GE
Grid Solutions

845

Transformer Protection System

Transformer Protection, Control and Management

Instruction manual

Product version: 2.4x
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RoHS Compliant

WORLDWIDE 10 YEAR WARRANTY

REGISTERED ISO 9001 GE MULTILIN

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GE Multilin 845 Transformer Protection System instruction manual for revision 2.4x.

Part number: 1601-0651-AA (May 2019)

NOTICE

May contain components with FCC ID: XF6-RS9110N1122 and IC ID: 8407A-RS9110N1122.

Table of Contents

4.ABOUT SETPOINTS

5.DEVICE, SYSTEM, INPUT AND OUTPUT SETPOINTS

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845 Transformer Protection System

Chapter 1: Introduction

The Multilin 845 relay is a microprocessor-based unit intended for the management and primary protection of the medium to large size medium voltage (MV) and high voltage (HV) power transformers. Both 2-winding and 3-winding transformers are supported. The 845 relay provides a number of primary and backup current and voltage based protection functions. This system allows for control of the circuit breakers at each winding plus a number of monitoring and control functions are also provided.

Overview

Each relay provides protection, control, and monitoring functions with both local and remote human interfaces. They also display the present trip/alarm conditions, and most of the more than 35 measured system parameters. Recording of past trip, alarm or control events, maximum demand levels, and energy consumption is also performed.

These relays contain many innovative features. To meet diverse utility standards and industry requirements, these features have the flexibility to be programmed to meet specific user needs. This flexibility will naturally make a piece of equipment difficult to learn. To aid new users in getting basic protection operating quickly, setpoints are set to typical default values and advanced features are disabled. These settings can be reprogrammed at any time.

Programming can be accomplished with the front panel keys and display. Due to the numerous settings, this manual method can be somewhat laborious. To simplify programming and provide a more intuitive interface, setpoints can be entered with a PC running the EnerVista 8 Setup software provided with the relay. Even with minimal computer knowledge, this menu-driven software provides easy access to all front panel functions. Actual values and setpoints can be displayed, altered, stored, and printed. If settings are stored in a setpoint file, they can be downloaded at any time to the front panel program port of the relay via a computer cable connected to the USB port of any personal computer.

A summary of the available functions and a single-line diagram of protection and control features is shown below. For a complete understanding of each feature operation, refer to Chapter 4: About Setpoints, and to the detailed feature descriptions in the Chapter that follow. The logic diagrams include a reference to every setpoint related to a feature and show all logic signals passed between individual features. Information related to the selection of settings for each setpoint is also provided.

Description of the 845 Transformer Protection Relay

CPU

Relay functions are controlled by two processors: a Freescale MPC5125 32-bit microprocessor that measures all analog signals and digital inputs and controls all output relays, and a Freescale MPC8358 32-bit microprocessor that controls all the advanced Ethernet communication protocols.

Analog Input and Waveform Capture

Magnetic transformers are used to scale-down the incoming analog signals from the source instrument transformers. The analog signals are then passed through a 11.5 kHz low pass analog anti-aliasing filter. All signals are then simultaneously captured by sample and hold buffers to ensure there are no phase shifts. The signals are converted to digital values by a 16-bit A/D converter before finally being passed on to the CPU for analysis.

The 'raw' samples are scaled in software, then placed into the waveform capture buffer, thus emulating a fault recorder. The waveforms can be retrieved from the relay via the EnerVista 8 Series Setup software for display and diagnostics.

Frequency

Frequency measurement is accomplished by measuring the time between zero crossings of the composite signal of three-phase bus voltages, line voltage or three-phase currents. The signals are passed through a low pass filter to prevent false zero crossings. Frequency tracking utilizes the measured frequency to set the sampling rate for current and voltage which results in better accuracy for the Discrete Fourier Transform (DFT) algorithm for off-nominal frequencies.

The main frequency tracking source uses three-phase bus voltages. The frequency tracking is switched automatically by an algorithm to the alternative reference source, i.e., three-phase currents signal or line voltage for the configuration of tie-breaker, if the frequency detected from the three-phase voltage inputs is declared invalid. The switching will not be performed if the frequency from the alternative reference signal is detected invalid. Upon detecting valid frequency on the main source, the tracking will be switched back to the main source. If a stable frequency signal is not available from all sources, then the tracking frequency defaults to the nominal system frequency.

Phasors, Transients, and Harmonics

All waveforms are processed eight times every cycle with a DC decaying removal filter and a Discrete Fourier Transform (DFT). The resulting phasors have fault current transients and all harmonics removed. This results in an overcurrent relay that is extremely secure and reliable and one that will not overreach.

Processing of AC Current Inputs

The DC Decaying Removal Filter is a short window digital filter, which removes the DC decaying component from the asymmetrical current present at the moment a fault occurs. This is done for all current signals used for overcurrent protection; voltage signals use the same DC Decaying Removal Filter. This filter ensures no overreach of the overcurrent protection.

The Discrete Fourier Transform (DFT) uses exactly one cycle of samples to calculate a phasor quantity which represents the signal at the fundamental frequency; all harmonic components are removed. All subsequent calculations (e.g. power, etc.) are based upon the current and voltage phasors, such that the resulting values have no harmonic components. RMS (root mean square) values are calculated from one cycle of samples prior to filtering.

Protection Elements

All voltage, current and frequency protection elements are processed eight times every cycle to determine if a pickup has occurred or a timer has expired. The voltage and current protection elements use RMS current/voltage, or the magnitude of the phasor.

Figure 1-1: Single Line Diagram

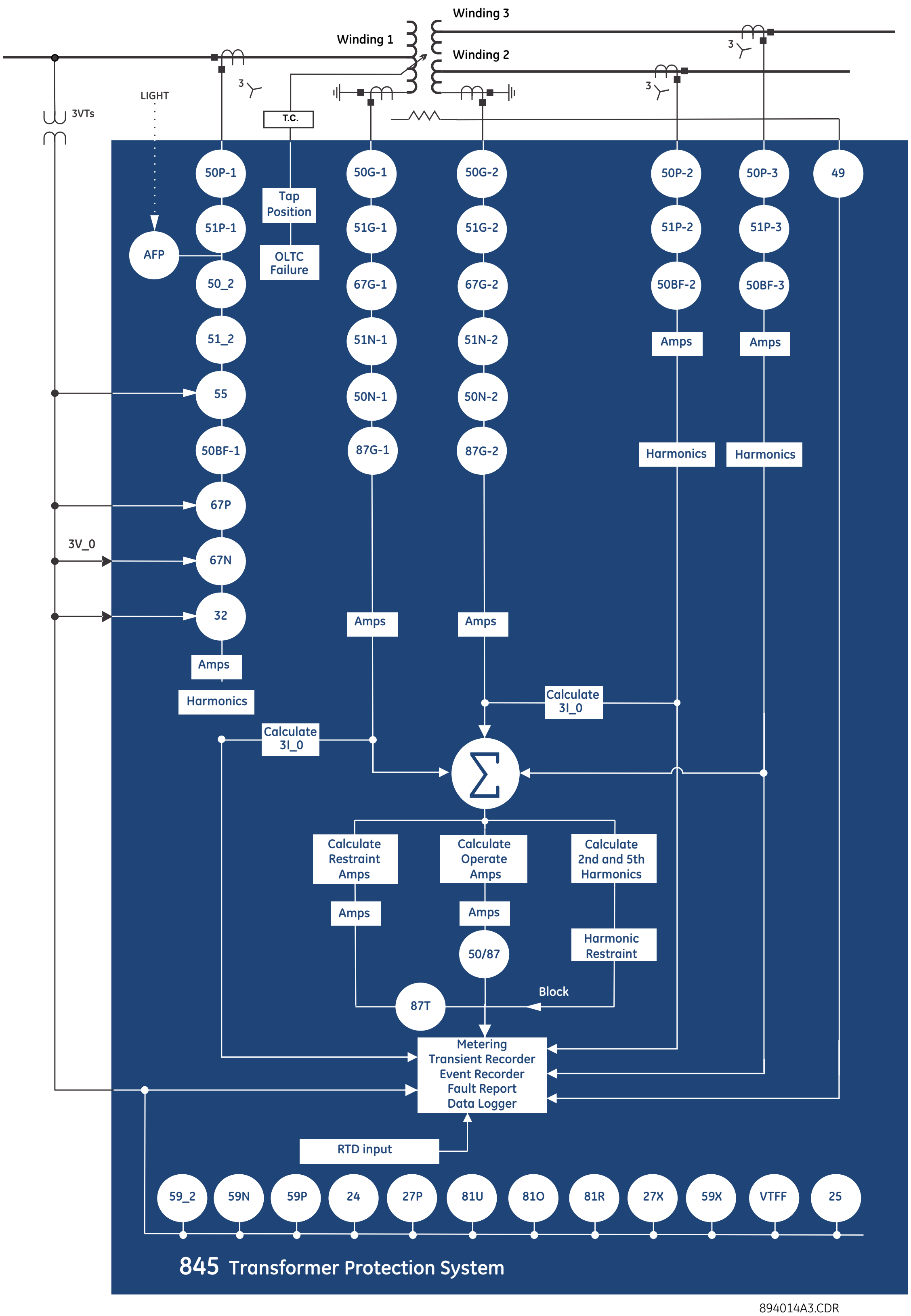

Table 1-1: ANSI Device Numbers and Functions

ANSI Device	Description
24	Volts per Hertz
25	Synchrocheck
27P	Phase Undervoltage
27X	Auxiliary Undervoltage
32	Directional Power
49	Hottest Spot Temperature
	Aging Factor
	Loss of Life
50/87	Instantaneous Differential Overcurrent
50BF	Breaker Failure
50G	Ground Instantaneous Overcurrent
50N	Neutral Instantaneous Overcurrent
50P	Phase Instantaneous Overcurrent
50_2	Negative Sequence Instantaneous Overcurrent
51G	Ground Time Overcurrent
51N	Neutral Time Overcurrent
51P	Phase Time Overcurrent
51_2	Negative Sequence Time Overcurrent
55	Power Factor
59N	Neutral Overvoltage
59P	Phase Overvoltage
59X	Auxiliary Overvoltage
59_2	Negative Sequence Overvoltage
67G	Ground Directional Element
67N	Neutral Directional Element
67P	Phase Directional Element
81O	Overfrequency
81U	Underfrequency
81R	Frequency Rate of Change
87G	Restricted Ground Fault (RGF)
87T	Transformer Differential
AFP	Arc Flash Protection
VTFF	Voltage Transformer Fuse Failure

Table 1-2: Other Device Functions

Description
Analog Input
Analog Output
Breaker Arcing Current (I^2t)
Breaker Control
Breaker Health
Data Logger
Demand
Digital Counters
Event Recorder
Fault Report
FlexElements
FlexLogic Equations
Flex States
IEC 61850 Communications
Metering: current, voltage, power, PF, energy, frequency, harmonics, THD
Modbus User Map
Non-volatile Latches
OPC-UA Communications
Output Relays
Setpoint Groups (6)
Transformer Dissolved Gas Analysis
Transformer Energization Reports
Transformer Integrated Fault Report
Transformer Overload
Transformer Loss of Life
Trip Bus (6)
Transient Recorder (Oscillography)
Trip and Close Coil Monitoring
User-programmable LEDs
User-programmable Pushbuttons
Virtual Inputs (32)
Virtual Outputs (32)

Figure 1-2: Main Menu Hierarchy

Security Overview

The following security features are available:

BASIC SECURITY

The basic security feature is present in the default offering of the 845 relay. The 845 introduces the notion of roles for different levels of authority. Roles are used as login names with associated passwords stored on the device. The following roles are available at present: Administrator, Operator, Factory and Observer, with a fixed permission structure for each one. Note that the Factory role is not available for users, but strictly used in the manufacturing process.

