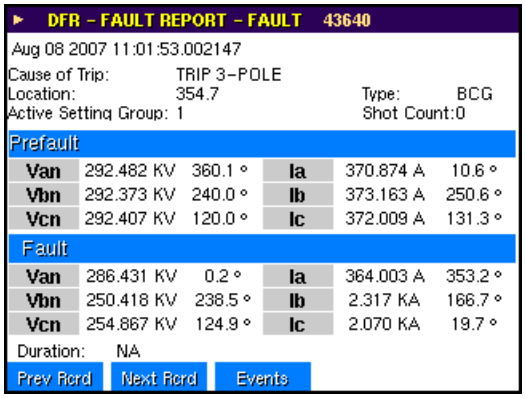
The **Memory Available** indication is green when less than 80% of the memory has been filled. It is yellow when the amount of memory filled is between 80% and 99%, and it is red if 100% of the memory is filled.

Figure 2: Digital fault reporter summary screen



The fault report screen displays the detailed fault data for each fault This data includes the fault and prefault current and voltage data, as well as the cause of trip, trip type, active setting group, shot count, and duration data.

Figure 3: Fault report front panel screen



Fault report operation

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

If a number of protection elements are ORed to create a fault report trigger, the first operation of any element causing the OR gate output to become high triggers a fault report. However, If other elements operate during the fault and the first operated element

has not been reset (the OR gate output is still high), the fault report is not triggered again. Considering the reset time of protection elements, there is very little chance that fault report can be triggered twice in this manner.

Each fault report is stored as a file, and the relay capacity is fifteen (15) files. An sixteenth (16th) trigger overwrites the oldest file. Individual fault report features store their files in the same memory space. The sixteenth report will overwrite the first one regardless which fault report feature produced the sixteenth and the first records.

The EnerVista software is required to view all captured data. The front panel interface can be used to view the following information:

- Prefault and fault current and voltage phasors
- Active setting group
- Date and time of trigger
- Reclose shot number
- Fault type
- Distance location of the fault

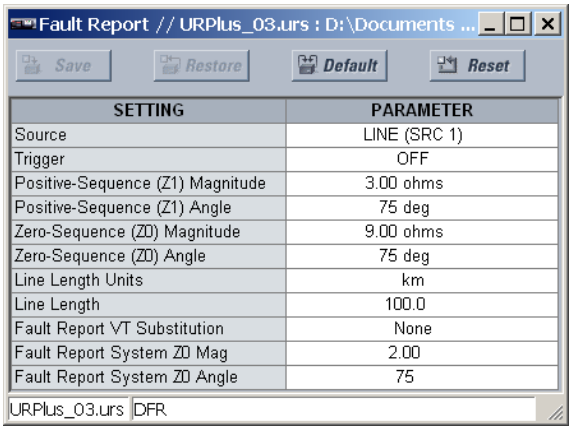
Fault type determination

Fault type determination is required for calculation of fault location. The fault determination algorithm uses the angle between the negative-sequence and positive-sequence components of the relay currents. To improve accuracy and speed of operation, the fault components of the currents are used. That is, the pre-fault phasors are subtracted from the measured current phasors. In addition to the angle relationships, certain extra checks are performed on magnitudes of the negative-sequence and zero-sequence currents.

Fault report settings

Select the **Settings > DFR > Fault Report** menu item to open the fault report configuration window.

Figure 4: Fault report configuration settings



The following settings are available for the fault report.

Source

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)

Default: SRC1

This setting selects the source for input currents, voltages, and disturbance detection.

Trigger

Range: any FlexLogic operand
Default: OFF

This setting assigns the FlexLogic operand representing the protection elements requiring operational fault location calculations. The distance to fault calculations are initiated by this signal.

Positive-Sequence (Z1) Magnitude

Range: 0.01 to 250.00 ohms in steps of 0.01
Default: 3.00 ohms

This setting specifies the magnitude of positive-sequence impedance of the transmission line or feeder in secondary ohms.

Positive-Sequence (Z1) Angle

Range: 25 to 90° in steps of 1
Default: 75°

This setting specifies the angle of positive-sequence impedance of the transmission line or feeder in secondary ohms.

Zero-Sequence (Z0) Magnitude

Range: 0.01 to 650.00 ohms in steps of 0.01
Default: 9.00 ohms

This setting specifies the magnitude of zero-sequence impedance of the transmission line or feeder in secondary ohms.

Zero-Sequence (Z0) Angle

Range: 25 to 90° in steps of 1
Default: 75°

This setting specifies the angle of zero-sequence impedance of the transmission line or feeder in secondary ohms.

Line Length Units

Range: km, miles
Default: km

This setting selects the units used for fault location calculations.

Line Length

Range: 0.0 to 2000.0 in steps of 0.1
Default: 100.0

This setting specifies the length of the transmission line or feeder in the defined line length units.

Fault Report VT Substitution

Range: None, I0, V0
Default: None

Program this setting to “None” if the C90^{Plus} is fed from wye-connected VTs. If delta-connected VTs are used, and the C90^{Plus} is supplied with the neutral (3V0) voltage, set to “V0”. The method is still exact, as the fault locator would combine the line-to-line voltage measurements with the neutral voltage measurement to re-create the line-to-ground voltages. It required to configure the delta and neutral voltages under the source indicated as input for the fault report. Also, the C90^{Plus} checks if the auxiliary signal configured is marked as “Vn” by the user (under VT setup), and inhibit the fault location if the auxiliary signal is labeled differently.

If the broken-delta neutral voltage is not available to the relay, an approximation is possible by assuming the missing zero-sequence voltage to be an inverted voltage drop produced by the zero-sequence current and the user-specified equivalent zero-sequence system impedance behind the relay: V_0 = –Z_0 × I_0. In order to enable this mode of operation, set the value to "I0".

Fault Report System Z0 Magnitude

Range: 0.01 to 650.00 ohms in steps of 0.01

Default: 2.00 ohms

This setting is used only when the **Fault Report VT Substitution** value is "I0". The magnitude is to be entered in secondary ohms. This impedance is an average system equivalent behind the relay. It can be calculated as zero-sequence Thevenin impedance at the local bus with the protected line/feeder disconnected. The method is accurate only if this setting matches perfectly the actual system impedance during the fault. If the system exhibits too much variability, this approach is questionable and the fault location results for single-line-to-ground faults shall be trusted with accordingly. It should be kept in mind that grounding points in vicinity of the installation impact the system zero-sequence impedance (grounded loads, reactors, zig-zag transformers, shunt capacitor banks, etc.).

Fault Report System Z0 Angle

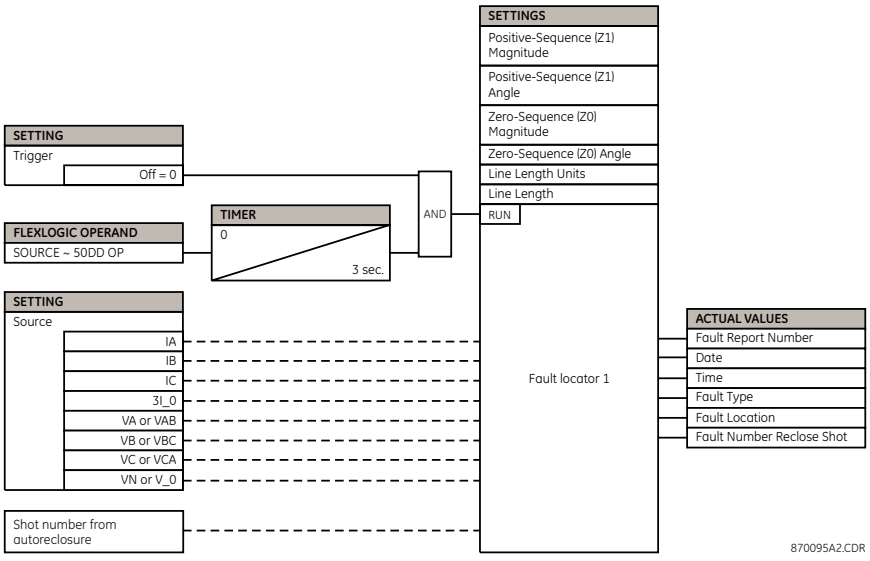
Range: 25 to 90° in steps of 1

Default: 75°

This setting is used only when the **Fault Report VT Substitution** value is "I0" and represents the corresponding angle for the **Fault Report System Z0 Magnitude** setting above.

The figure shows the fault locator logic.

Figure 5: Fault locator scheme logic



Fast load shedding reports

When the contingency timer resets, the fast load shedding controller produces a fast load shedding (FLS) report containing a summary of the FLS event. The reports may be viewed on the front panel HMI screen, and via EnerVista UR^{Plus} Setup . The EnerVista software can also export each of these reports from the C90^{Plus} in the form of an ASCII CSV (comma-separated values) text file.

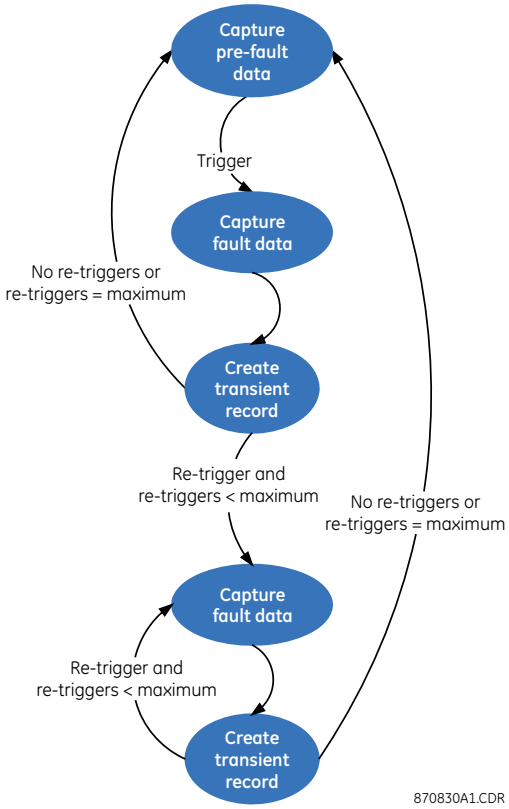
The last 16 fast load shedding reports are retained in the C90^{Plus} non-volatile memory.

Transient recorder

The transient recorder is designed to capture short duration events, such as faults at a high resolution. Under normal operation, the transient recorder continuously captures pre-fault data and stores this data in memory. When a trigger is received, the transient recorder captures the data during the period of the fault. Both the pre-fault and fault data are stored as records in non-volatile memory within the C90^{Plus}.

The transient recorder captures the instantaneous values of all voltage and current signals connected to the C90^{Plus}. In addition, the user can configure digital and analog channels, each of which can be used to trigger or re-trigger the transient recorder. A re-trigger captures an additional record but with no pre-fault data. Triggered and re-triggered records are merged into a single file, and the maximum number of re-triggers for a particular fault is user-programmable.

Figure 6: Trigger and re-trigger sequence



The length of a transient record is also user-configurable. The number of transient records stored by the C90^{Plus} is a function of the record length, the time-resolution of the recording, and of the number of configured channels. The C90^{Plus} automatically calculates the number of transient records based on the user-defined setting values.

The transient recorder has two storage modes: protected and automatic overwrite. When the memory is filled, either no new records are written to memory (protected mode) or the oldest record is overwritten (automatic overwrite mode).

The C90^{Plus} contains a finite amount of memory for record storage. The following table shows how the transient recorder configuration affects the number of available records.

Table 1: Transient records stored by the C90^{Plus} (examples)

Records	Sampling rate	Digital channels	Analog channels	Record length
8	256 samples/cycle	128	16	57 cycles
24	256 samples/cycle	128	16	22 cycles
48	256 samples/cycle	128	16	11 cycles
8	128 samples/cycle	128	16	104 cycles
24	128 samples/cycle	128	16	40 cycles
48	128 samples/cycle	128	16	20 cycles
20	64 samples/cycle	128	16	80 cycles
64	64 samples/cycle	128	16	26 cycles
24	32 samples/cycle	64	8	135 cycles
64	32 samples/cycle	64	8	53 cycles
41	16 samples/cycle	64	8	124 cycles
64	16 samples/cycle	64	8	81 cycles

Front panel indications

The digital fault reporter summary screen provides an indication that the transient recorder is ready to capture data and has memory available. In protected mode, the **Ready to Capture** indication is green when all of the following conditions hold:

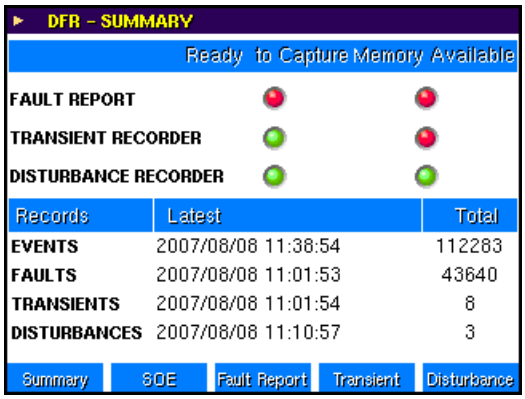
- The transient recorder is enabled
- The block trigger input is not asserted
- Memory is available
- A record capture is not currently in progress

Otherwise the indication is red. In automatic overwrite mode, the **Ready to Capture** indication is green when all of the following conditions hold:

- The transient recorder is enabled
- The block trigger input is not asserted
- A record capture is not currently in progress

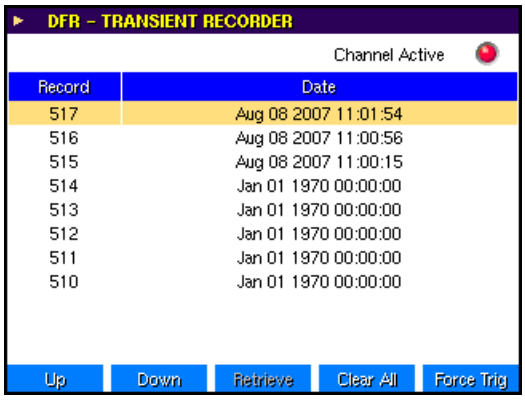
The **Memory Available** indication is green when less than 80% of the memory has been filled. It is yellow when the amount of memory filled is between 80% and 99%, and it is red if 100% of the memory is filled.

Figure 7: Digital fault reporter summary screen



The transient recorder screen shows the individual records stored on the device. This screen also has an indication of any active triggers (red indication) for the transient recorders. If a continuous trigger is permanently active, it does not fill the memory of the recorder. After the first record is generated it is effectively disabled by the trigger logic; however, its status displays on this screen. The user can also force triggering of the recorder from this screen.

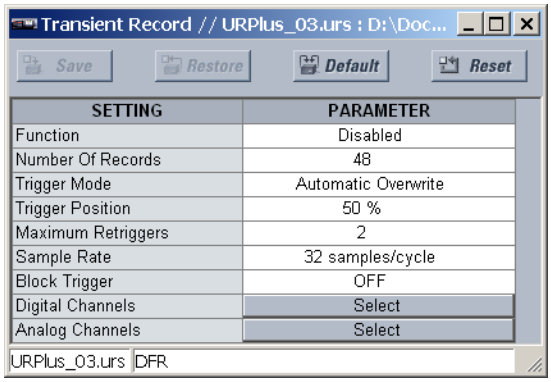
Figure 8: Transient recorder screen



Transient recorder settings

Select the **Settings > DFR > Transient Record** menu item to open the transient recorder function configuration window.

Figure 9: Transient recorder function settings



The following settings are available.

Function

Range: Enabled, Disabled
Default: Enabled

This setting enables and disables the transient recorder function.

Number Of Records

Range: 1 to 64 in steps of 1
Default: 48

This setting specifies the total number of transient records that can be stored in the C90^{Plus}. A larger setting results in a shorter record length, and *vice-versa*.

Trigger Mode

Range: Automatic Overwrite, Protected
Default: Automatic Overwrite

If this setting is selected as "Automatic Overwrite", then the oldest record is overwritten once the number of stored records reaches the setting value. If this setting is "Protected", then no new records are stored once the number of records reaches the setting value.

Trigger Position

Range: 1 to 100% in steps of 1
Default: 50%

This setting specifies the amount of pre-trigger data stored in a record expressed as a percentage of record length.

Maximum Re-Triggers

Range: 1 to 4 in steps of 1
Default: 2

This setting selects the maximum number of re-trigger records that can be generated for an event. The value is limited to one less than the number of records that can be stored (up to a maximum of four records).

Sample Rate

Range: 16, 32, 64, 128, or 256 samples per cycle, or OFF
Default: 32

This setting selects the time-resolution of the transient record. A larger setting necessarily results in a shorter record length.

Block Trigger

Range: any FlexLogic operand or shared operand
Default: OFF

When the operand assigned to this setting is asserted, all triggers to the transient recorder are inhibited.


NOTE

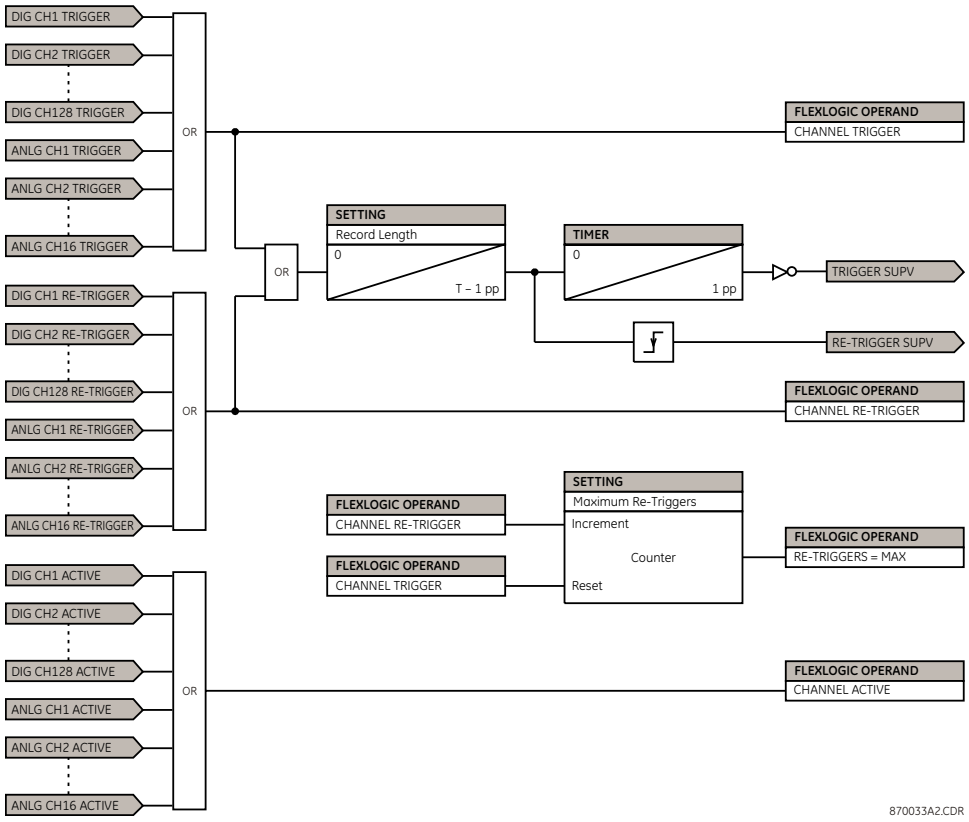
When changes are made to the transient recorder settings, all existing transient records are cleared.


NOTE

The transient recorder starts collecting data upon power up or after the recorder is cleared. If a trigger occurs immediately after a power up or the clearing of transient records, and there is not enough pre-trigger data, then the pre-trigger is set to the amount of data collected and does not reflect the value specified by the user.

The figure shows the transient recorder trigger logic.

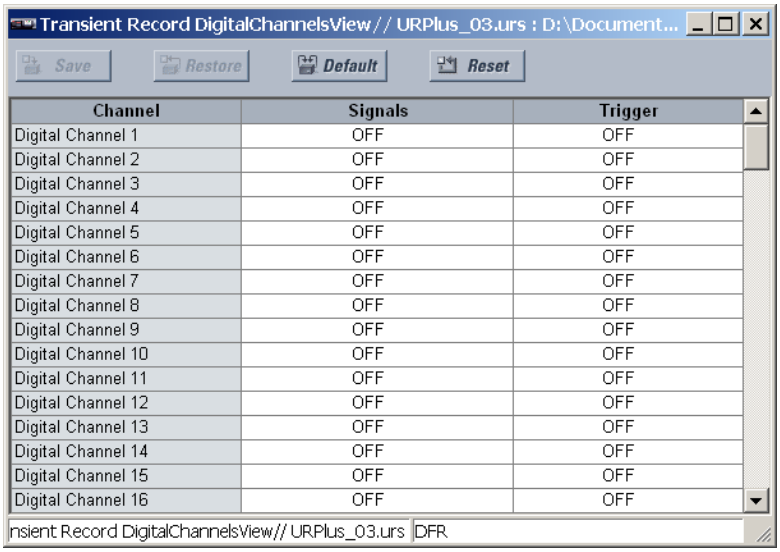
Figure 10: Transient recorder trigger logic



Transient recorder digital channels

Up to 128 digital channels can be assigned to the transient recorder. Each channel can be individually configured by clicking the digital channels **Select** button in the transient recorder window to open the transient recorder digital channels window.

Figure 11: Digital channel configuration settings



The following settings are available for each digital channel.

Signals

Range: any FlexLogic operand or shared operand

Default: OFF

This setting specifies an operand to use as a transient recorder digital channel. The pull-down list of available signals is populated with enabled protection functions. Selected operands are automatically assigned as channels and as triggers according to their importance and can be de-assigned by the user.

For example, when ground time overcurrent 1 has been enabled, the following assignments are made from the list of available operands.

Table 2: Ground time overcurrent 1 signal example

Available signals (operands)	Operand assigned as a...	
	Digital channel	Trigger
GND TOC1 DPO	Yes	No
GND TOC1 OP	Yes	Yes
GND TOC1 PKP	Yes	No

Trigger

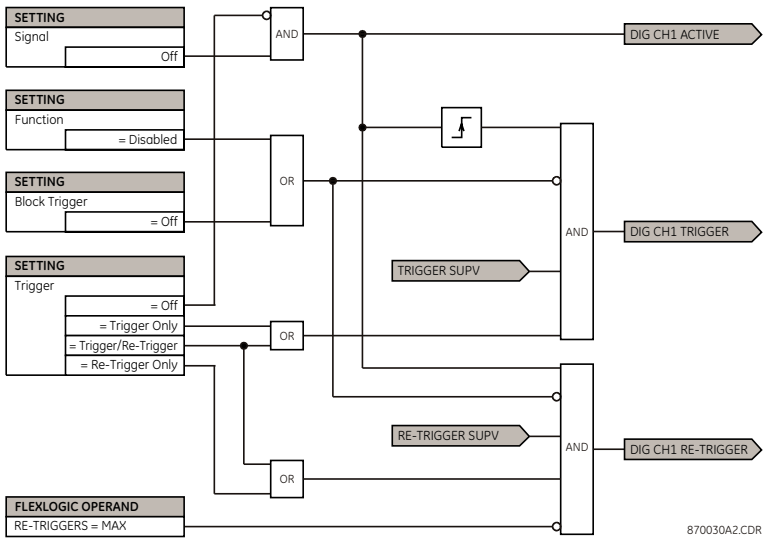
Range: Off, Trigger Only, Trigger/Re-Trigger, Re-Trigger Only

Default: Off

This setting selects the trigger function of the digital channel. When set to "Trigger Only" or "Trigger/Re-Trigger", the transient recorder initiates data capture for an OFF-ON transition of the channel signal. The resulting record contains both pre-fault and fault data and the channel must return to the off state before it can generate a subsequent trigger.

When set to "Trigger/Re-Trigger" or "Re-Trigger Only", the transient recorder is re-triggered if the signal is still asserted at the end of the trigger period. The resulting record contains fault data only. A re-trigger is re-generated at the end of a transient record if the signal is still asserted and if the number of re-triggers is less than the value specified by the **Maximum Re-Triggers** setting.

Figure 12: Digital channel triggering logic

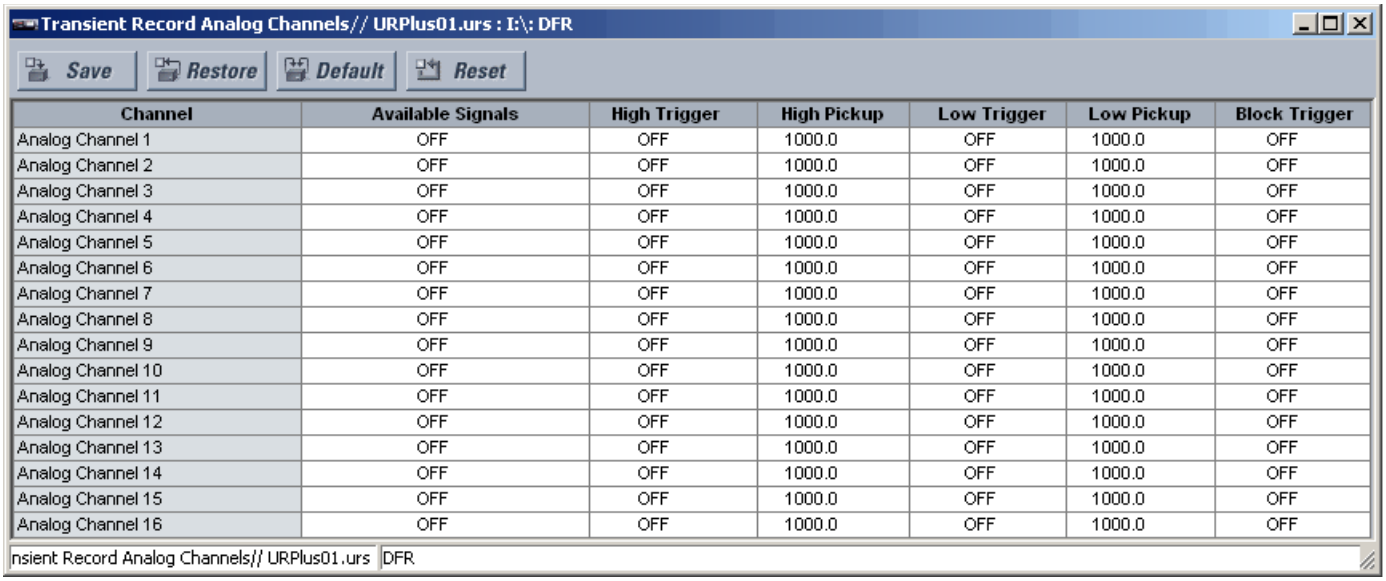


Transient recorder analog channels

Up to 16 analog channels may be assigned to the transient recorder. Each channel can be individually configured by clicking the analog channel **Select** button in the transient recorder window to open the transient recorder analog channels window. Note that the

fast load shedding (FLS) FlexAnalog parameters are recorded with a resolution of 10 kW in the range of ±327 MW. The unit for analog trigger settings where the **Available Signal** setting is an FLS FlexAnalog parameter is 1 W; the pickup tolerance is 10000 W.

Figure 13: Analog channel configuration settings



Channel	Available Signals	High Trigger	High Pickup	Low Trigger	Low Pickup	Block Trigger
Analog Channel 1	OFF	OFF	1000.0	OFF	1000.0	OFF
Analog Channel 2	OFF	OFF	1000.0	OFF	1000.0	OFF
Analog Channel 3	OFF	OFF	1000.0	OFF	1000.0	OFF
Analog Channel 4	OFF	OFF	1000.0	OFF	1000.0	OFF
Analog Channel 5	OFF	OFF	1000.0	OFF	1000.0	OFF
Analog Channel 6	OFF	OFF	1000.0	OFF	1000.0	OFF
Analog Channel 7	OFF	OFF	1000.0	OFF	1000.0	OFF
Analog Channel 8	OFF	OFF	1000.0	OFF	1000.0	OFF
Analog Channel 9	OFF	OFF	1000.0	OFF	1000.0	OFF
Analog Channel 10	OFF	OFF	1000.0	OFF	1000.0	OFF
Analog Channel 11	OFF	OFF	1000.0	OFF	1000.0	OFF
Analog Channel 12	OFF	OFF	1000.0	OFF	1000.0	OFF
Analog Channel 13	OFF	OFF	1000.0	OFF	1000.0	OFF
Analog Channel 14	OFF	OFF	1000.0	OFF	1000.0	OFF
Analog Channel 15	OFF	OFF	1000.0	OFF	1000.0	OFF
Analog Channel 16	OFF	OFF	1000.0	OFF	1000.0	OFF

The following settings are available for each analog channel.

Available Signal

Range: any FlexAnalog quantity
Default: as shown above

This setting selects the FlexAnalog value to be recorded for the channel. The size of each record depends in part on the number of parameters selected. Channels set to "Off" are ignored.

High Triggering

Range: Off, Trigger Only, Trigger/Re-Trigger, Re-Trigger Only
Default: Off

This setting selects the high triggering function for the analog channel. When set to "Trigger Only" or "Trigger/Re-Trigger", the transient recorder initiates data capture when the magnitude of the signal is greater than the value of the **High Pickup** setting. The resulting record contains pre-fault and fault data. The channel must return to the OFF state before it can generate a subsequent trigger.

When set to "Re-Trigger Only" or "Trigger/Re-Trigger", the transient recorder is re-triggered when the magnitude of the signal is greater than the value of the **High Pickup** setting. The resulting record contains fault data only. A re-trigger is again generated at the end of a transient record if the magnitude is greater than the **High Pickup** and if the number of re-triggers is less than the **Maximum Re-Trigger** setting.

Note that only phasor magnitudes, RMS magnitudes, frequency, and power can be used as analog triggers.

High Pickup

Range: 0.0 to 1000000.0 in steps of 0.1
Default: 1000.0

This setting specifies the magnitude of the signal required to produce a trigger or re-trigger. This setting is expressed in primary values. The units are dependent on the value of the **Available Signal** setting.

Low Triggering

Range: Enabled, Disabled

Default: Disabled

This setting selects the low triggering function for the analog channel. When set to "Trigger Only" or "Trigger/Re-Trigger", the transient recorder initiates data capture when the magnitude of the signal is less than the value of the **Low Pickup** setting. The resulting record contains both pre-fault and fault data. The channel must return to the off state before it can generate a subsequent trigger.

When set to "Trigger/Re-Trigger" or "Trigger Only", the transient recorder is re-triggered when the magnitude of the signal is less than the value of the **Low Pickup** setting. The resulting transient record contains fault data only. A re-trigger is generated again at the end of the record if the magnitude is less than the **Low Pickup** and if the number of re-triggers is less than the **Maximum Re-Trigger** setting.

Note that only phasor magnitudes, RMS magnitudes, frequency, and powercan be used as analog triggers.

Low Pickup

Range: 0.0 to 1000000.0 in steps of 0.1

Default: 1000.0

This setting specifies the magnitude of the signal required to produce a trigger or re-trigger. This setting is expressed in primary values. The units are dependent on the value of the **Available Signal** setting.

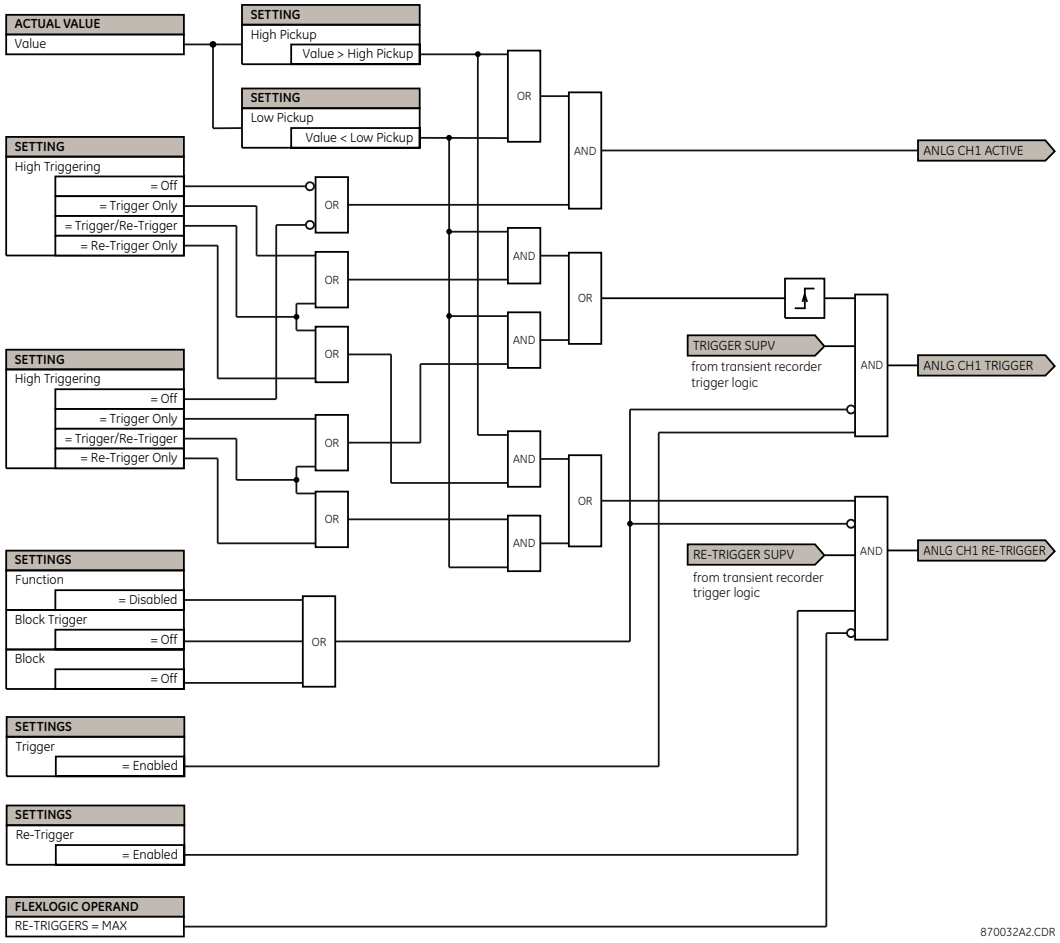
Block Trigger

Range: any FlexLogic operand or shared logic operand

Default: OFF

When the operand assigned to this setting is asserted, all high and low triggers to the specified analog channel are inhibited.

Figure 14: Analog channel trigger logic

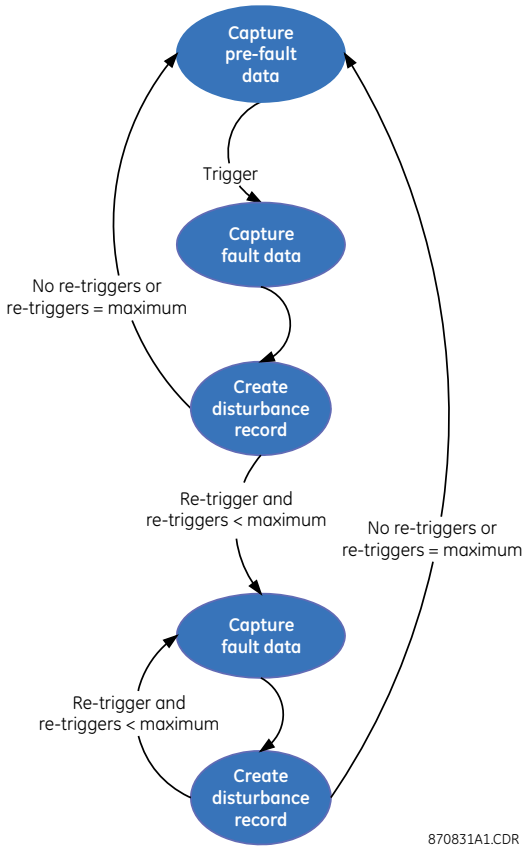


Disturbance recorder

The disturbance recorder is designed to capture long duration events, such as power swings at a resolution of one sample per cycle. Under normal operation, the disturbance recorder is continuously capturing pre-event data and storing this data in memory. When a trigger is received, the disturbance recorder will capture the data during the post-event period. Both the pre-event and post-event data are stored as a record in non-volatile memory within the C90^{Plus}.

The disturbance recorder captures the user-configured digital and analog channels, each of which can be used to trigger or re-trigger the disturbance recorder. A re-trigger captures an additional record but with no pre-event data. Triggered and re-triggered records are merged into a single file, and the maximum number of re-triggers for a particular event is user-programmable.

Figure 15: Trigger and re-trigger sequence



The number of disturbance records is also user-configurable. The length of disturbance records stored by the C90^{Plus} can store is a function of the number of records and the number of configured channels. The C90^{Plus} automatically calculates the record length based on user settings. The following table shows the record length for some representative configurations.