The 845 can still use the Setpoint access switch feature, but enabling the feature can be done only by an Administrator. Setpoint access is controlled by a keyed switch to offer some minimal notion of security.

CYBERSENTRY

The CyberSentry Embedded Security feature is a software option that provides advanced security services. When the software option is purchased, the Basic Security is automatically disabled.

CyberSentry provides security through the following features:

- An Authentication, Authorization, Accounting (AAA) Remote Authentication Dial-In User Service (RADIUS) client that is centrally managed, enables user attribution, and uses secure standards based strong cryptography for authentication and credential protection.
- A Role-Based Access Control (RBAC) system that provides a permission model that allows access to 845 device operations and configurations based on specific roles and individual user accounts configured on the AAA server. At present the defined roles are: Administrator, Operator and Observer.
- Strong encryption of all access and configuration network messages between the EnerVista software and 845 devices using the Secure Shell (SSH) protocol, the Advanced Encryption Standard (AES), and 128-bit keys in Galois Counter Mode (GCM) as specified in the U.S. National Security Agency Suite B extension for SSH and approved by the National Institute of Standards and Technology (NIST) FIPS-140-2 standards for cryptographic systems.
- Security event reporting through the Syslog protocol for supporting Security Information Event Management (SIEM) systems for centralized cyber security monitoring.

There are two types of authentication supported by CyberSentry that can be used to access the 845 device:

- Device Authentication – in which case the authentication is performed on the 845 device itself, using the predefined roles as users (No RADIUS involvement).
  - 845 authentication using local roles may be done either from the front panel or through EnerVista.
- Server Authentication - in which case the authentication is done on a RADIUS server, using individual user accounts defined on the server. When the user accounts are created, they are assigned to one of the predefined roles recognized by the 845
  - 845 authentication using RADIUS server may be done only through EnerVista.

NOTICE

WiFi and USB do not currently support CyberSentry security. For this reason WiFi is disabled by default if the CyberSentry option is purchased. WiFi can be enabled, but be aware that doing so violates the security and compliance model that CyberSentry is supposed to provide.

NOTICE

Enervista Viewpoint Monitor does not currently support CyberSentry security.

When both 845 device and server authentication are enabled, the 845 automatically directs authentication requests to the 845 device or the respective RADIUS server, based on user names. If the user ID credential does not match one of the device local accounts, the 845 automatically forwards the request to a RADIUS server when one is provided. If a RADIUS server is provided, but is unreachable over the network, server authentication requests are denied. In this situation, use local 845 device accounts to gain access to the 845 system.

USER ROLES

User Access Levels are used to grant varying permissions to specific user roles. User roles are used by both Basic Security and CyberSentry.

The following user roles are supported:

- **Administrator**: The Administrator role has complete read and write access to all settings and commands. The role does not allow concurrent access. The Administrator role also has an operand to indicate when it is logged on.
- **Operator**: The Operator role is present to facilitate operational actions that may be programmed and assigned to buttons on the front panel. The Operator has read/write access to all settings under the command menu/section. The Operator can also use the Virtual Input command under the control menu/section. The Operator can view settings from EnerVista or the front panel but does not have the ability to change any settings. This role is not a concurrent role.
- **Observer**: The Observer role has read-only access to all 845 settings. This role allows concurrent access. The Observer is the default role if no authentication has been done to the device. This role can download settings files and records from the device.
- **Factory**: This is an internal non-user accessible role used for manufacturing diagnostics. The ability to enable or disable this role is a security setting that the Administrator controls.

GENERAL RULES FOR USER ROLES WITH CYBERSENTRY

1. The only concurrent role is Observer. If the user is logged in through serial, front panel, or over the network, that counts as the role being logged in for concurrency reasons.
2. Both EnerVista and the front panel provide a one-step logoff. For the front panel, the root menu has a logoff command. From EnerVista right-clicking on a device and providing a logoff function from the context menu is sufficient.
3. The EnerVista Login Screen has “User Name:” and “Password:” fields for the default remote (Radius) authentication, but when a “Local Authentication” checkbox is selected the “User Name:” field changes to a drop down menu where the user can select one of the predefined roles on the 845.

845 Order Codes

NOTE

Support of some of the features described in the "Setpoints" section are order code dependent. Each 8 Series unit is ordered with a number of required and optional modules. Each of these modules can be supplied in a number of configurations specified at the time of ordering.

NOTE

Not all order code combinations are possible. Refer to http://store.gegridsolutions.com/ViewProduct.aspx?Model=845 for available order code combinations.

The information to specify an 845 relay is provided in the following Order Code figure:

Figure 1-3: 845 Order Codes

	845 – E ** ** ** * * * * * * * * * * * * * * * * N	845 Transformer Protection System
Application	E	Standard
Phase Currents —Slot J	P1	1A three-phase current inputs (J1), voltage (J2)
	P5	5A three-phase current inputs (J1), voltage (J2)
Phase Currents —Slot K	H1	1A three-phase inputs (K1) - two windings with voltage
	H5	5A three-phase inputs (K1) - two windings with voltage
	R1	1A three-phase inputs (K1), 1A three-phase inputs (K2) - three windings with voltage
	R5	5A three-phase inputs (K1), 5A three-phase inputs (K2) - three windings with voltage
Ground Currents	G1	1A ground input (1 per phase current bank)
	G5	5A ground inputs (1 per phase current bank)
Power Supply	H	110 to 250 V DC/110 to 230 V AC
	L	24 to 48 V DC
Slot B	N	None
	R	6 X RTDS (Pt100, Ni100, Ni120)
	S	6 X RTDS (Pt100, Ni100, Ni120, Cu10)
Slot C	N	None
	R	6 X RTDS (Pt100, Ni100, Ni120)
	S	6 X RTDS (Pt100, Ni100, Ni120, Cu10)
Slot F	A	2 Form A (Vmon) Relays, 2 Form C Relays, 1 Critical Failure Relay, 7 Digital Inputs (Int/Ext Supply)
	M	4 SSR (High-Speed, High-Break), 1 Critical Failure Relay, 7 Digital Inputs (Int/Ext supply)
Slot G	N	None
	A	2 Form A (Vmon) Relays, 3 Form C Relays, 7 Digital Inputs (Int/Ext Supply)
	L	7 DcmA O/P, 4 DcmA I/P, 1 RTD, 1 Ohms Input
	M	4 SSR (High-Speed, High-Break), 1 Form C Relay, 7 Digital Inputs (Int/Ext supply)
Slot H	N	None
	A	2 Form A Relays, 3 Form C Relays, 7 Digital Inputs (Int/Ext supply)
	F	10 Digital Inputs, 4 Arc Flash Inputs
	M	4 SSR (High-Speed, High-Break), 1 Form C Relay, 7 Digital Inputs (Int/Ext supply)
Faceplate	M	Basic: Membrane Keypad with 3 Pushbuttons
	G	Standard: Rugged Keypad with 3 Pushbuttons
Current Protection	S	Basic: 87T, 50/87, 50P, 50N, 50G, 51P, 51N, 51G, Transformer Overload
	M	Standard: Basic, 50_2, 51_2, RGF
	A	Advanced: Standard, 67P, 67G, 67N
Voltage Monitoring and Protection	S	Standard: 27P, 27X, 59P, 59N, 59X, 81O/U
	P	Advanced: Standard, 24, 25, 32, 55, 59_2, 81R
Control	F	Standard: Setpoint Group Control, Virtual Inputs, Trip Bus, Breaker Control, FlexLogic, 50BF, VTFF
	T	Advanced HMI: Standard, Tab Pushbuttons, Annunciator Panel, Configurable SLDs with Bay Control
Monitoring	B	Basic: Breakers Coil Monitoring, Breaker Arcing, Harmonics, THD, Demand, Trip Counters, Harmonic Derating Factor
	C	Standard: Basic, Breaker Health, Health Report, Thermal Elements, Tap Changer, Learned Data, Energization and Historical Max Record
	A	Advanced: Standard, Harmonic Detection
	M	M&D: Standard, Dissolved Gas Analysis, Integrated Fault Report
Communications[1]	S E	Standard: Front USB, 1 x Rear RS485 (Modbus RTU, DNP 3.0, IEC 60870-5-103), 1 x Ethernet (Modbus TCP, DNP)
	1 E	Advanced: Front USB, 1 x Rear RS485, 2 x Ethernet Fiber, Modbus RTU/TCP, DNP 3.0, IEC 60870-5-103/104, 1588, SNTP, OPC-UA
	1 P	Advanced, PRP
	3 A	Advanced, Extended IEC 61850
	3 E	Advanced, PRP, Extended IEC 61850
Advanced Communications Connector	N	None
	S	ST, Multi-mode 1310 nm
	C	RJ45, Copper 10/100M
Wireless Communication	N	None
	W	WiFi 802.11
Security	B	Basic
	A	Advanced: CyberSentry Level 1
Future Option	N	Not Available

1. Communications options 2A and 2E have been discontinued.

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NOTICE

Harsh Environment Coating is a standard feature on all 8 Series units.

Advanced security is only available with advanced communications (1E, 1P, 3A, 3E). When the advanced communications option is selected, the Ethernet port on the main CPU is disabled.

NOTICE

Remote Module I/O (RMIO)

The Remote RTD module provides additional protection.

	RMIO[1]	–	*	G	G	*	*	
Power Supply			**L**	|	|	|	|	24 - 48 V DC
			H	|	|	|	|	110 - 250 V DC / 110 - 230 V AC
I/O Module 1				**G**	|	|	|	Remote Module I/O (3 - 100 Ohm Platinum RTDs)
I/O Module 2					**G**	|	|	Remote Module I/O (3 - 100 Ohm Platinum RTDs)
I/O Module 3[2]						**G**	|	Remote Module I/O (3 - 100 Ohm Platinum RTDs)
						X	|	None
I/O Module 4							**G**	Remote Module I/O (3 - 100 Ohm Platinum RTDs)
							X	None

1. RMIO requires firmware version 2.00 and later and hardware version B. Check the hardware version under **Status > Information > Main CPU**. If RMIO support is required for relays with earlier hardware versions, contact the factory.
2. RMIO comes standard with 6 RTDs (Modules 1 and 2).

892800RMIO-A1.fm

Other Accessories

- 18J0-0030 8 Series Depth Reducing Collar - 1 3/8"
- 18J0-0029 8 Series Depth Reducing Collar - 3"

Specifications

To obtain the total operating time, i.e. from the presence of a trip condition to initiation of a trip, add 8 ms output relay time to the operate times listed below.