Table 3: Disturbance records stored by the C90^{Plus}

Records	Digital channels	Analog channels	Record length
1	32	64	2393 cycles
5	32	64	1025 cycles
10	32	64	598 cycles
1	32	32	4520 cycles
10	32	32	1129 cycles
20	32	32	616 cycles
2	32	16	6100 cycles
5	32	16	3486 cycles
10	32	16	2033 cycles
20	32	16	1108 cycles
5	32	8	5811 cycles
10	32	8	3389 cycles
20	32	8	1848 cycles
30	32	8	1270 cycles

The recorder has two storage modes: protected and automatic overwrite. When the memory is filled, either no new records are written to memory (protected mode) or the oldest record is overwritten (automatic overwrite mode).

Front panel indications

The digital fault reporter summary screen provides an indication that the disturbance recorder is ready to capture data and has memory available. In protected mode, the **Ready to Capture** indication is green when all of the following conditions hold:

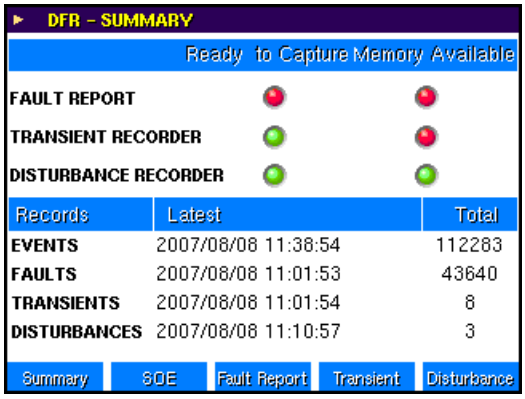
- The disturbance recorder is enabled
- The block trigger input is not asserted
- Memory is available
- A record capture is not currently in progress

Otherwise the indication is red. In automatic overwrite mode, the **Ready to Capture** indication is green when all of the following conditions hold:

- The disturbance recorder is enabled
- The block trigger input is not asserted
- A record capture is not currently in progress

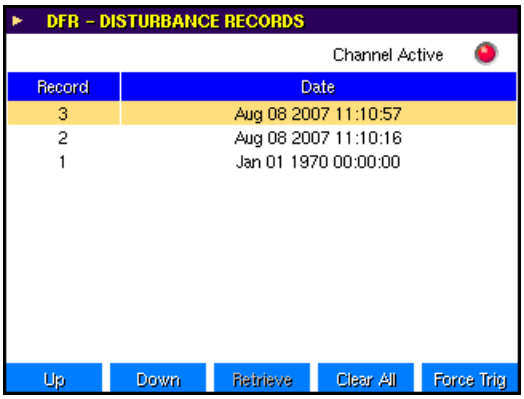
The **Memory Available** indication is green when less than 80% of the memory has been filled. It is yellow when the amount of memory filled is between 80% and 99%, and it is red if 100% of the memory is filled.

Figure 16: Digital fault reporter summary screen



The disturbance recorder screen shows the individual records stored on the device. This screen also has an indication of any active triggers (red indication) for the disturbance recorders. If a continuous trigger is permanently active, it does not fill the memory of the recorder. After the first record is generated it is effectively disabled by the trigger logic; however, its status displays on this screen. The user can also force triggering of the recorder from this screen.

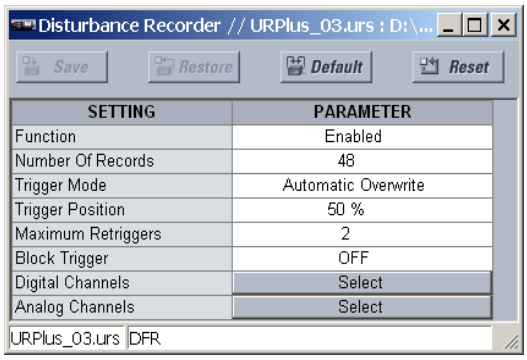
Figure 17: Disturbance recorder screen



Disturbance recorder settings

Select the **Settings > DFR > Disturbance Record** menu item to open the disturbance recorder function configuration window.

Figure 18: Disturbance recorder function settings



The following settings are available.

Function

Range: Enabled, Disabled

Default: Disabled

This setting enables and disables the disturbance recorder function.

Number of Records

Range: 1 to 64 in steps of 1

Default: 48

This setting specifies the total number of disturbance records that can be stored in the C90^{Plus}. A larger setting results in a shorter record length, and *vice-versa*.

Trigger Mode

Range: Automatic Overwrite, Protected

Default: Automatic Overwrite

If this setting value is “Automatic Overwrite”, then the oldest disturbance record will be overwritten once the number of stored records reaches the setting value. If this value is “Protected”, then no new disturbance record are stored once the number of records reaches the setting value.

Trigger Position

Range: 1 to 100% in steps of 1

Default: 50%

This setting specifies the amount of pre-trigger data stored in a disturbance record expressed as a percentage of the disturbance record length.

Maximum Re-Triggers

Range: 1 to 4 in steps of 1

Default: 2

This setting selects the maximum number of re-trigger records that can be generated for a disturbance event. The value is limited to one less than the number of records that can be stored (up to a maximum of four records).

Block Trigger

Range: any FlexLogic operand or shared operand

Default: OFF

When the operand assigned to this setting is asserted, all triggers to the disturbance recorder are inhibited.

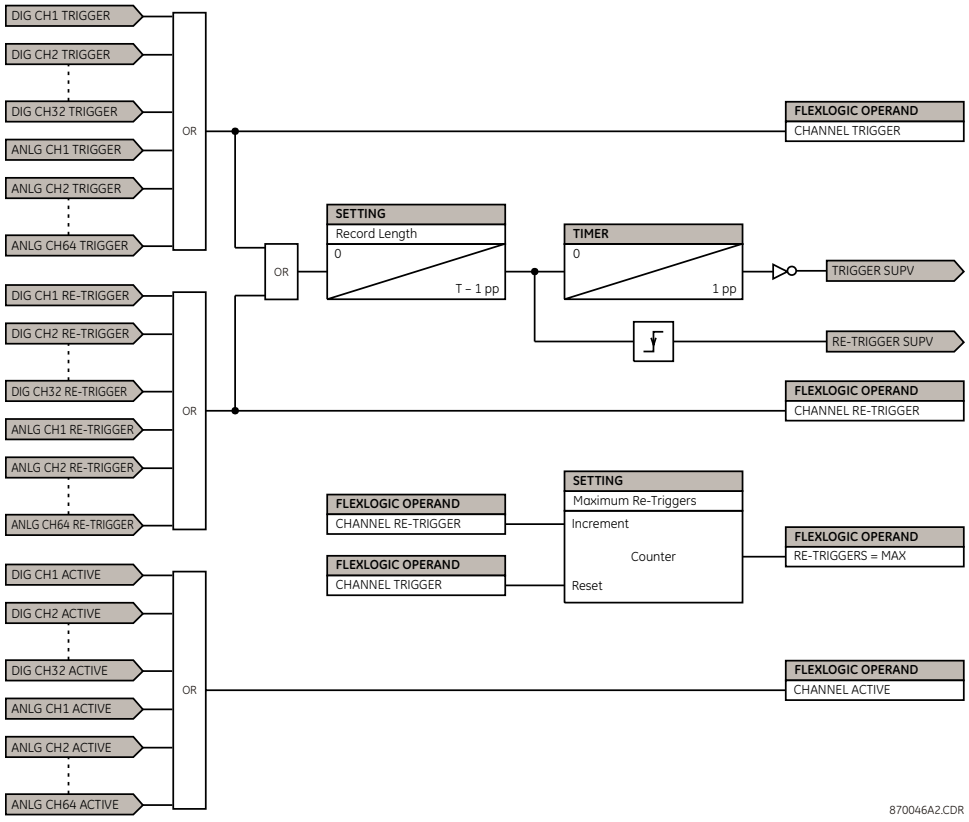
NOTE

When changes are made to the disturbance recorder settings, all existing disturbance records are cleared.

NOTE

The disturbance recorder starts collecting data upon power up or after the recorder is cleared. If a trigger occurs immediately after a power up or the clearing of disturbance records, and there is not enough pre-trigger data, then the pre-trigger is set to the amount of data collected and does not reflect the value specified by the user.

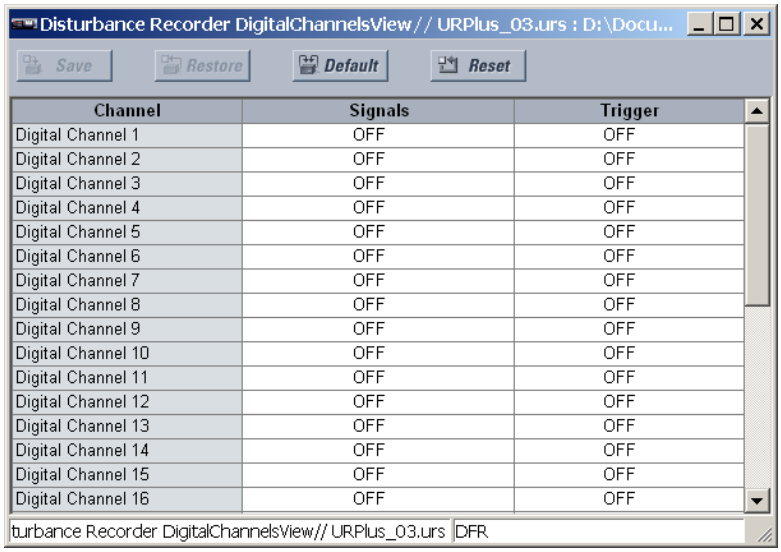
Figure 19: Disturbance recorder trigger logic



Disturbance recorder digital channels

Up to 32 digital channels can be assigned to the disturbance recorder. Each channel can be individually configured by clicking the digital channels **Select** button in the disturbance recorder window to open the disturbance recorder digital channels window.

Figure 20: Digital channel configuration settings



The following settings are available for each disturbance recorder digital channel.

Signals

Range: any FlexLogic operand or shared operand
Default: Off

This setting selects an operand to act as a trigger for the digital channel.

The pull-down list of available signals is populated according to the protection functions that have been enabled. Selected signals are automatically assigned as channels and as triggers according to their importance. These signals can be deactivated by the user. For example, if ground time overcurrent 1 has been enabled, then the following assignments are made.

Table 4: Example disturbance recorder signal assignment

Available signals	Assignment	
	Digital channel	Trigger
GND TOC1 DPO	Yes	No
GND TOC1 OP	Yes	Yes
GND TOC1 PKP	Yes	No

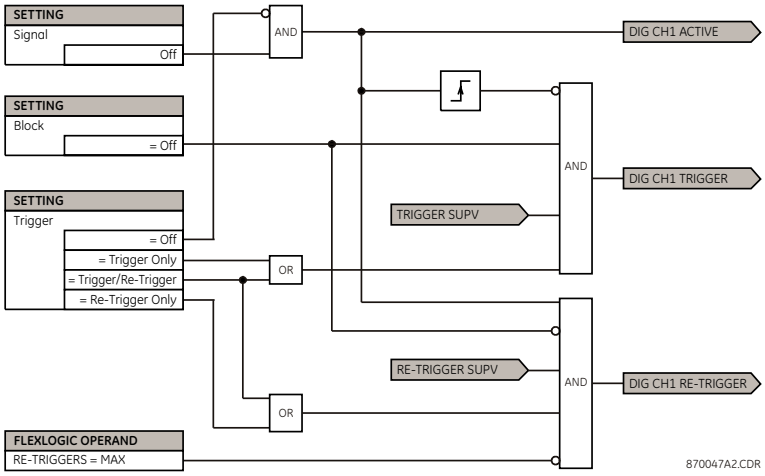
Trigger

Range: Off, Trigger Only, Trigger/Re-Trigger, Re-Trigger Only
Default: Off

This setting selects the trigger function of the digital channel. When set to "Trigger Only" or "Trigger/Re-Trigger", the disturbance recorder initiates data capture for an OFF-ON transition of the channel signal. The resulting record contains both pre-fault and fault data and the channel must return to the off state before it can generate a subsequent trigger.

When set to "Trigger/Re-Trigger" or "Re-Trigger Only", the disturbance recorder is re-triggered if the signal is still asserted at the end of the trigger period. The resulting record contains fault data only. A re-trigger is re-generated at the end of a disturbance record if the signal is still asserted and if the number of re-triggers is less than the value specified by the **Maximum Re-Triggers** setting.

Figure 21: Disturbance recorder digital channels input logic



Disturbance recorder analog channels

Up to 64 analog channels can be assigned to the transient recorder. Each channel can be individually configured by clicking the analog channel **Select** button in the disturbance recorder window to open the disturbance recorder analog channels window. Note that fast load shedding (FLS) FlexAnalog parameters are recorded with a resolution of 10 kW in the range of ±327 MW. The unit for analog trigger settings where the **Available Signals** setting is an FLS FlexAnalog paramter is 1 W; the pickup tolerance is 10000 W.

Figure 22: Analog channel configuration settings

Disturbance Record AnalogChannelsView // Station PA-1: URPlus-Bala: Settings: DFR

Save | Restore | Default | Reset

Channel	Available Signals	High Trigger	High Pickup	Low Trigger
Analog Channel 1	OFF	OFF	1.000	OFF
Analog Channel 2	OFF	OFF	1.000	OFF
Analog Channel 3	OFF	OFF	1.000	OFF
Analog Channel 4	OFF	OFF	1.000	OFF
Analog Channel 5	OFF	OFF	1.000	OFF
Analog Channel 6	OFF	OFF	1.000	OFF
Analog Channel 7	OFF	OFF	1.000	OFF
Analog Channel 8	OFF	OFF	1.000	OFF
Analog Channel 9	OFF	OFF	1.000	OFF
Analog Channel 10	OFF	OFF	1.000	OFF
Analog Channel 11	OFF	OFF	1.000	OFF
Analog Channel 12	OFF	OFF	1.000	OFF
Analog Channel 13	OFF	OFF	1.000	OFF
Analog Channel 14	OFF	OFF	1.000	OFF
Analog Channel 15	OFF	OFF	1.000	OFF
Analog Channel 16	OFF	OFF	1.000	OFF

URPlus-Bala | Settings: DFR

The following settings are available for each disturbance recorder analog channel.

Available Signals

Range: any FlexAnalog quantity
Default: Off

This setting specifies the FlexAnalog quantity to be recorded for the channel. The size of each disturbance record depends in part on the number of parameters selected. Parameters set to "Off" are ignored.

High Triggering

Range: Off, Trigger Only, Trigger/Re-Trigger, Re-Trigger Only
Default: Off

This setting selects the high triggering function for the analog channel. When set to "Trigger Only" or "Trigger/Re-Trigger", the disturbance recorder will initiate data capture when the magnitude of the signal is greater than the value of the **High Pickup** setting. The resulting record will contain pre-fault and fault data. The channel must return to the OFF state before it can generate a subsequent trigger.

When set to "Re-Trigger Only" or "Trigger/Re-Trigger", the disturbance recorder will be re-triggered when the magnitude of the signal is greater than the value of the **High Pickup** setting. The resulting record will contain fault data only. A re-trigger is again generated at the end of a disturbance record if the magnitude is greater than the **High Pickup** and if the number of re-triggers is less than the **Maximum Re-Trigger** setting.

Note that only phasor magnitudes, RMS magnitudes, frequency, and power may be used as analog triggers.

High Pickup

Range: 0.0 to 1000000.0 in steps of 0.1
Default: 1000.0

This setting specifies the magnitude of the signal required to produce a trigger or re-trigger. This setting is expressed in primary values. The units are dependent on the value of the **Available Signal** setting.

Low Triggering

Range: Off, Trigger Only, Trigger/Re-Trigger, Re-Trigger Only
Default: Off

This setting selects the low triggering function for the analog channel. When set to "Trigger Only" or "Trigger/Re-Trigger", the disturbance recorder initiates data capture when the magnitude of the signal is less than the value of the **Low Pickup** setting. The resulting record contains both pre-fault and fault data. The channel must return to the off state before it can generate a subsequent trigger.

When set to "Trigger/Re-Trigger" or "Trigger Only", the disturbance recorder is re-triggered when the magnitude of the signal is less than the value of the **Low Pickup** setting. The resulting disturbance record contains fault data only. A re-trigger is generated again at the end of the record if the magnitude is less than the **Low Pickup** and if the number of re-triggers is less than the **Maximum Re-Trigger** setting.

Note that only phasor magnitudes, RMS magnitudes, frequency, and power can be used as analog triggers.

Low Pickup

Range: 0.0 to 1000000.0 in steps of 0.1
Default: 1000.0

This setting specifies the magnitude of the signal required to produce a trigger or re-trigger. This setting is expressed in primary values. The units are dependent on the value of the **Available Signal** setting.

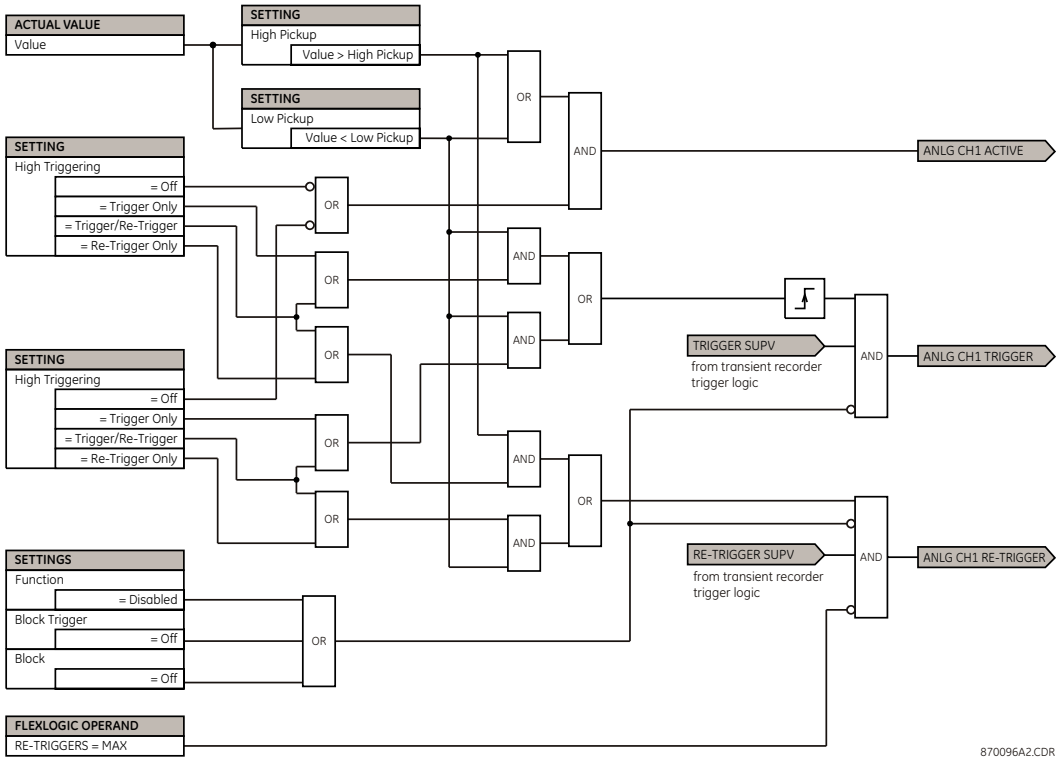
Block Trigger

Range: any FlexLogic operand

Default: Off

The FlexLogic operand assigned to this setting blocks triggering of the disturbance recorder analog channel.

Figure 23: Analog channel trigger logic



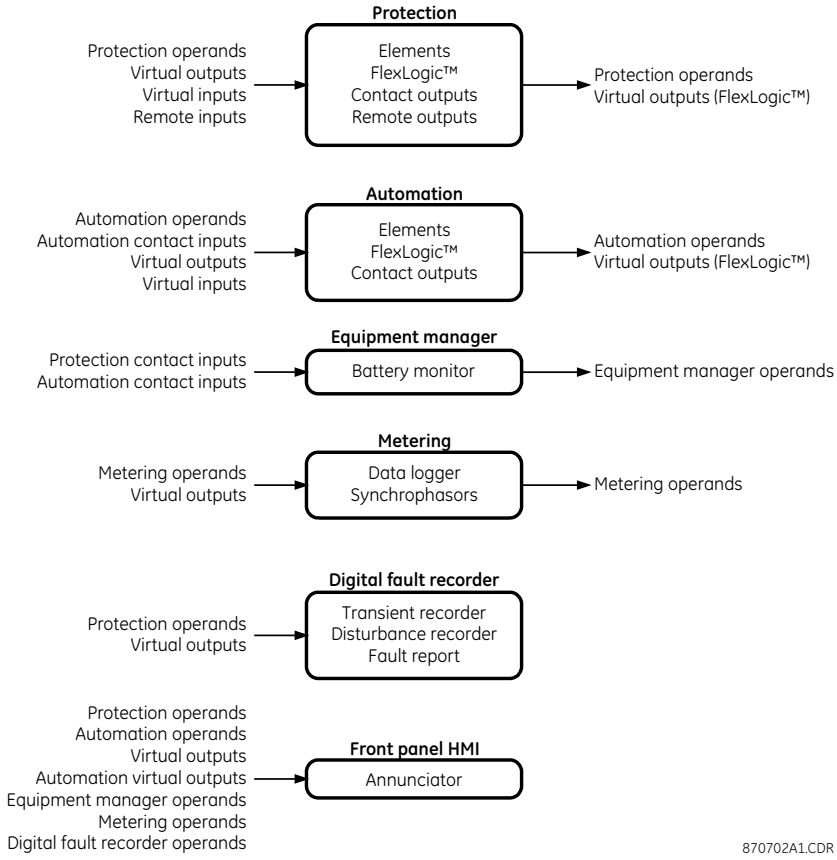
Using shared operands in the digital fault recorder

The EnerVista UR^{Plus} Setup software groups the C90^{Plus} system into the following seven primary functions. Each function has its own setting parameters and each generates its own outputs in the form of operands.

- Communications
- Protection
- Automation.
- Digital fault recorder (DFR)
- Metering
- Equipment manager
- Self-tests
- Front panel interface (HMI)

However, it is often desirable for an output from an element within one function can be available to an element within another function. For instance, it may be useful for the digital fault recorder to record the output operands of any protection element. Consequently a fixed, predetermined set of operands is available as to each function, as shown.

Figure 24: Default operand list by function



The content of each operand list is dependent on the selected order code.

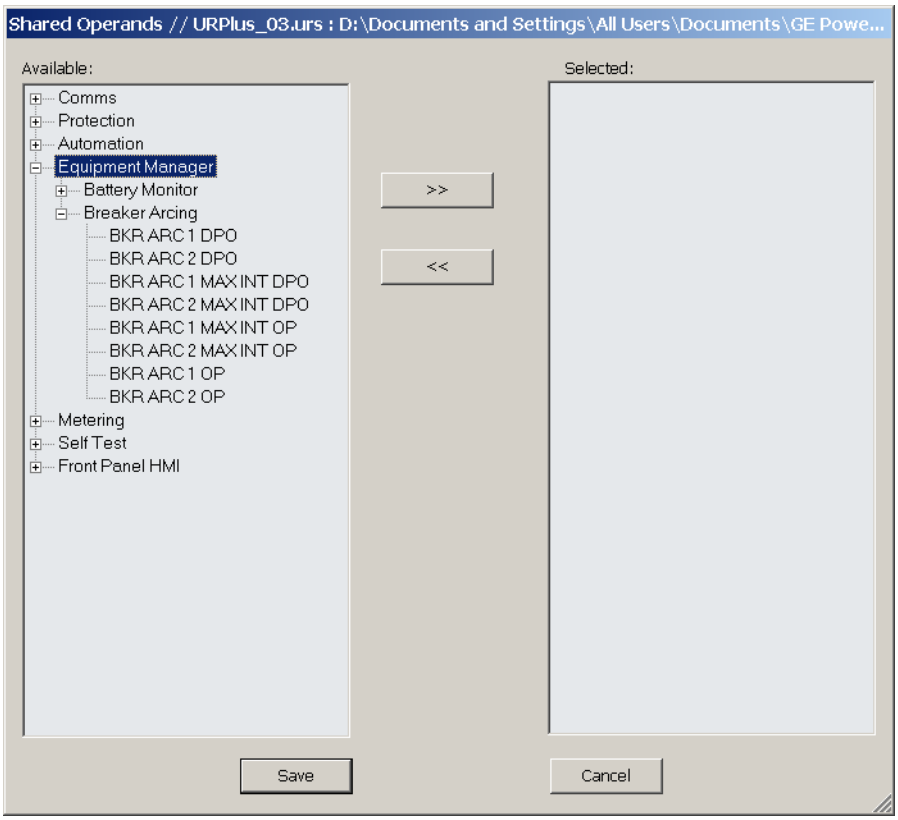
The shared operands functionality expands upon this system. With this feature, an output from any element can be assigned as a shared operand within the EnerVista UR^{Plus} Setup software. These signals can then be assigned as inputs to other functions.

For example, assume that the GND TOC1 OP protection operand is required as a signal within the automation function. This operand would then be assigned as a shared operand, and would subsequently become available to the automation function. A total of 64 operands can be assigned as shared operands within each function.

Shared digital fault recorder operands

Select the **Settings > DFR > Shared Operands** menu item to select the shared digital fault recorder operands.

Figure 25: Shared operands configuration window



The left side of this screen displays all C90^{Plus} operands that are available to the digital fault recorder function as shared operands. Select any operands from the other five primary features by clicking on the **>>** button. Operands can be de-assigned as shared operands by clicking the **<<** button.

Digital fault recorder FlexAnalog parameters

The following digital fault recorder FlexAnalog parameters (analog operands) are available for the C90^{Plus}. They are listed alphabetically by operand syntax.

Fault report analog operands

Fault Ia Mag [1] ..... Metered phase A fault current magnitude from fault report
Fault Ia Ang [1] ..... Metered phase A fault current angle from fault report
Fault Ib Mag [1] ..... Metered phase B fault current magnitude from fault report
Fault Ib Ang [1] ..... Metered phase B fault current angle from fault report
Fault Ic Mag [1] ..... Metered phase C fault current magnitude from fault report
Fault Ic Ang [1] ..... Metered phase C fault current angle from fault report
Fault Va Mag [1] ..... Metered phase A fault voltage magnitude from fault report
Fault Va Ang [1] ..... Metered phase A fault voltage angle from fault report
Fault Vb Mag [1] ..... Metered phase B fault voltage magnitude from fault report
Fault Vb Ang [1] ..... Metered phase B fault voltage angle from fault report
Fault Vc Mag [1] ..... Metered phase C fault voltage magnitude from fault report
Fault Vc Ang [1] ..... Metered phase C fault voltage angle from fault report

Fault Location [1] ..... Metered fault location from fault report
Prefault Ia Mag [1] ..... Metered phase A pre-fault current magnitude from fault report
Prefault Ia Ang [1] ..... Metered phase A pre-fault current angle from fault report
Prefault Ib Mag [1] ..... Metered phase B pre-fault current magnitude from fault report
Prefault Ib Ang [1] ..... Metered phase B pre-fault current angle from fault report
Prefault Ic Mag [1] ..... Metered phase C pre-fault current magnitude from fault report
Prefault Ic Ang [1] ..... Metered phase C pre-fault current angle from fault report
Prefault Va Mag [1] ..... Metered phase A pre-fault voltage magnitude from fault report
Prefault Va Ang [1] ..... Metered phase A pre-fault voltage angle from fault report
Prefault Vb Mag [1] ..... Metered phase B pre-fault voltage magnitude from fault report
Prefault Vb Ang [1] ..... Metered phase B pre-fault voltage angle from fault report
Prefault Vc Mag [1] ..... Metered phase C pre-fault voltage magnitude from fault report
Prefault Vc Ang [1] ..... Metered phase C pre-fault voltage angle from fault report

C90Plus Controller

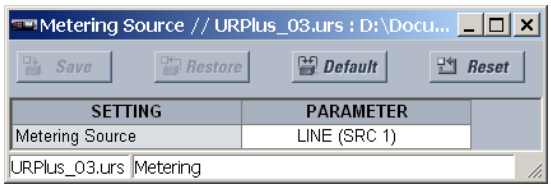
Chapter 11: Metering

This section outlines how to program the C90Plus metering features.

Metering source

Select the **Settings > Metering > Metering Source** menu item to open the metering source configuration window.

Figure 1: Metering source configuration settings



The following setting is available.

Name

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)
Default: LINE (SRC 1)

This setting selects the source to use for calculating metered quantities available through the front panel interface. For breaker-and-a-half schemes, select a source that sums the current from both breakers to measure the total load on the transmission line.

Phasor measurement unit

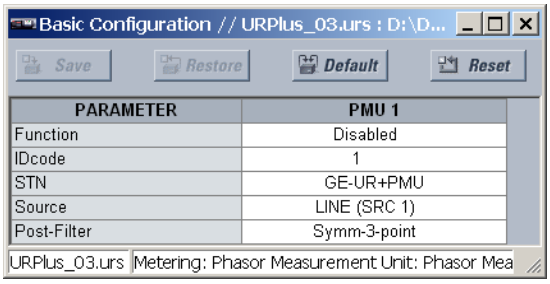
The phasor measurement unit menus allow specifying basic parameters of the measurements process such as signal source, ID and station name, calibration data, triggering, recording, and content for transmission on each of the supported phasor measurement unit ports. The reporting ports menus allow specifying the content and rate

of reporting on each of the supported ports. The phasor measurement unit settings are organized in five logical groups: basic configuration, calibration, communications, triggering, and recording.

Phasor measurement unit configuration

Select the **Settings > Metering > Phasor Measurement Unit > Phasor Measurement Unit > Basic Configuration** menu item to open the phasor measurement unit configuration window.

Figure 2: Phasor measurement unit configuration settings



The settings allow for the configuration of basic synchrophasor data, such as functions, source settings, and names. The following settings are available for each phasor measurement unit.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables the phasor measurement unit functionality. Any associated functions (such as the recorder or triggering comparators) do not function if this setting is "Disabled". Use the command frame to force the communication portion of the feature to start/stop transmission of data. When the transmission is turned off, the phasor measurement unit is fully operational in terms of calculating and recording the phasors.

IDcode

Range: 1 to 65534 in steps of 1
Default: 1

This setting assigns a numerical ID to the phasor measurement unit. It corresponds to the IDCODE field of the data, configuration, header, and command frames of the C37.118 protocol. The phasor measurement unit uses this value when sending data, configuration, and header frames and responds to this value when receiving the command frame.

STN

Range: 16 alphanumeric characters
Default: GE-UR+PMU

This setting assigns an alphanumeric ID to the phasor measurement unit station. It corresponds to the STN field of the configuration frame of the C37.118 protocol. This value is a 16-character ASCII string as per the C37.118 standard.

Source

Range: LINE (SRC 1), BKR 1 (SRC 2), BKR 2 (SRC 3)
Default: LINE (SRC 1)

This setting specifies one of the available C90^{Plus} signal sources for processing in the phasor measurement unit. Note that any combination of voltages and currents can be configured as a source. The current channels could be configured as sums of physically connected currents. This facilitates phasor measurement unit applications in breaker-

and-a-half, ring-bus, and similar arrangements. The phase measurement unit feature calculates voltage phasors for actual voltage (A, B, C, and auxiliary) and current (A, B, C, and ground) channels of the source, as well as symmetrical components (0, 1, and 2) of both voltages and currents. When configuring communication and recording features of the phasor measurement unit, the user can select—from the above superset—the content to be sent out or recorded.

Post-Filter

Range: None, Symm-3-point, Symm-5-point, Symm-7-point
Default: Symm-3-point

This setting specifies amount of post-filtering applied to raw synchrophasor measurements. The raw measurements are produced at the rate of nominal system frequency using one-cycle data windows. This setting is provided to deal with interfering frequencies and to balance speed and accuracy of synchrophasor measurements for different applications. The following filtering choices are available:

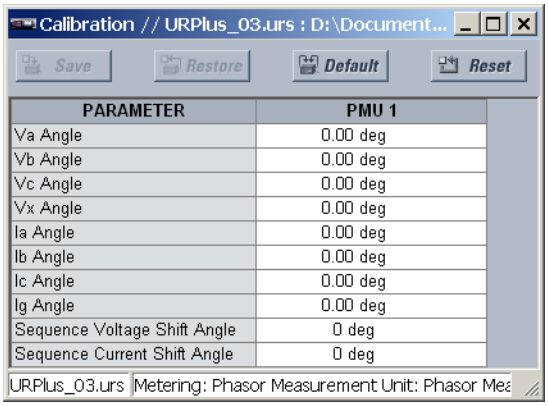
- None — No post-filtering
- Symm-3-point — Symmetrical three-point filter (one historical point, one present point, one future point)
- Symm-5-point — Symmetrical five-point filter (two historical points, one present point, two future points)
- Symm-7-point — Symmetrical seven-point filter (three historical points, one present point, three future points)

This setting applies to all channels of the phasor measurement unit. It is effectively for recording and transmission on all ports configured to use data for the phasor measurement unit.

Phasor measurement unit calibration

Select the **Settings > Metering > Synchrophasors > PMU Calibration** menu item to open the phasor measurement unit calibration window.

Figure 3: Phasor measurement unit calibration settings



The following settings are available for each phasor measurement unit. These settings specify user angle calibration data. This data is combined with the factory adjustments to shift the phasors for better accuracy.

Va Angle, Vb Angle, Vc Angle, Vx Angle

Range: –5.00 to 5.00° in steps of 0.05
Default: 0.00°

These settings recognize applications with protection class voltage and current sources, and allow the user to calibrate each channel (phase A, B, and C voltage, as well as auxiliary voltage) individually to offset errors introduced by VTs, CTs, and cabling. The setting values are effectively added to the measured angles. Therefore, enter a positive correction of the secondary signal lags the true signal; and negative value if the secondary signal leads the true signal.

Ia Angle, Ib Angle, Ic Angle, Ig Angle

Range: –5.00 to 5.00° in steps of 0.05
Default: 0.00°

These settings recognize applications with protection class voltage and current sources, and allow the user to calibrate each channel (ground current and phase A, B, and C currents) individually to offset errors introduced by VTs, CTs, and cabling. The setting values are effectively added to the measured angles. Therefore, enter a positive correction of the secondary signal lags the true signal; and negative value if the secondary signal leads the true signal.

Sequence Voltage Shift Angle

Range: –180 to 180° in steps of 30
Default: 0°

This setting allows correcting positive and negative-sequence voltages for vector groups of power transformers located between the phasor measurement unit voltage point and the reference node. This angle is effectively added to the positive-sequence voltage angle, and subtracted from the negative-sequence voltage angle. Note the following.

- When this setting value is not "0°", the phase and sequence voltages will not agree. Unlike sequence voltages, the phase voltages cannot be corrected in a general case, and therefore are reported as measured.
- When receiving synchrophasor date at multiple locations, with possibly different reference nodes, it may be more beneficial to allow the central locations to perform the compensation of sequence voltages.
- This setting applies to phasor measurement unit data only. The C90^{Plus} calculates symmetrical voltages independently for protection and control purposes without applying this correction.
- When connected to line-to-line voltages, the phasor measurement unit calculates symmetrical voltages with the reference to the AG voltage, and not to the physically connected AB voltage.

Sequence Current Shift Angle

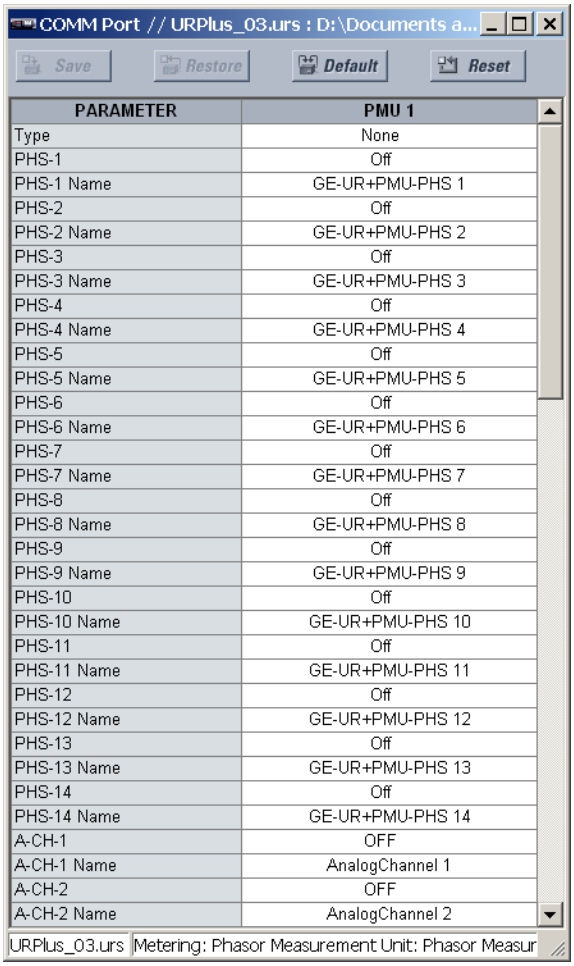
Range: –180 to 180° in steps of 30
Default: 0°

This setting allows correcting positive and negative-sequence currents for vector groups of power transformers located between the phasor measurement unit current point and the reference node. The setting has the same meaning for currents as the **Sequence Voltage Shift Angle** setting has for voltages. Normally, the two correcting angles are set identically, except rare applications when the voltage and current measuring points are located at different windings of a power transformer.

Phasor measurement unit communications

Select the **Settings > Metering > Phasor Measurement Unit > Communication > Comm Port** menu item to open the phasor measurement unit communications window for port 1.

Figure 4: Phasor measurement unit communications configuration



PARAMETER	PMU 1
Type	None
PHS-1	Off
PHS-1 Name	GE-UR+PMU-PHS 1
PHS-2	Off
PHS-2 Name	GE-UR+PMU-PHS 2
PHS-3	Off
PHS-3 Name	GE-UR+PMU-PHS 3
PHS-4	Off
PHS-4 Name	GE-UR+PMU-PHS 4
PHS-5	Off
PHS-5 Name	GE-UR+PMU-PHS 5
PHS-6	Off
PHS-6 Name	GE-UR+PMU-PHS 6
PHS-7	Off
PHS-7 Name	GE-UR+PMU-PHS 7
PHS-8	Off
PHS-8 Name	GE-UR+PMU-PHS 8
PHS-9	Off
PHS-9 Name	GE-UR+PMU-PHS 9
PHS-10	Off
PHS-10 Name	GE-UR+PMU-PHS 10
PHS-11	Off
PHS-11 Name	GE-UR+PMU-PHS 11
PHS-12	Off
PHS-12 Name	GE-UR+PMU-PHS 12
PHS-13	Off
PHS-13 Name	GE-UR+PMU-PHS 13
PHS-14	Off
PHS-14 Name	GE-UR+PMU-PHS 14
A-CH-1	OFF
A-CH-1 Name	AnalogChannel 1
A-CH-2	OFF
A-CH-2 Name	AnalogChannel 2

The following settings are available for the communication port on each phasor measurement unit.

Type

Range: None, Network
Default: None

This setting specifies the first communication port for transmission of the phasor measurement unit data. The three ports are configured under individual menus.

PHS-1, PHS-2, PHS-3,..., PHS-14

Range: Off, Va, Vb, Vc, Vx, Ia, Ib, Ic, Ig, V1, V2, V0, I1, I2, I0
Default: Off

These settings select synchrophasors to be transmitted from the superset of all synchronized measurements. The available synchrophasor values are

- Va — The first voltage channel, either Va or Vab
- Vb — The second voltage channel, either Vb or Vbc
- Vc — The third voltage channel, either Vc or Vca
- Vx — The fourth voltage channel
- Ia — Phase A current, physical channel or summation as per the source settings
- Ib — Phase B current, physical channel or summation as per the source settings
- Ic — Phase C current, physical channel or summation as per the source settings

- Ig — Fourth current channel, physical or summation as per the source settings
- V1 — Positive-sequence voltage, referenced to Va
- V2 — Negative-sequence voltage, referenced to Va
- V0 — Zero-sequence voltage
- I1 — Positive-sequence current, referenced to Ia
- I2 — Negative-sequence current, referenced to Ia
- I0 — Zero-sequence current

These settings allow for optimizing the frame size and maximizing transmission channel usage, depending on a given application. Select "Off" to suppress transmission of a given value.

PHS-1 Name, PHS-2 Name, PHS-3 Name,..., PHS-14 Name

Range: 16 alphanumeric characters

Default: GE-UR+PMU1-V1, GE-UR+PMU1-V2, GE-UR-PMU1+V3,..., GE-UR+PMU1-V14

These settings allow for custom naming of the synchrophasor channels. Sixteen-character ASCII strings are allowed as in the CHNAM field of the configuration frame. These names are typically based on station, bus, or breaker names.

A-CH-1, A-CH-2, A-CH-3,..., A-CH-8

Range: available FlexAnalog values

Default: Off

These settings select any analog data measured by the relay to be included as a user-selectable analog channel of the data frame. Up to eight analog channels can be configured to send any FlexAnalog value from the relay. Examples include active and reactive power, per phase or three-phase power, power factor, temperature via RTD inputs, and THD. The configured analog values are sampled concurrently with the synchrophasor instant and sent as 16-bit integer values.

A-CH-1 Name, A-CH-2 Name, A-CH-3 Name,..., A-CH-8 Name

Range: 16 alphanumeric characters

Default: AnalogChannel1, AnalogChannel2, AnalogChannel3,..., AnalogChannel8

These settings allow for custom naming of the analog channels. Sixteen-character ASCII strings are allowed as in the CHNAM field of the configuration frame.

D-CH-1, D-CH-2, D-CH-3,..., D-CH-16

Range: any metering logic operand or shared operand

Default: Off

These settings select any digital flag measured by the relay to be included as a user-selectable digital channel of the data frame. Up to sixteen analog channels can be configured to send any operand from the relay. The configured digital flags are sampled concurrently with the synchrophasor instant. The values are mapped into a two-byte integer number, with byte 1 LSB corresponding to the digital channel 1 and byte 2 MSB corresponding to digital channel 16.

D-CH-1 Name, D-CH-2 Name, D-CH-3 Name,..., D-CH-16 Name

Range: 16 alphanumeric characters

Default: DigitalChannel1, DigitalChannel2, DigitalChannel3,..., DigitalChannel16

These settings allow for custom naming of the digital channels. Sixteen-character ASCII strings are allowed as in the CHNAM field of the configuration frame.

D-CH-1 Normal State, D-CH-2 Normal State, D-CH-3 Normal State,..., D-CH-16 Normal State

Range: On, Off

Default: Off

These settings allow for specifying a normal state for each digital channel. These states are transmitted in configuration frames to the data concentrator.

Phasor measurement unit triggering

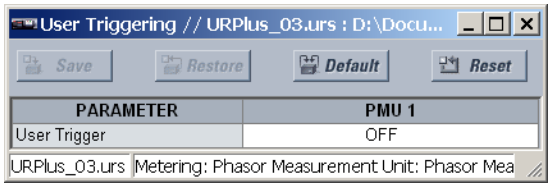
Each logical phasor measurement unit (PMU) contains five triggering mechanisms to facilitate triggering of the associated PMU recorder and cross-triggering of other PMUs of the system. They are

- Overfrequency and underfrequency
- Overvoltage and undervoltage
- Overcurrent
- Overpower
- High rate of change of frequency

The pre-configured triggers can be augmented with a user-programmable trigger. This trigger can be built freely using programmable logic of the relay. The entire triggering logic is refreshed once every two power system cycles.

Select the **Settings > Metering > Phasor Measurement Unit > Triggering > User Triggering** menu item to open the phasor measurement unit user-programmable trigger window.

Figure 5: User-programmable trigger configuration setting



The following user-programmable trigger setting is available.

Function

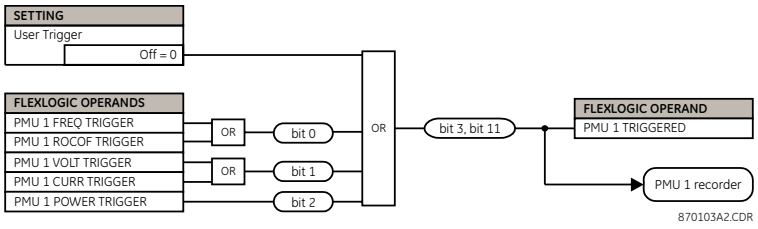
Range: any metering operand or shared operand

Default: OFF

This setting selects an operand to use as a user-specified trigger.

All five triggering functions and the user-programmable trigger are consolidated (ORed) and connected to the PMU recorder. Each trigger can be programmed to log its operation into the event recorder. The five triggers drive the STAT bits of the data frame to inform the destination of the synchrophasor data regarding the cause of trigger. The following convention is adopted to drive bits 11, 3, 2, 1, and 0 of the STAT word.

Figure 6: STAT bits logic

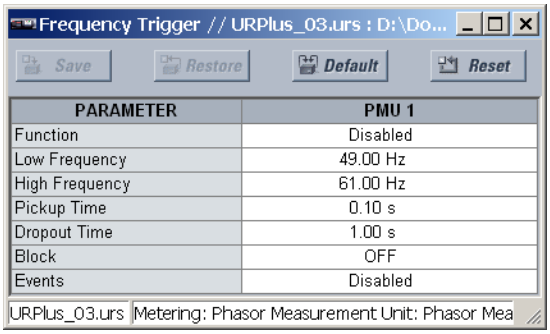


Frequency triggering

The trigger responds to the frequency signal of the phasor measurement unit source. The frequency is calculated from either phase voltages, auxiliary voltage, phase currents and ground current, in this hierarchy, depending on the source configuration as per C90^{Plus} standards. This element requires the frequency is above the minimum measurable value. If the frequency is below this value, such as when the circuit is de-energized, the trigger drops out.

Select the **Settings > Metering > Phasor Measurement Unit > Triggering > Frequency Trigger** menu item to open the phasor measurement unit frequency triggering window.

Figure 7: Frequency triggering configuration settings



The following settings are available for each phasor measurement unit.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the phasor measurement unit frequency triggering function.

Low Frequency

Range: 20.00 to 70.00 Hz in steps of 0.01
Default: 49.00 Hz

This setting specifies the low threshold for the abnormal frequency trigger. The comparator applies a 0.03 Hz hysteresis.

High Frequency

Range: 20.00 to 70.00 Hz in steps of 0.01
Default: 61.00 Hz

This setting specifies the high threshold for the abnormal frequency trigger. The comparator applies a 0.03 Hz hysteresis.

Pickup Time

Range: 0.00 to 600.00 seconds in steps of 0.01
Default: 0.10 seconds

This setting is used to filter out spurious conditions and avoid unnecessary triggering of the recorder.

Dropout Time

Range: 0.00 to 600.00 seconds in steps of 0.01
Default: 1.00 seconds

This setting is used to extend the trigger after the situation returned to normal. This setting is of particular importance when using the recorder in the forced mode (recording as long as the triggering condition is asserted).

Block

Range: any metering logic operand or shared operand

Default: Off

Assertion of the operand assigned to this setting blocks operation of the phasor measurement unit frequency triggering function.

Events

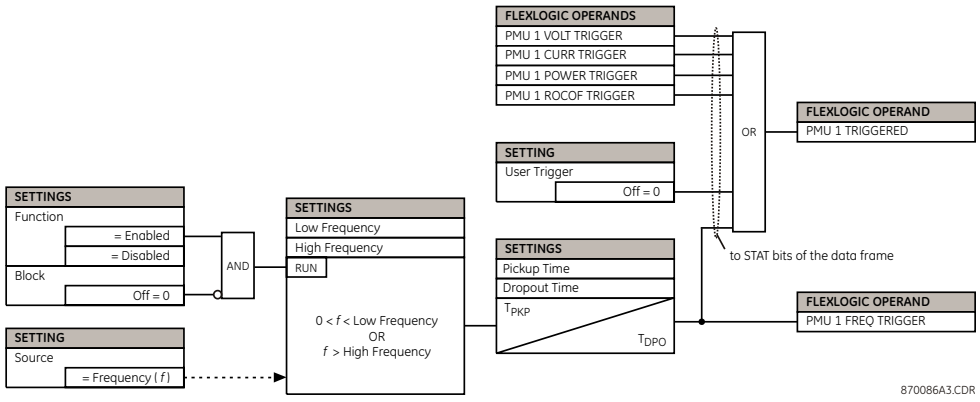
Range: Enabled, Disabled

Default: Disabled

This setting enables and disables the logging of phasor measurement unit frequency triggering events in the sequence of events recorder.

The figure shows the logic for the phasor measurement unit frequency triggering function.

Figure 8: Frequency triggering scheme logic

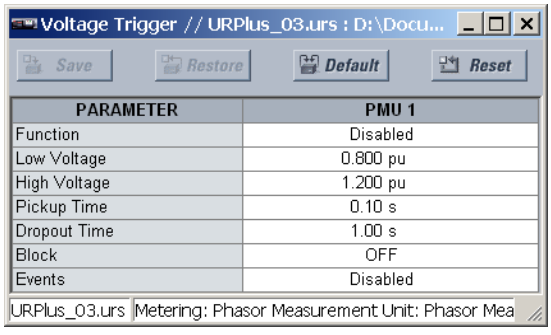


Voltage triggering

This phasor measurement unit voltage triggering function responds to abnormal voltage. Separate thresholds are provided for low and high voltage. In terms of signaling its operation, the element does not differentiate between the undervoltage and overvoltage events. The trigger responds to the phase voltage signal of the phasor measurement unit source. All voltage channels (A, B, and C or AB, BC, and CA) are processed independently and could trigger the recorder. A minimum voltage supervision of 0.1 pu is implemented to prevent pickup on a de-energized circuit, similarly to the undervoltage protection element.

Select the **Settings > Metering > Phasor Measurement Unit > Triggering > Voltage Trigger** menu item to open the phasor measurement unit voltage triggering window.

Figure 9: Voltage triggering configuration settings



The following settings are available for each phasor measurement unit.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the phasor measurement unit voltage triggering function.

Low Voltage

Range: 0.250 to 1.250 pu in steps of 0.001
Default: 0.800 pu

This setting specifies the low threshold for the abnormal voltage trigger, in per-unit values of the phasor measurement unit source. A value of 1 pu is a nominal voltage value defined as the nominal secondary voltage times VT ratio. The comparator applies a 3% hysteresis.

High Voltage

Range: 0.750 to 1.750 pu in steps of 0.001
Default: 1.200 pu

This setting specifies the high threshold for the abnormal voltage trigger, in per-unit values of the phasor measurement unit source. A value of 1 pu is a nominal voltage value defined as the nominal secondary voltage times VT ratio. The comparator applies a 3% hysteresis.

Pickup Time

Range: 0.00 to 600.00 seconds in steps of 0.01
Default: 0.10 seconds

This setting can be used to filter out spurious conditions and avoid unnecessary triggering of the recorder.

Dropout Time

Range: 0.00 to 600.00 seconds in steps of 0.01
Default: 1.00 seconds

This setting can be used to extend the trigger after the situation returned to normal. This setting is of particular importance when using the recorder in the forced mode (recording as long as the triggering condition is asserted).

Block

Range: any metering logic operand or shared operand
Default: OFF

Assertion of the operand assigned to this setting blocks operation of the phasor measurement unit voltage triggering function.

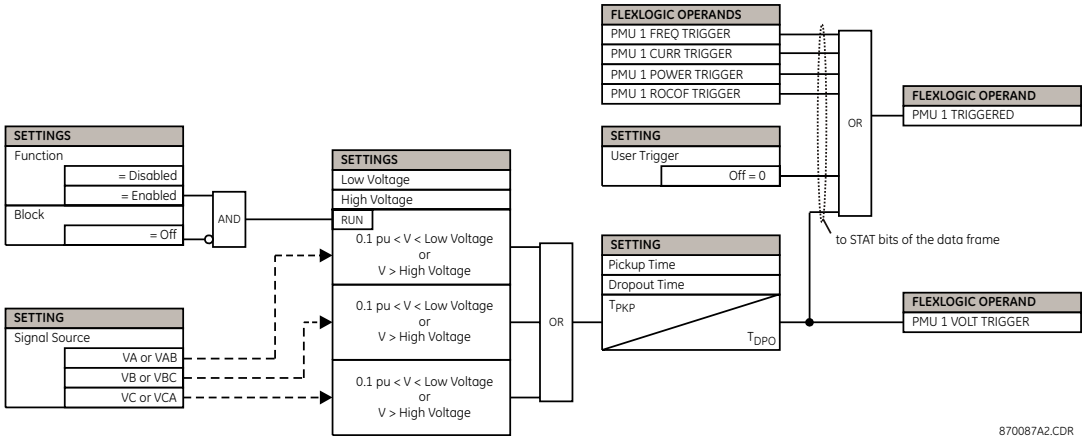
Events

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the logging of phasor measurement unit voltage triggering events in the sequence of events recorder.

The figure shows the logic for the phasor measurement unit voltage triggering function.

Figure 10: Voltage triggering scheme logic

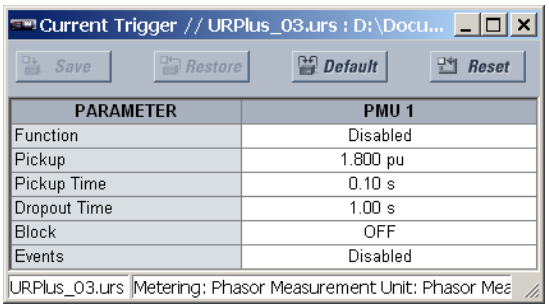


Current triggering

This phasor measurement unit current triggering function responds to elevated current. The trigger responds to the phase current signal of the phasor measurement unit source. All current channel (A, B, and C) are processed independently and could trigger the recorder.

Select the **Settings > Metering > Phasor Measurement Unit > Triggering > Current Trigger** menu item to open the phasor measurement unit current triggering window.

Figure 11: Current triggering configuration settings



The following settings are available for each phasor measurement unit.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the phasor measurement unit current triggering function.

Pickup

Range: 0.100 to 30.000 pu in steps of 0.001
Default: 1.800 pu

This setting specifies the pickup threshold for the overcurrent trigger, in per-unit values of the phasor measurement unit source. A value of 1 pu is a nominal primary current. The comparator applies a 3% hysteresis.

Pickup Time

Range: 0.00 to 600.00 seconds in steps of 0.01
Default: 0.10 seconds

This setting is used to filter out spurious conditions and avoid unnecessary triggering of the recorder.

Dropout Time

Range: 0.00 to 600.00 seconds in steps of 0.01

Default: 1.00 seconds

This setting is used to extend the trigger after the situation returned to normal. This setting is of particular importance when using the recorder in the forced mode (recording as long as the triggering condition is asserted).

Block

Range: any metering logic operand or shared operand

Default: Off

Assertion of the operand assigned to this setting blocks operation of the phasor measurement unit current triggering function.

Events

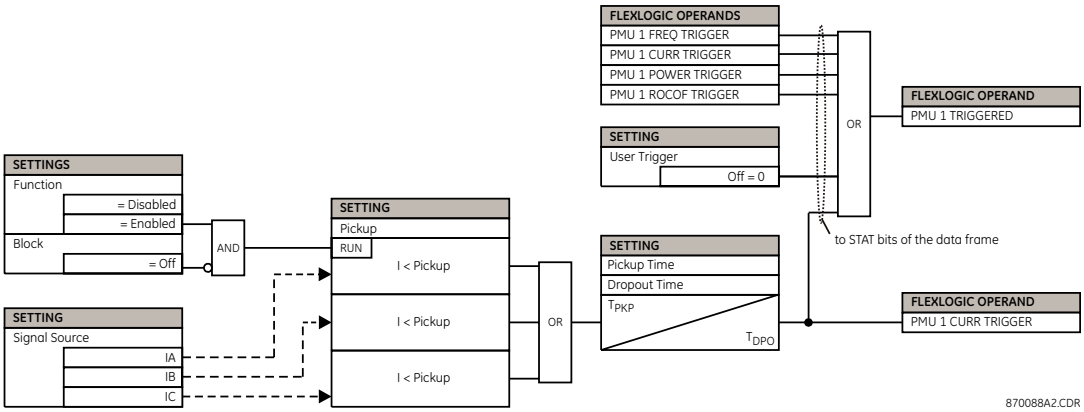
Range: Enabled, Disabled

Default: Disabled

This setting enables and disables the logging of phasor measurement unit current triggering events in the sequence of events recorder.

The figure shows the logic for the phasor measurement unit current triggering function.

Figure 12: Phasor measurement unit current triggering logic

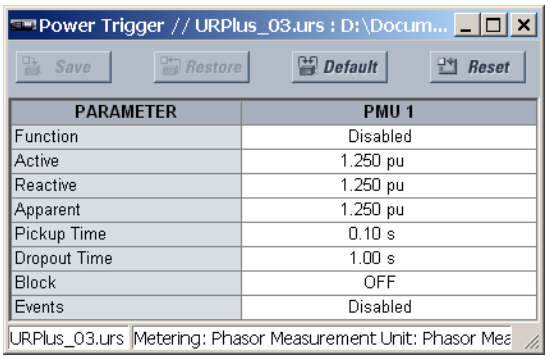


Power triggering

The phasor measurement unit power triggering function responds to abnormal power. Separate thresholds are provided for active, reactive, and apparent powers. In terms of signaling its operation the element does not differentiate between the three types of power. The trigger responds to the single-phase and three-phase power signals of the phasor measurement unit source.

Select the **Settings > Metering > Phasor Measurement Unit > Triggering > Power Trigger** menu item to open the phasor measurement unit power triggering window.

Figure 13: Power triggering configuration settings



The following settings are available for each phasor measurement unit.

Function

Range: Enabled, Disabled

Default: Disabled

This setting enables and disables the phasor measurement unit power triggering function.

Active

Range: 0.250 to 3.000 pu in steps of 0.001

Default: 1.250 pu

This setting specifies the pickup threshold for the active power of the source. For single-phase power, 1 pu represents the product of 1 pu voltage and 1 pu current, or the product of nominal secondary voltage, the VT ratio, and the nominal primary current. For the three-phase power, 1 pu is three times the value for single-phase power. The comparator applies a 3% hysteresis.

Reactive

Range: 0.250 to 3.000 pu in steps of 0.001

Default: 1.250 pu

This setting specifies the pickup threshold for the reactive power of the source. For single-phase power, 1 pu represents the product of 1 pu voltage and 1 pu current, or the product of nominal secondary voltage, the VT ratio and the nominal primary current. For the three-phase power, 1 pu is three times the value for single-phase power. The comparator applies a 3% hysteresis.

Apparent

Range: 0.250 to 3.000 pu in steps of 0.001

Default: 1.250 pu

This setting specifies the pickup threshold for the apparent power of the source. For single-phase power, 1 pu represents the product of 1 pu voltage and 1 pu current, or the product of nominal secondary voltage, the VT ratio and the nominal primary current. For the three-phase power, 1 pu is three times the value for single-phase power. The comparator applies a 3% hysteresis.

Pickup Time

Range: 0.00 to 600.00 seconds in steps of 0.01

Default: 0.10 seconds

This setting is used to filter out spurious conditions and avoid unnecessary triggering of the recorder.

Dropout Time

Range: 0.00 to 600.00 seconds in steps of 0.01
Default: 1.00 seconds

This setting is used to extend the trigger after the situation returned to normal. This setting is of particular importance when using the recorder in the forced mode (recording as long as the triggering condition is asserted).

Block

Range: any metering logic operand or shared operand
Default: OFF

Assertion of the operand assigned to this setting blocks operation of the phasor measurement unit power triggering function.

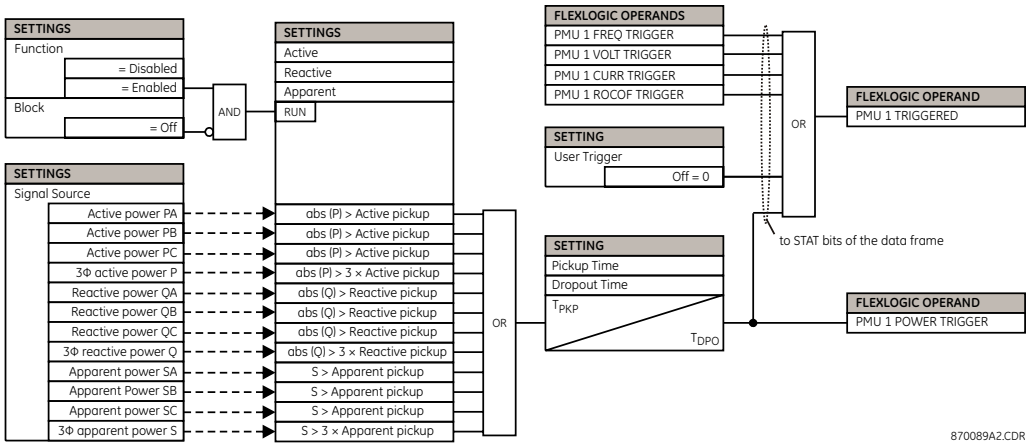
Events

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the logging of phasor measurement unit power triggering events in the sequence of events recorder.

The figure shows the logic for the phasor measurement unit power triggering function.

Figure 14: Phasor measurement unit power triggering logic

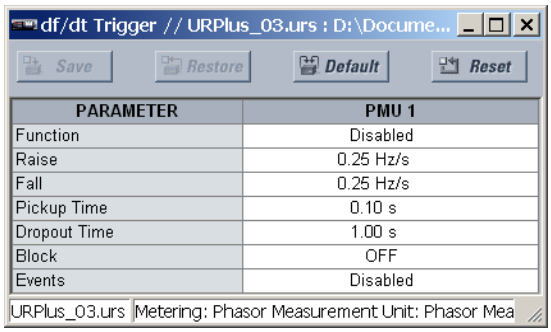


Frequency rate of change triggering

This phasor measurement unit frequency rate of change triggering function responds to the rate of change of frequency. Separate thresholds are provided for rising and dropping frequency. The trigger responds to the rate of change of frequency (df/dt) of the phasor measurement unit (PMU) source.

Select the **Settings > Metering > Phasor Measurement Unit > Triggering > df/dt Trigger** menu item to open the phasor measurement unit frequency rate of change triggering window.

Figure 15: Frequency rate of change triggering configuration settings



The following settings are available for each phasor measurement unit.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the phasor measurement unit frequency rate of change triggering function.

Raise

Range: 0.10 to 15.00 Hz/s in steps of 0.01
Default: 0.25 Hz/s

This setting specifies the pickup threshold for the rate of change of frequency in the raising direction (positive df/dt). The comparator applies a 3% hysteresis.

Fall

Range: 0.10 to 15.00 Hz/s in steps of 0.01
Default: 0.25 Hz/s

This setting specifies the pickup threshold for the rate of change of frequency in the falling direction (negative df/dt). The comparator applies a 3% hysteresis.

Pickup Time

Range: 0.00 to 600.00 seconds in steps of 0.01
Default: 0.10 seconds

This setting can be used to filter out spurious conditions and avoid unnecessary triggering of the recorder.

Dropout Time

Range: 0.00 to 600.00 seconds in steps of 0.01
Default: 1.00 seconds

This setting can be used to extend the trigger after the situation returned to normal. This setting is of particular importance when using the recorder in the forced mode (recording as long as the triggering condition is asserted).

Block

Range: any metering logic operand or shared operand
Default: OFF

Assertion of the operand assigned to this setting blocks operation of the phasor measurement unit frequency rate of change triggering function.

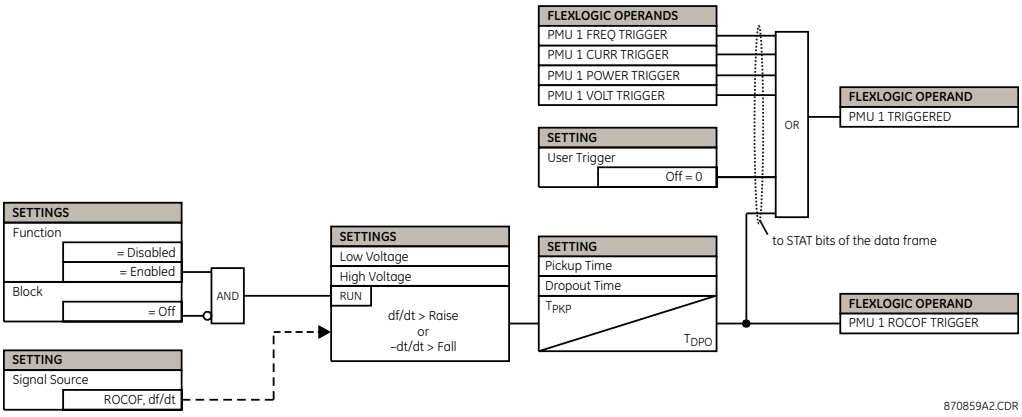
Events

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the logging of phasor measurement unit frequency rate of change triggering events in the sequence of events recorder.

The figure shows the logic for the phasor measurement unit frequency rate of change triggering function.

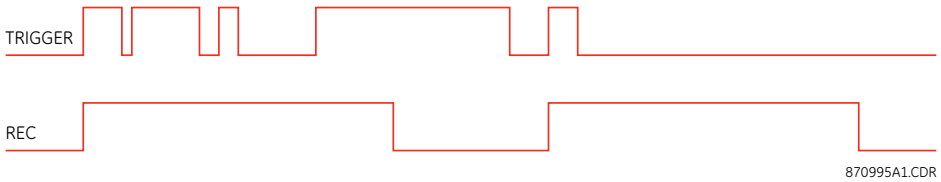
Figure 16: Phasor measurement unit frequency rate of change triggering logic



Phasor measurement unit recording

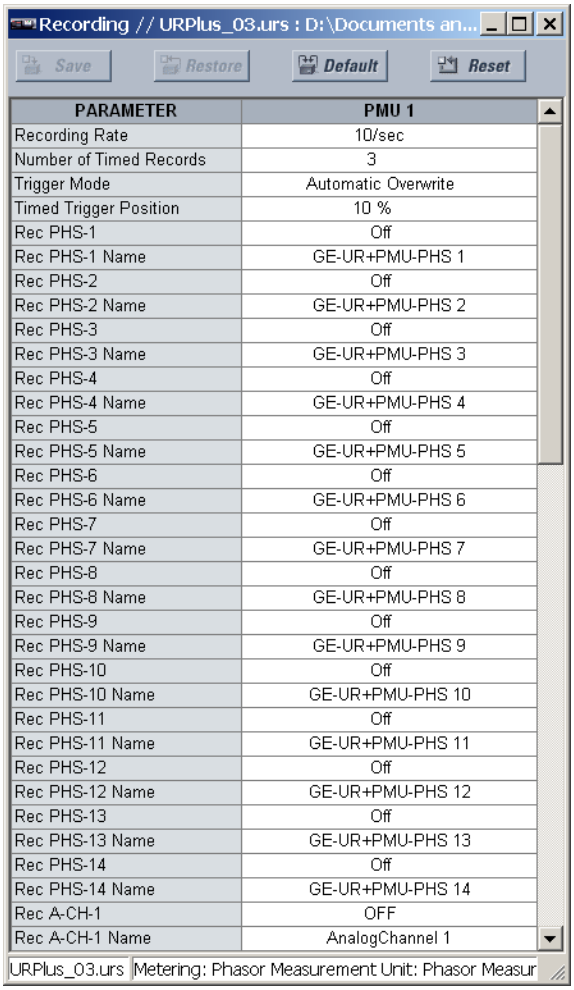
Each logical phasor measurement unit (PMU) is associated with a recorder. The triggering condition is programmed via the **Settings > Metering > Phasor Measurement Unit > Triggering** menu. The recorder works with polar values using resolution as in the phasor measurement unit actual values.

Figure 17: Phasor measurement unit recording



Select the **Settings > Metering > Phasor Measurement Unit > Recording** menu item to open the phasor measurement unit recording window.

Figure 18: Phasor measurement unit recording configuration settings



PARAMETER	PMU 1
Recording Rate	10/sec
Number of Timed Records	3
Trigger Mode	Automatic Overwrite
Timed Trigger Position	10 %
Rec PHS-1	Off
Rec PHS-1 Name	GE-UR+PMU-PHS 1
Rec PHS-2	Off
Rec PHS-2 Name	GE-UR+PMU-PHS 2
Rec PHS-3	Off
Rec PHS-3 Name	GE-UR+PMU-PHS 3
Rec PHS-4	Off
Rec PHS-4 Name	GE-UR+PMU-PHS 4
Rec PHS-5	Off
Rec PHS-5 Name	GE-UR+PMU-PHS 5
Rec PHS-6	Off
Rec PHS-6 Name	GE-UR+PMU-PHS 6
Rec PHS-7	Off
Rec PHS-7 Name	GE-UR+PMU-PHS 7
Rec PHS-8	Off
Rec PHS-8 Name	GE-UR+PMU-PHS 8
Rec PHS-9	Off
Rec PHS-9 Name	GE-UR+PMU-PHS 9
Rec PHS-10	Off
Rec PHS-10 Name	GE-UR+PMU-PHS 10
Rec PHS-11	Off
Rec PHS-11 Name	GE-UR+PMU-PHS 11
Rec PHS-12	Off
Rec PHS-12 Name	GE-UR+PMU-PHS 12
Rec PHS-13	Off
Rec PHS-13 Name	GE-UR+PMU-PHS 13
Rec PHS-14	Off
Rec PHS-14 Name	GE-UR+PMU-PHS 14
Rec A-CH-1	OFF
Rec A-CH-1 Name	AnalogChannel 1

The following settings are available for each phasor measurement unit.

Recording Rate

Range: 1, 2, 5, 10, 12, 15, 20, 25, 30, 50, or 60 times per second

Default: 10 times per second

This setting specifies the recording rate for the record content. Not all recording rates are applicable to either 50 or 60 Hz systems (for example, recording at 25 phasors a second in a 60 Hz system). The relay supports decimation by integer number of phasors from the nominal system frequency. If the rate of 25 is selected for the 60 Hz system, the relay decimates the rate of 60 phasors a second by round (60 / 25) = 2; that is, it records at 60 / 2 = 30 phasors a second.

Number of Timed Records

Range: 1 to 128 in steps of 1

Default: 3

This setting specifies how many timed records are available for a given logical phasor measurement unit. The length of each record equals available memory divided by the content size and number of records. The higher the number of records, the shorter each record. The relay supports a maximum of 128 records.

Trigger Mode

Range: Automatic Overwrite, Protected

Default: Automatic Overwrite

This setting specifies what happens when the recorder uses its entire available memory storage. If set to "Automatic Overwrite", the last record is erased to facilitate new recording, when triggered. If set to "Protected", the recorder stops creating new records when the entire memory is used up by the old un-cleared records.

The following set of figures illustrate the concept of memory management via the **Trigger Mode** setting.

Figure 19: Memory management in automatic overwrite mode

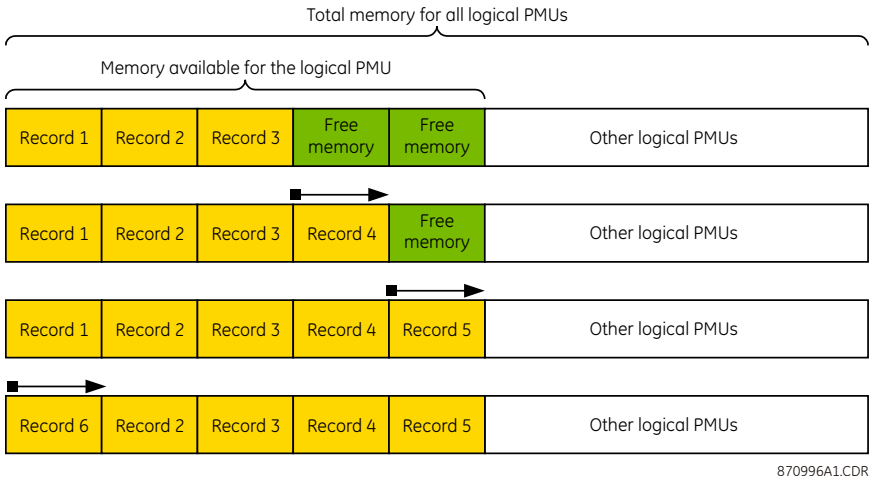
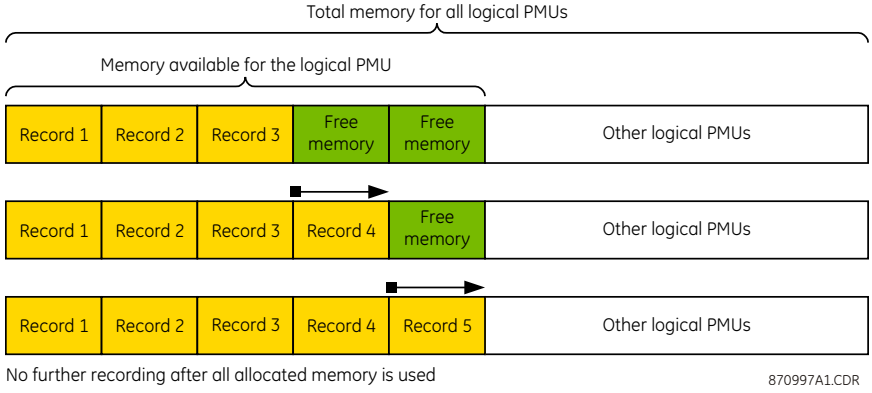


Figure 20: Memory management in protected mode



Timed Trigger Position

Range: 1 to 50% in steps of 1

Default: 10%

This setting specifies the amount of pre-trigger data in percent of the entire record. This setting applies only to the timed mode of recording.