Device

ANNUNCIATOR PANEL

Number of Elements: 1 (36 indicators)
Layout: Grid of 2x2 or 3x3
Data Storage: Non-volatile memory
Mode: Self-reset, latched, acknowledgeable
Display Text: 3 lines of 15 characters maximum
Visual Indication: Flashing: 2Hz @ 50% duty cycle

CUSTOM CONFIGURATIONS

Config Mode: Simplified, Regular

Protection

ARC FLASH HS PHASE/GROUND INSTANTANEOUS OVERCURRENT HS 50P/50G

Current: Phasor Magnitude (special high speed algorithm)
Pickup Level: 0.050 to 30.000 × CT in steps of 0.001 × CT
Dropout Level: 97 to 98% of Pickup
Level Accuracy: For 0.1 to 0.2 × CT: ± 0.2% of reading or 1.5% of rated, whichever is greater
For > 0.2 × CT: ± 1.5% of reading
Operate Time: 4 ms at >6 × Pickup at 60 Hz
5 ms at >6 × Pickup at 50 Hz
4-8 ms at > (3-6) × Pickup at 60 Hz
4-10 ms at > (3-6) × Pickup at 50 Hz

TRANSFOMER PERCENT DIFFERENTIAL PROTECTION

Differential/Restraint Characteristic: Dual Slope, Dual Breakpoint
Minimum Pickup level: 0.05 to 1.00 × CT in steps of 0.01
Slope 1 range: 1 to 100% in steps of 1%
Slope 2 range: 1 to 100% in steps of 1%
Breakpoint 1: 0.50 to 2.00 × CT in steps of 0.01
Breakpoint 2: 2.00 to 30.00 × CT in steps of 0.01
2nd harmonic inhibit level: 0.1 to 40.0% in steps of 0.1%
2nd harmonic inhibit mode: Per-phase, Average, 2-out-of-3, 1-out-of-3
5th harmonic inhibit level: 1.0 to 40.0% in steps of 0.1%
Dropout level: 97 to 98% of Pickup
Operate time: < 16/22 ms at >3 × Pickup @60Hz (harmonic inhibits disabled/enabled)
< 18/26 ms at >3 × Pickup @50Hz (harmonic inhibits disabled/enabled)
Level accuracy: ± 0.5% of reading current, or ±1% of rated

TRANSFORMER OVERLOAD

Operating Parameter:	Winding 1, 2, 3 loads
Pickup level:	50 to 300% in steps of 1%
Dropout level:	97 to 98% of Pickup
Level Accuracy:	Per current input
Operate time:	<25 ms at >3 × Pickup at 60 Hz, <30 ms at >3 × Pickup at 50 Hz
Timer Accuracy:	±3% of delay setting or ± ¼ cycle (whichever is greater) from pickup to operate

INSTANTANEOUS PHASE DIFFERENTIAL FUNCTION

Pickup level:	3.00 to 30.00 per unit in steps 0.01
Dropout level:	97 to 98% of Pickup
Operate time:	<12 ms at >3 × Pickup@60Hz <15 ms at >3 × Pickup@50Hz

PHASE/NEUTRAL/GROUND TIME OVERCURRENT (51P/N/G)

Current:	Phasor or RMS
Pickup Level:	0.050 to 30.000 × CT in steps of 0.001 × CT
Dropout Level:	97 to 98% of Pickup
Level Accuracy:	For 0.1 to 2.0 × CT: ±0.5% of reading or ±0.4% of rated, whichever is greater; For > 2.0 × CT: ±1.5% of reading
Curve Shape:	IEEE Extremely/Very/Moderately Inverse; ANSI Extremely/Very/Normally/Moderately Inverse; Definite Time, IEC A/B/C and Short Inverse; IAC Extremely/Very/Inverse/Short Inverse; FlexCurve A/B/C/D, I^2t, I^4t
Curve Multiplier:	0.05 to 600.00 in steps of 0.01
Reset Time:	Instantaneous, Timed
Curve Timing Accuracy:	Currents > 1.03 to 20 × pickup: ± 3% of operate time or ± ½ cycle (whichever is greater) from pickup to operate
Voltage Restrained Function (51V):	Modifies Pickup from 0.1 < V < 0.9 VT Nominal in a fixed linear relationship

NOTICE

Add 1.5 cycles to the curve time to obtain the TOC operating time, i.e., from fault inception until operation.

NEGATIVE SEQUENCE TIME OVERCURRENT (51_2)

Operating Parameter:	I_2 (Fundamental Phasor Magnitude)
Pickup Level:	0.050 to 30.000 × CT in steps of 0.001 × CT
Dropout Level:	97 to 98% of Pickup
Level Accuracy:	For 0.1 to 2.0 × CT:± 0.5% of reading or ±0.4% of rated, whichever is greater For > 2.0 × CT: ± 1.5% of reading
Curve Shape:	IEEE Extremely/Very/Moderately Inverse ANSI Extremely/Very/Normally/Moderately Inverse IEC Curve A/B/C and Short Inverse IAC Extreme/Very/Inverse/Short Inverse FlexCurve A/B/C/D I^2t, I^4t, Definite Time
Curve Multiplier:	0.05 to 600.00 in steps of 0.01
Reset Time:	Instantaneous, Timed
Curve Timing Accuracy:	Currents > 1.1 × pickup: ± 3% of curve delay or ± ½ cycle (whichever is greater) from pickup to operate

NOTE

Add 1.5 cycles to the curve time to obtain the TOC operating time, i.e., from fault inception until operation.

PHASE/NEUTRAL/GROUND INSTANTANEOUS OVERCURRENT (50P/N/G)

Current (for Phase IOC only): Phasor or RMS
Current (for Neutral/Ground IOC only): Fundamental Phasor Magnitude
Pickup Level: 0.050 to 30.000 × CT in steps of 0.001 × CT
Dropout Level: 97 to 98% of Pickup
Level Accuracy: For 0.1 to 2.0 × CT: ±0.5% of reading or ±0.4% of rated, whichever is greater
For > 2.0 × CT: ±1.5% of reading
Operate Time: <12 ms typical at 3 × Pickup at 60 Hz (Phase/Ground IOC)
<16 ms typical at 3 × Pickup at 60 Hz (Neutral IOC)
<15 ms typical at 3 × Pickup at 50 Hz (Phase/Ground IOC)
<20 ms typical at 3 × Pickup at 50 Hz (Neutral IOC)

NOTE

Operating time specifications given above are applicable when RMS inputs are used. Typical times are average operate times over multiple test cases.

Timer Accuracy: ±3% of delay setting or ± ¼ cycle (whichever is greater) from pickup to operate

NEGATIVE SEQUENCE INSTANTANEOUS OVERCURRENT (50_2)

Current: I_2 Fundamental Phasor Magnitude
Pickup Level: 0.050 to 30.000 × CT in steps of 0.001 × CT
Dropout Level: 97 to 98% of Pickup
Level Accuracy: For 0.1 to 2.0 × CT: ±0.5% of reading or ± 0.4% of rated, whichever is greater
For > 2.0 × CT: ± 1.5% of reading
Pickup Time Delay: 0.000 to 6000.000 s in steps of 0.001 s
Dropout Time Delay: 0.000 to 6000.000 s in steps of 0.001 s
Overreach: < 2%
Operate Time: < 12 ms typical at 3 × Pickup at 60 Hz
< 15 ms typical at 3 × Pickup at 50 Hz
Timer Accuracy: ±3% of delay setting or ± ¼ cycle (whichever is greater) from pickup to operate

PHASE DIRECTIONAL OVERCURRENT (67P)

Relay Connection: 90°(Quadrature)
Quadrature Voltage: ABC phase seq.: phase A (Vbc), phase B (Vca), phase C (Vab);
ACB phase seq.: phase A (Vcb), phase B (Vac), phase C (Vba)
Polarizing Voltage Threshold: 0.050 to 3.000 × VT in steps of 0.001 × VT
Current Sensitivity Threshold: 0.05 × CT
Characteristic Angle: 0° to 359° in steps of 1°
Angle Accuracy: ± 2°
Operation Time (FlexLogic™ operands): Reverse to Forward transition: < 12 ms, typically;
Forward to Reverse transition: <8 ms, typically

NEUTRAL DIRECTIONAL OVERCURRENT (67N)

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
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° (both voltage and current (1A/5A only) polarizing signals)
Pickup Level: ....0.050 to 30.000 × CT in steps of 0.001 × CT
Dropout Level: ....97 to 98% of Pickup
Operate Time (no direction transition): .....< 16 ms at 3 × Pickup at 60 Hz
< 20 ms at 3 × Pickup at 50 Hz

GROUND DIRECTIONAL OVERCURRENT (67G)

Directionality: ....Co-existing forward and reverse
Polarizing: ....Voltage
Polarizing Voltage: ....V_0 or VX
Polarizing Current: ....Isg
Operating Current: ....Ig
Level Sensing: ....Ig, Isg
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°
Pickup Level: ....0.050 to 30.000 × CT in steps of 0.001
Dropout Level: ....97 to 98%
Operate Time (no direction transition): .....< 12 ms typical at 3 × Pickup at 60 Hz
< 15 ms typical at 3 × Pickup at 50 Hz

RESTRICTED GROUND (EARTH) FAULT (87G)

Operating Parameter: ....Ia, Ib, Ic and Ig (Fundamental Phasor Magnitude)
Pickup Level: ....0.050 to 30.000 × CT in steps of 0.001 × CT (phase CT)
Ground Supervision Level: ....0.050 to 30.000 × CT in steps of 0.001 × CT (ground CT)
Dropout Level: ....97 to 98% of Pickup
Slope Range: ....0 to 100% in steps of 1%
Pickup Delay: ....0.000 to 6000.000 s in steps of 0.001 s
Level Accuracy: ....For 0.1 to 2.0 × CT: ±0.5% of reading or ±0.4% of rated, whichever is greater
For > 2.0 × CT: ± 1.5% of reading
Operate Time: ....<25 ms at 1.1 × slope × Imax at 60 Hz, typically
<30 ms at 1.1 × slope × Imax at 50 Hz, typically
Timing Accuracy: ....±3% of delay setting or ± ¼ cycle (whichever is greater) from pickup to operate

PHASE UNDERVOLTAGE (27P)

Voltage:	Fundamental Phasor Magnitude
Minimum Voltage:	0.00 to 1.50 x VT in steps of 0.01 x VT
Pickup Level:	0.00 to 1.50 x VT in steps of 0.01 x VT
Dropout Level:	102 to 103% of Pickup
Level Accuracy:	±0.5% of reading from 10 to 208 V
Phases Required for Operation:	Any one, Any two, All three
Undervoltage Curves:	Definite Time, GE IAV Inverse Time or FlexCurves A/B/C/D
Pickup Time Delay:	0.000 to 6000.000 s in steps of 0.001s
Operate Time:	< 20 ms at 0.90 x pickup at 60 Hz < 25 ms at 0.90 x pickup at 50 Hz
Curve Timing Accuracy:	at < 0.90 x pickup: ± 3.5% of curve delay or ± ½ cycle (whichever is greater) from pickup to operate

AUXILIARY UNDERVOLTAGE (27X)

Operating Parameter:	Vx (Phasor)
Minimum Voltage:	0.00 to 1.50 x VT in steps of 0.01 x VT
Pickup Level:	0.00 to 1.50 x VT in steps of 0.01 x VT
Dropout Level:	102 to 103% of Pickup
Level Accuracy:	± 0.5% of reading from 10 to 208 V
Undervoltage Curves:	Definite Time, GE IAV Inverse Time or FlexCurves A/B/C/D
Pickup Time Delay:	0.000 to 6000.000 s in steps of 0.001 s
Operate Time:	< 20 ms at 0.90 x pickup at 60 Hz < 25 ms at 0.90 x pickup at 50 Hz
Curve Timing Accuracy:	at < 0.90 x pickup: ± 3.5% of curve delay or ± ½ cycle (whichever is greater) from pickup to operate

PHASE OVERVOLTAGE (59P)

Voltage:	Fundamental Phasor Magnitude
Pickup Level:	0.02 to 3.00 x VT in steps of 0.01 x VT
Dropout Level:	97 to 98% of Pickup
Level Accuracy:	±0.5% of reading from 10 to 208 V
Phases Required for Operation:	Any one, Any two, All three
Pickup Time Delay:	0.000 to 6000.000 s in steps of 0.001s (Definite Time)
Dropout Time Delay:	0.000 to 6000.000 s in steps of 0.001s (Definite Time)
Pickup Accuracy:	Per phase voltage input channel error
Operate Time:	< 25 ms at 1.1 x pickup at 60Hz < 30 ms at 1.1 x pickup at 50Hz
Timer Accuracy:	± 3% of delay setting or ± ¼ cycle (whichever is greater) from pickup to operate