Rec PHS-1, Rec PHS-2, Rec PHS-3,..., Rec PHS-14

Range: available synchrophasor values

Default: Off

These settings specify synchrophasors to be recorded from the superset of all synchronized measurements as indicated in the following table. These settings allow for optimizing the record size and content depending on a given application. Select "Off" to suppress recording of a given value.

Table 1: Available synchrophasor values

Value	Description
Va	First voltage channel, either Va or Vab
Vb	Second voltage channel, either Vb or Vbc
Vc	Third voltage channel, either Vc or Vca
Vx	Fourth voltage channel
Ia	Phase A current, physical channel or summation as per the source settings
Ib	Phase B current, physical channel or summation as per the source settings
Ic	Phase C current, physical channel or summation as per the source settings
Ig	Fourth current channel, physical channel or summation as per the source settings
V1	Positive-sequence voltage, referenced to Va
V2	Negative-sequence voltage, referenced to Va
V0	Zero-sequence voltage, referenced to Va
I1	Positive-sequence current, referenced to Ia
I2	Negative-sequence current, referenced to Ia
I0	Zero-sequence current

Rec PHS-1 Name, Rec PHS-2 Name, Rec PHS-3 Name,..., Rec PHS-14 Name

Range: 16 character ASCII string

Default: GE-UR+PMU-PHS1, GE-UR+PMU-PHS2, GE-UR+PMU-PHS3,..., GE-UR+PMU-PHS14

These settings allow for custom naming of the synchrophasor channels. Sixteen-character ASCII strings are allowed as in the CHNAM field of the configuration frame. Typically these names are based on station, bus, or breaker names.

Rec A-CH-1, Rec A-CH-2, Rec A-CH-3,..., Rec A-CH-8

Range: available FlexAnalog values

Default: OFF

These settings specify analog data measured by the relay to be included as a user-selectable analog channel of the record. Up to eight analog channels can be configured to record any FlexAnalog value from the relay. Examples include active and reactive power, per phase or three-phase power, power factor, and THD. The configured analogs are sampled concurrently with the synchrophasor instance.

Rec A-CH-1 Name, Rec A-CH-2 Name, Rec A-CH-3 Name,..., Rec A-CH-8 Name

Range: 16 character ASCII string

Default: AnalogChannel1, AnalogChannel2, AnalogChannel3,..., AnalogChannel8

These settings allow for custom naming of the analog channels. Sixteen-character ASCII strings are allowed as in the CHNAM field of the configuration frame.

Rec D-CH-1, Rec D-CH-2, Rec D-CH-3,..., Rec D-CH-16

Range: any metering logic operand or shared operand

Default: OFF

These settings specify any digital flag measured by the relay to be included as a user-selectable digital channel in the record. Up to digital analog channels can be configured to record any operand from the relay. The configured digital flags are sampled concurrently with the synchrophasor instance.

Rec D-CH-1 Name, Rec D-CH-2 Name, Rec D-CH-3 Name,..., Rec D-CH-16 Name

Range: 16 character ASCII string

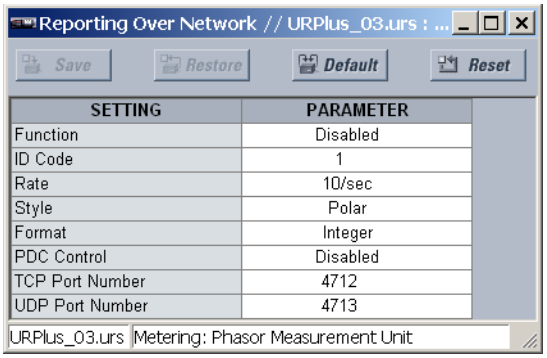
Default: AnalogChannel1, AnalogChannel2, AnalogChannel3,..., AnalogChannel16

This setting allows custom naming of the digital channels. Sixteen-character ASCII strings are allowed as in the CHNAM field of the configuration frame.

Phasor measurement unit reporting over network

The phasor measurement unit Ethernet connection works simultaneously with other communication means over Ethernet. The network reporting feature is programmed via the **Settings > Metering > Phasor Measurement Unit > Reporting Over Network** menu.

Figure 21: Phasor measurement unit reporting over network configuration settings



The following settings are available for each phasor measurement unit.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the phasor measurement unit reporting over network feature.

ID Code

Range: 1 to 65534 in steps of 1
Default: 1

This setting specifies an IDCODE for the entire port. Individual phasor measurement unit streams transmitted over this port are identified via their own IDCODEs as per the phasor measurement unit IDCODE settings. This IDCODE is to be used by the command frame to start and stop transmission, and request configuration or header frames.

Rate

Range: 1, 2, 5, 10, 12, 15, 20, 25, 30, 50, or 60 times per second
Default: 10 times per second

This setting specifies the reporting rate for the network (Ethernet) port. This value applies to all phasor measurement unit streams of the device that are assigned to transmit over this port.

Style

Range: Polar, Rectangular
Default: Polar

This setting selects between reporting synchrophasors in rectangular (real and imaginary) or in polar (magnitude and angle) coordinates. This setting complies with bit-0 of the format field of the C37.118 configuration frame.

Format

Range: Integer, Floating
Default: Integer

This setting selects between reporting synchrophasors as 16-bit integer or 32-bit IEEE floating point numbers. This setting complies with bit 1 of the format field of the C37.118 configuration frame. Note that this setting applies to synchrophasors only—the user-selectable FlexAnalog channels are always transmitted as 32-bit floating point numbers.

PDC Control

Range: Enabled, Disabled

Default: Disabled

The synchrophasor standard allows for user-defined controls originating at the PDC, to be executed on the phasor measurement unit. The control is accomplished via an extended command frame. The relay decodes the first word of the extended field, EXTFRAME, to drive 16 dedicated FlexLogic operands: PDC NETWORK CNTRL 1 (from the least significant bit) to PDC NETWORK CNTRL 16 (from the most significant bit). Other words, if any, in the EXTFRAME are ignored. The operands are asserted for 5 seconds following reception of the command frame. If the new command frame arrives within the 5 second period, the FlexLogic operands are updated, and the 5 second timer re-starts.

This setting enables or disables the control. When enabled, all 16 operands are active; when disabled, all 16 operands remain reset.

TCP Port Number

Range: 1 to 65535 in steps of 1

Default: 4712

This setting selects the TCP port number to use for network reporting.

UDP Port Number

Range: 1 to 65535 in steps of 1

Default: 4713

This setting selects the UDP port number to use for network reporting.

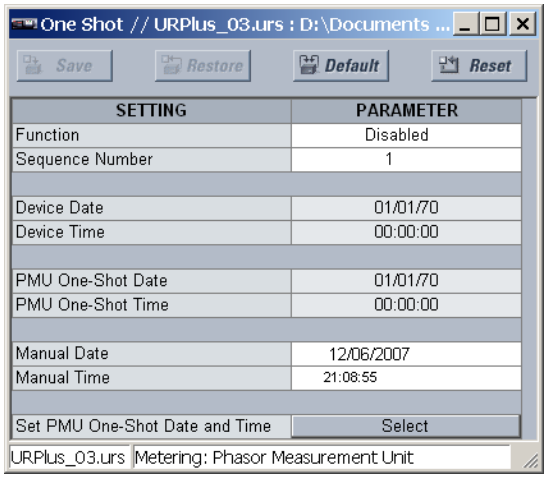
Phasor measurement unit one-shot

The phasor measurement unit one-shot feature allows pre-scheduling a phasor measurement unit measurement at a specific point in time. This functionality can be used to test for accuracy of the phasor measurement unit, and for manual collection of synchronized measurements through the system.

Phasor measurement unit one-shot settings

Select the **Settings > Metering > Phasor Measurement Unit > One-Shot** menu item to open the phasor measurement unit one-shot window.

Figure 22: Phasor measurement unit one-shot configuration settings



The following settings are available for each phasor measurement unit.

Function

Range: Enabled, Disabled

Default: Disabled

This setting enables and disables the phasor measurement unit one-shot feature.

Sequence Number

Range: 0 to nominal frequency – 1, in steps of 1

Default: 1

When the **Device Date** and **Device Time** match the **PMU One-Shot Date** and **PMU One-Shot Time**, the C90^{Plus} compares the present sequence number of the measured synchrophasors with this setting value. When the two numbers match, the function saves the actual values as the one-shot actual values. This allows manual read-out of the synchrophasor values for the pre-set time and pre-set sequence number (via supported communication protocols such as Modbus or DNP and the EnerVista UR^{Plus} Setup software).

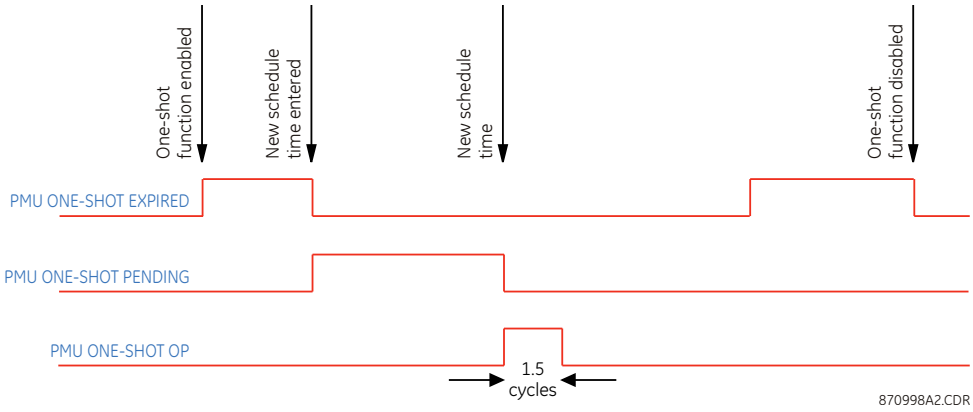
When the values are saved as one-shot values, the function also asserts a PMU ONE-SHOT OP metering logic operand. This operand may be configured to drive an output contact and trigger an external measuring device such as a digital scope with the intent to verify the accuracy of the phasor measurement unit under test.

With reference to the figure below, the phasor measurement unit one-shot function (when enabled) controls three metering logic operands.

- The PMU ONE-SHOT EXPIRED operand indicates that the one-shot operation has been executed.
- The PMU ONE-SHOT PENDING operand indicates that the one-shot operation is pending; that is, the present time is before the scheduled one-shot time.
- The PMU ONE-SHOT OP operand indicates the one-shot operation.

When the phasor measurement unit one-shot function is disabled, all three operands are de-asserted. The one-shot function applies to all logical phasor measurement units of a given C90^{Plus} relay.

Figure 23: Phasor measurement unit one-shot operands



Device Date

Range: date in MM/DD/YYYY format

Default: 01/01/1970

This value reflects the date programmed in the C90^{Plus}. This date cannot be modified from this window.

Device Time

Range: time in HH:MM:SS format

Default: 00:00:00

This value reflects the time programmed in the C90^{Plus}. This time cannot be modified from this window.

PMU One-Shot Date

Range: date in MM/DD/YYYY format

Default: 01/01/2007

When the phasor measurement unit one-shot feature is enabled, the C90^{Plus} continuously compares the device date with this value.

PMU One-Shot Time

Range: time in HH:MM:SS format

Default: 00:00:00

When the phasor measurement unit one-shot feature is enabled, the C90^{Plus} continuously compares the device date with this value.

Manual Date

Range: date in MM/DD/YYYY format

Default: 01/01/2007

The **PMU One-Shot Date** is updated to the value specified by this setting when the **Set PMU One-Shot Date and Time** command is executed.

Manual Time

Range: time in HH:MM:SS format

Default: 00:00:00

The **PMU One-Shot Time** is updated to the value specified by this setting when the **Set PMU One-Shot Date and Time** command is executed.

Testing the accuracy of the phasor measurement unit

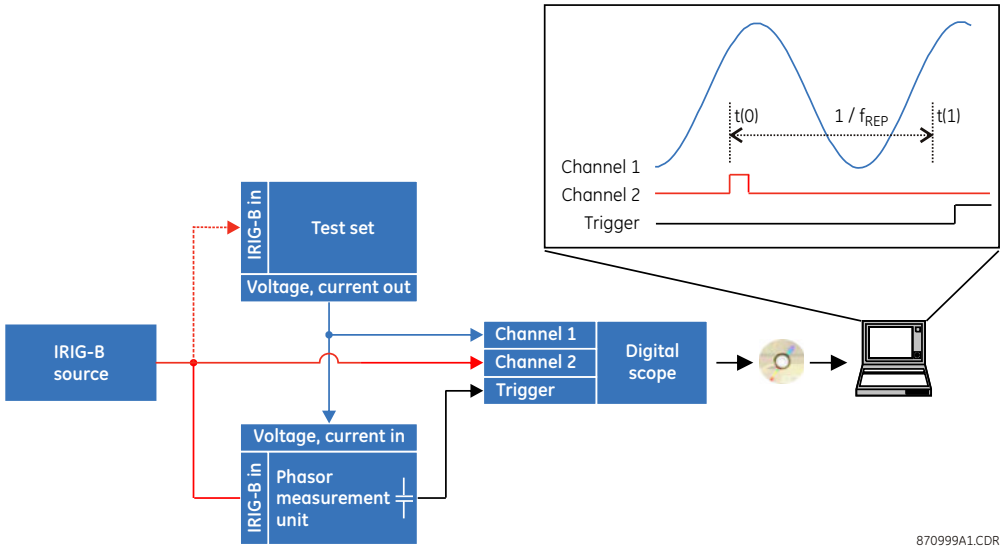
The phasor measurement unit one-shot feature can be used to test accuracy of the synchrophasor measurement. GPS-synchronized tests sets perform a similar function to PMUs: instead of measuring the phasor from physical signals with respect to the externally provided time reference, they produce the physical signals with respect to the externally provided time reference, given the desired phasor values. Therefore the GPS-synchronized test sets cannot be automatically assumed more accurate then the phasor measurement units under test. This calls for a method to verify both the measuring device (PMU) and the source of signal (test set).

With reference to the figure below, the one-shot feature could be configured to trigger a high-accuracy scope to capture both the time reference signal (rising edge of the 1 pps signal of the IRIG-B time reference), and the measured waveform. The high-accuracy high-sampling rate record of the two signals captured by the scope can be processed using digital tools to verify the magnitude and phase angle with respect to the time reference signal. As both the time reference and the measured signals are raw inputs to the phasor measurement unit under test, their independently captured record, processed using third-party software, is a good reference point for accuracy calculations. Such a record proves useful when discussing the test results, and should be retained as a part of the testing documentation.

Note that the phasor measurement unit under test does not have to be connected to a real GPS receiver as the accuracy is measured with respect to the timing reference provided to the phasor measurement unit and not to the absolute UTC time. Therefore a simple IRIG-B generator could be used instead. Also, the test set does not have to support GPS synchronization. Any stable signal source can be used. If both the phasor measurement unit under test and the test set use the timing reference, they should be driven from the

same IRIG-B signal: either the same GPS receiver or IRIG-B generator. Otherwise, the setpoints of the test set and the phasor measurement unit measurements should not be compared as they are referenced to different time scales.

Figure 24: Testing synchrophasor measurement accuracy



Collecting synchronized measurements *ad hoc*

The phasor measurement unit one-shot feature can be used for *ad hoc* collection of synchronized measurements in the network. Two or more phasor measurement units can be pre-scheduled to freeze their measurements at the same time. When frozen, the measurements can be collected using the EnerVista software or a protocol client.

Data logger

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

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

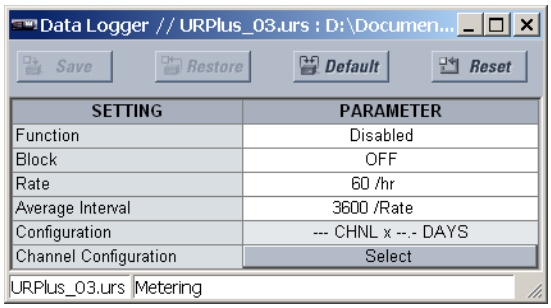
Between the recording intervals, the data logger calculates the maximum, minimum, and the average value of each channel. At the end of the interval either the maximum, minimum, or average value is written to the data logger depending on the mode setting. This ensures that data is not missed if a low rate setting is selected.

In addition, the maximum value, timestamp of maximum, minimum value, time stamp of minimum are calculated for the channel for the duration of recording since the start of recording. A high, low, high-high, and low-low alarm can be configured for each channel.

Data logger function configuration

Select the **Settings > Metering > Data Logger > Function** menu item to open the data logger configuration window.

Figure 25: Data logger configuration settings



The following settings are available for the data logger.

Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disables the data logger.

Block

Range: any metering logic operand or shared operand
Default: OFF

Assertion of the operand assigned to this setting blocks data logger functionality.

Rate

Range: 1 to 3600 samples per hour in steps of 1
Default: 60 samples per hour

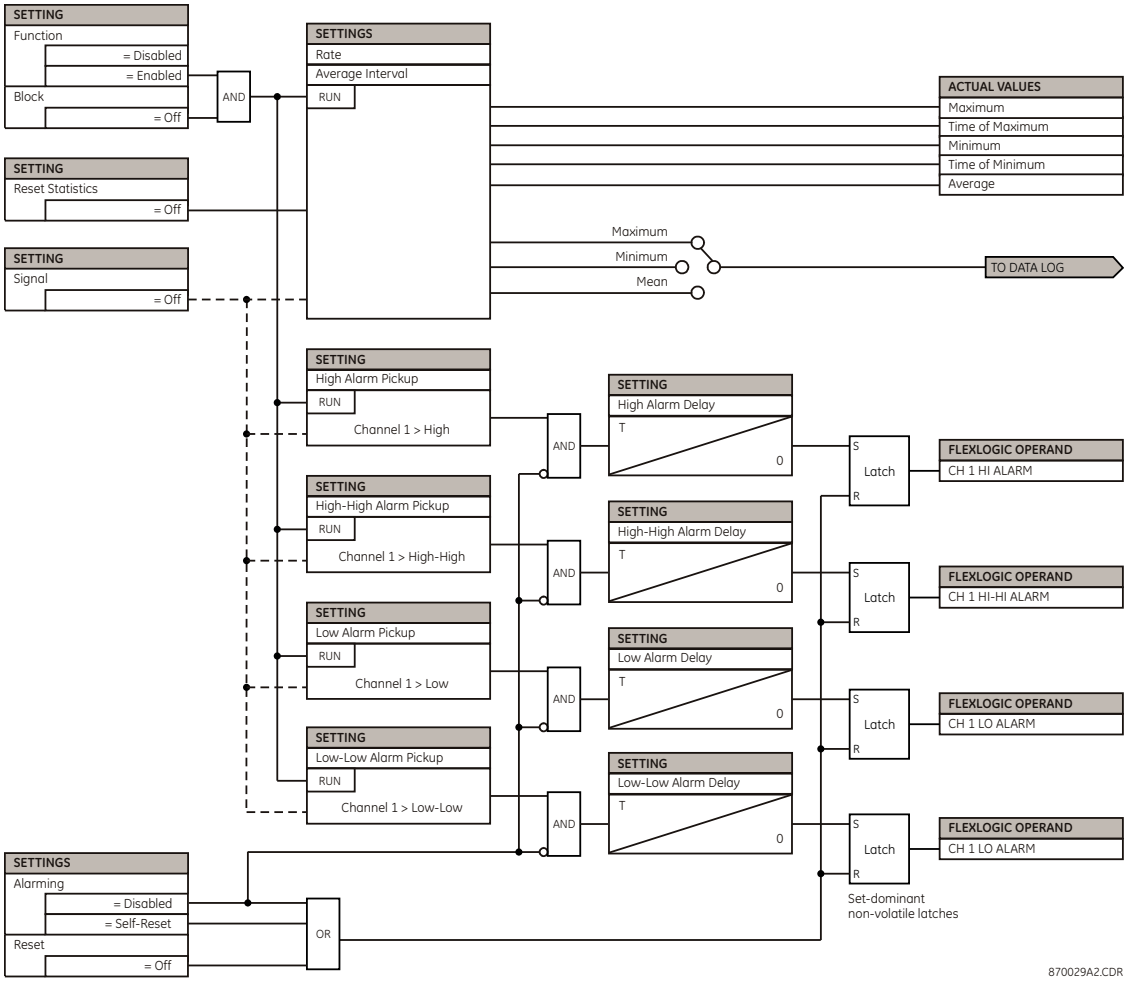
This setting determines how often data is written to the data log.

Average Interval

Range: 1/rate to 86400/rate in steps of 1/rate
Default: 3600/rate

This setting selects the time interval for which the average value is calculated. This number is expressed as a multiple of the **Rate** setting. For instance, if the **Rate** is set to "60/hr" and the **Average Interval** is "1440/rate" then a 24-hour average is calculated.

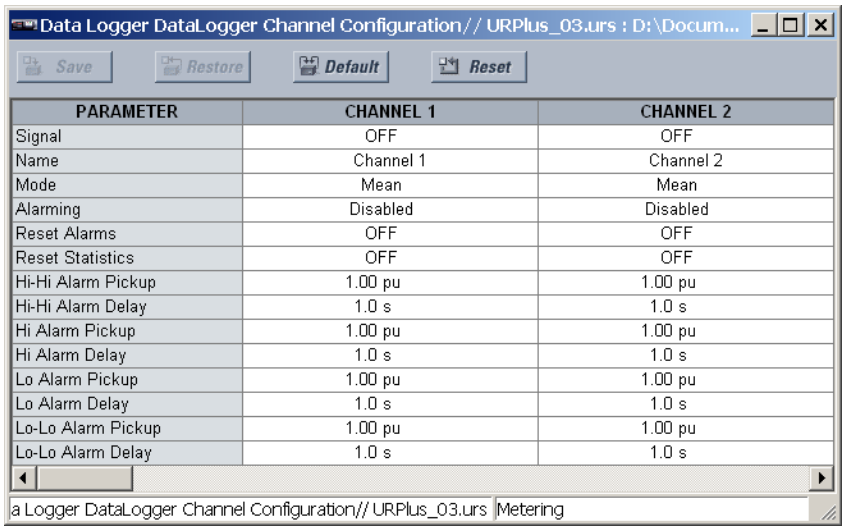
Figure 26: Data logger scheme logic



Data logger channel configuration

Select the **Settings > Metering > Data Logger > Channel Configuration** menu item to open the data logger configuration window.

Figure 27: Data logger channel configuration settings



PARAMETER	CHANNEL 1	CHANNEL 2
Signal	OFF	OFF
Name	Channel 1	Channel 2
Mode	Mean	Mean
Alarming	Disabled	Disabled
Reset Alarms	OFF	OFF
Reset Statistics	OFF	OFF
Hi-Hi Alarm Pickup	1.00 pu	1.00 pu
Hi-Hi Alarm Delay	1.0 s	1.0 s
Hi Alarm Pickup	1.00 pu	1.00 pu
Hi Alarm Delay	1.0 s	1.0 s
Lo Alarm Pickup	1.00 pu	1.00 pu
Lo Alarm Delay	1.0 s	1.0 s
Lo-Lo Alarm Pickup	1.00 pu	1.00 pu
Lo-Lo Alarm Delay	1.0 s	1.0 s

The following settings are available for all sixteen data logger channels.

Signal

Range: any FlexAnalog parameter
Default: Off

This setting selects the metering value to be recorded for the data logger channel.

Name

Range: up to 12 alphanumeric characters
Default: Channel 1

This setting specifies the name of the data logger channel.

Mode

Range: Max, Min, Mean
Default: Mean

This setting defines which value (maximum, minimum, or mean) is written to the data logger.

Alarming

Range: Disabled, Self-Reset, Latched
Default: Disabled

When this setting is “Disabled”, alarming is inhibited. When set to “Self-Reset”, alarms are reset as soon as the signal drops below the pickup value. When set to “Latched”, the alarms remain active until the reset input is asserted.

Reset Alarms

Range: any metering logic operand or shared operand
Default: OFF

The alarms are reset when the operand assigned to this setting is asserted and the **Alarming** setting is selected as “Latched”.

Reset Statistics

Range: any metering logic operand or shared operand
Default: OFF

The maximum, minimum, time of maximum, and time of minimum statistics are reset when the operand assigned to this setting is asserted.

High Alarm Pickup, Low Alarm Pickup, High-High Alarm Pickup, Low-Low Alarm Pickup

Range: –90.00 to 90.00 pu in steps of 0.01

Default: 1.00 pu

These settings specify the pickup thresholds for the alarm in per-unit values. A fixed hysteresis of 3% is applied.

High Alarm Delay, Low Alarm Delay, High-High Alarm Delay, Low-Low Alarm Delay

Range: 1.0 to 300.0 seconds in steps of 0.1

Default: 1.0 seconds

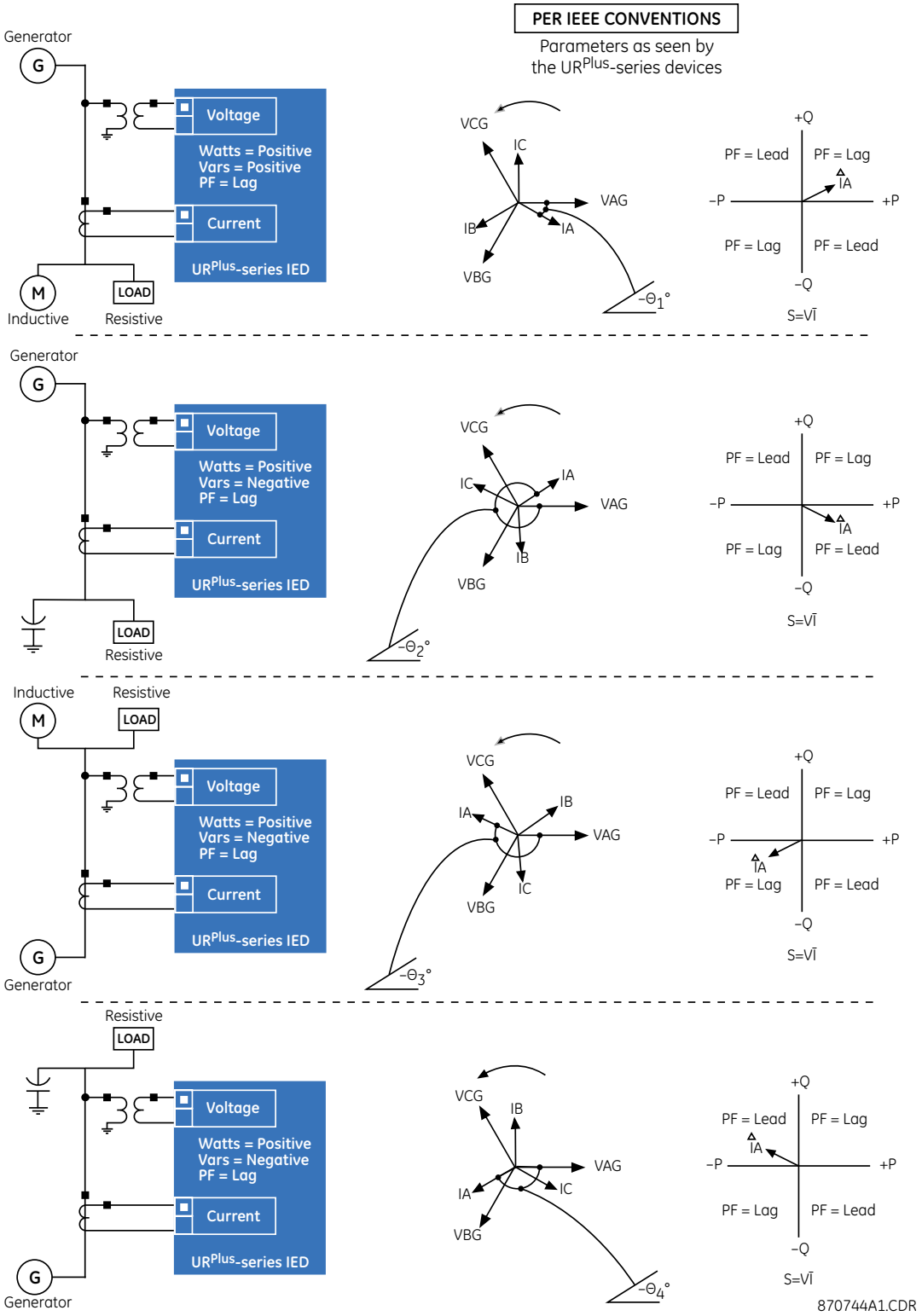
These settings specify the time delays for the four alarm pickup types.

Metered values

This section describes the metered values available for each source. Metered values presented for each source depend on the phase and auxiliary VTs and phase and ground CTs assignments for the particular source. For example, if no phase VT is assigned to a particular source, then no voltage, energy, and power values are available.

The following figure illustrates the metering conventions for measuring power and energy established for use in C90^{Plus} devices.

Figure 28: Flow direction of signed values for watts and vars



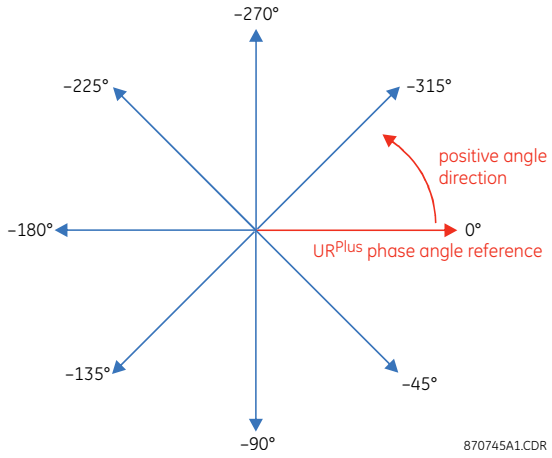
All phasors calculated by the C90^{Plus} and used for protection, control and metering functions are rotating phasors that maintain the correct phase angle relationships with each other at all times.

For display and oscillography purposes, all phasor angles in a given device are referred to an AC input channel pre-selected by the **Frequency and Phase Reference** setting in the **Settings > Protection > Power System > Frequency** menu. This setting defines a particular AC signal source to be used as the reference.

The C90^{Plus} first determines if any phase VT bank is indicated in the source. If it is, voltage channel VA of that bank is used as the angle reference. Otherwise, the C90^{Plus} determines if any auxiliary VT bank is indicated. If it is, the auxiliary voltage channel of that bank is used as the angle reference. If neither of these two conditions are satisfied, then two more steps of this hierarchical procedure to determine the reference signal include the phase CT bank and the ground CT bank.

If the AC signal pre-selected by the C90^{Plus} upon configuration is not measurable, then the phase angles are not referenced. The phase angles are assigned as positive in the leading direction and negative in the lagging direction to more closely align with power system metering conventions. The following figure illustrates these.

Figure 29: C90^{Plus} phase angle measurement convention



The C90^{Plus} calculates voltage symmetrical components for the power system phase A line-to-neutral voltage, and symmetrical components of the currents for the power system phase A current. Owing to the above definition, phase angle relations between the symmetrical currents and voltages stay the same irrespective of the connection of instrument transformers. This is important for setting directional protection elements that use symmetrical voltages.

For display and oscillography purposes the phase angles of symmetrical components are referenced to a common value specified by the **Frequency and Phase Reference** setting.

The following voltages and currents are measured for wye-connected instrument transformers in the ABC phase rotation:

$$V_0 = \frac{1}{3}(V_{AG} + V_{BG} + V_{CG});\ \ I_0 = \frac{1}{3}(I_A + I_B + I_C) \qquad \textbf{Eq. 1}$$

$$V_1 = \frac{1}{3}(V_{AG} + aV_{BG} + a^2V_{CG});\ \ I_1 = \frac{1}{3}(I_A + aI_B + a^2I_C) \qquad \textbf{Eq. 2}$$

$$V_2 = \frac{1}{3}(V_{AG} + a^2V_{BG} + aV_{CG});\ \ I_2 = \frac{1}{3}(I_A + a^2I_B + aI_C) \qquad \textbf{Eq. 3}$$

The following voltages and currents are measured for wye-connected instrument transformers in the ACB phase rotation:

$$V_0 = \frac{1}{3}(V_{AG} + V_{BG} + V_{CG});\ \ I_0 = \frac{1}{3}(I_A + I_B + I_C) \quad \textbf{Eq. 4}$$

$$V_1 = \frac{1}{3}(V_{AG} + a^2V_{BG} + aV_{CG});\ \ I_1 = \frac{1}{3}(I_A + a^2I_B + aI_C) \quad \textbf{Eq. 5}$$

$$V_2 = \frac{1}{3}(V_{AG} + aV_{BG} + a^2V_{CG});\ \ I_2 = \frac{1}{3}(I_A + aI_B + a^2I_C) \quad \textbf{Eq. 6}$$

The following voltages and currents are measured for delta-connected instrument transformers in the ABC phase rotation. The zero-sequence voltage (V_0) not measurable under the delta connection of instrument transformers and is defaulted to zero.

$$V_1 = \frac{1\angle -30°}{3\sqrt{3}}(V_{AB} + aV_{BC} + a^2V_{CA});\ I_1 = \frac{1\square -30°}{3\sqrt{3}}(I_A + aI_B + a^2I_C) \quad \textbf{Eq. 7}$$

$$V_2 = \frac{1\angle 30°}{3\sqrt{3}}(V_{AB} + a^2V_{BC} + aV_{CA});\ \ I_2 = \frac{1\angle 30°}{3\sqrt{3}}(I_A + a^2I_B + aI_C) \quad \textbf{Eq. 8}$$

The following voltages and currents are measured for delta-connected instrument transformers in the ACB phase rotation. The zero-sequence voltage (V_0) is not measurable under the delta connection of instrument transformers and is defaulted to zero.

$$V_1 = \frac{1\angle 30°}{3\sqrt{3}}(V_{AB} + a^2V_{BC} + aV_{CA});\ \ I_1 = \frac{1\angle 30°}{3\sqrt{3}}(I_A + a^2I_B + aI_C) \quad \textbf{Eq. 9}$$

$$V_2 = \frac{1\angle -30°}{3\sqrt{3}}(V_{AB} + aV_{BC} + a^2V_{CA});\ I_1 = \frac{1\angle -30°}{3\sqrt{3}}(I_A + aI_B + a^2I_C) \quad \textbf{Eq. 10}$$

In the above equations, *a* represents phase rotation operator that rotates a phasor vector forward by 120° ($a = 1\angle 120°$).

For example, consider a wye connected VT with the following system voltages (in secondary volts): $V_{AG} = 13.9\ V\angle 0°$, $V_{BG} = 76.2\ V\angle -125°$, $V_{CG} = 79.7\ V\angle -250°$, $V_{AB} = 84.9\ V\angle -313°$, $V_{BC} = 138.3\ V\angle -97°$, and $V_{CA} = 85.4\ V\angle -241°$. For simplicity, the power system voltages are phase-referenced to V_{AG}. However, any value can be chosen as a reference. It is important to remember that displayed values are always referenced as to the voltage specified by the **Frequency and Phase Reference** setting.

$$\begin{aligned} V_0 &= \frac{1}{3}(V_{AG} + V_{BG} + V_{CG}) \\ &= \frac{1}{3}(13.9\angle 0° + 76.2\angle -125° + 79.7\angle -250°) \\ &= 19.5\angle -192° \end{aligned} \quad \textbf{Eq. 11}$$

$$\begin{aligned} V_1 &= \frac{1}{3}(V_{AG} + aV_{BG} + a^2V_{CG}) \\ &= \frac{1}{3}(13.9\angle 0° + 1\angle 120° \times 76.2\angle -125° + 1\angle 240° \times 79.7\angle -250°) \\ &= 56.5\angle -7° \end{aligned} \quad \textbf{Eq. 12}$$

$$\begin{aligned} V_2 &= \frac{1}{3}(V_{AG} + a^2V_{BG} + aV_{CG}) \\ &= \frac{1}{3}(13.9\angle 0° + 1\angle 240° \times 76.2\angle -125° + 1\angle 120° \times 79.7\angle -250°) \\ &= 23.3\angle -187° \end{aligned} \quad \textbf{Eq. 13}$$

As another example, consider a delta connected VT with the following system voltages (in secondary volts): $V_{AB} = 84.9\ V\angle 0°$, $V_{BC} = 138.3\ V\angle -144°$, and $V_{CA} = 85.4\ V\angle -288°$. For simplicity, the power system voltages are phase-referenced to V_{AB}. However, any value

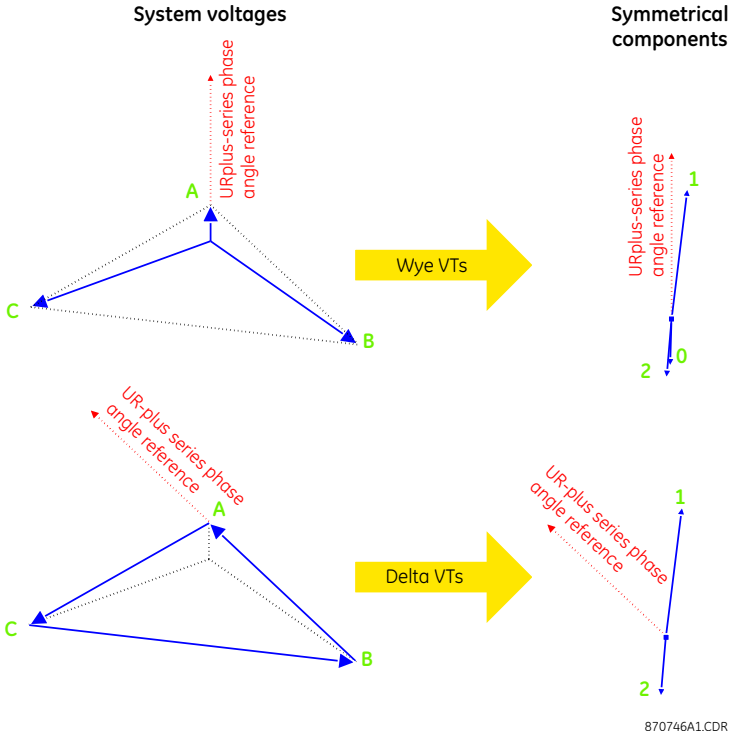
can be chosen as a reference. It is important to remember that displayed values are always referenced as to the voltage specified by the **Frequency and Phase Reference** setting.

$$V_1 = \frac{1\angle -30°}{3\sqrt{3}}(V_{AB} + a^2 V_{BC} + aV_{CA})$$
$$= \frac{1\angle -30°}{3\sqrt{3}}(84.9\angle 0° + 1\angle 240° \times 138.3\angle -144° + 1\angle 120° \times 85.4\angle -288°)$$
$$= 56.5\angle -54° \quad \textbf{Eq. 14}$$

$$V_2 = \frac{1\angle -30°}{3\sqrt{3}}(V_{AB} + aV_{BC} + a^2 V_{CA})$$
$$= \frac{1\angle -30°}{3\sqrt{3}}(84.9\angle 0° + 1\angle 120° \times 138.3\angle -144° + 1\angle 240° \times 85.4\angle -288°)$$
$$= 23.3\angle -234° \quad \textbf{Eq. 15}$$

The examples above are illustrated in the following figure.

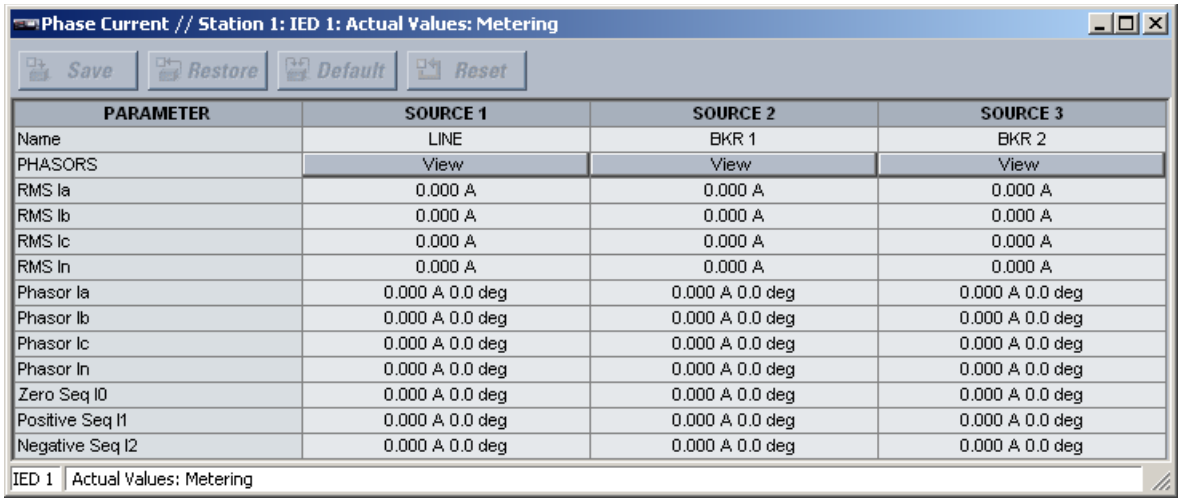
Figure 30: Measurement convention for symmetrical components



Phase current metering

Select the **Actual Values > Metering > Phase Current** menu item to open the metered phase current window.

Figure 31: Phase current metering window



PARAMETER	SOURCE 1	SOURCE 2	SOURCE 3
Name	LINE	BKR 1	BKR 2
PHASORS	View	View	View
RMS Ia	0.000 A	0.000 A	0.000 A
RMS Ib	0.000 A	0.000 A	0.000 A
RMS Ic	0.000 A	0.000 A	0.000 A
RMS In	0.000 A	0.000 A	0.000 A
Phasor Ia	0.000 A 0.0 deg	0.000 A 0.0 deg	0.000 A 0.0 deg
Phasor Ib	0.000 A 0.0 deg	0.000 A 0.0 deg	0.000 A 0.0 deg
Phasor Ic	0.000 A 0.0 deg	0.000 A 0.0 deg	0.000 A 0.0 deg
Phasor In	0.000 A 0.0 deg	0.000 A 0.0 deg	0.000 A 0.0 deg
Zero Seq I0	0.000 A 0.0 deg	0.000 A 0.0 deg	0.000 A 0.0 deg
Positive Seq I1	0.000 A 0.0 deg	0.000 A 0.0 deg	0.000 A 0.0 deg
Negative Seq I2	0.000 A 0.0 deg	0.000 A 0.0 deg	0.000 A 0.0 deg

The following actual values display for each source.

Name

Range: up to 20 alphanumeric characters

This value displays the user-programmed name for each source.

Phasors

Clicking the **View** button for this value allows the user to configure and display a graphical representation of selected current and voltage phasors. See Observing current and voltage phasors on page 1for details.

RMS Ia, RMS Ib, RMS Ic, RMS In

Range: 0 to 999999.999 A in steps of 0.001

These values display the phase A, phase B, phase C, and neutral RMS current on each source.

Phasor Ia, Phasor Ib, Phasor Ic, Phasor In

Range: 0 to 999999.999 A in steps of 0.001; –359.0° to 0.0° in steps of 0.1°

These values display the magnitude and phase angles for phase A, phase B, phase C, and neutral current on each source.

Zero Seq I0

Range: 0 to 999999.999 A in steps of 0.001; –359.0° to 0.0° in steps of 0.1°

This value displays the magnitude and phase angle for the zero-sequence current (I_0) on each source.

Positive Seq I1

Range: 0 to 999999.999 A in steps of 0.001; –359.0° to 0.0° in steps of 0.1°

This value displays the magnitude and phase angle for the positive-sequence current (I_1) on each source.

Negative Seq I2

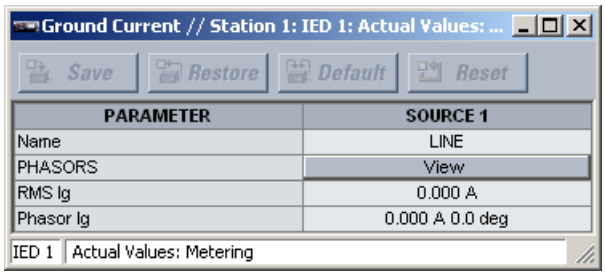
Range: 0 to 999999.999 A in steps of 0.001; –359.0° to 0.0° in steps of 0.1°

This value displays the magnitude and phase angle for the negative-sequence current (I_2) on each source.

Ground current metering

Select the **Actual Values > Metering > Ground Current** menu item to open the metered ground current window.

Figure 32: Ground current metering window



The following actual values display for each applicable source.

Name

Range: up to 20 alphanumeric characters

This value displays the user-programmed name for each source.

Phasors

Clicking the **View** button for this value allows the user to configure and display a graphical representation of selected current and voltage phasors. See Observing current and voltage phasors on page 1for details.

RMS Ig

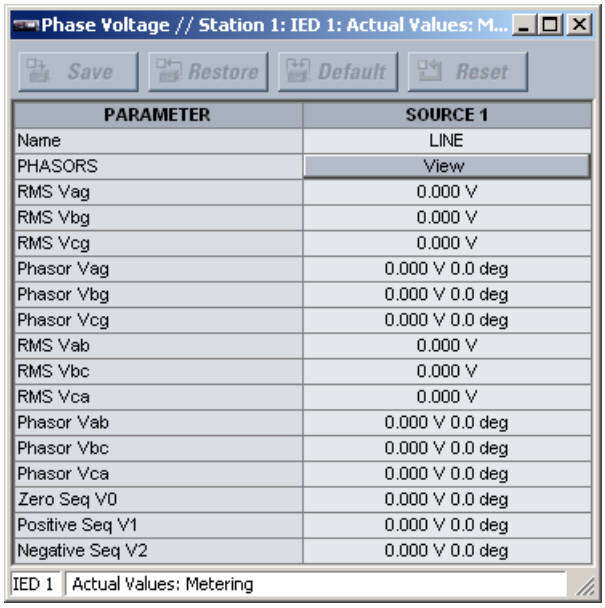
Range: 0 to 999999.999 A in steps of 0.001

This actual value displays the ground RMS current RMS for each source.

Phase voltage metering

Select the **Actual Values > Metering > Phase Voltage** menu item to open the metered phase voltage window.

Figure 33: Phase voltage metering window



The following actual values display for each applicable source.

Name

Range: up to 20 alphanumeric characters

This value displays the user-programmed name for each source.

Phasors

Clicking the **View** button for this value allows the user to configure and display a graphical representation of selected current and voltage phasors. See Observing current and voltage phasors on page 1for details.

RMS Vag, RMS Vbg, RMS Vcg

Range: 0 to 999999.999 V in steps of 0.001

These values display the phase A to ground, phase B to ground, and phase C to ground RMS voltage values for each source.

Phasor Vag, Phasor Vbg, Phasor Vcg

Range: 0 to 999999.999 V in steps of 0.001; –359.0° to 0.0° in steps of 0.1°

These values display the magnitude and phase angles for the phase A to ground, phase B to ground, and phase C to ground voltage phasors for each source.

RMS Vab, RMS Vbc, RMS Vca

Range: 0 to 999999.999 V in steps of 0.001

These values display the phase AB, phase BC, and phase CA RMS voltage values for each source.

Phasor Vab, Phasor Vbc, Phasor Vca

Range: 0 to 999999.999 V in steps of 0.001; –359.0° to 0.0° in steps of 0.1°

These values display the magnitude and phase angles for the phase AB, phase BC, and phase CA voltage phasors for each source.

Zero Seq V0

Range: 0 to 999999.999 V in steps of 0.001; –359.0° to 0.0° in steps of 0.1°

This value displays the magnitude and phase angle for the zero-sequence voltage (V_0) on each source.

Positive Seq V1

Range: 0 to 999999.999 V in steps of 0.001; –359.0° to 0.0° in steps of 0.1°

This value displays the magnitude and phase angle for the positive-sequence voltage (V_1) on each source.

Negative Seq V2

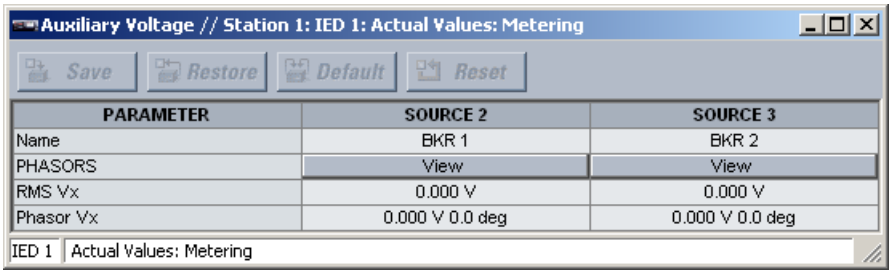
Range: 0 to 999999.999 V in steps of 0.001; –359.0° to 0.0° in steps of 0.1°

This value displays the magnitude and phase angle for the negative-sequence voltage (V_2) on each source.

Auxiliary voltage metering

Select the **Actual Values > Metering > Auxiliary Voltage** menu item to open the metered auxiliary voltage window.

Figure 34: Auxiliary voltage metering window



The following actual values display for each applicable source.

Name

Range: up to 20 alphanumeric characters

This value displays the user-programmed name for each source.

Phasors

Clicking the **View** button for this value allows the user to configure and display a graphical representation of selected current and voltage phasors. See Observing current and voltage phasors on page 1for details.

RMS Vx

Range: 0 to 999999.999 V in steps of 0.001

This actual value displays the auxiliary RMS voltage value for each source.

Phasor Vx

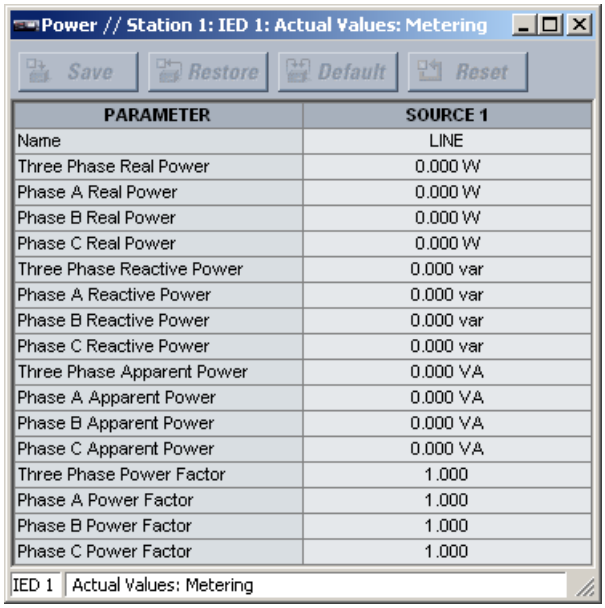
Range: 0 to 999999.999 V in steps of 0.001; –359.0° to 0.0° in steps of 0.1°

This actual value displays the magnitude and phase angle for the auxiliary voltage phasor for each source.

Power metering

Select the **Actual Values > Metering > Power** menu item to open the metered power window. The metered values for real power, apparent power, reactive power, and power factor display.

Figure 35: Power metering window



The following actual values display for each applicable source.

Name

Range: up to 20 alphanumeric characters

This value displays the user-programmed name for each source.

Three Phase Real Power, Phase A Real Power, Phase B Real Power, Phase C Real Power

Range: –1000000000.000 to 1000000000.000 W in steps of 0.001

These actual values display the metered real power for phase A, B, and C, as well as the three-phase real power, for each applicable source.

Three Phase Reactive Power, Phase A Reactive Power, Phase B Reactive Power, Phase C Reactive Power

Range: –1000000000.000 to 1000000000.000 W in steps of 0.001

These actual values display the metered reactive power for phase A, B, and C, as well as the three-phase reactive power, for each applicable source.

Three Phase Apparent Power, Phase A Apparent Power, Phase B Apparent Power, Phase C Apparent Power

Range: –1000000000.000 to 1000000000.000 W in steps of 0.001

These actual values display the metered apparent power for phase A, B, and C, as well as the three-phase apparent power, for each applicable source.

Three Phase Power Factor, Phase A Power Factor, Phase B Power Factor, Phase C Power Factor

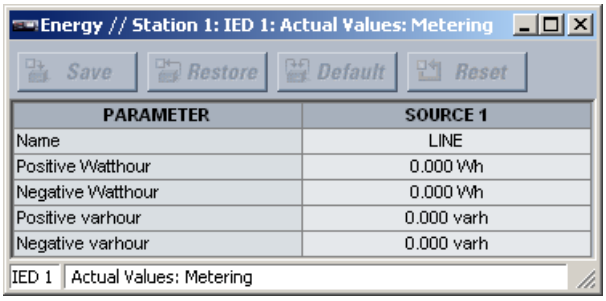
Range: –0.999 to 1.000 in steps of 0.001

These actual values display the metered power factor for phase A, B, and C, as well as the three-phase power factor, for each applicable source.

Energy metering

Select the **Actual Values > Metering > Energy** menu item to open the metered energy window. The metered values for real energy and reactive energy display. Because energy values are accumulated, record these values and then reset immediately prior to changing CT or VT characteristics.

Figure 36: Energy metering window



The following actual values display for each applicable source.

Name

Range: up to 20 alphanumeric characters

This value displays the user-programmed name for each source.

Positive Watthour, Negative Watthour

Range: 0.000 to 1000000000000.000 Wh in steps of 0.001

These actual values display the metered real energy for each applicable source.

Positive varhour, Negative varhour

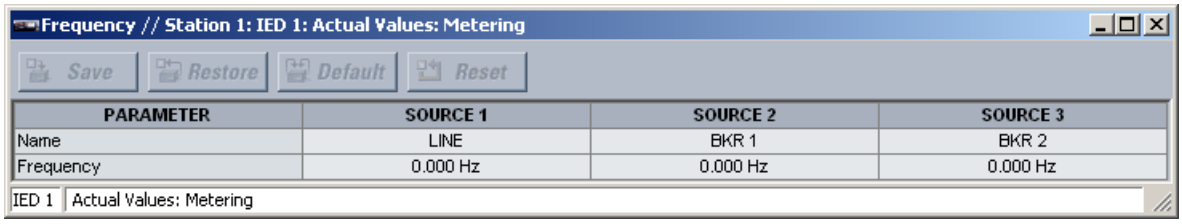
Range: 0.000 to 1000000000000.000 varh in steps of 0.001

These actual values display the metered reactive energy for each applicable source.

Frequency metering

Select the **Actual Values > Metering > Frequency** menu item to open the metered frequency window. Source frequency is measured via software-implemented zero-crossing detection of an AC signal. The signal is either a Clarke transformation of three-phase voltages or currents, auxiliary voltage, or ground current as per the source configuration. The signal used for frequency estimation is low-pass filtered. The final frequency measurement is passed through a validation filter that eliminates false readings due to signal distortions and transients.

Figure 37: Frequency metering window



The following actual values display for each applicable source.

Name

Range: up to 20 alphanumeric characters

This value displays the user-programmed name for each source.

Frequency

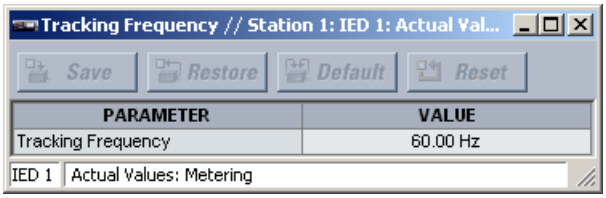
Range: 0.000 to 90.000 Hz in steps of 0.001

These actual values display the metered frequency for each applicable source.

Tracking frequency

Select the **Actual Values > Metering > Tracking Frequency** menu item to open the tracking frequency window.

Figure 38: Tracking frequency window



The following actual value displays.

Tracking Frequency

Range: 0.00 to 90.00 Hz in steps of 0.01

This actual value displays 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 > Protection > Power System > Frequency** menu.

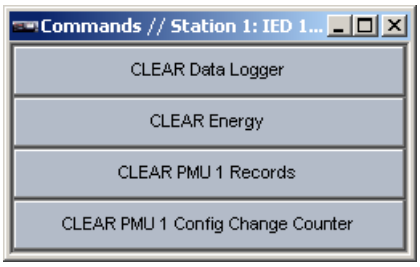
For additional information, refer to:

Power system frequency on page 170

Clearing metered values

Select the **Actual Values > Metering > Commands** menu item to open the metering commands menu. The commands allow the user to clear accumulated metering values.

Figure 39: Metering commands window



The following commands are available.

Clear Data Logger

Click this button to clear the accumulated data logger actual values.

Clear Energy

Click this button to clear the accumulated energy actual values.

Clear PMU 1 Records

Click this button to clear the phasor measurement unit records.

Clear PMU 1 Config Change Counter

Click this button to clear the phasor measurement unit configuration change counter records.

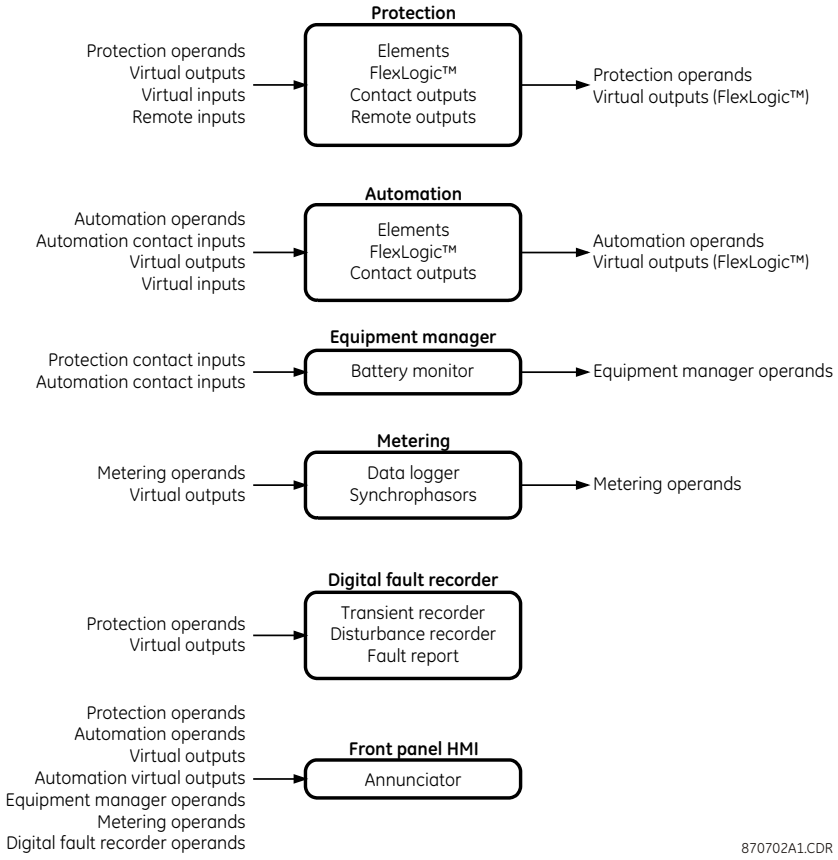
Using shared operands in metering

The EnerVista UR^{Plus} Setup software groups the C90^{Plus} system into the following seven primary functions. Each function has its own setting parameters and each generates its own outputs in the form of operands.

- Communications
- Protection
- Automation.
- Digital fault recorder (DFR)
- Metering
- Equipment manager
- Self-tests
- Front panel interface (HMI)

However, it is often desirable for an output from an element within one function can be available to an element within another function. For instance, it may be useful for the digital fault recorder to record the output operands of any protection element. Consequently a fixed, predetermined set of operands is available as to each function, as shown.

Figure 40: Default operand list by function



The content of each operand list is dependent on the selected order code.

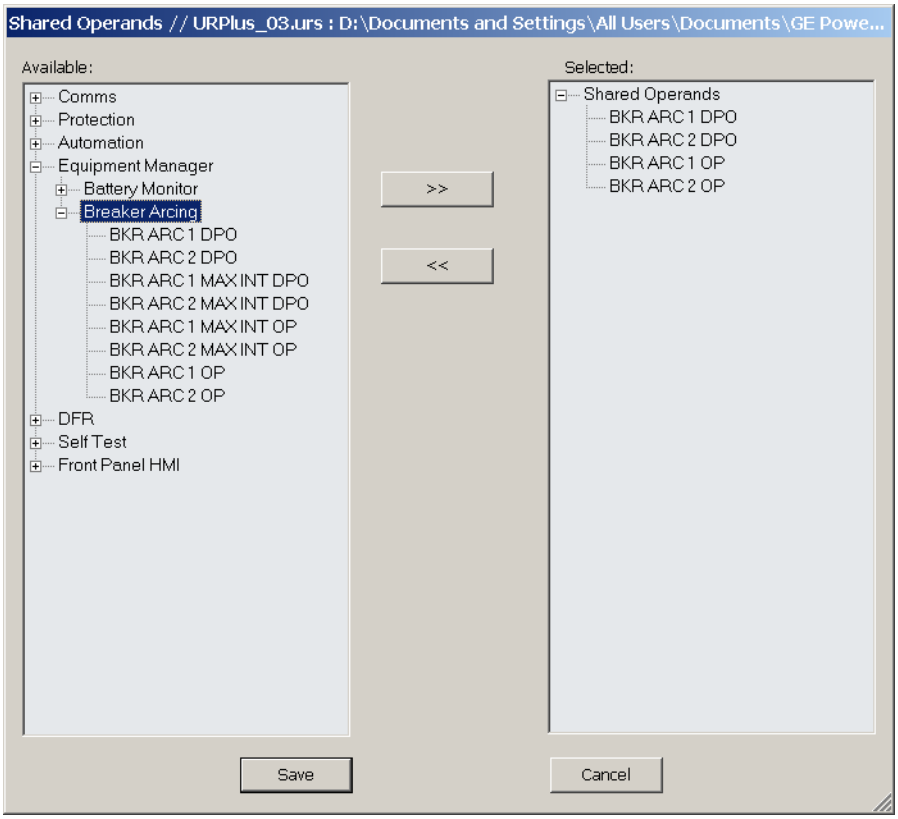
The shared operands functionality expands upon this system. With this feature, an output from any element can be assigned as a shared operand within the EnerVista UR^{Plus} Setup software. These signals can then be assigned as inputs to other functions.

For example, assume that the GND TOC1 OP protection operand is required as a signal within the automation function. This operand would then be assigned as a shared operand, and would subsequently become available to the automation function. A total of 64 operands can be assigned as shared operands within each function.

Shared metering operands

Select the **Settings > Metering > Shared Operands** menu item to select the shared metering operands.

Figure 41: Shared operands configuration window

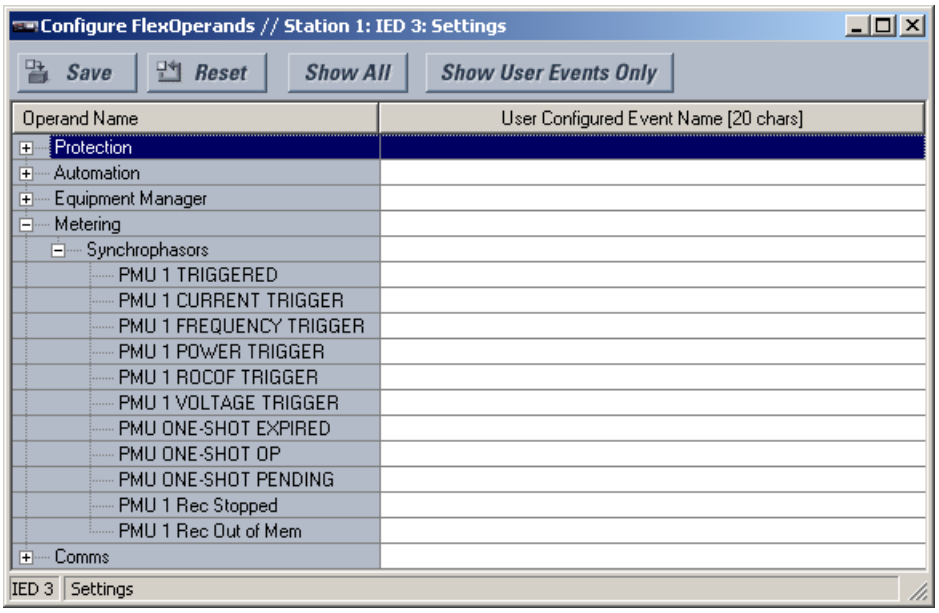


The left side of this screen displays all C90^{Plus} operands that are available to the metering function as shared operands. Select any operands from the other five primary features by clicking the **>>** button. Operands can be de-assigned as shared operands by clicking the **<<** button.

Customizing the metering logic operands

Select the **Settings > Configure FlexOperands** menu item to open the user-configurable operands window.

Figure 42: User-configurable metering logic operands window



The left side of this screen displays all operands that are currently available to the C90^{Plus}. The metering logic operands are displayed by selecting the **Metering** tree item. Each operand can be renamed with a user-specified value to provide additional information or match specific applications.

User Configured Event Name

Range: up to 20 alphanumeric characters

Default: ---

Each available metering logic operand can be renamed to a user-specified value. This feature allows users to rename operands to allow for clearer identification or to match specific applications. The new operand name appears in protection and automation logic, in settings that take operands as their value, and in event reports.

Metering logic operands

The following metering logic operands are available for the C90^{Plus}. They are listed alphabetically by operand syntax. If required, these operands can be assigned user-defined names through the **Settings > Configure FlexOperands** menu item.

Data logger operands

D LOG CH1 HI ALM ..... Asserted while the data logger channel 1 high alarm is active.

D LOG CH1 HI-HI ALM ..... Asserted while the data logger channel 1 high-high alarm is active.

D LOG CH1 LO ALM ..... Asserted while the data logger channel 1 low alarm is active.

D LOG CH1 LO-LO ALM ..... Asserted while the data logger channel 1 low-low alarm is active.

D LOG CH2 ... . The operands listed above are also available for data loggers 2 through 16.

Phasor measurement unit operands

PMU 1 CURR TRIGGER ..... Asserted when the overcurrent trigger of phasor measurement unit 1 operates.

PMU 1 FREQ TRIGGER ..... Asserted when the abnormal frequency trigger of phasor measurement unit 1 operates.

PMU 1 POWER TRIGGER ..... Asserted when the overpower trigger of phasor measurement unit 1 operates.

PMU 1 ROCOF TRIGGER ..... Asserted when the rate of change of frequency trigger of phasor measurement unit 1 operates.

PMU 1 TRIGGERED ..... Asserted when the phasor measurement unit 1 triggers. No events or targets are generated by this operand.

PMU 1 VOLT TRIGGER ..... Asserted when the abnormal voltage trigger of phasor measurement unit 1 operates.

Phasor measurement unit one-shot operands

PMU ONE-SHOT EXPIRED ..... Asserted after the one-shot operation executes.

PMU ONE-SHOT OP ..... Asserted upon one-shot operation.

PMU ONE-SHOT PENDING ..... Asserted while the one-shot operation is pending. That is, while the present time is before the scheduled one-shot time.

Metering FlexAnalog parameters

The following metering FlexAnalog parameters (analog operands) are available for the C90^{Plus}. They are listed alphabetically by operand syntax.

Phasor measurement unit analog operands

PMU 1 Conf Ch ..... Metered configuration change counter value for phasor measurement unit 1

PMU 1 df dt ..... Metered frequency rate of change value for phasor measurement unit 1

PMU 1 Freq ..... Metered frequency value for phasor measurement unit 1

PMU 1 Num Triggers ..... Metered number of triggers for phasor measurement unit 1

PMU 1 Ia Mag ..... Metered phase A current magnitude for phasor measurement unit 1

PMU 1 Ia Ang ..... Metered phase A current angle for phasor measurement unit 1

PMU 1 Ib Mag ..... Metered phase B current magnitude for phasor measurement unit 1

PMU 1 Ib Ang ..... Metered phase B current angle for phasor measurement unit 1

PMU 1 Ic Mag ..... Metered phase C current magnitude for phasor measurement unit 1

PMU 1 Ic Ang ..... Metered phase C current angle for phasor measurement unit 1

PMU 1 Ig Mag ..... Metered ground current magnitude for phasor measurement unit 1

PMU 1 Ig Ang ..... Metered ground current angle for phasor measurement unit 1

PMU 1 I0 Mag ..... Metered zero-sequence current magnitude for phasor measurement unit 1

PMU 1 I0 Ang ..... Metered zero-sequence current angle for phasor measurement unit 1

PMU 1 I1 Mag ..... Metered positive-sequence current magnitude for phasor measurement unit 1

PMU 1 I1 Ang ..... Metered positive-sequence current angle for phasor measurement unit 1

PMU 1 I2 Mag ..... Metered negative-sequence current magnitude for phasor measurement unit 1

PMU 1 I2 Ang ..... Metered negative-sequence current angle for phasor measurement unit 1
PMU 1 Va Mag ..... Metered phase A voltage magnitude for phasor measurement unit 1
PMU 1 Va Ang ..... Metered phase A voltage angle for phasor measurement unit 1
PMU 1 Vb Mag ..... Metered phase B voltage magnitude for phasor measurement unit 1
PMU 1 Vb Ang ..... Metered phase B voltage angle for phasor measurement unit 1
PMU 1 Vc Mag ..... Metered phase C voltage magnitude for phasor measurement unit 1
PMU 1 Vc Ang ..... Metered phase C voltage angle for phasor measurement unit 1
PMU 1 Vx Mag ..... Metered auxiliary voltage magnitude for phasor measurement unit 1
PMU 1 Vx Ang ..... Metered auxiliary voltage angle for phasor measurement unit 1
PMU 1 V0 Mag ..... Metered zero-sequence voltage magnitude for phasor measurement unit 1
PMU 1 V0 Ang ..... Metered zero-sequence voltage angle for phasor measurement unit 1
PMU 1 V1 Mag ..... Metered positive-sequence voltage magnitude for phasor measurement unit 1
PMU 1 V1 Ang ..... Metered positive-sequence voltage angle for phasor measurement unit 1
PMU 1 V2 Mag ..... Metered negative-sequence voltage magnitude for phasor measurement unit 1
PMU 1 V2 Ang ..... Metered negative-sequence voltage angle for phasor measurement unit 1

Frequency metering analog operands

SRC 1 Frequency ..... Metered frequency for source 1.
SRC 2 Frequency ..... Metered frequency for source 2
SRC 3 Frequency ..... Metered frequency for source 3
SRC 4 Frequency ..... Metered frequency for source 4

Current metering analog operands

SRC 1 Ia RMS ..... Metered RMS phase A current for source 1.
SRC 1 Ib RMS ..... Metered RMS phase B current for source 1
SRC 1 Ic RMS ..... Metered RMS phase C current for source 1
SRC 1 In RMS ..... Metered RMS neutral current for source 1
SRC 1 Ia Angle ..... Metered phase A current angle for source 1
SRC 1 Ia Mag ..... Metered phase A current magnitude for source 1
SRC 1 Ib Angle ..... Metered phase B current angle for source 1
SRC 1 Ib Mag ..... Metered phase B current magnitude for source 1
SRC 1 Ic Angle ..... Metered phase C current angle for source 1
SRC 1 Ic Mag ..... Metered phase C current magnitude for source 1
SRC 1 In Angle ..... Metered neutral current angle for source 1
SRC 1 In Mag ..... Metered neutral current magnitude for source 1
SRC 1 Ig Angle ..... Metered ground current angle for source 1
SRC 1 Ig Mag ..... Metered ground current magnitude for source 1
SRC 1 I0 Angle ..... Metered zero-sequence current angle for source 1
SRC 1 I0 Mag ..... Metered zero-sequence current magnitude for source 1
SRC 1 I1 Angle ..... Metered positive-sequence current angle for source 1

SRC 1 I1 Mag ..... Metered positive-sequence current magnitude for source 1
SRC 1 I2 Angle ..... Metered negative-sequence current angle for source 1
SRC 1 I2 Mag ..... Metered negative-sequence current magnitude for source 1
SRC 2 ..... The analog parameters shown above are available for sources 2 and above.

Power metering analog operands

SRC 1 P ..... Metered three-phase real power for source 1.
SRC 1 Pa ..... Metered phase A real power for source 1
SRC 1 Pb ..... Metered phase B real power for source 1
SRC 1 Pc ..... Metered phase C real power for source 1
SRC 1 Q ..... Metered three-phase reactive power for source 1.
SRC 1 Qa ..... Metered phase A reactive power for source 1
SRC 1 Qb ..... Metered phase B reactive power for source 1
SRC 1 Qc ..... Metered phase C reactive power for source 1
SRC 1 S ..... Metered three-phase apparent power for source 1.
SRC 1 Sa ..... Metered phase A apparent power for source 1
SRC 1 Sb ..... Metered phase B apparent power for source 1
SRC 1 Sc ..... Metered phase C apparent power for source 1
SRC 1 PF ..... Metered three-phase power factor for source 1.
SRC 1 PF A ..... Metered phase A power factor for source 1
SRC 1 PF B ..... Metered phase B power factor for source 1
SRC 1 PF C ..... Metered phase C power factor for source 1
SRC 2 ..... The analog parameters shown above are available for sources 2 and above.