AUXILIARY OVERVOLTAGE (59X)

Operating Parameter:	Vx (Phasor)
Pickup Level:	0.00 to 3.00 x VT in steps of 0.01 x VT
Dropout Level:	97 to 98% of Pickup
Level Accuracy:	±0.5% of reading from 10 to 240 V
Overvoltage Curves:	Definite Time, Inverse Time, FlexCurves A/B/C/D
Pickup Time Delay:	0.000 to 6000.000 s in steps of 0.001s
Dropout Time Delay:	0.000 to 6000.000 s in steps of 0.001s
Pickup Accuracy:	'Auxiliary voltage input channel error
Operate Time:	< 30 ms at 1.1 x pickup at 60Hz
Curve Timing Accuracy:	at >1.1 x PKP: 3.5% of operate time ± ½ cycle (whichever is greater) from pickup to operate
Timer Accuracy:	± 3% of operate time or ± ½ cycle (whichever is greater)

NEUTRAL OVERVOLTAGE (59N)

Operating Parameter:......................................3V_0 calculated from phase to ground voltages
Pickup Level:..0.02 to 3.00 × VT in steps of 0.01 × VT
Dropout Level: ....97 to 98% of Pickup
Level Accuracy:...±0.5% of reading from 10 to 208 V
Neutral Overvoltage Curves: ....Definite time, FlexCurve A/B/C/D
Pickup Time Delay:..0.000 to 6000.000 s in steps of 0.001 s (Definite Time)
Dropout Time Delay: ....0.000 to 6000.000 s in steps of 0.001 s (Definite Time)
Operate Time:..< 25 ms at 1.1 × pickup at 60Hz
< 30 ms at 1.1 × pickup at 50Hz
Curve Timing Accuracy: ....at > 1.1 × Pickup: ± 3% of curve delay or ± 1 cycle (whichever is greater) from pickup to operate

NEGATIVE SEQUENCE OVERVOLTAGE (59_2)

Operating Parameter:......................................V_2
Pickup Level:..0.00 to 3.00 × VT in steps of 0.01 × VT
Dropout Level: ....97 to 98% of Pickup
Level Accuracy:...± 0.5% of reading from 10 to 208 V
Pickup Time Delay:..0.000 to 6000.000 s in steps of 0.001 s
Dropout Time Delay: ....0.000 to 6000.000 s in steps of 0.001 s
Operate Time:..< 25 ms at 1.1 × pickup at 60 Hz
< 30 ms at 1.1 × pickup at 50 Hz
Timer Accuracy: .... ± 3% of delay setting or ± ¼ cycle (whichever is greater) from pickup to operate

VOLTS PER HERTZ (24)

Voltages:...Phasor only
Pickup Level:..0.80 to 4.00 in steps of 0.01 pu
Dropout Level: ....97 to 98% of pickup
Level Accuracy:...±0.02 pu
Timing Curves: ....Definite Time; IEC Inverse A/B/C; FlexCurves A, B, C, and D
TD Multiplier: ....0.05 to 600.00 s in steps of 0.01
Reset Delay:...0.00 to 6000.000 s in steps of 0.01
Timer Accuracy: ....±3% of operate time or ±15 cycles (whichever is greater) for values greater than 1.1 × pickup
Number of Elements: 2

DIRECTIONAL POWER (32)

Measured Power: 3-phase
Number of Stages:...2
Characteristic Angle: ....0° to 359° in steps of 1°
Calibration Angle: ....0.00° to 0.95° in steps of 0.05°
Power Pickup Range:..–1.200 to 1.200 × Rated Power in steps of 0.001
Pickup Level Accuracy: ....± 1% or ± 0.001 × Rated Power, whichever is greater
Hysteresis:...2% or 0.001 × Rated Power, whichever is greater
Pickup Time Delay:..0.000 to 6000.000 s in steps of 0.001 s
Operate Time:..< 55 ms at 1.1 × pickup at 60 Hz
< 65 ms at 1.1 × pickup at 50 Hz
Timer Accuracy: ....± 3% of delay setting or ± ¼ cycle (whichever is greater) from pickup to operate

UNDERFREQUENCY (81U)

Pickup Level: .... 20.00 to 65.00 Hz in steps of 0.01
Dropout Level: .... Pickup + 0.03 Hz
Pickup Time Delay: .... 0.000 to 6000.000 s in steps of 0.001s
Dropout Time Delay: .... 0.000 to 6000.000 s in steps of 0.001s
Minimum Operating Voltage: .... 0.000 to 1.250 × VT in steps of 0.001 × VT
Minimum Operating Current: .... 0.000 to 30.000 × CT in steps of 0.001 × CT
Level Accuracy: .... ± 0.01 Hz
Timer Accuracy: .... ± 3% of delay setting or ± ¼ cycle (whichever is greater) from pickup to operate
Operate Time: .... typically 7.5 cycles at 0.1 Hz/s change
typically 7 cycles at 0.3 Hz/s change
typically 6.5 cycles at 0.5 Hz/s change

NOTICE Typical times are average Operate Times including variables such as frequency change instance, test method, etc., and may vary by ± 0.5 cycles.

OVERFREQUENCY (81O)

Pickup Level: .... 20.00 to 65.00 Hz in steps of 0.01
Dropout Level: .... Pickup - 0.03 Hz
Pickup Time Delay: .... 0.000 to 6000.000 s in steps of 0.001 s
Dropout Time Delay: .... 0.000 to 6000.000 s in steps of 0.001 s
Minimum Operating Voltage: .... 0.000 to 1.250 × VT in steps of 0.001 × VT
Level Accuracy: .... ± 0.01 Hz
Timer Accuracy: .... ± 3% of delay setting or ± ¼ cycle (whichever is greater) from pickup to operate
Operate Time: .... typically 7.5 cycles at 0.1 Hz/s change
typically 7 cycles at 0.3 Hz/s change
typically 6.5 cycles at 0.5 Hz/s change

NOTICE Typical times are average Operate Times including variables such as frequency change instance, test method, etc., and may vary by ± 0.5 cycles.

FREQUENCY RATE OF CHANGE (81R)

df/dt Trend: .... Increasing, Decreasing, Bi-directional
df/dt Pickup Level: .... 0.10 to 15.00 Hz/s in steps of 0.01 Hz/s
df/dt Dropout Level: .... 96% of Pickup Level
df/dt Level Accuracy: .... 80 mHz/s or 3.5%, whichever is greater
Minimum Frequency: .... 20.00 to 80.00 Hz in steps of 0.01 Hz
Maximum Frequency: .... 20.00 to 80.00 Hz in steps of 0.01 Hz
Minimum Voltage Threshold: .... 0.000 to 1.250 × VT in steps of 0.001 × VT
Minimum Current Threshold: .... 0.000 to 30.000 × CT in steps of 0.001 × CT
Pickup Time Delay: .... 0.000 to 6000.000 s in steps of 0.001 s
Timer Accuracy: .... ± 3% of delay setting or ± ¼ cycle (whichever is greater) from pickup to operate
95% Settling Time for df/dt: .... < 24 cycles
Operate Time: .... typically 10 cycles at 2 × Pickup

RTD PROTECTION

Pickup: .... 1°C to 250°C in steps of 1°C
Hysteresis: .... 2°C
Timer Accuracy: .... <2 s
Elements: .... Trip and Alarm

FLEXELEMENTS

Number of elements: 8
Operating signal:..Any analog actual value, or two values in a differential mode
Operating signal mode: ....Signed, or Absolute value
Operating mode: ....Level, Delta
Comparison direction: ....Over, Under
Operate time:...FlexElements are processed once per cycle (16 ms at 60 Hz, 20 ms at 50 Hz)
Pickup Level:...-30.000 to 30.000 pu in steps of 0.001 pu
Hysteresis:...0.1 to 50.0% in steps of 0.1%
Delta dt: ....40 msec to 45 days
Pickup and dropout delays: ....0.000 to 6000.000 s in steps of 0.001 s

Control

ARC FLASH SENSOR/FIBER

Number of Point Sensors: 4
Detection Radius:..180 degree
Maximum Fiber Length (Point Sensor):.....18 ft
Fiber Size:..1000 um
Mode:...Multi-mode
Connector:...Small Media Interface (SMI)
Fiber Type:...Plastic Optical Fiber
Bend Radius: ....>25 mm

BREAKER CONTROL

Operation:..Asserted FlexLogic Operands
Function: ....Opens/closes, blocks, bypasses blocks to the feeder breaker

BREAKER FAILURE

Mode:...3-pole
Current Supervision: ....phase and neutral current (fundamental phasor magnitude)
Current Supervision Pickup:...........................0.050 to 30.000 × CT in steps of 0.001 × CT
Current Supervision Dropout: ....97 to 98% of pickup
Current Supervision Accuracy:.....................For 0.1 to 2.0 × CT: ± 0.5% of reading or ± 0.4% of rated (whichever is greater), For > 2.0 × CT: ± 1.5% of reading
Time Delay:..0.000 to 6000.000 s in steps of 0.001 s
Timer Accuracy: ....± 3% of delay setting or ± ¼ cycle (whichever is greater) from pickup to operate
Reset Time: ....< 10 ms typical at 2 x Pickup at 60 Hz, < 12 ms typical at 2 x Pickup at 50 Hz

LOCAL CONTROL MODE

Number of Elements: 1
Select Before Operate Mode: ....Disabled, Enabled
Mode:...Local Mode ON, Local Mode OFF
Display Status:...LM (local mode) displayed in banner
Tagging:..Disabled, Enabled

SWITCH CONTROL

Operation:..Local (PB control and SLD) and Remote (asserted FlexLogic operands)
Function: ....Opens/Closes the disconnect switch
Timers: ....0.000 to 6000.000 s in steps of 0.001 s

SYNCHROCHECK (25)

Maximum Frequency Difference: .... 0.01 to 5.00 Hz in steps of 0.01 Hz for frequency window of f_{nom} ± 5 Hz
Maximum Angle Difference: .... 1° to 100° in steps of 1°
Maximum Voltage Difference: .... 10 to 600000 V in steps of 1 V
Hysteresis for Maximum Frequency Difference: .... 0.01 to 0.10 Hz in steps of 0.01 Hz
Breaker Closing Time: .... 0.000 to 6000.000 s in steps of 0.001 s
Dead Source Function: .... None, LB & DL, DB & LL, DB & DL, DB OR DL, DB XOR DL
Dead/Live Levels for Bus and Line: .... 0.00 to 1.50 x VT in steps of 0.01 x VT

TRIP BUS

Number of Elements: 6
Number of Inputs: 16
Pickup Time Delay: .... 0.000 to 6000.000 s in steps of 0.001 s
Dropout Time Delay: .... 0.000 to 6000.000 s in steps of 0.001 s
Operate Time: .... < 2 ms at 60 Hz
Timer Accuracy: .... ± 3% of delay time or ± ¼ cycle (whichever is greater) from pickup to operate

Monitoring

HARMONIC DERATING

Timer Accuracy: .... ±3% of delay setting or ±3 cycle (whichever is greater) from pickup to operate

TRIP CIRCUIT MONITOR (TCM)

Applicable Voltage: .... 20 to 250 VDC
Trickle Current: .... 1 to 2.5 mA
Timing Accuracy: .... ± 3 % or ± 4 ms, whichever is greater

CLOSE CIRCUIT MONITOR (CCM)

Applicable Voltage: .... 20 to 250 VDC
Trickle Current: .... 1 to 2.5 mA
Timing Accuracy: .... ± 3 % or ± 4 ms, whichever is greater