Energy metering analog operands

SRC 1 Pos Watth ..... Metered three-phase real power for source 1.
SRC 1 Neg Watth ..... Metered phase A real power for source 1
SRC 1 Pos Varh ..... Metered phase B real power for source 1
SRC 1 Neg Varh ..... Metered phase C real power for source 1
SRC 2 ..... The analog parameters shown above are available for sources 2 and above.

Voltage metering analog operands

SRC 1 Vag RMS ..... Metered RMS phase A to ground voltage for source 1.
SRC 1 Vbg RMS ..... Metered RMS phase B to ground voltage for source 1
SRC 1 Vcg RMS ..... Metered RMS phase C to ground voltage for source 1
SRC 1 Vag Angle ..... Metered phase A to ground voltage angle for source 1
SRC 1 Vag Mag ..... Metered phase A to ground voltage magnitude for source 1
SRC 1 Vbg Angle ..... Metered phase B to ground voltage angle for source 1
SRC 1 Vbg Mag ..... Metered phase B to ground voltage magnitude for source 1
SRC 1 Vcg Angle ..... Metered phase C to ground voltage angle for source 1
SRC 1 Vcg Mag ..... Metered phase C to ground voltage magnitude for source 1
SRC 1 Vab RMS ..... Metered RMS phase A to B voltage for source 1.
SRC 1 Vbc RMS ..... Metered RMS phase B to C voltage for source 1
SRC 1 Vca RMS ..... Metered RMS phase C to A voltage for source 1
SRC 1 Vab Angle ..... Metered phase A to B voltage angle for source 1
SRC 1 Vab Mag ..... Metered phase A to B voltage magnitude for source 1
SRC 1 Vbc Angle ..... Metered phase B to C voltage angle for source 1
SRC 1 Vbc Mag ..... Metered phase B to C voltage magnitude for source 1

SRC 1 Vca Angle ..... Metered phase C to A voltage angle for source 1
SRC 1 Vca Mag ..... Metered phase A to A voltage magnitude for source 1
SRC 1 Vx RMS ..... Metered RMS auxiliary voltage for source 1
SRC 1 Vx Angle ..... Metered auxiliary voltage angle for source 1
SRC 1 Vx Mag ..... Metered auxiliary voltage magnitude for source 1
SRC 1 V0 Angle ..... Metered zero-sequence voltage angle for source 1
SRC 1 V0 Mag ..... Metered zero-sequence voltage magnitude for source 1
SRC 1 V1 Angle ..... Metered positive-sequence voltage angle for source 1
SRC 1 V1 Mag ..... Metered positive-sequence voltage magnitude for source 1
SRC 1 V2 Angle ..... Metered negative-sequence voltage angle for source 1
SRC 1 V2 Mag ..... Metered negative-sequence voltage magnitude for source 1
SRC 2... ..... The analog parameters shown above are available for sources 2 and above.

Tracking frequency analog operand

Tracking frequency ..... Metered tracking frequency

C90Plus Controller

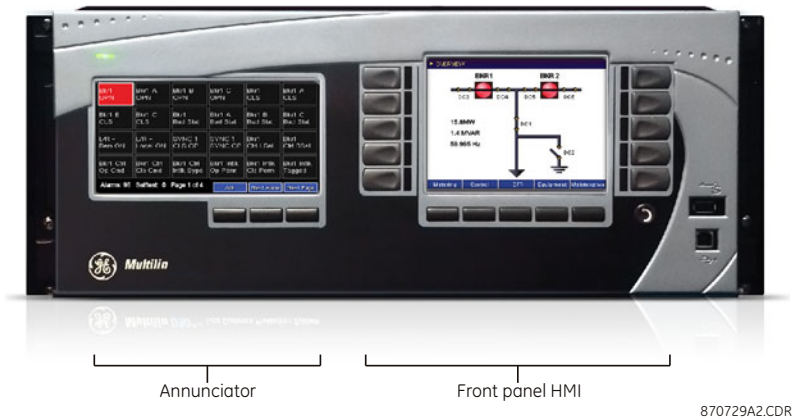
Chapter 12: Local interface

This section outlines how to program the C90Plus local interface features.

Local interface overview

The front panel of the C90Plus provides a color LCD annunciator alarm panel functionality with an optional second LCD display for front panel HMI functions that include user configurable metering and control pages, access to the digital fault recorder, physical input/output status and equipment maintenance functions. Keys are provided at the bottom of each display for navigation and at both sides of the front panel HMI display for assigned user control actions. These control actions can include selection of a breaker or a disconnect switch in a select-before-operate sequence, or direct operation of a user definable push-button or selector switch element. Up to thirty pushbutton instances, ten selector switch instances, 30 disconnect switches, and 6 breakers are supported on the C90Plus.

Figure 1: Front panel interface overview



Annunciator panel

The annunciator is a color, TFT panel located that emulates the functionality found in a conventional annunciator unit. The annunciator provides indications on the status of system alarm points and actual values. It also displays self-test messages and product information for the unit.

Annunciator operation

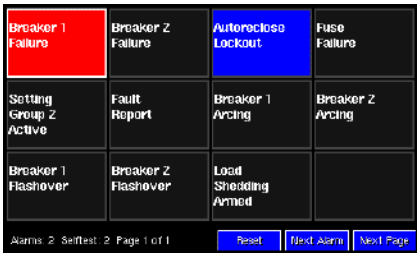
The annunciator supports three types of alarms: self-reset, latched, and acknowledgeable. Each location in an annunciator display page can be configured to be one of the three alarm types and can also display an optional metered value. The value of each self-reset alarm is refreshed approximately once every half second.

Alarms are organized in a table and numbered increasing from left to right horizontally and then top to bottom. The first alarm in the top left corner of the first page is denoted as indicator 1 by the EnerVista UR^{Plus} Setup software. The top left location of the next page is the bottom right alarm number on the previous page plus one. Up to 288 individual alarms or metered values can be configured.

Each location in the alarm table can be configured as an alarm only, metering only, or mixed content. With the exception of metering only table entries, a FlexLogic alarm input operand is required for each alarm table location. Selecting an operand of "None" hides the entry from view.

Alarms can display up to three lines of text using a specified foreground and background color. A configured metering value replaces the specified line of text. The figure shows a typical annunciator display.

Figure 2: Typical annunciator display

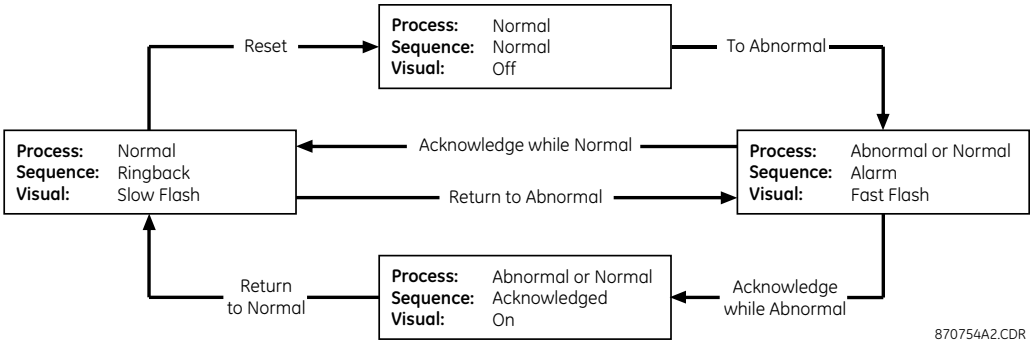


There are three control buttons at the bottom of the display.

- The Next Page button navigates through the configured alarm, self-test and product information pages. It should be noted that pages that contain no configured alarms are not displayed.
- The Next Alarm button navigates horizontally though the current alarms that are active, from left-to-right, starting with the first row of alarms. A border is drawn around the current alarm.
- The Ack/Reset button is used to acknowledge alarms or reset latched and acknowledgeable alarms that are in the ringback state.

The annunciator alarm sequence conforms to ISA 18.1-1979 (R1992) standard, type R.

Figure 3: Annunciator alarm sequence



The annunciator states are described in the following table.

Table 1: Acknowledgeable alarm states

Sequence (initial state)	Process (status)	Pushbutton (input)	Sequence (final state)	Visual indication
Normal	Normal	N/A	N/A	Off
Normal	Abnormal	N/A	Alarm	Fast flash
Alarm	Normal	N/A	Alarm	Fast flash
Alarm	Normal	Acknowledged	Normal	Off
Alarm	Abnormal	Acknowledged	Acknowledged	On
Acknowledged	Abnormal	N/A	Acknowledged	On
Acknowledged	Normal	N/A	Ringback	Slow flash
Ringback	Normal	Reset	Normal	Off
Ringback	Abnormal	N/A	Acknowledged	On

The visual indications display as follows:

- Off — Grey text on a darker grey background
- On — User-configurable
- Fast flash — Alternating between the off state and the on state two times per second
- Slow flash — Alternating between the off state and the on state one time per second

In the event of an alarm, the page containing the alarm will be promoted to active page. If there are multiple pages with alarms, the page with the lowest page number is promoted.

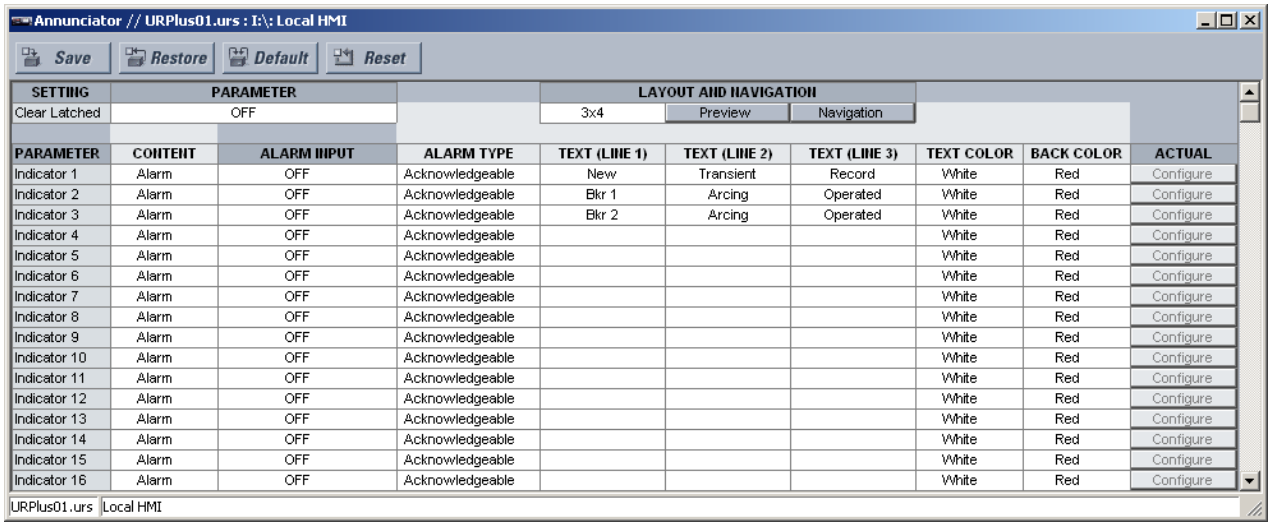
If there are alarms on multiple pages, and alarms on some pages have already been acknowledged (but not cleared) by the user, then the pages with active alarms move ahead of the pages that have acknowledged alarms. The user always has to navigate through the pages of alarms to view them.

Display of alarm pages is prioritized according to active window (unacknowledged or flashing alarm) and page number (for example, if two pages have an unacknowledged alarm, the page with the lowest number is automatically promoted as the displayed page).

Annunciator configuration

Select the **Settings > Local HMI > Annunciator Panel** menu item to open the annunciator configuration page.

Figure 4: Annunciator configuration page



The following settings are available to configure the annunciator. The settings descriptions apply to all 288 alarms, with different default values.

Clear Latched

Range: any FlexLogic operand or shared operand
Default: OFF

This setting allows the user to designate a FlexLogic operand to clear all the latched alarms when the operand transitions to an active state. For example, a central station HMI can simultaneously clear all IED alarms remotely by assigning this value to a virtual input.

Page Layout

Range: 3 × 4, 4 × 6, 6 × 8
Default: 3 × 4

This setting specifies the number of alarms shown per page. This setting applies globally to all alarm pages. For example if "4 × 6" is selected, then 288 alarms can be displayed on 12 pages. Note that annunciator pages that do not contain at least one configured alarm are automatically hidden.

Content

Range: Actual, Alarm, Mixed
Default: Alarm

This setting specifies if the corresponding alarm consists of a single metered value (set to "Actual"), contains a single alarm indication (set to "Alarm"), or contains both a metered value and an alarm indication (set to "Mixed").

See Configuring metering values on page 510for details on configuring the alarm when **Content** is set to "Actual".

Alarm Input

Range: any FlexLogic operand or shared operand
Default: see above

This setting specifies the input signal connected to the alarm.

Alarm Type

Range: Acknowledgeable, Latched, Self-Reset

Default: Acknowledgeable

This setting specifies the alarm type. Self-reset alarms track the state of the corresponding input operand. Latched alarms can be reset using the Ack/Reset button at the bottom of the display. Acknowledgeable alarms follow the state transitions listed in the previous section.

Text (Line 1), Text (Line 2), Text (Line 3)

Range: up to ten alphanumeric characters

Default: product-specific defaults or blank

These settings specify the displayed text on the corresponding line in the alarm indicator. Three lines can be displayed if the page layout is 3 × 4 or 4 × 6. For 6 × 8 layouts, only the first two lines are displayed. Note that a specified metering value replaces the text for the selected line.

Text Color

Range: Black, Red, Yellow, Blue, Green, Teal, Purple, White, Dark Red, Dark Yellow, Dark Blue, Dark Green, Dark Teal, Dark Purple, Grey

Default: White

This setting specifies the color of the alarm indicator text.

Back Color

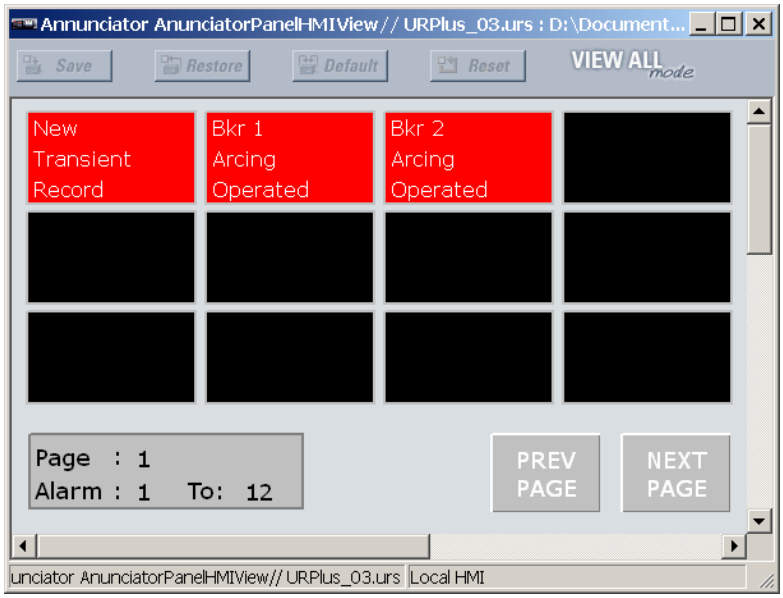
Range: Black, Red, Yellow, Blue, Green, Teal, Purple, White, Dark Red, Dark Yellow, Dark Blue, Dark Green, Dark Teal, Dark Purple, Grey

Default: Red

This setting specifies the color of the alarm indicator text.

The **Preview** button displays a static image of the front panel alarm page (as it appears when active) so that the user can verify the layout and color of the indicators.

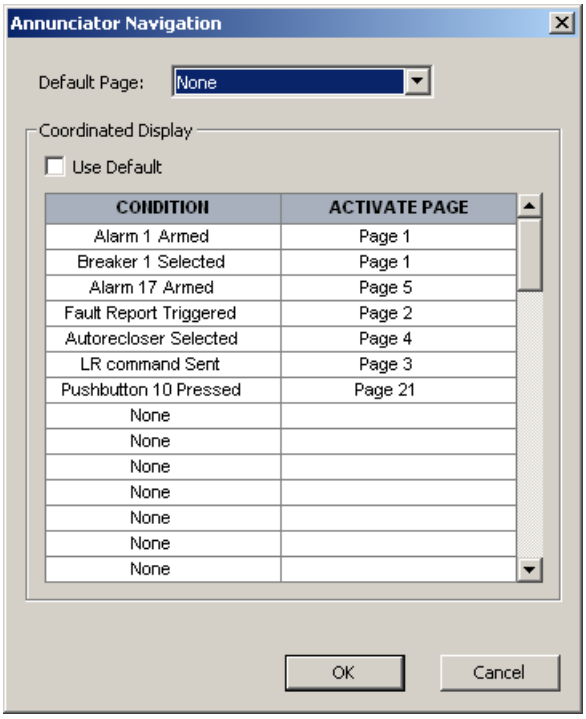
Figure 5: Annunciator preview window



The **Navigation** button allows the user can specify which annunciator alarm page is displayed under various conditions, including selection of a breaker or disconnect switch from a user-configurable line diagram, any configured alarm becoming active, any user-

programmable pushbutton or selector switch button being activated, a new fault report being triggered, selection of the autorecloser in the single line diagram, or toggling of the local/remote status.

Figure 6: Annunciator navigation dialog



If the **Use Default** check box is selected and the **Default Page** is set to "None", selection of the alarm page to display follows the following sequence:

- In the event of a new alarm, the page containing the alarm is promoted to the active page. If there are multiple pages with alarms, the lowest numbered page is promoted.
- If there are alarms on multiple pages, and alarms on some pages have already been acknowledged but not reset by the user, then the lowest numbered page with an alarm is promoted above any page that has an acknowledged alarm.

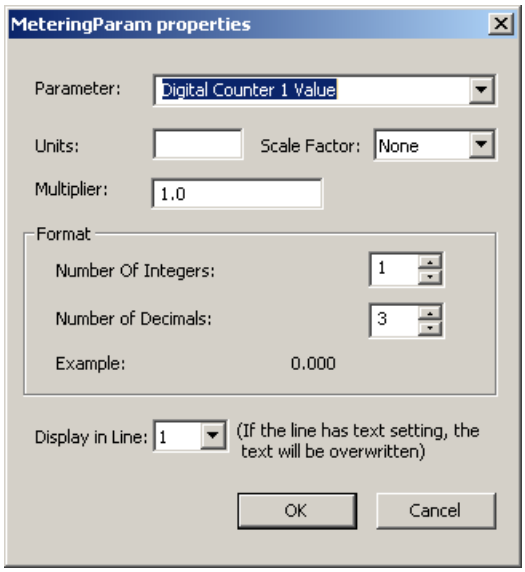
The **Default Page** menu item allows the user to select the page that is displayed after the user-specified period of inactivity has elapsed.

The C90^{Plus} is shipped with a complete range of default annunciator settings. These may be modified according to the specific applications.

Configuring metering values

The following window displays when the **Configure** button is clicked for metered value indicators. This window allows the user to configure metering values.

Figure 7: Metering value properties



The following parameters are available.

Parameter

Range: any FlexAnalog parameter
Default: Digital Counter 1 Value

This setting selects a FlexAnalog parameter that specifies the metered value to display in the annunciator alarm.

Units

Range: up to 4 alphanumeric characters
Default: ---

This setting specifies a four-character alphanumeric string that is used in the annunciator display of the corresponding metered value.

Scale Factor

Range: None, k (kilo), M (Mega), G (Giga)
Default: None

This setting allows the user to specify the scaling factor for the metering units value.

Multiplier

Range: dependent on selected analog value
Default: 1.0

This setting allows the user to specify a multiplier for the metering parameter value. The range is restricted to correspond to the selected actual value parameter.

Number of Integers

Range: 1 to 12 in steps of 1
Default: 1

This setting specifies the number of integers in the displayed analog value. It can be used to provide for leading character spacing of the resultant display value.

Number of Decimals

Range: 1 to 10 in steps of 1
Default: 3

This setting specifies the number of decimal places in the displayed analog value.

Display in Line

Range: 1, 2, 3

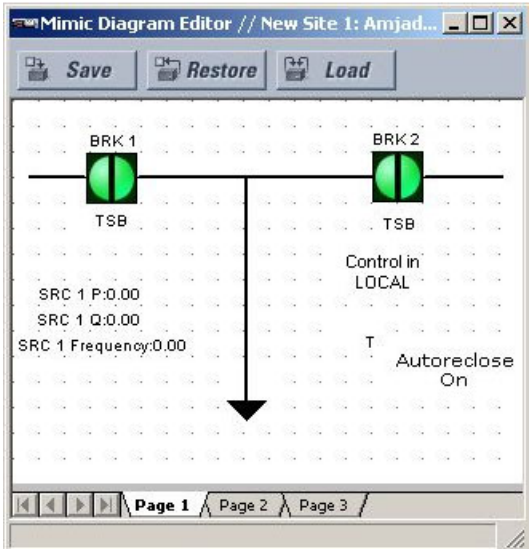
Default: 1

This setting specifies which line in the annunciator alarm to display the metered value. It can be displayed in lines 1, 2, or 3 if the page layout is 3 × 4 or 4 × 6. For 6 × 8 layouts, it can only be displayed in lines 1 or 2.

Mimic diagram editor

The mimic diagram editor allows users to create customized single line diagrams (mimic diagrams) for the front panel display. Select the **Settings > Local HMI > Mimic Diagram Editor** menu item to open the mimic diagram editing window.

Figure 8: Mimic diagram editor with example diagram

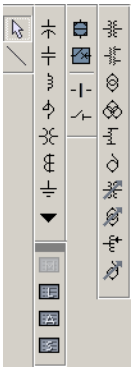


There are 1 top level pages in the mimic diagram editor.

Each top level diagram has up to 10 sub-level diagrams corresponding to each of the active components. The sub-level diagram is rendered when the corresponding active component is selected for operation. To create a sub-level diagram, first select the breaker or switch instance in the diagram editor then right-click the mouse button and select the **GoTo SLD** item. A new diagram is created and populated with the selected active component and a new tab added to the diagram editor.

A components library is included on the upper-right side of the EnerVista software. These include dynamic power components, static power components, and text blocks. To create the single line diagram, select the desired component and then click the drawing pane to place the component. Once on the drawing plane, the component can be positioned accordingly.

Figure 9: Mimic diagram components library



The following functions are available for the mimic diagram editor:

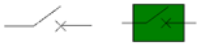
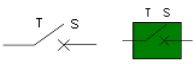
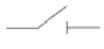
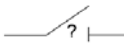
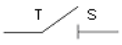
- Circuit breakers
- Disconnect and earthing switches
- Busbars
- Transformers
- Capacitor banks
- Reactors
- CTs and VTs
- Transmission lines
- Grounding

The circuit breakers, disconnects, and earthing switches can be configured to automatically display the actual status of these devices. All other devices are static. As such, they are used for information only and cannot dynamically change states.

Dynamic symbols

The following dynamic symbols are available. The symbols can be displayed in the standard UR^{Plus}-series format or as IEC style symbols.

Figure 10: Mimic diagram editor dynamic symbols

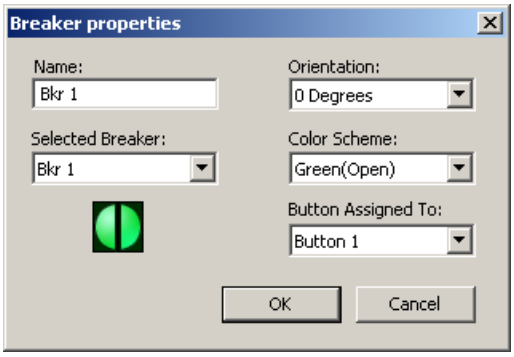
Components	Symbols		Notes
	Standard	IEC	
Circuit breakers in the open position			: Only this symbol is defined in the IEC standard; the others are created
Circuit breakers in the closed position			Created symbols
Circuit breakers with bad status			Created symbols
Tagged circuit breakers			Device is tagged (T); status is substituted (S). Created symbols
Switches in the open position			: Only this symbol is defined in the IEC standard; the others are created
Switches in the closed position			Created symbols
Switches with bad status			Created symbols
Switches in the intermediate position			Created symbols
Tagged switches			Device is tagged (T); status is substituted (S). Created symbols

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A maximum of 10 dynamic components is allowed for each mimic diagram.

When a dynamic symbol is selected and added to the diagram, a window appears to configure the device. This allows the user to specify the name and orientation of the device. For example, the figure shows the breaker properties device configuration window.

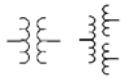
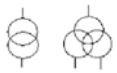
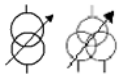
Figure 11: Breaker properties device configuration



Static symbols

The following static symbols are available. The symbols can be displayed in the standard UR^{Plus}-series format or as IEC style symbols.

Figure 12: Mimic diagram editor static symbols

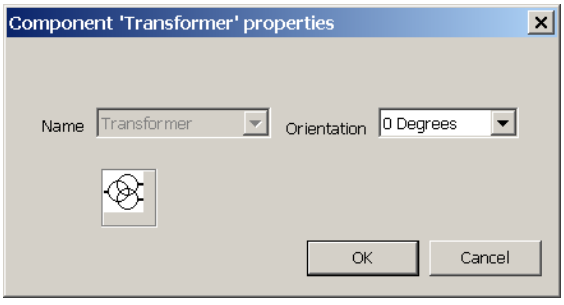
Components	Symbols	
	Standard	IEC
Transformer		
Autotransformer		
Transformer with tap changer		
Autotransformer with tap changer		
Capacitor bank		
Reactor		
VT		
CT		
Grounding		
Busbar and transmission lines		

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For more information on these symbols, see the ANSI/IEEE 315A and IEC 617 standards. There is no limit on the number of static symbols per screen, provided that they fit within the screen dimensions.

When a static symbol selected and added to the diagram, a window appears to configure the device. This allows the user to specify the orientation of the device; the name of a static device cannot be changed. For example, the figure shows the transformer properties device configuration window.

Figure 13: Transformer properties device configuration



Metering blocks

Metering blocks are used to display various metered quantities. These blocks allow the user to display specific analog values in the configurable mimic diagram. The following table outlines the metered text block type. A maximum of six metering blocks can be used per mimic diagram page.

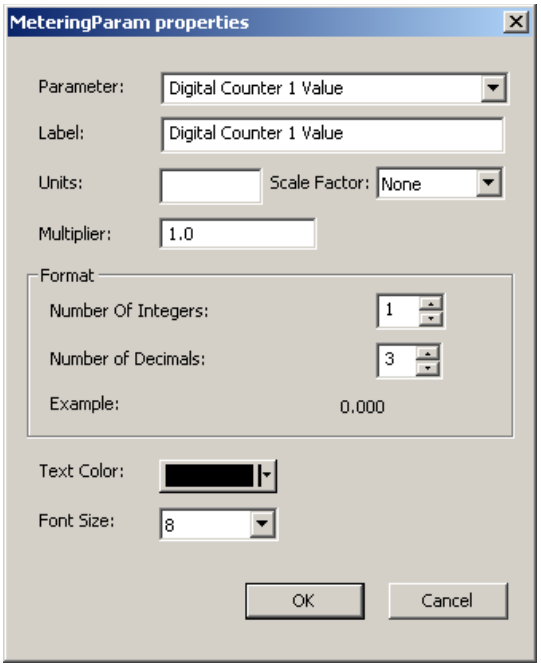
Figure 14: Mimic diagram metering block symbol

Text block type	Interface symbols	
	Button	Example display
Metered text block		-63.6 W -2.9 VAR 59.962 Hz

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The properties of a metering block can be configured by right-clicking the box and selecting the **Properties** item to open the Metering Properties configuration window.

Figure 15: Metering properties window



The following items are available.

Parameter

Range: any analog actual value
Default: Analog 1 (VA1)

This setting selects the actual value to be displayed in the metering block.

Label

Range: up to 40 ASCII characters
Default: Analog 1 (VA1)

This setting allows the user to specify a custom label for the metering block if the actual value name is insufficient.

Units

Range: up to 4 ASCII characters
Default: ---

This setting allows the user to specify a custom units value for the metering block if the actual value unit designation is insufficient.

Scale Factor

Range: G (Giga), M (Mega), k (kilo), None

Default: None

This setting allows the user to select a scaling factor for the metering units value. The range is restricted to correspond to the selected analog value parameter.

Multiplier

Range: dependent on the selected analog value

Default: None

This setting allows the user to specify the multiplier for the metering units value if the scaling factor is set to "None".

Number of Integers

Range: 1 to 12 in steps of 1

Default: 1

This setting selects the number of integer places displayed for the metering block.

Number of Decimals

Range: 0 to 10 in steps of 1

Default: 3

This setting selects the number of decimal places displayed for the metering block.

Text Color

Range: available system colors

Default: Black

This setting specifies the displayed text color for the metering block.

Font Size

Range: 8, 10, 12

Default: 8

This setting specifies the displayed font size for the metering block.

Text blocks

Text blocks are used to display various control quantities. These text blocks allow the user to display specified control states in the configurable mimic diagram. The table outlines the three types of text blocks available. A maximum of three text blocks can be used per mimic diagram.

Figure 16: Mimic diagram text block symbols

Text block type	Interface symbols	
	Button	Example display
Local/remote text block		Control in LOCAL
Autoreclose text block		Autoreclose On
Select-to-operate text block		SELECT TO OPERATE

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View modes

The mimic diagram editor has three viewing modes: edit mode, overview mode, and control mode. These modes are toggled via the three mode buttons on menu bar.

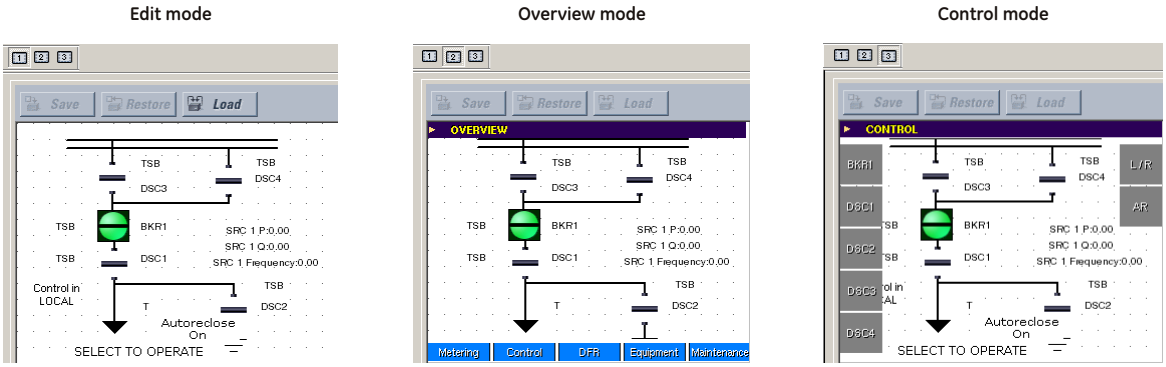
The edit mode is used when creating and modifying mimic diagrams with the editor.

The overview mode provides a preview of how the mimic diagram appears on the overview screen of the front panel interface.

The control mode provides a preview of how the mimic diagram appears on the control screen of the front panel interface.

These modes allow the user to ensure that the mimic diagram displays appropriately in all display screens. The following figure illustrates the viewing modes.

Figure 17: Mimic diagram view modes



Pre-configured mimic diagrams

The EnerVista UR^{Plus} Setup software contains a library of 12 pre-configured mimic diagrams that can be loaded into the mimic diagram editor. Click the **Load** button to load a pre-configured mimic diagram from the library. User-created mimic diagrams can also be saved into this library. The following pre-configured diagrams are available:

- Breaker-and-a-half scheme
- Breaker-and-a-half scheme with breaker disconnects
- Breaker-and-a-half scheme with breaker and line disconnects
- Breaker-and-a-half scheme with breaker, line, and ground disconnects
- Breaker-and-a-half scheme with line disconnect
- Breaker-and-a-half scheme with line and ground disconnects
- Double-bus bypass scheme 1
- Double-bus bypass scheme 2
- Double-bus bypass scheme with line and ground disconnects
- Single-bus scheme
- Single-bus scheme with line disconnect
- Single-bus scheme with line and ground disconnects

Breakers and disconnect switches are pre-assigned to 12 diagrams shown in the following figures. If a breaker or disconnect switch has not been enabled, then the device displays as a solid block.

Figure 18: Pre-configured mimic diagram 1 (breaker-and-a-half scheme)

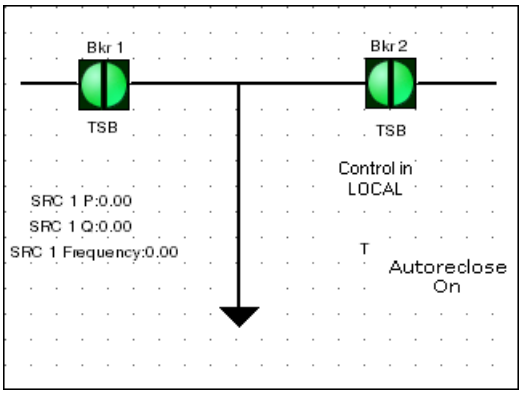


Figure 19: Pre-configured mimic diagram 2 (breaker-and-a-half scheme with breaker disconnects)

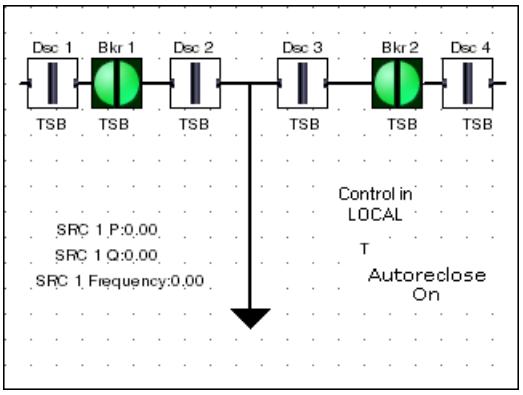


Figure 20: Pre-configured mimic diagram 3 (breaker-and-a-half scheme, with breaker and line disconnects)

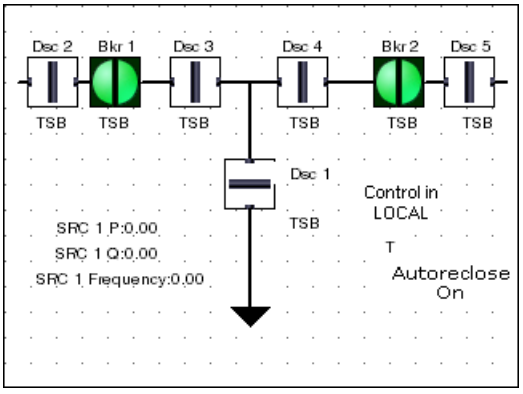


Figure 21: Pre-configured mimic diagram 4 (breaker-and-a-half scheme, with breaker, line, and ground disconnects)

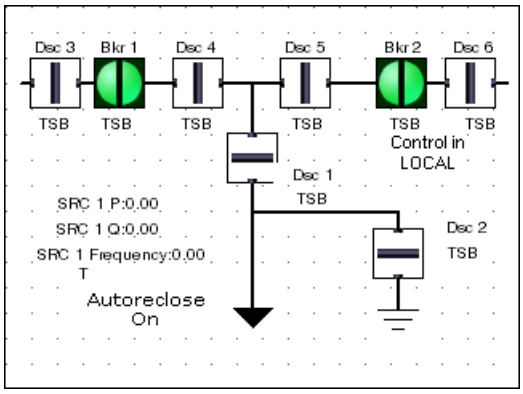


Figure 22: Pre-configured mimic diagram 5 (breaker-and-a-half scheme with line disconnect)

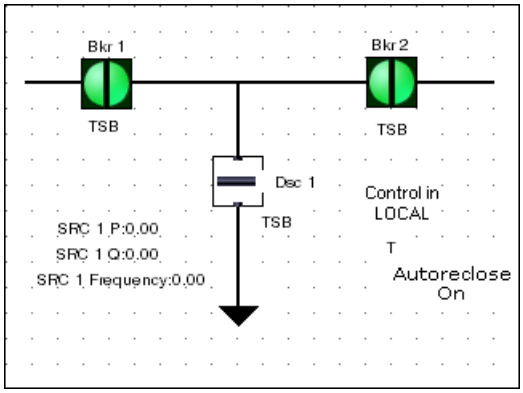


Figure 23: Pre-configured mimic diagram 6 (breaker-and-a-half scheme with line and ground disconnects)

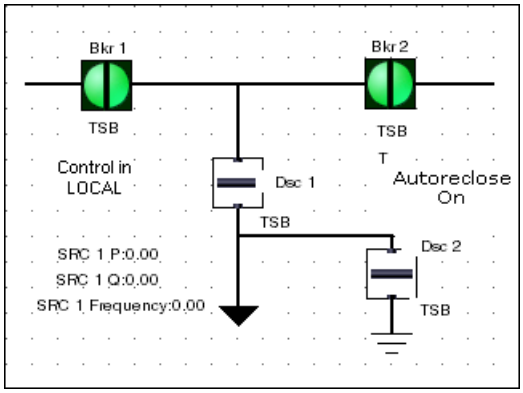


Figure 24: Pre-configured mimic diagram 7 (double-bus bypass scheme 1)

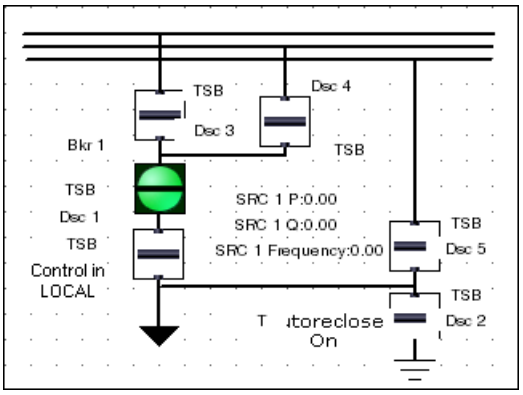


Figure 25: Pre-configured mimic diagram 8 (double-bus bypass scheme 2)

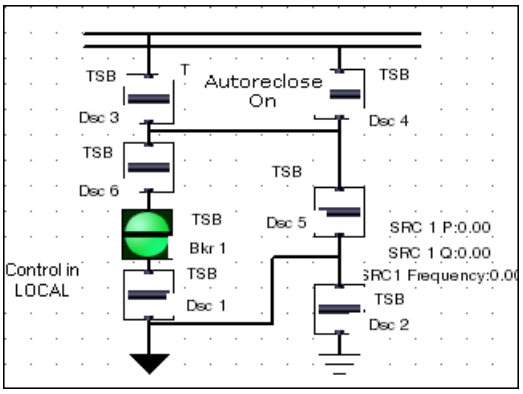


Figure 26: Pre-configured mimic diagram 9 (double-bus bypass scheme with line and ground disconnects)

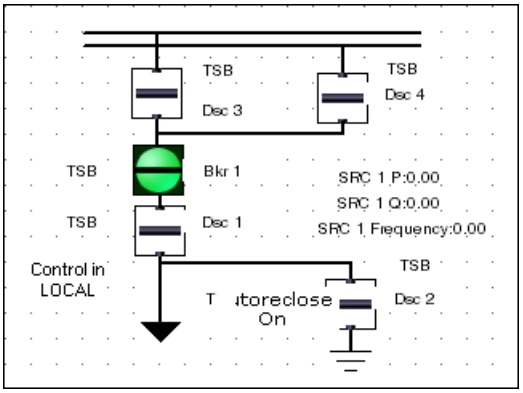


Figure 27: Pre-configured mimic diagram 10 (single-bus scheme)

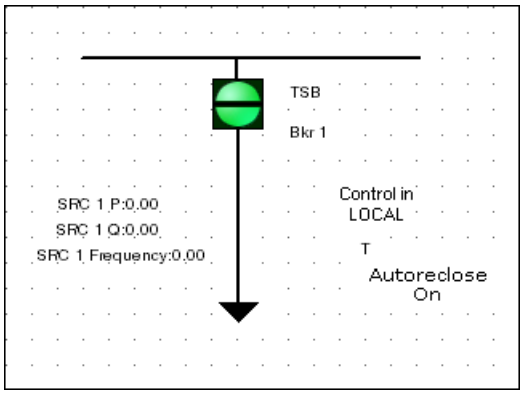


Figure 28: Pre-configured mimic diagram 11 (single-bus scheme with line disconnect)

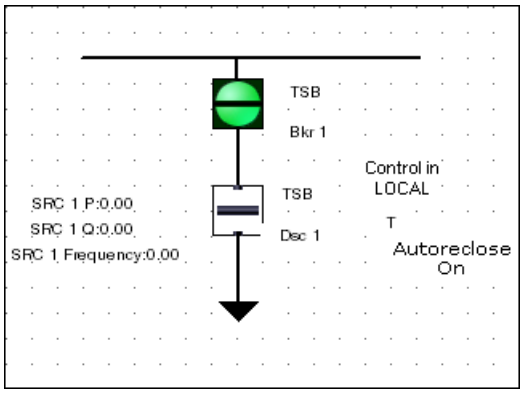
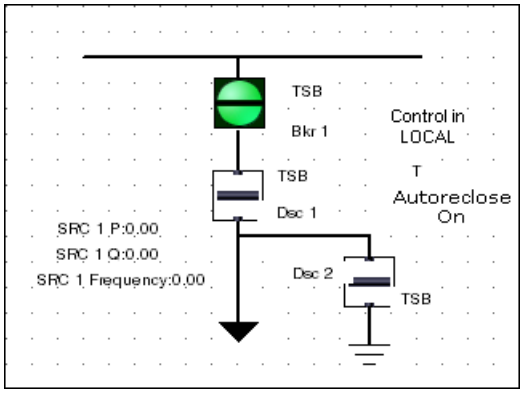


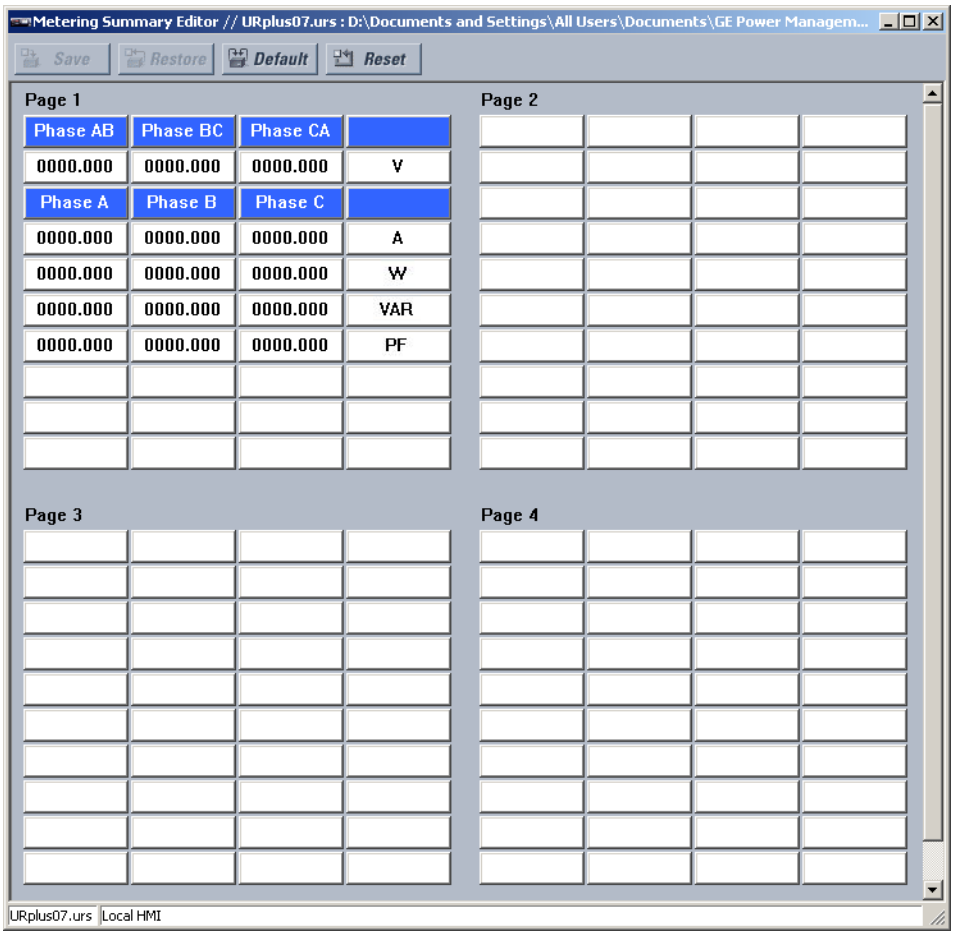
Figure 29: Pre-configured mimic diagram 12 (single-bus scheme with line and ground disconnects)



Metering summary editor

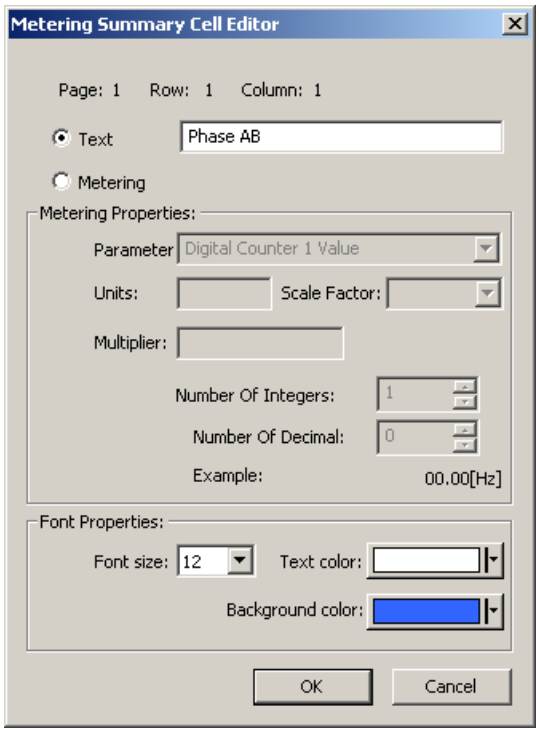
Select the **Settings > Local HMI > Metering Summary Editor** menu item to open the metering configuration window.

Figure 30: Metering summary editor window



A click of the left mouse button in a metering location opens the following window. The user can enter header text of a selected font size and color, or select a metered quantity from the drop-down list. A metered quantity can be a system voltage, current, real or reactive power on a per-phase basis, for any configured source.

Figure 31: Metering configuration window



Text

Range: up to 20 alphanumeric characters
Default: ---

This setting defines the selected metering cell as a text box. These are typically used as headings. Specify up to 10 alphanumeric characters.

Parameter

Range: any FlexAnalog parameter
Default: Digital Counter 1 Value

This setting selects a FlexAnalog parameter that specifies the metered value to display in the metering cell.

Units

Range: up to 4 alphanumeric characters
Default: ---
This setting specifies a four-character alphanumeric string that is used in the metering cell display for the corresponding metered value.

Scale Factor

Range: G (Giga), M (Mega), k (kilo), None
Default: None

This setting allows the user to select a scaling factor for displayed metered value. The range is restricted to correspond to the selected analog value parameter.

Multiplier

Range: dependent on selected analog value
Default: ---

This setting allows the user to specify a multiplier for the metering parameter value if the scaling factor is set to "None". The range is restricted to correspond to the selected actual value parameter.

Number of Integers

Range: 1 to 6 in steps of 1
Default: 1

This setting specifies the number of integers in the displayed metering cell. It can be used to provide for leading character spacing of the resultant display value.

Number of Decimals

Range: 1 to 6 in steps of 1
Default: 3

This setting specifies the number of decimal places in the displayed metering cell.

Font Size

Range: 8, 10, 12
Default: 10

This setting specifies the font size to use for the displayed metering cell.

Text Color

Range: available system colors
Default: Black

This setting specifies the text color to use for the foreground text in the displayed metering cell.

Background Color

Range: available system colors
Default: White

This setting specifies the color to use in the background for the displayed metering cell.

User-programmable pushbuttons

The C90^{Plus} supports thirty user-programmable pushbuttons and 10 selector switches. Each of the selector switch instances can be assigned to one of the available HMI control keys on the three pushbutton screens. The mapping of pushbutton instances to control keys is fixed. Pushbuttons 1 through 10 are on the first screen, 11 through 20 on the second screen, and 21 through 30 on the third screen. Pushbuttons are numbered starting with the top-left control key, increasing from top-to-bottom on the left side of the display and then from top-to-bottom on the right side of the display.

The user can specify the text for the navigation menu entry for each pushbutton page. If a page does not contain any configured pushbutton or selector switch instances, the navigation menu is disabled and the menu text is grayed out.

For each pushbutton and selector switch instance, the user supplies the text that is drawn in the rectangle adjacent to the control key for each switch position. For pushbuttons, text can be specified for both the ON and OFF states.

The pushbutton configuration is started when the user clicks the **Configure** setting in the user-programmable pushbutton settings window.



The C90^{Plus} must be in the programmed state and the corresponding selector switch or pushbutton element must be enabled before the control keys affect a change to the element state.

User-programmable pushbutton operation

User-programmable pushbuttons provide a simple and error-free method of entering digital state (on, off) information. The digital state can be entered locally (by directly pressing the front panel pushbutton) or remotely (via operands) into logic equations, protection elements, and control elements. Typical applications include breaker control, autorecloser blocking, setting groups changes and the control of selector switches.

Each pushbutton asserts its own on-state and off-state 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 asserts.

The pushbuttons can be automatically controlled by asserting user-specified operands. The pushbutton reset status is declared when the PUSHBUTTON 1 OFF operand is asserted. The activation and deactivation of user-programmable pushbuttons is dependent on whether latched or self-reset mode is selected.

In latched mode, a pushbutton can be set (activated) by asserting the set operand or by directly pressing the associated front panel pushbutton. The pushbutton maintains the set state until deactivated by the reset command or after a user-specified time delay. The state of each pushbutton is stored in non-volatile memory and maintained through a loss of control power. The pushbutton is reset (deactivated) in latched mode by asserting the reset operand or by directly pressing the associated active front panel pushbutton. The pushbutton can also be programmed to reset automatically through user-specified 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.

In self-reset mode, a pushbutton will remain active for the time it is pressed (the pulse duration) plus a user-specified dropout time. If the pushbutton is activated via logic equations, the pulse duration is specified by only the user-specified dropout time. The time the set operand remains assigned has no effect on the pulse duration. The pushbutton is reset (deactivated) in self-reset mode when a user-specified dropout delay expires.



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

The local and remote operation of each user-programmable pushbutton can be inhibited through user settings. If local locking is applied, the pushbutton ignores set and reset commands executed through the front panel pushbuttons. If remote locking is applied, the pushbutton ignores set and reset commands executed through logic operands.

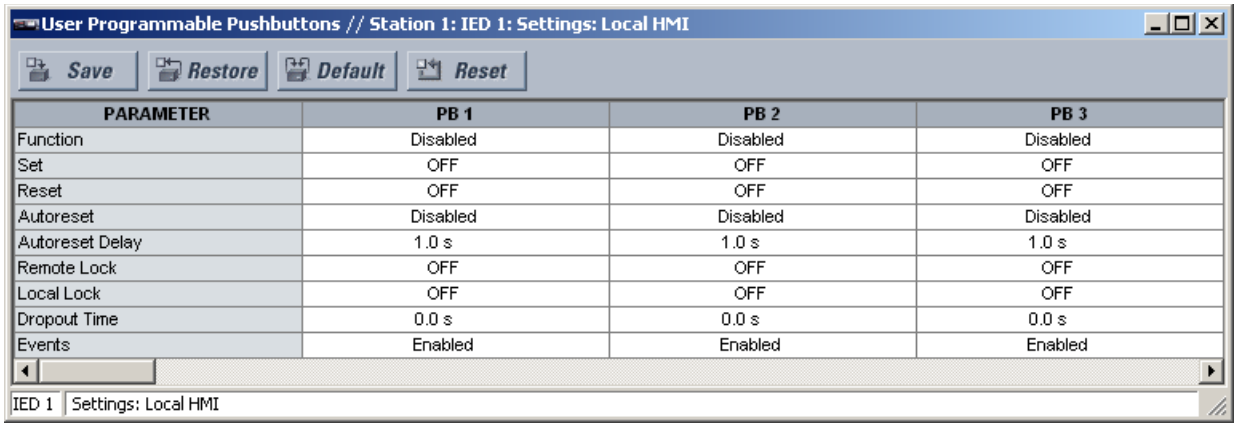
The locking functions are not applied to the autorestart feature. In this case, the inhibit function can be used in SBO control operations to prevent the pushbutton function from being activated and ensuring *one-at-a-time* select operation. The locking functions can also be used to prevent the accidental pressing of the front panel pushbuttons. The separate inhibit of the local and remote operation simplifies the implementation of local/remote control supervision.

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

User-programmable pushbuttons settings

Select the **Settings > Local HMI > User-Programmable Pushbuttons** menu item to open the user-programmable pushbuttons settings window.

Figure 32: User-programmable pushbuttons configuration settings



The following settings are available for each user-programmable pushbutton.

Function

Range: Disabled, Latched, Self-Reset

Default: Disabled

This setting selects the pushbutton operating characteristic. If set to "Disabled", the pushbutton is not active and the corresponding operands (both on-state and off-state operands) are de-asserted. If set to "Self-Reset", the control logic is activated by the pulse (longer than 100 ms) issued when the pushbutton is physically initiated via the front panel interface or virtually initiated via logic.

When in "Self-Reset" mode and activated locally, the pushbutton control logic asserts the corresponding on-state operand as long as the pushbutton remains physically initiated. After the pushbutton is released, the de-assertion of the operand is delayed by the drop out timer. The off-state operand is asserted when the pushbutton element is deactivated. If the pushbutton is activated remotely, the pushbutton control logic asserts the corresponding on-state operand only for the time specified by the **Dropout Time** setting.

If set to "Latched", the pushbutton control logic alternates the state of the corresponding operand between the on-state and off-state on each button press or by virtually activating the pushbutton (assigning set and reset operands). In latched mode, the operand states are stored in non-volatile memory. If the power supply goes off, the correct state of the pushbutton is retained upon subsequent power-up.

Set

Range: any FlexLogic operand or shared operand

Default: OFF

When the operand assigned to this setting is asserted, the pushbutton is operated and the PUSHBUTTON 1 ON operand is asserted. The duration of the incoming set signal must be at least 100 ms.

Reset

Range: any FlexLogic operand or shared operand

Default: OFF

When the operand assigned to this setting is asserted, the pushbutton is reset and the PUSHBUTTON 1 OFF operand is asserted. This setting is applicable only if the pushbutton is in latched mode. The duration of the incoming set signal must be at least 100 ms.

Autoreset

Range: Disabled, Enabled

Default: Disabled

This setting enables the user-programmable pushbutton autoreset feature. This setting is applicable only if the pushbutton is in latched mode.

Autoreset Delay

Range: 0.2 to 600.0 seconds in steps of 0.1

Default: 1.0 seconds

This setting specifies the time delay for automatic reset of the pushbutton when in the latched mode.

Remote Lock

Range: any FlexLogic operand or shared operand

Default: OFF

When the operand assigned to this setting is asserted, pushbutton operation from operands assigned to the **Set** or **Reset** settings is inhibited.

Local Lock

Range: any FlexLogic operand or shared operand

Default: OFF

When the operand assigned to this setting is asserted, pushbutton operation from the front panel interface is inhibited. This locking functionality is not applicable to pushbutton autoreset.

Dropout Time

Range: 0.0 to 60.0 seconds in steps of 0.1

Default: 0.0 seconds

This setting specifies the duration of the pushbutton active status after the pushbutton has been released. This setting applies only to self-reset mode and is required to set the duration of the pushbutton operating pulse.

Events

Range: Disabled, Enabled

Default: Enabled

This setting enables and disables the logging of user-programmable pushbutton events in the sequence of events recorder.

The figures show the user-programmable pushbutton 1 logic. The logic is functionally identical for all user-programmable pushbuttons.

Figure 33: User-programmable pushbutton logic, sheet 1 of 2

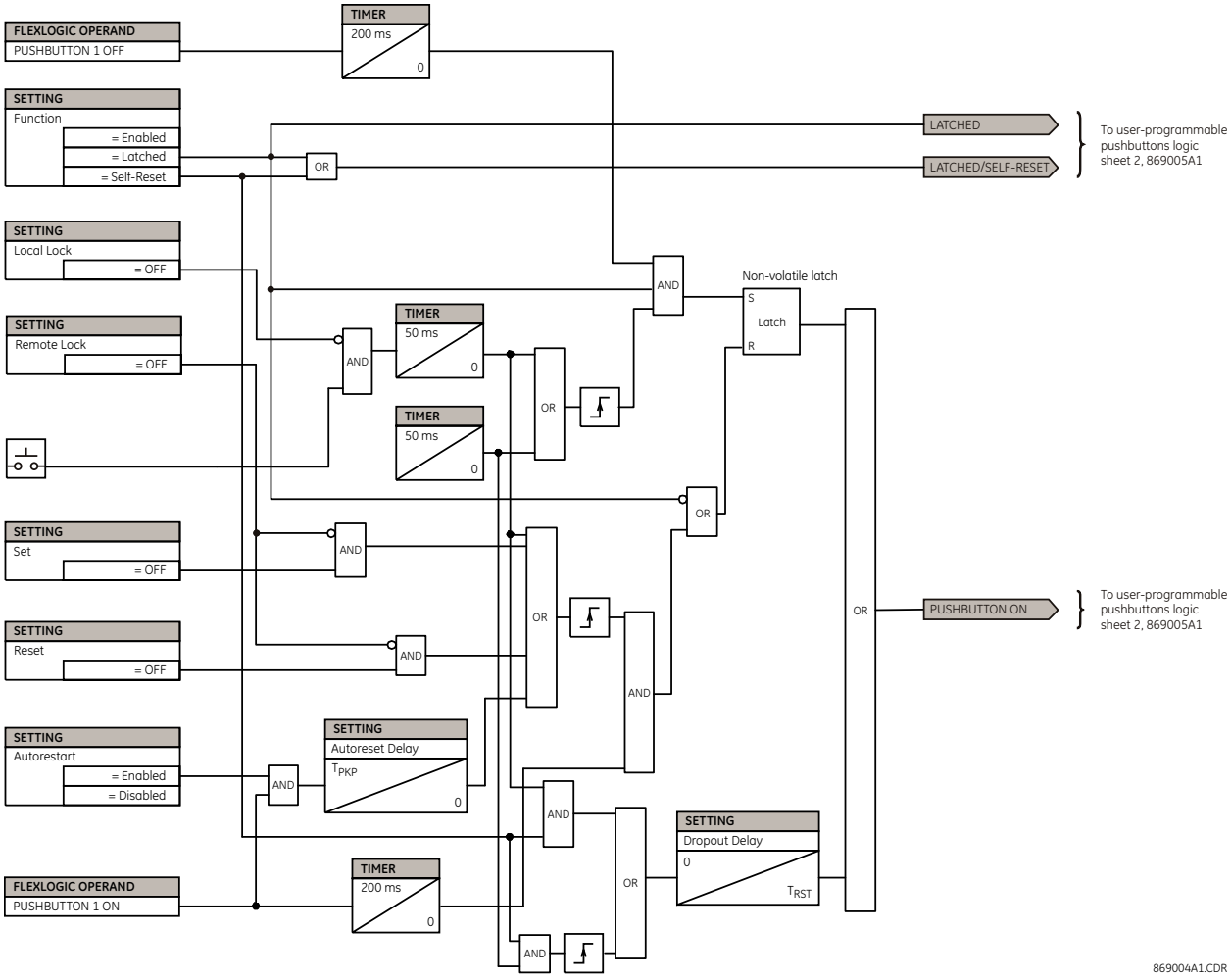
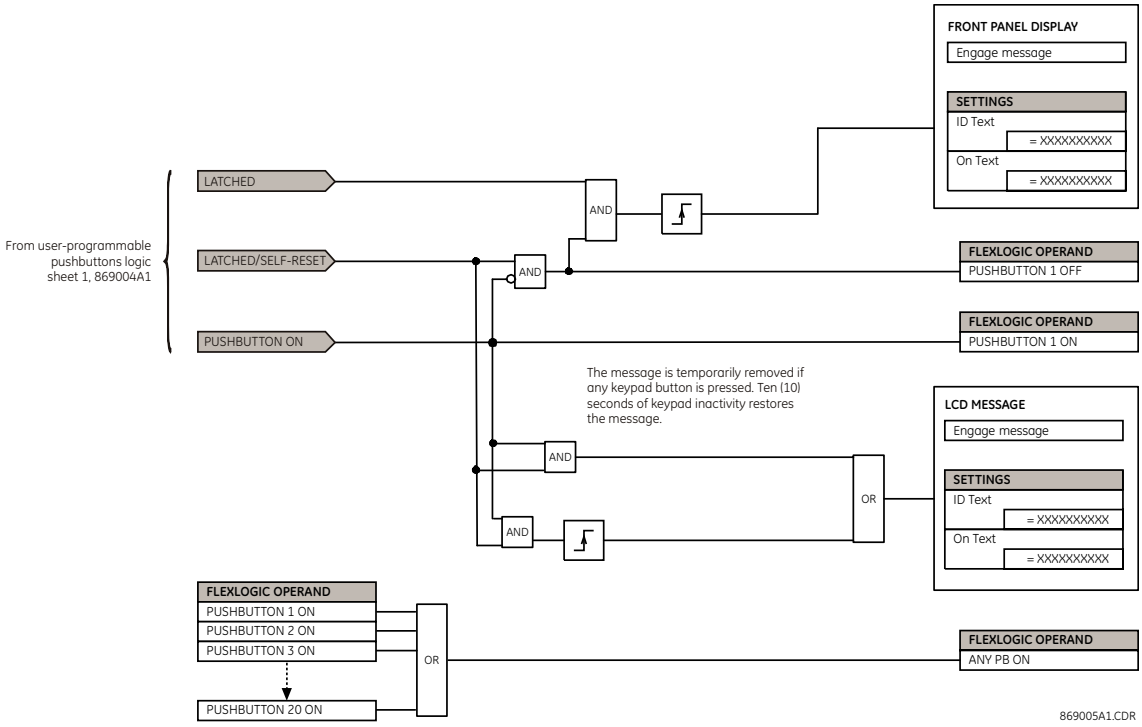


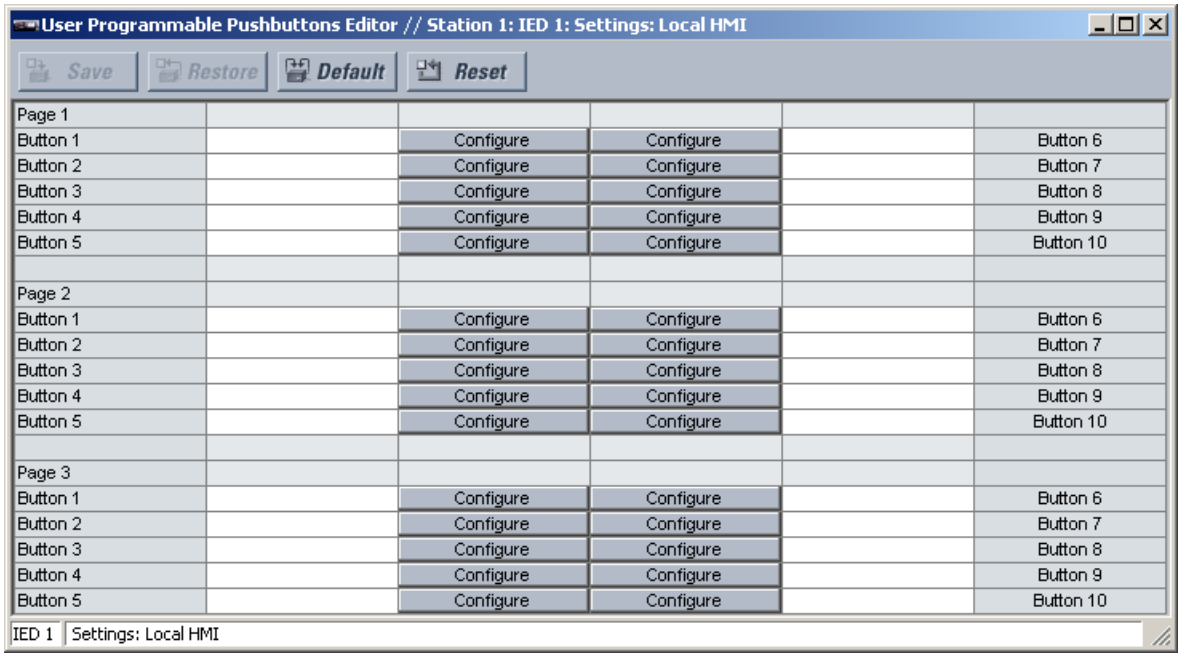
Figure 34: User-programmable pushbutton logic, sheet 2 of 2



User-programmable pushbuttons editor

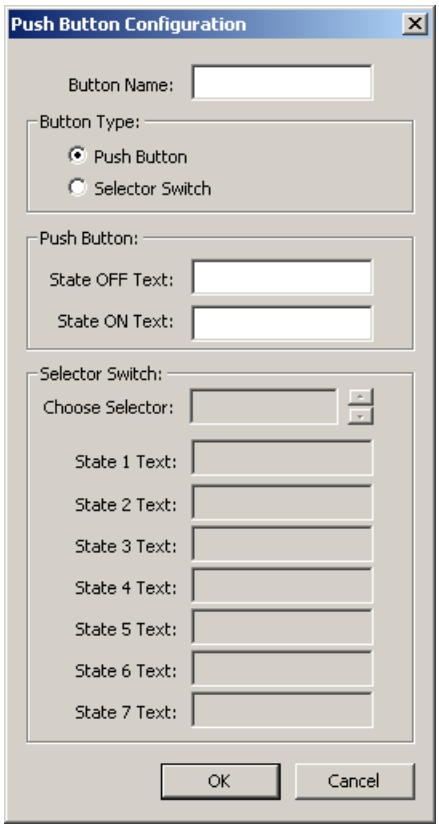
Select the **Settings > Local HMI > User-Programmable Pushbuttons Editor** menu item to open the user-programmable pushbuttons editor window.

Figure 35: User-programmable pushbuttons editor settings



Click the **Configure** button to access the pushbutton configuration settings. The following screen displays for each user-programmable pushbutton.

Figure 36: Pushbutton configuration window



The following settings are available.

Button Name

Range: up to 20 alphanumeric characters
Default: ---

This setting allows the user to assign a pushbutton or selector switch name that appears on the user-programmable pushbutton window and on the display page when the corresponding pushbutton element or selector switch element is disabled.

Button Type

Range: Pushbutton, Selector Switch
Default: Pushbutton

This setting defines the type of switch associated with each control key.

State OFF Text

Range: up to 20 alphanumeric characters
Default: ---

This setting specifies the text to display under the button name when the pushbutton is in the OFF state.

State ON Text

Range: up to 20 alphanumeric characters
Default: ---

This setting specifies the text to display under the button name when the pushbutton is in the ON state.

Choose Selector

Range: 1 to 10 in steps of 1

Default: 1

This setting selects the selector switch number to associate with the current control key. This setting is available only when the **Button Type** is "Selector Switch".

State 1 Text, State 2 Text,..., State 10 Text

Range: up to 19 alphanumeric characters

Default: ---

These settings specify the text to display under the selector switch name for each switch position. These settings are available only when the **Button Type** is "Selector Switch"

C90Plus Controller

Chapter 13: Security

This section outlines how to program the C90Plus security features.

Password security

It is recommended that passwords be programmed for each security level and assigned to specific personnel. There are two user password security access levels: command and setting.

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

- Operate breakers via the front panel interface
- Change the state of virtual inputs
- Clear event records
- Clear oscillography records
- Clear fault reports
- Change the system date and time
- Clear energy records
- Operate control pushbuttons

The setting access level allows the user to make any changes to any of the setting values and operate in test mode.

The command and setting passwords are not programmed when the device is shipped from the factory. When a command or setting password is set to null, the password security feature is disabled.

The C90Plus supports password entry from a local or remote connection.

Local access is defined as any access to settings or commands via the faceplate interface. This includes both keypad entry and the faceplate serial USB connection. Remote access is defined as any access to settings or commands via any rear Ethernet port. Any changes to the local or remote passwords enables this functionality.

The RS485 port can be configured as a either a local or remote connection through the serial port **Connection** setting.

When entering a settings or command password via Ethernet or the serial USB interface, the user must enter the corresponding password level shown in the following table.

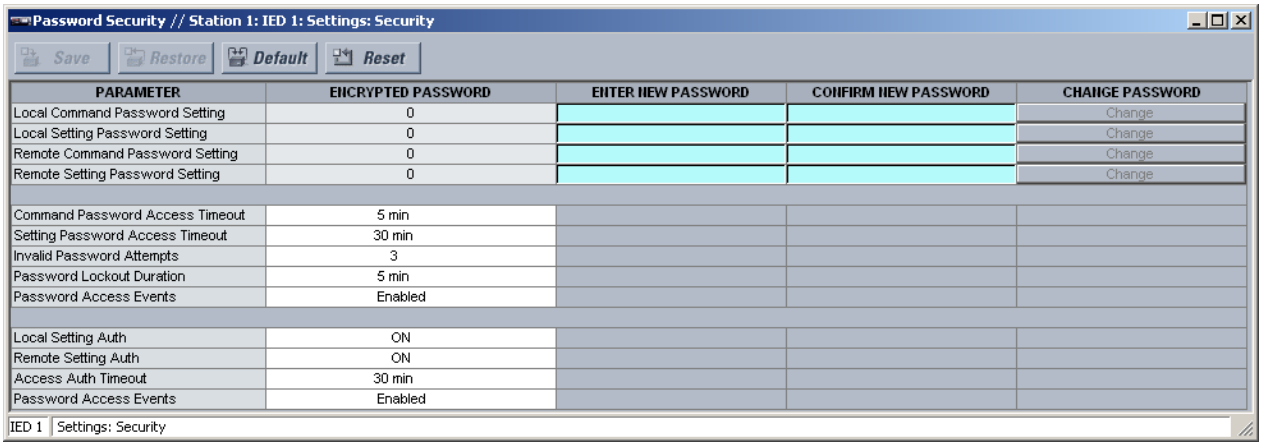
Table 1: Required password levels for various connection types

Connection type	Password required
Front panel USB	Local
Rear Ethernet port	Remote
Rear RS485 port, with Connection setting as "Local"	Local
Rear RS485 port, with Connection setting as "Remote"	Remote

Password security settings

Select the **Settings > Security > Password Security** menu item to open the password security settings window.

Figure 1: Password security configuration settings



The password security settings are arranged into three groups: password settings, access supervision, and dual permission security access. Passwords can consist of up to 12 alphanumeric characters, excluding all non-printing characters as well as the "space" character (ASCII code 32), " ` " (ASCII code 60), " \ " (ASCII code 92), " / " (ASCII code 47), and " | " (ASCII code 124). Also, the password cannot be programmed as "0". The following password settings are available.

Local Command Password

Range: up to 12 visible ASCII characters (see restrictions above)

Default: null

The value of the local command password is specified here. For the password to be successfully entered, the values in the Enter New Password and Confirm New Password fields must be identical.

If an entered password is lost (or forgotten), consult the factory with the corresponding Encrypted Password value.

Local Setting Password

Range: up to 12 visible ASCII characters (see restrictions above)

Default: null

The value of the local setting password is specified here. For the password to be successfully entered, the values in the Enter New Password and Confirm New Password fields must be identical.

If an entered password is lost (or forgotten), consult the factory with the corresponding Encrypted Password value.

Remote Command Password

Range: up to 12 visible ASCII characters (see restrictions above)

Default: null

The value of the remote command password is specified here. For the password to be successfully entered, the values in the **Enter New Password** and **Confirm New Password** fields must be identical.

If an entered password is lost (or forgotten), consult the factory with the corresponding **Encrypted Password** value.

Remote Setting Password

Range: up to 12 visible ASCII characters (see restrictions above)

Default: null

The value of the remote setting password is specified here. For the password to be successfully entered, the values in the **Enter New Password** and **Confirm New Password** fields must be identical.

If an entered password is lost (or forgotten), consult the factory with the corresponding **Encrypted Password** value.

The access supervision settings allow the user to specify the length of inactivity required before returning to the restricted access level. The following access supervision settings are available.

Command Password Access Timeout

Range: 5 to 480 minutes in steps of 1

Default: 5 minutes

This setting specifies the length of inactivity (no local or remote access) required to return to restricted access from the command password level.

Setting Password Access Timeout

Range: 5 to 480 minutes in steps of 1

Default: 30 minutes

This setting specifies the length of inactivity (no local or remote access) required to return to restricted access from the setting password level.

Invalid Password Attempts

Range: 2 to 5 in steps of 1

Default: 3

This setting specifies the number of times an incorrect password can be entered within a three-minute time span before lockout occurs and applies to both the setting and command passwords.