BREAKER ARCING CURRENT

Mode: 3-pole
Principle: .... accumulates breaker duty (I^2t) during fault
Initiation: .... any operand
Alarm Threshold: .... 0 to 50000 kA2-cycle in steps of 1 kA2-cycle
Timer Accuracy: .... ± 3% of delay setting or ± ¼ cycle (whichever is greater) from pickup to operate

BREAKER HEALTH

Timer Accuracy: .... ± 3% of delay setting or ± 1 cycle (whichever is greater) from pickup to operate

POWER FACTOR (55)

Switch-In Level: .... 0.01 Lead to 1 to 0.01 Lag in steps of 0.01
Dropout Level: .... 0.01 Lead to 1 to 0.01 Lag in steps of 0.01
Delay: .... 0.000 to 6000.000 s in steps of 0.001 s
Minimum Operating Voltage: .... 0.00 to 1.25 x VT in steps of 0.01 x VT
Level Accuracy: .... ± 0.02
Timer Accuracy: .... ± 3% of delay setting or ± 1¼ cycle (whichever is greater) from pickup to operate

FAULT REPORTS

Number of Reports: 15
Captured Data: .... Pre-fault and fault phasors for all CT and VT banks, pre-fault and fault trigger operands, user-programmable analog channels 1 to 32

DEMAND

Measured Values: Phase A/B/C present and maximum current, three-phase present, maximum real/reactive/apparent power, minimum real/reactive/apparent power
Measurement Type: Thermal Exponential, 90% response time (programmed): 5, 10, 15, 20, 30 minutes
Block Interval / Rolling Demand, time interval (programmed): 5, 10, 15, 20, 30 minutes
Current Pickup Level: 10 to 10000 in steps of 1 A
Dropout Level: 96-98% of Pickup level
Level Accuracy: ± 2%

WINDING HOTTEST-SPOT

Operating Quantity: Computed temperature in °C
Pickup Level: 50 to 300°C in steps of °C (122°F to 572°F in steps of 1°F)
Dropout Level: 1°C below pickup
Pickup Delay: 0 to 60000 minutes in steps of 1 min

AGING ACCELERATION FACTOR

Operating Quantity: Computed Aging Acceleration Factor, per-unit
Pickup Level: 1 pu to 10 pu in steps of 0.1 pu
Pickup Delay: 0 to 60000 minutes in step of 1 min

XFMR LOSS OF LIFE

Operating Quantity: Computed Accumulated Transformer Loss of Life, hours
Pickup Level: 0 to 300000 hours in steps of 1 hour

TAP CHANGER FAILURE

Operating Parameter: Tap Changer Position
Time Delay: 0.00 to 600.00 s
Timer Accuracy: ±3% of delay setting or ±2 cycles (whichever is greater) from pickup to operate

HARMONIC DETECTION

Operating Parameter: Current 2nd, 3rd, 4th, 5th harmonic or THD per phase
Timer Accuracy: Harmonics: ±3% of delay setting or ±1/4 cycle (whichever is greater) from pickup to operate
THD: ±3% of delay setting or ±3 cycles (whichever is greater) from pickup to operate

Recording

TRANSIENT RECORDER

Default AC Channels: 12 currents + 4 voltages
Configurable Channels: 16 analog and 64 digital channels
Sampling Rate: 128/c, 64/c, 32/c, 16/c, 8/c
Trigger Source: Any element pickup, dropout or operate, digital input or output change of state, FlexLogic operand
Trigger Position: 0 to 100%
Storage Capability: Non-volatile memory

EVENT DATA

Number of Records: 1024 (matches the existing Event Recorder)
Data Storage: Non-volatile memory
Time-tag Accuracy: One microsecond
Settings: 64 Configurable FlexAnalog parameters, Event Selector
Actuals: Selected Event Number, Timestamp of Selected Event, Cause of Selected Event, 64 Configurable FlexAnalog values
Commands: None (using existing Clear Event Recorder)

DATA LOGGER

Data Logger channels: 16
Data Logger Rate: 1 cycle, 1 sec., 30 sec., 1 min., 15 min., 30 min., 1 hour, 6 hours, 8 hours, 12 hours, 24 hours
Inputs: Any analog parameter from the list of available analog parameters
Data Collection Mode: Continuous, Triggered
Trigger Source: Any digital flag from the list of digital flags
Trigger Position: 0 to 50% in steps of 1%
Channel 1(16) Mode: Sample, Min, Max, Mean

EVENT RECORDER

Number of events: 1024
Header: relay name, order code, firmware revision
Content: any element pickup, any element operate, digital input change of state, digital output change of state, self-test events
Data Storage: non-volatile memory
Time-tag Accuracy: to one microsecond

LAST TRIP DATA

Number of Records: 1
Data Storage: Non-volatile memory
Time-tag Accuracy: One microsecond
Actuals: Event Number of Last Trip,
Timestamp of Last Trip,
Cause of Last Trip,
64 Configurable FlexAnalog values
Commands: Clear Last Trip Data

User-Programmable Elements

FLEXLOGIC

Lines of code: 1024
Supported operations: NOT, XOR, OR (2 to 16 inputs), AND (2 to 16 inputs), NOR (2 to 16 inputs), NAND (2 to 16 inputs), latch (reset-dominant), edge detectors, timers
Inputs: any logical variable, contact, or virtual input
Number of timers: 32
Pickup delay: 0 to 60000 (ms, sec., min.) in steps of 1
Dropout delay: 0 to 60000 (ms, sec., min.) in steps of 1
Timer accuracy: ±3% of delay setting or ±¼ cycle (whichever is greater) from pickup to operate

FLEXELEMENTS

Number of elements: 8
Operating signal: Any analog actual value, or two values in a differential mode
Operating signal mode: Signed, or Absolute value
Operating mode: Level, Delta
Comparison direction: Over, Under
Pickup Level: -30.000 to 30.000 pu in steps of 0.001 pu
Hysteresis: 0.1 to 50.0% in steps of 0.1%
Delta dt: 40 msec to 45 days
Pickup and dropout delays: 0.000 to 6000.000 s in steps of 0.001 s

FLEXSTATES

Number of States: 256 logical variables grouped under 16 Modbus addresses
Programmability: Any FlexLogic operand, any digital input, any virtual input, any remote input

NON-VOLATILE LATCHES

Type: ....Set-dominant or Reset-dominant
Range: ....16 individually programmed
Output: ....Stored in non-volatile memory
Execution sequence: ....As input prior to protection, control and FlexLogic

FLEXCURVES

Number: ....4 (A, B, C, D)
Reset points: ....40 (0.00 to 0.98 × pickup)
Operate points: ....80 (1.03 to 20.0 × pickup)
Time delay: ....0 to 200,000,000 ms in steps of 1 ms
Saturation level: ....20 times the pickup level

TAB PUSHBUTTONS

Number of elements: ....1 (20 Tab Pushbuttons)
Data Storage: ....Non-volatile memory
Mode: ....Self-reset, latched
Display Message: ....2 lines; 15 characters per line
Dropout Timer: ....0.000 to 60.000 s in steps of 0.005
Auto-reset Timer: ....0.2 to 600.0 s in steps of 0.1
Hold Timer: ....0.1 to 10.0 s in steps of 0.1
Timer Accuracy: ....±3% of delay setting or ±¼ cycle (whichever is greater) from pickup to operate

USER-PROGRAMMABLE LEDS

Number: ....17 (14 + 3 PB LEDS) for Membrane and Rugged Front Panels
Programmability: ....any logic variable, contact, or virtual input
Reset mode: .... self-reset or latched

USER-PROGRAMMABLE PUSHBUTTONS

Number of pushbuttons: ....3 (Membrane and Rugged Front Panels)
Mode: ....Self-reset, latched
Display message: ....2 lines of 13 characters on each line
Dropout timer: ....0.000 to 60.000 s in steps of 0.005
Auto-reset timer: ....0.2 to 600.0 s in steps of 0.1
Hold timer: ....0.0 to 10.0 s in steps of 0.1

Metering

RMS PARAMETERS

Currents

Parameters: ....Phase A, B, C, Neutral, Ground
Accuracy: ....± 0.25% of reading or ± 0.2% of rated (whichever is greater) from 0.1 to 2.0 × CT
± 1% of reading > 2.0 × CT

Voltages

Parameters: ....Wye VTs: A-n, B-n, C-n, A-B, B-C, C-A, Average Phase, Neutral and Residual
Delta VTs: A-B, B-C, C-A, Neutral and Residual
Accuracy: ....± 0.5% of reading from 15 to 208 V
± 2% for open Delta connections

Real Power (Watts)

Range: ....-214748364.8 kW to 214748364.7 kW
Parameters: ....Wye VTs: 3-phase and per phase
Delta VTs: 3-phase only
Accuracy: ....± 1.0% of reading or 0.2 kW (whichever is greater) at -0.8 < PF ≤ -1.0 and 0.8 < PF < 1.0

Reactive Power (Vars)

Range:.. -214748364.8 kvar to 214748364.7 kvar
Parameters:................................. Wye VTs: 3-phase and per phase
Delta VTs: 3-phase only
Accuracy: .... ± 1.0% of reading or 0.2 kvar (whichever is greater) at -0.2 < PF ≤ 0.2

Apparent Power (VA)

Range:.. 0 kVA to 214748364.7 kVA
Parameters:................................. Wye VTs: 3-phase and per phase
Delta VTs: 3-phase only
Accuracy: .... ± 1.0% of reading or 0.2 kVA (whichever is greater)

Power Factor

Parameters:................................. 3-phase; per phase if VT is Wye
Range:.. 0.01 Lag to 1.00 to 0.01 Lead
Accuracy: .... ± 0.02 for 50 Hz and 60 Hz; ± 0.05 for 25 Hz

Watt-hours (positive and negative)

Range:.. 0.000 MWh to 4294967.295 MWh
Parameters:................................. 3-phase only
Update Rate:............................... 50 ms
Accuracy: .... ± 2.0% of reading

Var-hours (positive and negative)

Range:.. 0.000 Mvarh to 4294967.295 Mvarh
Parameters:................................. 3-phase only
Update Rate:............................... 50 ms
Accuracy: .... ± 2.0% of reading

PHASORS

Current

Parameters:................................. Phase A, B, C, Neutral and Ground
Magnitude Accuracy: .... ± 0.5% of reading or ± 0.2% of rated (whichever is greater) from 0.1 to 2.0 x CT
± 1.0% of reading > 2.0 x CT
Angle Accuracy: .... 2° (3° for 25 Hz)

Voltages

Parameters:................................. Wye VTs: A-n, B-n, C-n, A-B, B-C, C-A, Average Phase, Neutral and Residual;
Delta VTs: A-B, B-C, C-A, Neutral and Residual
Magnitude Accuracy: .... ± 0.5% of reading from 15 to 208 V;
± 1% for open Delta connections;
± 10% for 25 Hz with 150 V <V < 208V
Angle Accuracy: .... 0.5° (15 V <V < 208 V)

FREQUENCY

Range:.. 2.000 to 90.000 Hz
Accuracy at:................................. V = 15 to 208 V: ± 0.01 Hz (input frequency 15 to 70 Hz);
I = 0.1 to 0.4 x CT: ± 0.020 Hz (input frequency 15 to 70 Hz);
I > 0.4 x CT: ± 0.01 Hz (input frequency 15 to 70 Hz)

CURRENT AND VOLTAGE HARMONICS

Parameters:................................. Magnitude of each harmonic and THD
Range:.. 2^{nd} to 25^{th} harmonic: per-phase displayed as % of f_1 fundamental frequency
THD: per-phase displayed as % of f_1

DEMAND

Measured Values:....Phase A/B/C present and maximum current, three-phase present, maximum real/reactive/apparent power, minimum real/reactive/apparent power
Measurement Type:....Thermal Exponential, 90% response time (programmed): 5, 10, 15, 20, 30 minutes
Block Interval / Rolling Demand, time interval (programmed): 5, 10, 15, 20, 30 minutes
Current Pickup Level:....10 to 10000 in steps of 1 A
Dropout Level:....96-98% of Pickup level
Level Accuracy:....± 2%

NOTE

Factory tested at 25°C

Inputs

AC CURRENTS

CT Rated Primary:....1 to 12000 A
CT Rated Secondary:....1 A or 5 A based on relay ordering
Burden:....< 0.2 VA at rated secondary
Short Term CT Withstand:....1 second at 100 x rated current
2 seconds at 40 x rated current
continuous at 3 x rated current

AC VOLTAGE

VT Range:....10 to 260 V
Nominal Frequency:....20 to 65 Hz
Burden:....<0.25 VA at 120 V
Conversion Range:....1 to 275 V
Voltage Withstand:....continuous at 260 V to neutral
1 min/hr at 420 V to neutral

ANALOG INPUTS

Current Input (mA DC):....0 to 1mA, 0 to 5mA, 0 to 10mA, 0 to 20mA, 4 to 20mA (configurable)
Input Impedance:....375 Ω ± 10%
Conversion range:....0 to +21 mA DC
Accuracy:....± 1% of full scale,
Type:....Passive
Sampling Interval:....Typically 500 ms
Cable:....Twisted-pair shielded cable

FREQUENCY

Nominal frequency setting:....50 Hz, 60 Hz
Sampling frequency:....64 samples per power cycle
128 samples per power cycle (available for transient recorder
Tracking frequency range:....3 to 72 Hz

ARC FLASH SENSOR/FIBER

Number of Point Sensors: 4
Detection Radius: 180 degree
Maximum Fiber Length (Point Sensor): 18 ft
Fiber Size: 1000 um
Mode: Multi-mode
Connector: Small Media Interface (SMI)
Fiber Type: Plastic Optical Fiber
Bend Radius: >25 mm

CONTACT INPUTS

Number of Inputs: Based on relay order code
Type: Wet or Dry
Type: Wet or Dry (Wet for I/O Card C)
Wet Contacts: 300 V DC maximum
Selectable thresholds: Programmable:
17 VDC (For 24 VDC Operating Voltage)
33 VDC (For 48 VDC and 60VDC Operating Voltage)
84 VDC (For 110 VDC and 125 VDC Operating Voltage)
166 VDC (For 220 VDC and 250 VDC Operating Voltage)
Tolerance: 17VDC: Vlow(off)<10V, Vhigh(on)>19V
33VDC: Vlow(off)<23V, Vhigh(on)>38V
84VDC: Vlow(off)<70V, Vhigh(on)>88V
166VDC: Vlow(off)<140V, Vhigh(on)>176V
Recognition time: 1 ms (typical)
Debounce time: 0.0 to 16.0 ms in steps of 0.5 ms
Continuous current draw (burden): 2 mA
Continuous current draw (burden): 2 mA (1 mA for I/O Card C)

NOTICE

The maximum load current that can be delivered by the internal +24 V supply is 80 mA. When using the internal +24 V supply this current limitation must be considered.

CLOCK

Setup: Date and Time, Daylight Saving Time, UTC (Coordinated Universal Time)
Backup Retention: 31 days

NOTICE

For relays with Hardware Revision A, Clock Backup Retention is 1 hour. Check the Hardware Revision under **Status > Information > Main CPU**.

IRIG-B INPUT

Auto-detect: DC and AM
Amplitude Modulation: 1 V to 10 V pk-to-pk
DC Shift: TTL
Input Impedance: 40 kΩ
Isolation: 2 kV
IRIG-B Format: IEEE 1344-1995 (with control bits extension)

RTD INPUTS

Types (3-wire): ....100 Ω Platinum, 120 Ω Nickel, 100 Ω Nickel, 10 Ω Copper (RMIO only supports 100 Ω Platinum)

Sensing current:....................5 mA

Range: ....–40 to +250°C (-40 to +482°F)

Accuracy:....................±2°C (±4°F)

Isolation:....................36 V pk-pk (a group of RTDs to ground)
2 kV from base unit (RMIO only)

Lead Resistance:....................25 Ohms max. per lead for platinum or nickel and 3 Ohms max. per lead for copper RTDs

RTD Inputs Available:....................6 RTD inputs with one module or 12 inputs with 2 modules (IO cards R or S).
1 RTD input with IO card L.
6 to 12 RTD inputs with RMIO modules 1 through 4

Cable:....................Three-wire shielded cable

OHMS INPUT

Type: ....Resistance (ohms)

Range: ....0 to 500 Ω or 0.5 to 5.1 kΩ

Bias current: ....1.9 mA through the full range

Accuracy:....................± 1% (of full scale based on input range)

TAP CHANGER

Operating Parameter:....................BCD, ohms In 1, Analog Ip 1

Tap Changer Range:....................-19 to +39

Accuracy:....................Per Input accuracy

Outputs

ANALOG OUTPUTS

Range (configurable):....................0 to 1mA, 0 to 5mA, 0 to 10mA, 0 to 20mA, 4 to 20mA

Max. load resistance:....................10 kΩ @ 1 mA,
600 Ω @ 20 mA

Accuracy:....................± 1% of full scale

Isolation:....................500V DC for one minute (functional isolation between analog inputs and output group; and each group of chassis)

Driving Signal:....................any Analog quantity

Sampling Interval: ....Typically 500 ms

Upper and lower limit
(for the driving signal):....................-90 to 90 pu in steps of 0.001

Cable:....................Twisted-pair shielded cable

FORM A AND FORM C OUTPUT RELAYS, I/O CARDS A AND M

Maximum Working Voltage:	300VDC/300VAC
Make and short-time carry current:	30A/0.2s per IEEE C37.90
Maximum Continuous Current per contact:	10A
Total maximum current for contacts connected to common potential:	10A
Breaking Capacity (DC inductive) with respect to source voltage, @L/R = 40 ms (10000 Operation, per IEC 60255-1 2009-08):	24 V-1 A 48 V-0.5 A 125 V-0.3 A 250 V-0.2 A
Breaking Capacity (DC resistive) with respect to source voltage:	24 V-10 A 48 V-1.5A 125 V-0.4 A 250 V-0.3 A
Breaking Capacity (AC inductive) with respect to source voltage, @PF= 0.35 or less:	A300, Pilot duty 720 VA
Breaking Capacity (AC resistive) with respect to source voltage:	277V-10A
Operating Time (coil energization to contact closure, resistive load):	<8ms
Contact Material:	Silver alloy
Mechanical Endurance (no load):	> 10,000
Maximum Frequency of operation:	360/h
Protection Device across contact:	EMI Suppression Cap, 1nF

NOTICE

For order codes with a combined total of 2 or 3 type A and M I/O cards, the following ratings are applied to meet UL508 requirements: 1 second on / 10 seconds off, 9% duty cycle.

FORM-A VOLTAGE MONITOR

Applicable voltage:	20 to 250 VDC
Trickle current:	1 to 2.5 mA
Timer acurracy:	± 3% of operate time or ± 1/4 cycle (whichever is greater)

SOLID STATE RELAYS ON I/O CARD M

Maximum Working Voltage: ....300 VDC
Make and short-time carry current: ....30A/0.2 s per IEEE C37.90
Maximum Continuous Current per contact: ....10 A
Total maximum current for contacts connected to common potential: ....10 A
Breaking Capacity (DC inductive) with respect to source voltage, @L/R = 40 ms (10000 Operation, per IEC 60255-1 2009-08): ....250 VDC - 10 A (or 2.5 kW) (Maximum 10 A and 300 VDC
Breaking Capacity (DC resistive) with respect to source voltage: ....250 V - 30 A (or 7500 W)
Breaking Capacity (AC inductive) with respect to source voltage, @PF= 0.35 or less: ....NA
Breaking Capacity (AC resistive) with respect to source voltage: ....N/A
Operating Time (coil energization to contact closure, resistive load): ....<0.2 ms
Contact Material: ....Hybrid
Mechanical Endurance (no load): ....> 10,000
Maximum Frequency of operation: 360/h
Protection Device across contact: ....MO V, rated @ 250 VAC/320 VDC

PULSED OUTPUTS

Mode: ....3-phase positive and negative active energy measurement, 3-phase positive and negative reactive energy measurements
Principle: ....Pulsed output is energized for one second and then de-energized for one second after the programed energy increment.

Power Supply

POWER SUPPLY

Nominal DC Voltage: ....125 to 250 V
Minimum DC Voltage: ....88 V
Maximum DC Voltage: ....300 V
Nominal AC Voltage: ....100 to 240 V at 50/60 Hz
Minimum AC Voltage: ....88 V at 50 to 60 Hz
Maximum AC Voltage: ....265 V at 50 to 60 Hz
Voltage loss ride through: ....20 ms duration

POWER SUPPLY (FOR “L” DC ONLY OPTION)

Nominal DC Voltage: ....24 V to 48 V
Minimum DC Voltage: ....20 V
Maximum DC Voltage: ....60 V

POWER CONSUMPTION

Typical: ....20 W / 40 VA
Maximum: ....34 W / 70 VA

Communications

ETHERNET – BASE OFFERING

Modes: 10/100 Mbps
One Port: RJ45
Protocol: Modbus TCP, DNP

ETHERNET – CARD OPTION “C” - 2X COPPER (RJ45) PORTS

Modes: 10/100 MB
Two Ports: RJ45 (with this option both enabled ports are on the communications card; the Ethernet port located on the base CPU is disabled)
Protocols: Modbus TCP, DNP3.0, IEC60870-5-104, IEC 61850 Ed.2, IEC 61850 Ed.2 GOOSE, IEEE 1588 (PTP version 2), SNTP, IEC 62439-3 clause 4 (PRP)

ETHERNET – CARD OPTION “S” - 2X ST FIBER PORTS

Modes: 100 MB
Two Ports: ST (with this option both enabled ports are on the communications card; the Ethernet port located on the base CPU is disabled)
Protocols: Modbus TCP, DNP3.0, IEC60870-5-104, IEC 61850 Ed.2, IEC 61850 Ed.2 GOOSE, IEEE 1588 (PTP version 2), SNTP, IEC 62439-3 clause 4 (PRP), OPC-UA
Wavelength: 1310nm
Typical link distance: 4 km

USB

Standard specification: Compliant with USB 2.0
Protocols: Modbus TCP, TFTP

SERIAL

RS485 port: Isolated
Baud rates: Supports 9600, 19200, 38400, 57600, and 115200 kbps
Response time: 10 ms typical
Parity: None, Odd, Even
Protocol: Modbus RTU, DNP 3.0, IEC 60870-5-103
Maximum distance: 1200 m (4000 feet)
Isolation: 2 kV
Cable: Belden 9841 or similar 24 AWG stranded, shielded twisted-pair

WIFI

Standard specification: IEEE802.11bgn
Range: 30 ft (direct line of sight)

REMOTE MODBUS DEVICE PROFILE

Device Name: BSG3 (13 alphanumeric characters maximum)
IP Address: 0.0.0.0 – standard Ethernet address
Slave Address: 254 (1 to 254)
Modbus Port: 502 (0 to 10000, default 502)
Poll Rate: 3 minute (OFF, 3 to 120 minutes), the continuous mode poll interval is defined as the poll rate interval
Trigger: Off (any FlexLogic Operand), the trigger mode is based on the FlexLogic operand designed to trigger the poll

CAN (RMIO)

Maximum Distance: 250 m (820 ft)
Cable Type: Shielded or unshielded twisted pair
Cable Gauge: Belden 9841 or similar 24 AWG for distances up to 100m; 22 AWG for distances up to 250 m.