When lockout occurs for the command password level, the ACCESS LOC CMND DENY and ACCESS REM CMND DENY communication operands are set to "On". These operands are returned to the "Off" state upon expiration of the lockout. Likewise, when lockout occurs for the setting password level, the ACCESS LOC SETG DENY and ACCESS REM SETG DENY communication operands are set to "On". These operands are also returned to the "Off" state upon expiration of the lockout.

Password Lockout Duration

Range: 5 to 60 minutes in steps of 1

Default: 5 minutes

This setting specifies the time that the C90^{Plus} locks out command password access after the number of invalid password entries specified by the **Invalid Password Attempts** setting has occurred.

Password Access Events

Range: Enabled, Disabled

Default: Disabled

This setting enables and disables the logging of password access supervision events in the sequence of events recorder.

The dual permission security access feature provides a mechanism for customers to prevent unauthorized or unintended upload of settings to a device through the local or remote interfaces. The following dual permission security access settings are available.

Local Setting Authorization

Range: selected operands (see description below)

Default: ON

This setting is used for local (front panel USB and RS485 interface) setting access supervision. Valid operand values are either "ON" (default) or any physical contact input value.

If this setting is "ON", then local setting access functions as normal; that is, a local setting password is required. If this setting value is any contact input operand, then the operand must be asserted (set as on) prior to providing the local setting password to gain setting access.

Remote Setting Authorization

Range: any communications operand or shared operand

Default: ON

This setting is used for remote (Ethernet and RS485) 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 operand, then the operand must be asserted (set as on) prior to providing the remote setting password to gain setting access.

Access Authorization Timeout

Range: 5 to 480 minutes in steps of 1

Default: 30 minutes

This setting specifies the timeout delay for setting access. This setting is applicable when the **Local Setting Authorization** or **Remote Setting Authorization** settings are programmed to any operand except "ON" or "OFF". The states of any selected operands are continuously monitored for an off-to-on transition. When this occurs, setting access is permitted and the timer programmed with this setting value is started. When this timer expires, setting access is immediately denied. If access is permitted and an off-to-on transition of the selected operand is detected, the timeout is restarted. The status of this timer is updated every five seconds.

Password Access Events

Range: Enabled, Disabled

Default: Disabled

This setting enables and disables the logging of dual permission security access events in the event recorder.

Password security operation

In the event that an incorrect command or setting password has been entered three times within a three-minute time span, the ACCESS DENIED operand asserts and the C90^{Plus} does not allow setting or command access for the next five minutes. The operand de-asserts after the expiration of the five minute timeout.

The C90Plus provides a means to raise an alarm upon failed password entry. When password verification fails while accessing a password-protected level of the relay (either settings or commands), the UNAUTHORIZED ACCESS operand asserts. 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. Therefore, to apply this feature with security, password-protect the command level. The operand does not generate events.

EnerVista security management system

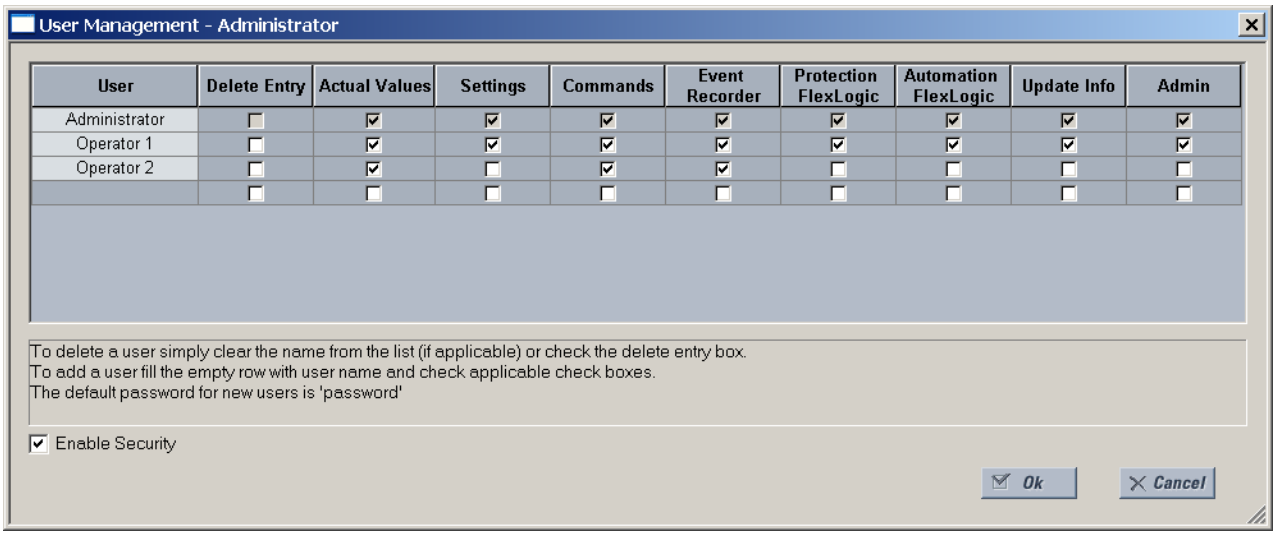
IThe EnerVista security management system is a role-based access control (RBAC) system that allows a security administrator to easily manage the security privileges of multiple users. This allows for access control of URPlus-series devices by multiple personnel within a substation and conforms to the 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.

Enabling the security management system

The EnerVista security management system is disabled by default. This allows access to the device immediately after installation. When security is disabled, all users are granted administrator access.

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



2. Check the **Enable Security** box in the lower-left corner to enable the security management system.

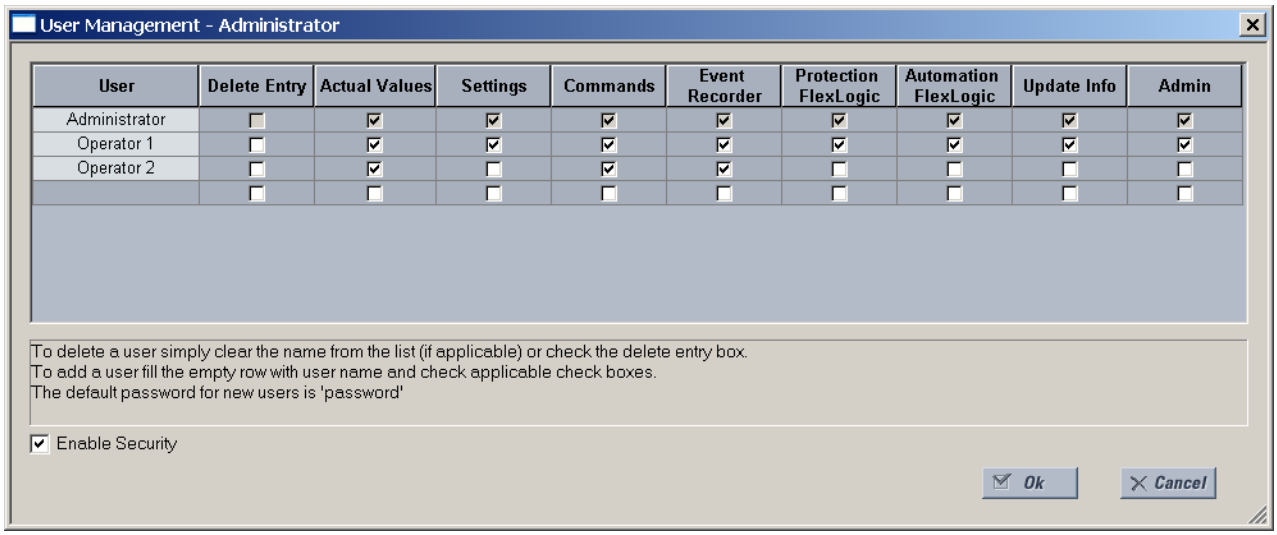
Security is now enabled for the EnerVista software. It is now necessary to enter a username and password upon start of the software.

Adding a new user

The following procedure describes how to add new users to the security management system. The following pre-requisites are required to add new users:

- The user adding the new user must have administrator rights
- The EnerVista security management system must be enabled

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



2. Enter a username in the **User** field. The username must be between 4 and 20 characters in length.
3. Select the user access rights by checking one or more of the fields shown.

Field	Description
Delete Entry	Checking this box deletes the user account when exiting the user management configuration window
Actual Values	Checking this box allows the user to read actual values
Settings	Checking this box allows the user to read setting values
Commands	Checking this box allows the user to execute commands
Event Recorder	Checking this box allows the user to use the digital fault recorder
Protection FlexLogic	Checking this box allows the user to read protection FlexLogic values
Automation Logic	Checking this box allows the user to read automation logic values
Update Info	Checking this box allows the user to write to any function to which they have read privileges. When any of the **Settings**, **Event Recorder**, **Protection FlexLogic**, and **Automation Logic** boxes are checked by themselves, the user is granted read access. When any of these are checked 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 checked, even if the **Update Info** field is checked.
Admin	When this box is checked, the user becomes an EnerVista UR^{Plus} Setup administrator, therefore receiving all of the administrative rights. Exercise caution when granting administrator rights.

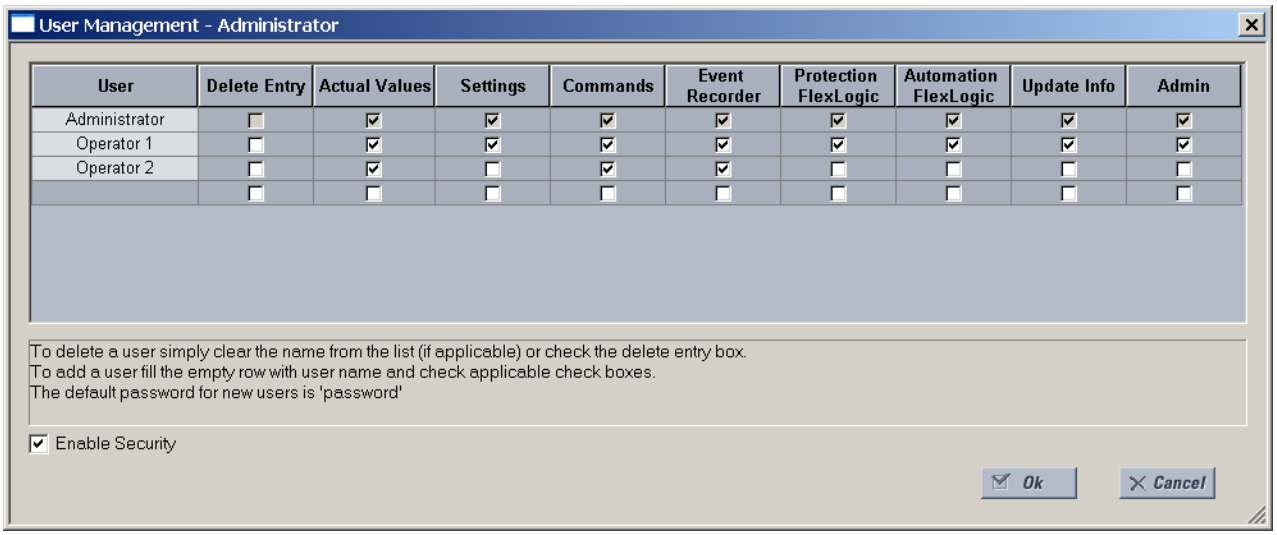
4. Click **OK** to add the new user to the security management system.

Modifying user privileges

The following procedure describes how to modify user privileges in the security management system. The following pre-requisites are required to add new users.

- The user modifying the privileges must have administrator rights
- The EnerVista security management system must be enabled

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



2. Locate the username in the **User** field.
3. Modify the user access rights by checking or clearing one or more of the fields shown.

Field	Description
Delete Entry	Checking this box deletes the user account when exiting the user management configuration window.
Actual Values	Checking this box allows the user to read actual values
Settings	Checking this box allows the user to read setting values
Commands	Checking this box allows the user to execute commands
Event Recorder	Checking this box allows the user to use the digital fault recorder
Protection FlexLogic	Checking this box allows the user to read protection FlexLogic values
Automation Logic	Checking this box allows the user to read automation logic values
Update Info	Checking this box allows the user to write to any function to which they have read privileges. When any of the **Settings**, **Event Recorder**, **Protection FlexLogic**, and **Automation Logic** boxes are checked by themselves, the user is granted read access. When any of these are checked 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 checked, even if the **Update Info** field is checked.
Admin	When this box is checked, the user becomes an EnerVista UR^{Plus} Setup administrator, therefore receiving all of the administrative rights. Exercise caution when granting administrator rights.

4. Click **OK** to save the changes to user to the security management system.

C90Plus Controller

Chapter 14: Testing

This section outlines the C90Plus testing features.

Test mode

The C90Plus provides test settings to verify that functionality using simulated conditions for contact inputs and outputs. To initiate the test mode, the **Test Mode Function** setting must be "Enabled" and the operand assigned to the **Test Mode Initiate** setting must be set to logic 1.

In particular, the test mode is initiated as follows:

- To initiate test mode through the C90Plus settings, set the **Test Mode Initiate** to "ON". The test mode starts when the **Test Mode Function** setting is changed from "Disabled" to "Enabled".
- To initiate test mode through a user-programmable condition, such as FlexLogic operand, set the **Test Mode Function** setting to "Enabled" and the **Test Mode Initiate** to the desired operand. The test mode starts when the selected operand assumes a logic 1 state.

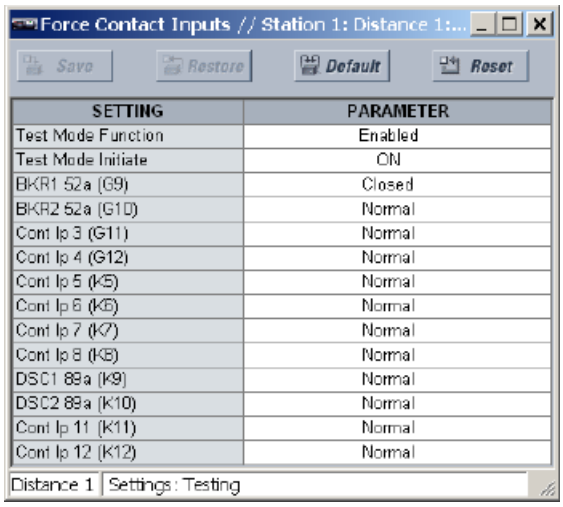
When in the test mode, the C90Plus remains fully operational, allowing for various testing procedures. The only difference between the normal operation and the test mode is the behavior of the input and output contacts. The former can be forced to report as open or closed or remain fully operational; the latter can be forced to open, close, freeze, or remain fully operational. The response of the digital input and output contacts to the test mode is programmed individually for each input and output using the force contact inputs and force contact outputs test functions described in the following sections.

Force contact inputs

The force contact inputs feature provides a method of performing checks on the function of all contact inputs. Once enabled, the C90Plus is placed into test mode, allowing this feature to override the normal function of contact inputs. All contact input operations return to normal when all settings for this feature are disabled.

Select the **Settings > Testing > Force Contact Inputs** menu item to open the force contact inputs configuration window.

Figure 1: Force contact inputs configuration settings



The following settings are available.

Test Mode Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disabled the test mode functionality.

Test Mode Initiate

Range: any FlexLogic operand
Default: ON

The test mode will initiate when the operand assigned to this setting is logic 1.

Cont Ip 1, Cont Ip 2, ..., Cont Ip 12

Range: Normal, Open, Closed
Default: Normal

These settings allow the C90^{Plus} contact inputs to respond to the test mode 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. This value should be selected if a given input must be operational during the test. This includes, for example, an input initiating the test, or being a part of a user pre-programmed test sequence.
- If set to "Open", the input is forced to report as opened (logic 0) for the entire duration of the test mode regardless of the voltage across the input terminals.
- If set to "Closed", the input is forced to report as closed (logic 1) for the entire duration of the test mode regardless of the voltage across the input terminals.

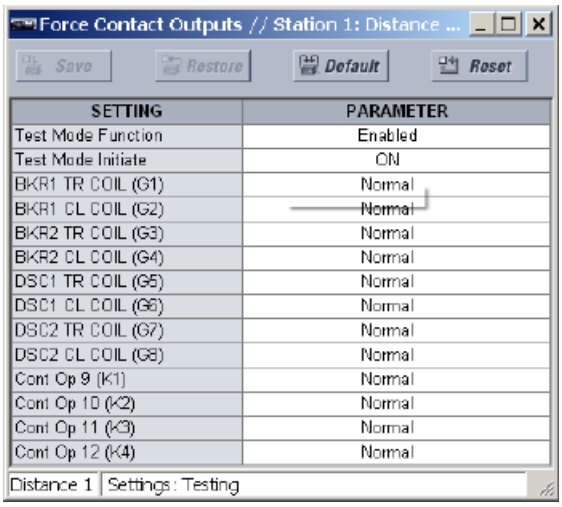
These setting names reflect the programmed contact input names.

Force contact outputs

The force contact output feature allows relay contact outputs to be pre-programmed to respond to the test mode. These settings are applied two ways. First, external circuits can be tested by energizing or de-energizing contacts. Second, by controlling the output contact state, relay logic can be tested and undesirable effects on external circuits avoided.

Select the **Settings > Testing > Force Contact Outputs** menu item to open the force contact outputs configuration window.

Figure 2: Force contact outputs configuration settings



The following settings are available.

Test Mode Function

Range: Enabled, Disabled
Default: Disabled

This setting enables and disabled the test mode functionality.

Test Mode Initiate

Range: any FlexLogic operand
Default: ON

The test mode initiates when the operand assigned to this setting is logic 1.

Cont Op 1, Cont Op 2, ..., Cont Op 12

Range: Normal, Energized, De-energized, Freeze
Default: Normal

These settings allow the C90^{Plus} contact outputs to respond to the test mode 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 for the entire duration of the test mode, regardless of the status of the operand configured to control the output contact
- If set to "De-energized", the output opens and remain open for the entire duration of the test mode regardless of the status of the operand configured to control the output contact
- If set to "Freeze", the output retains its position from before entering the test mode, regardless of the status of the operand configured to control the output contact

These setting names reflect the programmed contact output names.

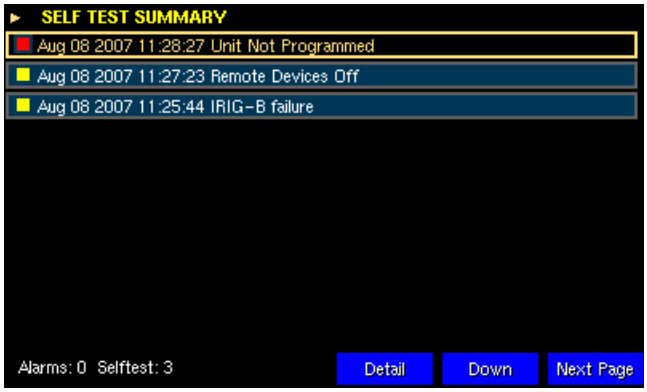
Self-tests

The C90^{Plus} performs a number of self-test diagnostic checks to ensure device integrity. When a self-test error occurs, an item displays in the self-test summary on the annunciator. All errors record an event in the event recorder.

Self-test error messages

The self-test error messages are displayed on the annunciator panel. Error messages can be accessed from the self-test tab. The self-test tab becomes illuminates when there are errors to report.

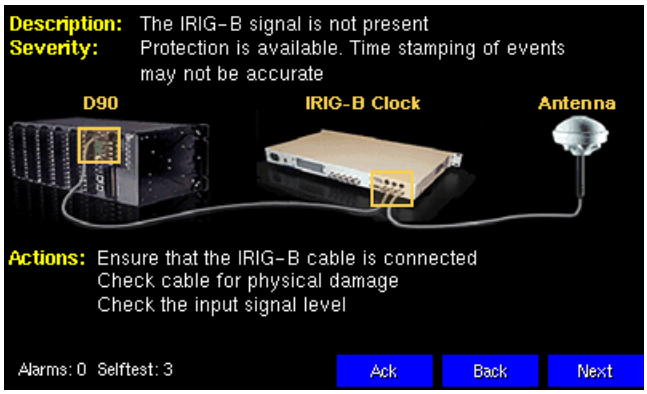
Figure 3: Typical self-test error page



There are three soft-keys associated with the self-test summary page.

- The **Next Page** soft-key cycles through the pages of alarms and to the error messages page. If there are more errors present than can be displayed, scroll bars appear to notify the user to scroll beyond the screen to view more error messages.
- The **Down** soft-key allows user to cycle through the self-test error messages from top to bottom. A white frame borders the selected self-test error message.
- The **Detail** soft-key displays additional details of the selected error message. A definition of problem, a graphical indication, and some possible solutions are displayed. The following figures shows the details about the IRIG-B FAILURE self-test error message.

Figure 4: IRIG-B failure message details



Self-test errors are classed as minor errors and major errors. The major self-test error messages are indicated in red on the annunciator display and are described as follows.

AC SLOT F FIRMWARE MISMATCH
AC SLOT J FIRMWARE MISMATCH

Description: There a firmware mismatch between the AC card in the indicated slot and the CPU.

Severity: Protection is not available, and relay is not operational.

If either of these messages appear, contact GE Digital Energy.

AC SLOT F NOT CALIBRATED
AC SLOT J NOT CALIBRATED

Description: The AC module in the indicated slot is not properly calibrated.

Severity: Device is temporarily out-of-service.

If either of these messages appear, first reset the alarm. If the alarm recurs, contact GE Digital Energy.

AC SLOT F TROUBLE
AC SLOT J TROUBLE

Description: The AC module in the indicated slot is not operational.

Severity: Device is temporarily out-of-service.

If either of these messages appear, first reset the alarm. If the alarm recurs, contact GE Digital Energy.

AUTOMATION LOGIC ERROR

Description: There is an error within an automation logic equation.

Severity: Protection is not available, and relay is not operational.

If this message appears, modify the automation logic to make it valid and reload.

CPU CARD TROUBLE

Description: The CPU module in the indicated slot is not operational.

Severity: Device is temporarily out-of-service

If this message appears, reset the alarm. If the alarm recurs, contact GE Digital Energy.

EXTERNAL IO 1 COMMUNICATIONS FAILURE
EXTERNAL IO 2 COMMUNICATIONS FAILURE

Description: A communications error has been encountered on the external input/output device.

Severity: Protection is not available.

If this message appears, check all external input/output modules against the order code. Ensure they are connected properly, then recycle the control power.

EXTERNAL IO 1 EQUIPMENT MISMATCH
EXTERNAL IO 2 EQUIPMENT MISMATCH

Description: The configuration of external input/output equipment does not match the order code stored in the CPU.

Severity: Protection is not available.

If this message appears, check all external input/output modules against the order code. Ensure they are connected properly, then recycle the control power.

EQUIPMENT MISMATCH

Description: The configuration of modules does not match the order code stored in the CPU.

Severity: Protection is not available.

If this message appears, check all modules against the order code. Ensure they are inserted properly, then recycle the control power.

IO SLOT E FIRMWARE MISMATCH
IO SLOT F FIRMWARE MISMATCH
IO SLOT G FIRMWARE MISMATCH
IO SLOT H FIRMWARE MISMATCH
IO SLOT J FIRMWARE MISMATCH
IO SLOT K FIRMWARE MISMATCH

Description: There a firmware mismatch between the input/output card in the indicated slot and the CPU.

Severity: Protection is not available, and relay is not operational.

If any of these messages appear, contact GE Digital Energy.

IO SLOT E NOT CALIBRATED
IO SLOT F NOT CALIBRATED
IO SLOT G NOT CALIBRATED
IO SLOT H NOT CALIBRATED
IO SLOT J NOT CALIBRATED
IO SLOT K NOT CALIBRATED

Description: The input/output module in the indicated slot is not properly calibrated.

Severity: Device is temporarily out-of-service.

If any of these messages appear, first reset the alarm. If the alarm recurs, contact GE Digital Energy.

IO SLOT E TROUBLE
IO SLOT F TROUBLE
IO SLOT G TROUBLE
IO SLOT H TROUBLE
IO SLOT J TROUBLE
IO SLOT K TROUBLE

Description: An input/output module in the indicated slot is not operational.

Severity: Device is temporarily out-of-service.

If any of these messages appear, first reset the alarm. If the alarm recurs, contact GE Digital Energy.

PROTECTION LOGIC ERROR

Description: There is an error within a protection FlexLogic equation.

Severity: Protection is not available, and relay is not operational.

If this message appears, modify the protection FlexLogic to make it valid and reload.

SETTINGS FILE ERROR

Description: The device contains invalid setting values.

Severity: Protection is not available.

If this message appears after an order code update or firmware upgrade, clear the message and load settings into the C90^{Plus}. In all other cases, contact GE Digital Energy.

SLOT B FIRMWARE MISMATCH
SLOT C FIRMWARE MISMATCH

Description: There a firmware mismatch between the card in the indicated slot and the CPU.

Severity: Protection is not available, and relay is not operational.

If either of these messages appear, contact GE Digital Energy.

SLOT B TROUBLE
SLOT C TROUBLE

Description: The module in the indicated slot is not operational.
Severity: Device is temporarily out-of-service.

If either of these messages appear, first reset the alarm. If the alarm recurs, contact GE Digital Energy.

SYSTEM EXCEPTION

Description: An internal error has occurred.
Severity: Device is temporarily out-of-service

If this message appears, reset the alarm. If the alarm recurs, contact GE Digital Energy for further instructions.

UNIT NOT PROGRAMMED

Description: The unit is configured as not programmed.
Severity: Protection is not available

If this message appears, confirm that the unit has the proper settings. Change the Relay Settings value to "Programmed".

The minor self-test error messages are indicated in yellow on the annunciator display and are described as follows.

AC SLOT F HIGH TEMP
AC SLOT J HIGH TEMP

Description: The ambient temperature is outside the specifications for the AC card in the indicated slot.
Severity: Relay remains operational.

If this message appears, ensure proper ventilation is provided.

CH 1 DIRECT DEVICE OFF
CH 2 DIRECT DEVICE OFF

Description: A direct device is specified in the configuration but is not connected to the network. This self-test should occur within 2 seconds of disconnecting the device.
Severity: Protection is available. Direct input/output messaging with the offline device is not available.

If this message appears, check that all devices that are connected to the direct input/output network are properly configured. Check the direct input/output wiring.

CH 1 DIRECT RING BREAK
CH 2 DIRECT RING BREAK

Description: The direct input/output settings are configured for a ring, but the connection is not in a ring. This self-test is asserted approximately 2 seconds after a disconnection occurs in a ring configuration.
Severity: Protection and direct input/output messaging is available. However, there is no redundant path available.

If this message appears, check the direct input/output configuration and wiring.

COMMUNICATION CARD TROUBLE

Description: An error has been encountered on the communications module.
Severity: Protection is available.

If this message appears, update the order code to clear the self-test error.

COMM HIGH TRAFFIC

Description: The C90^{Plus} is actively limiting IP bandwidth usage.
Severity: Protection is available.

This message indicates that the C90^{Plus} is actively limiting bandwidth usage in one or more Ethernet ports through the network filtering settings.

DELAYED AUTOMATION EXECUTION

Description: Execution of the automation logic is longer than specified.

Severity: Protection is available. Automation logic may not produce expected results.

If this message appears, review the automation logic to confirm correct programming. Move less critical tasks to an automation block with a slower scan.

FILE SYSTEM TROUBLE

Description: System files are missing on the flash disk during the boot process or files are deleted or modified after the system was booted.

Severity: Protection is available.

If this message appears, repeat the firmware upgrade process.

FRONT PANEL MISMATCH

Description: The order code does not match the front panel type.

Severity: Protection is available.

If this message appears, update the order code to clear the self-test error.

FRONT PANEL TROUBLE

Description: An error has been encountered on the front panel.

Severity: Protection is available.

If this message appears, update the order code to clear the self-test error.

HIGH TEMPERATURE

Description: The ambient temperature is outside the specifications.

Severity: Relay remains operational.

If this message appears, ensure proper ventilation is provided.

IR CH 1 FAIL
IR CH 2 FAIL

Description: These self-tests are caused by any one of the following: low Rx power (fiber option only), loss of signal alarm for fiber and G.703 options or RS422 clock problem (no clock or incorrect clock), yellow bit alarm (C37.94 option only), optical transceiver SPI interface failure (fiber option only), or Tx Fault (transmitter failure, monitored by the transceiver).

Severity: Protection is available. Timestamping of events can be inaccurate.

If either of these messages appear, check the inter-relay communications wiring. If the failure persists, then contact the factory.

IRIG-B FAILURE

Description: The IRIG-B input signal is not present.

Severity: Protection is available. Timestamping of events may not be accurate.

If this message appears, ensure that the IRIG-B receiver is operational and properly configured. Ensure that the IRIG-B cable is connected. Check cable integrity (that is, look for physical damage or perform a continuity test). Check the input signal level.

NON-VOLATILE DATA LOST

Description: Non-volatile data was lost.

Severity: Protection is available; however, some data loss may be encountered.

If this message appears, check all logs for lost or corrupt data. This includes the event recorder, transient recorder, fault reports, disturbance recorder, data logger, and phasor measurement unit recorder.

OVERFLOW RESULT

Description: An overflow error has occurred during automation logic execution.

Severity: Automation logic execution is not suspended, and protection is still available.

Automation logic implements saturated arithmetic operations. An operation resulted in a saturated result while running automation logic. Execution continues with the saturated result. Analyze and correct the automation logic equations.

POWER SUPPLY TROUBLE

Description: The power supply module has a problem.

Severity: Protection is available; however, power supply failure can occur. The 48 volt supply can also be impacted.

If this message appears, check that the voltage at the power supply input is within limits. If acceptable, check that the 48 volt supply is healthy. If not acceptable, contact GE Digital Energy.

REMOTE DEVICES OFF

Description: A remote device is specified in the configuration for GOOSE messaging but is not connected to the network.

Severity: Protection is available. GOOSE messaging with the offline device is not available.

If this message appears, check that all devices that are specified for GOOSE messaging are connected to the network, are functioning properly, and are correctly configured.

SNTP ERROR FAILURE

Description: The SNTP server is not responding.

Severity: Protection is available. Timestamping of events can be inaccurate.

If this message appears, check that the SNTP server is operational and correctly configured. Check for Ethernet LAN problems.

UNDEFINED RESULT

Description: An error has occurred during automation logic execution.

Severity: Automation logic execution is not suspended, and protection is still available.

Analyze and correct the automation logic equations.

Self-test logic operands

The following self-test logic operands are available for the C90^{Plus}. They are listed alphabetically by operand syntax.

Self-test error logic operands

AC SLOT F HIGH TEMP ..... Asserted when the AC SLOT F HIGH TEMP self-test error message is issued.

AC SLOT F TROUBLE ..... Asserted when the AC SLOT F TROUBLE self-test error message is issued.

AC SLOT J FMW MSMTCH ..... Asserted when the AC SLOT J FIRMWARE MISMATCH self-test error message is issued.

AC SLOT J HIGH TEMP ..... Asserted when the AC SLOT J HIGH TEMP self-test error message is issued.

AC SLOT J NOT CAL ..... Asserted when the AC SLOT J NOT CALIBRATED self-test error message is issued.

AC SLOT J TROUBLE ..... Asserted when the AC SLOT J TROUBLE self-test error message is issued.

ANY MAJOR ERROR ..... Asserted when any major self-test error message is issued.

ANY MINOR ERROR ..... Asserted when any minor self-test error message is issued.

AUTOMATION LOGIC ERR ..... Asserted when the AUTOMATION LOGIC ERROR self-test error message is issued.

CH1 DIR IO RING BRK..... Asserted when the CH1 DIRECT IO RING BREAK self-test error message is issued.

CH2 DIR IO RING BRK..... Asserted when the CH2 DIRECT IO RING BREAK self-test error message is issued.

CPU CARD TROUBLE..... Asserted when the CPU CARD TROUBLE self-test error message is issued.

DELAYED AUTOMATION..... Asserted when the DELAYED AUTOMATION self-test error message is issued.

EQUIPMENT MISMATCH..... Asserted when the EQUIPMENT MISMATCH self-test error message is issued.

FILE SYSTEM TROUBLE ..... Asserted when the FILE SYSTEM TROUBLE self-test error message is issued.

FRONT PANEL MISMATCH..... Asserted when the FRONT PANEL MISMATCH self-test error message is issued.

HIGH TEMPERATURE..... Asserted when the HIGH TEMPERATURE self-test error message is issued.

IO SLOT E FMW MSMTCH..... Asserted when the IO SLOT E FIRMWARE MISMATCH self-test error message is issued.

IO SLOT E NOT CAL..... Asserted when the IO SLOT E NOT CALIBRATED self-test error message is issued.

IO SLOT E TROUBLE..... Asserted when the IO SLOT E TROUBLE self-test error message is issued.

IO SLOT F FMW MSMTCH..... Asserted when the IO SLOT F FIRMWARE MISMATCH self-test error message is issued.

IO SLOT F NOT CAL..... Asserted when the IO SLOT F NOT CALIBRATED self-test error message is issued.

IO SLOT F TROUBLE..... Asserted when the IO SLOT F TROUBLE self-test error message is issued.

IO SLOT G FMW MSMTCH..... Asserted when the IO SLOT G FIRMWARE MISMATCH self-test error message is issued.

IO SLOT G NOT CAL..... Asserted when the IO SLOT G NOT CALIBRATED self-test error message is issued.

IO SLOT G TROUBLE..... Asserted when the IO SLOT G TROUBLE self-test error message is issued.

IO SLOT H FMW MSMTCH..... Asserted when the IO SLOT H FIRMWARE MISMATCH self-test error message is issued.

IO SLOT H NOT CAL..... Asserted when the IO SLOT H NOT CALIBRATED self-test error message is issued.

IO SLOT H TROUBLE..... Asserted when the IO SLOT H TROUBLE self-test error message is issued.

IO SLOT K FMW MSMTCH..... Asserted when the IO SLOT K FIRMWARE MISMATCH self-test error message is issued.

IO SLOT K NOT CAL..... Asserted when the IO SLOT K NOT CALIBRATED self-test error message is issued.

IO SLOT K TROUBLE..... Asserted when the IO SLOT K TROUBLE self-test error message is issued.

OVERFLOW RESULT..... Asserted when the OVERFLOW RESULT self-test error message is issued.

PROTECTION LOGIC ERR..... Asserted when the PROTECTION LOGIC ERROR self-test error message is issued.

REMOTE DEVICES OFF..... Asserted when the REMOTE DEVICES OFF self-test error message is issued.

SETTINGS ERR ..... Asserted when the SETTINGS ERROR self-test error message is issued.

SLOT B TROUBLE ..... Asserted when the SLOT B TROUBLE self-test error message is issued.

C90Plus Controller

Chapter 15: Appendix

This section includes the warranty statement and information about the document changes.

Warranty statement

General Electric Multilin Inc. (GE Multilin) warrants each relay it manufactures to be free from defects in material and workmanship under normal use and service for a period of 24 months from date of shipment from factory.

In the event of a failure covered by warranty, GE Multilin will undertake to repair or replace the relay providing the warrantor determined that it is defective and it is returned with all transportation charges prepaid to an authorized service centre or the factory. Repairs or replacement under warranty will be made without charge.

Warranty shall not apply to any relay which has been subject to misuse, negligence, accident, incorrect installation or use not in accordance with instructions nor any unit that has been altered outside a GE Multilin authorized factory outlet.

GE Multilin is not liable for special, indirect or consequential damages or for loss of profit or for expenses sustained as a result of a relay malfunction, incorrect application or adjustment.

For complete text of Warranty (including limitations and disclaimers), refer to GE Multilin Standard Conditions of Sale.

Revision history

The tables outline the releases and major changes to this C90Plus manual.

Table 1: Revision history

Publication number	Part number	Firmware	Release date	ECO
GEK-113252	--	1.5x	19 December 2007	---
GEK-113255	1601-9039-C1	1.6x	28 November 2008	08-0718
GEK-113255B	1601-9039-C2	1.6x	9 August 2012	12-3460
GEK-113238	1601-9039-D1	1.7x	30 January 2010	09-1486
GEK-113238B	1601-9039-D2	1.7x	9 August 2012	12-3460
GEK-113246	1601-9039-E1	1.8x	30 September 2010	10-2015
GEK-113246B	1601-9039-E2	1.8x	9 August 2012	12-3460
GEK-113466	1601-9039-F1	1.9x	30 April 2013	13-0104

Table 2: Major updates for version F1

Page	Change
--	General editing
--	Added Parallel Redundancy Protocol (PRP), including to the order code table and Communications > Network > Ethernet section
10	Added support for Windows 7 (64-bit), and Server 2008 (64-bit)
242	Updated Low Frequency and High Frequency ranges from "0.1 to 1.0 Hz in steps of 0.1" to "0.08 to 1.00 Hz in steps of 0.02"

C90Plus Controller

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