Testing & Certification

APPROVALS		
	Applicable Council Directive	**According to**
CE compliance	Low voltage directive	EN60255-27
	EMC Directive	EN60255-26
	R&TTE Directive	ETSI EN300 328, ETSI EN301 489-1, ETSI EN301-489-17, RoHS Directive 2011/65/EU
North America	cULus	UL508, e57838 NKCR, NRGU
		C22.2.No 14, e57838 NKCR7, NRGU7
ISO	Manufactured under a registered quality program	ISO9001

TESTING AND CERTIFICATION		
Test	**Reference Standard**	**Test Level**
Dielectric voltage withstand	EN60255-5/IEC60255-27	2.3 kV
Impulse voltage withstand	EN60255-5/IEC60255-27	5 kV
Insulation resistance	IEC60255-27	500 VDC
Damped Oscillatory	IEC61000-4-18	2.5 kV CM, 1 kV DM, 1 MHz
Electrostatic Discharge	EN61000-4-2	Level 4
RF immunity	EN61000-4-3	Level 3
Fast Transient Disturbance	EN61000-4-4	Class A and B
Surge Immunity	EN61000-4-5	Level 3
Conducted RF Immunity	EN61000-4-6	Level 3
Power Frequency Immunity	IEC60255-26	Class A & B
Voltage variation, interruption and Ripple DC	IEC60255-26	PQT levels based on IEC61000-4-29, IEC61000-4-11 and IEC61000-4-17
Radiated & Conducted Emissions	CISPR11 /CISPR22	Class A
Sinusoidal Vibration	IEC60255-21-1	Class 1
Shock & Bump	IEC60255-21-2	Class 1
Seismic	IEC60255-21-3	Class 2
Power magnetic Immunity	IEC61000-4-8	Level 5
Pulse Magnetic Immunity	IEC61000-4-9	Level 4
Damped Magnetic Immunity	IEC61000-4-10	Level 4
Voltage Dip & interruption	IEC61000-4-11	0, 40, 70, 80% dips, 250/300 cycle interrupts
Harmonic Immunity	IEC61000-4-13	Class 3
Conducted RF Immunity 0-150kHz	IEC61000-4-16	Level 4
Ingress Protection	IEC60529	IP54 front
Environmental (Cold)	IEC60068-2-1	-40C 16 hrs
Environmental (Dry heat)	IEC60068-2-2	85C 16hrs
Relative Humidity Cyclic	IEC60068-2-30	6 day humidity variant 2
EFT	IEEE/ANSI C37.90.1	4kV, 5 kHz
Damped Oscillatory	IEEE/ANSI C37.90.1	2.5 kV, 1 MHz

Dielectric Between contacts	IEEE C37.90	1500Vrms
Make and Carry	IEEE C37.90	30A /200 ops
Electrostatic Discharge (ESD)	IEEE/ANSI C37.90.3	8kV CD/ 15 kV AD
Product Safety	IEC60255-27	As per Normative sections
Rated Burden,	IEC60255-1	Sec 6.10
Contact Performance	IEC60255-1	Sec 6.11

Physical

DIMENSIONS

Size: .... *Refer to Chapter 2*

Weight: .... 9 kg [20.0 lbs]

Environmental

Ambient temperatures:	
Storage/Shipping:	-40°C to 85°C
Operating:	-40°C to 60°C
Humidity:	Operating up to 95% (non condensing) @ 55°C (As per IEC60068-2-30 Variant 2, 6 days)
Altitude:	2000m (standard base reference evaluated altitude) 5000m (maximum achievable altitude)
Pollution Degree:	II
Overvoltage Category:	II
Ingress Protection:	IP54 Front
Insulation Class:	1
Noise:	0 dB

Cautions and Warnings

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

Safety words and definitions

The following symbols used in this document indicate the following conditions

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

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

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

NOTICE **Indicates practices not related to personal injury.**

General Cautions and Warnings

The following general safety precautions and warnings apply.

⚠CAUTION

Before attempting to use the equipment, it is important that all danger and caution indicators are reviewed.

If the equipment is used in a manner not specified by the manufacturer or functions abnormally, proceed with caution. Otherwise, the protection provided by the equipment may be impaired and can result in impaired operation and injury.

⚠CAUTION

Hazardous voltages can cause shock, burns or death.

⚠CAUTION

Installation/service personnel must be familiar with general device test practices, electrical awareness and safety precautions must be followed.

Before performing visual inspections, tests, or periodic maintenance on this device or associated circuits, isolate or disconnect all hazardous live circuits and sources of electric power.

Failure to shut equipment off prior to removing the power connections could expose you to dangerous voltages causing injury or death.

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

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

Use the device only for its intended purpose and application.

Ensure that all ground paths are un-compromised for safety purposes during device operation and service.

All recommended equipment that should be grounded and must have a reliable and un-compromised grounding path for safety purposes, protection against electromagnetic interference and proper device operation.

Equipment grounds should be bonded together and connected to the facility's main ground system for primary power.

Keep all ground leads as short as possible.

In addition to the safety precautions mentioned all electrical connections made must respect the applicable local jurisdiction electrical code.

It is recommended that a field external switch, circuit breaker be connected near the equipment as a means of power disconnect. The external switch or circuit breaker is selected in accordance with the power rating.

This product itself is not Personal Protective Equipment (PPE). However, it can be used in the computation of site specific Arc Flash analysis when the arc flash option is ordered. If a new appropriate Hazard Reduction Category code for the installation is determined, user should follow the cautions mentioned in the arc flash installation section.

CAUTION

The critical fail relay must be connected to annunciate the status of the device when the Arc Flash option is ordered.

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

Only qualified personnel are to operate the device. Such personnel must be thoroughly familiar with all safety cautions and warnings in this manual and with applicable country, regional, utility, and plant safety regulations.

Hazardous voltages can exist in the power supply and at the device connection to current transformers, voltage transformers, control, and test circuit terminals. Make sure all sources of such voltages are isolated prior to attempting work on the device.

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

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

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

Use an external disconnect to isolate the mains voltage supply.

CAUTION

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

NOTICE

To ensure the settings file inside the relay is updated, wait 30 seconds after a setpoint change before cycling power.

NOTICE

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

Must-read Information

The following general statements apply and are repeated in the relevant sections of the manual.

NOTICE

- WiFi and USB do not currently support CyberSentry security. For this reason WiFi is disabled by default if the CyberSentry option is purchased. WiFi can be enabled, but be aware that doing so violates the security and compliance model that CyberSentry is supposed to provide.
- Before upgrading firmware, it is very important to save the current 845 settings to a file on your PC. After the firmware has been upgraded, it is necessary to load this file back into the 845.

- The SNTP, IRIG-B and PTP settings take effect after rebooting the relay.
- Commands may be issued freely through other protocols than Modbus (i.e., DNP, IEC 104, and, IEC 61850) without user authentication or encryption of data taking place, even if the relay has the advanced security feature enabled.
- Note that the factory role password may not be changed.
- In 845 both DNP and IEC104 protocol can work at the same time, but consider that there is only one point map. So, both protocols use the same configured points.
- The 52b contact is closed when the breaker is open and open when the breaker is closed.
- 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 change the directional signal. Some protection elements such as Instantaneous Overcurrent may respond to reverse faults before the directional signal has changed. A coordination time of at least 10 ms must therefore be added to all the instantaneous protection elements under the supervision of the Phase Directional element. If current reversal is a concern, a longer delay – in the order of 20 ms – is needed.
- The same curves used for the time overcurrent elements are used for Neutral Displacement. When using the curve to determine the operating time of the Neutral Displacement element, substitute the ratio of neutral voltage to Pickup level for the current ratio shown on the horizontal axis of the curve plot.
- If the 3-phase VT uses a delta connection and FREQUENCY INPUT is set to J2-3VT, the positive sequence voltage is used as the supervision voltage. In such conditions, the true supervision level is internally changed to 1/sqrt(3) of the user setting since the base of VT here is the phase-phase voltage.
- To monitor the trip coil circuit integrity, use the relay terminals “FA_1 NO” and “FA_1 COM” to connect the Trip coil, and provide a jumper between terminals “FA_1 COM” and “FA_1 OPT/V” voltage monitor).
- In Power factor monitoring, SWITCH-IN and SWITCH-OUT are mutually exclusive settings.
- The relay is not approved as, or intended to be, a revenue metering instrument. If used in a peak load control system, consider the accuracy rating and method of measurement employed, and the source VTs and CTs, in comparison with the electrical utility revenue metering system.
- In bulk oil circuit breakers, the interrupting time for currents is less than 25% of the interrupting rating and can be significantly longer than the normal interrupting time.
- For future reference, make a printout of the conversion report immediately after the conversion in case conversion reports are removed or settings modified from the 8 Series Setup Software.

Storage

Store the unit indoors in a cool, dry place. If possible, store in the original packaging. Follow the storage temperature range outlined in the Specifications.

Use the factory-provided dust caps on all Arc Flash sensor fiber and connectors when not in use, to avoid dust contamination in the transceiver and sensor plugs.

For Further Assistance

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

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

Repairs

The firmware and software can be upgraded without return of the device to the factory.

For issues not solved by troubleshooting, the process to return the device to the factory for repair is as follows:

- Contact a GE Grid Solutions Technical Support Center. Contact information is found in the first chapter.
- Obtain a Return Materials Authorization (RMA) number from the Technical Support Center.
- Verify that the RMA and Commercial Invoice received have the correct information.
- Tightly pack the unit in a box with bubble wrap, foam material, or styrofoam inserts or packaging peanuts to cushion the item(s). You may also use double boxing whereby you place the box in a larger box that contains at least 5 cm of cushioning material.
- Ship the unit by courier or freight forwarder, along with the Commercial Invoice and RMA, to the factory.
- Customers are responsible for shipping costs to the factory, regardless of whether the unit is under warranty.
- Fax a copy of the shipping information to the GE Grid Solutions service department.

Use the detailed return procedure outlined at
https://www.gegridsolutions.com/multilin/support/ret_proc.htm
The current warranty and return information are outlined at
https://www.gegridsolutions.com/multilin/warranty.htm

845 Transformer Protection System

Chapter 2: Installation

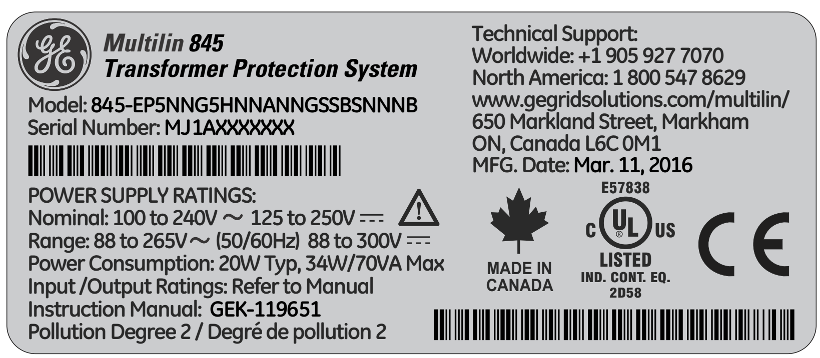
Mechanical Installation

This section describes the mechanical installation of the 845 system, including dimensions for mounting and information on module withdrawal and insertion.

Product Identification

The product identification label is located on the side panel of the 845. This label indicates the product model, serial number, and date of manufacture.

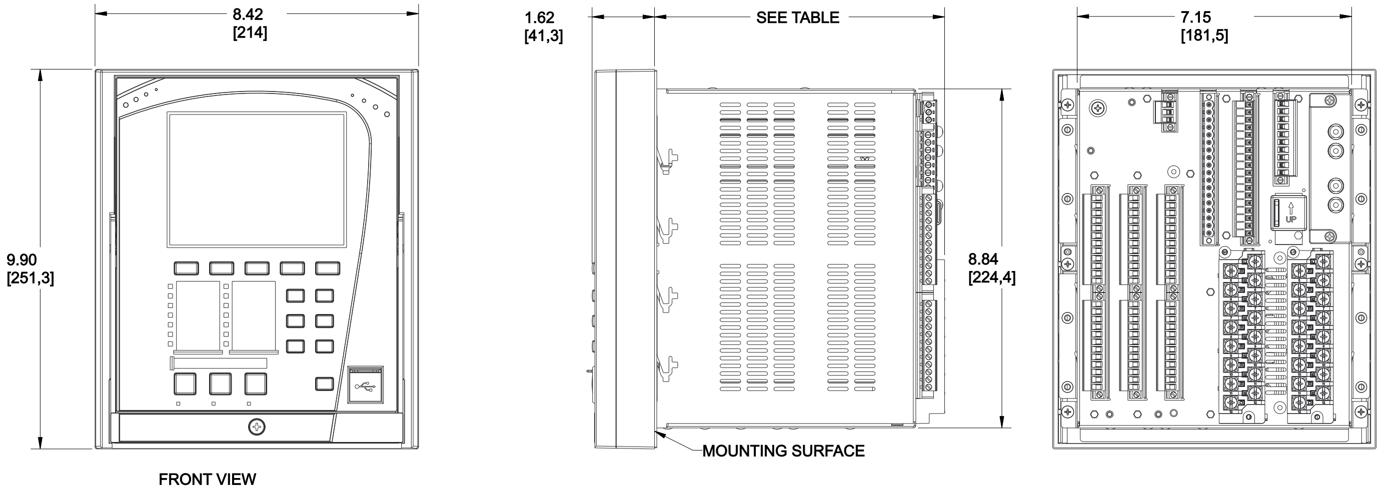
Figure 2-1: Product Label



Dimensions

The dimensions (in inches [millimeters]) of the 845 are shown below. Additional dimensions for mounting, and panel cutouts, are shown in the following sections.

Figure 2-2: 845 Dimensions



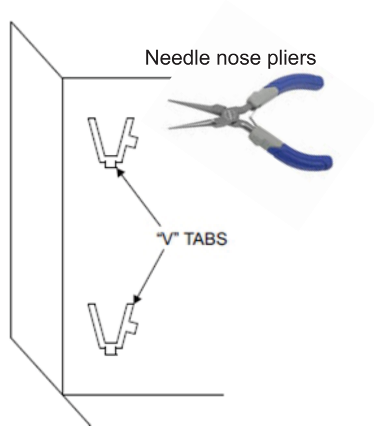
CONNECTOR PLUG TYPE	SCREW CONNECTION LOCATION	MAX DEPTH
RIGHT-ANGLE	SIDE	7.55[191.8]
STRAIGHT	FRONT	7.71[195.8]

Mounting

The 845 unit can be mounted two ways: standard panel mount or optional tab mounting, if required.

- **Standard panel mounting:**
  From the front of the panel, slide the empty case into the cutout. From the rear of the panel, screw the case into the panel at the 8 screw positions (see figures in Standard panel mount section).
- **Optional tab mounting:**
  The "V" tabs are located on the sides of the case and appear as shown in the following figure. Use needle nose pliers to bend the retaining "V" tabs outward to about 90°. Use caution and do not bend and distort the wall of the enclosure adjacent to the tabs. The relay can now be inserted and can be panel wired.

Figure 2-3: "V" Tabs Located on Case Side



Standard Panel Mount

The standard panel mount and cutout dimensions are illustrated below.

⚠CAUTION

To avoid the potential for personal injury due to fire hazards, ensure the unit is mounted in a safe location and/or within an appropriate enclosure.

Figure 2-4: Standard panel mount

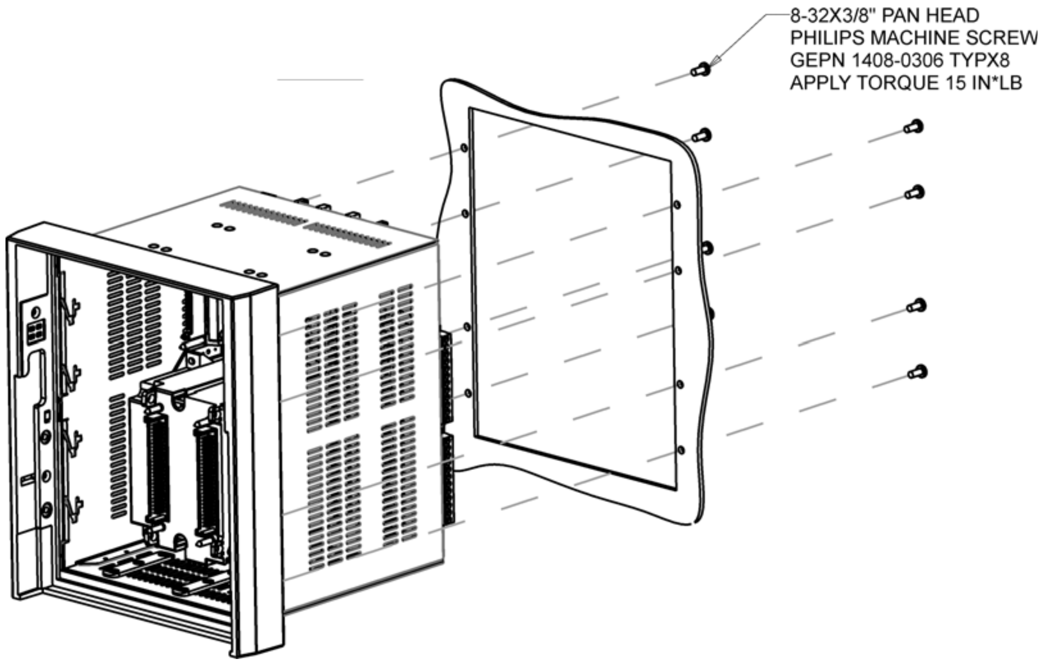
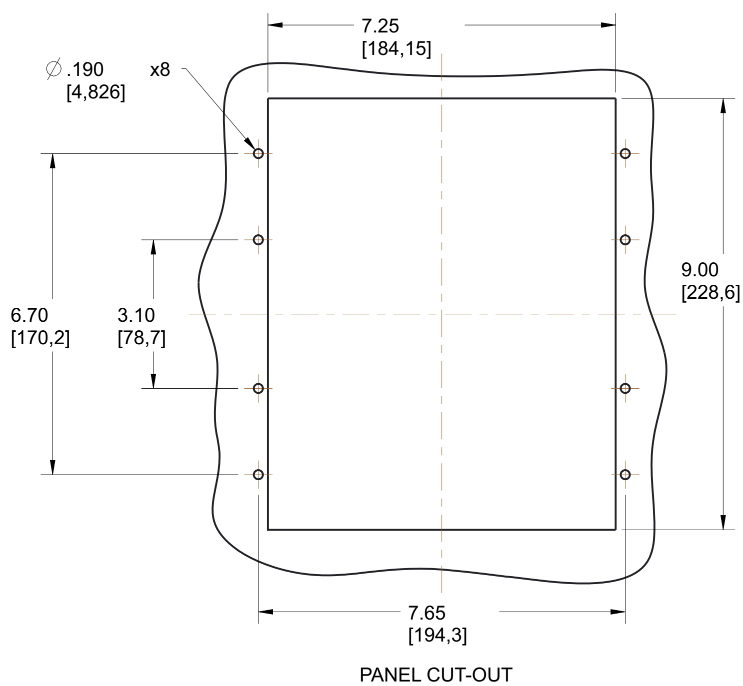


Figure 2-5: Panel cutout dimensions



Depth Reducing Collar

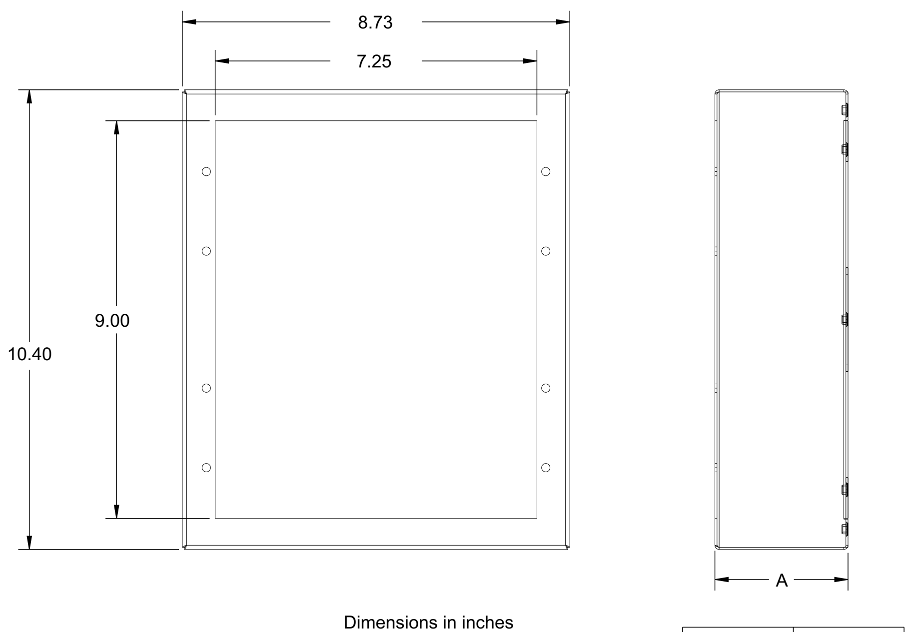
Two different sizes of optional depth reducing collar are available for mounting relays in narrow-depth service panels, or wherever space is an issue.

NOTE

The drill hole locations are different when a depth reducing collar is used. See Figure 2-7:Depth reducing collar panel cutout.

- 18J0-0030 8 Series Depth Reducing Collar - 1 3/8"
- 18J0-0029 8 Series Depth Reducing Collar - 3"

Figure 2-6: Depth reducing collar dimensions



GE PN	'A' DEPTH
1009-0310	1 3/8"
1009-0311	3"

892703A1.dwg

Figure 2-7: Depth reducing collar panel cutout

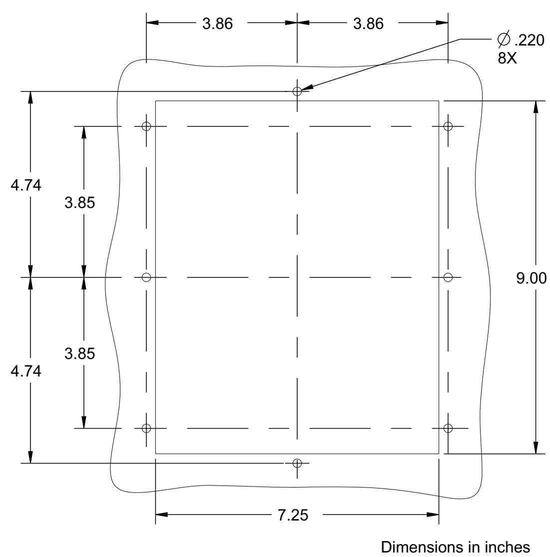
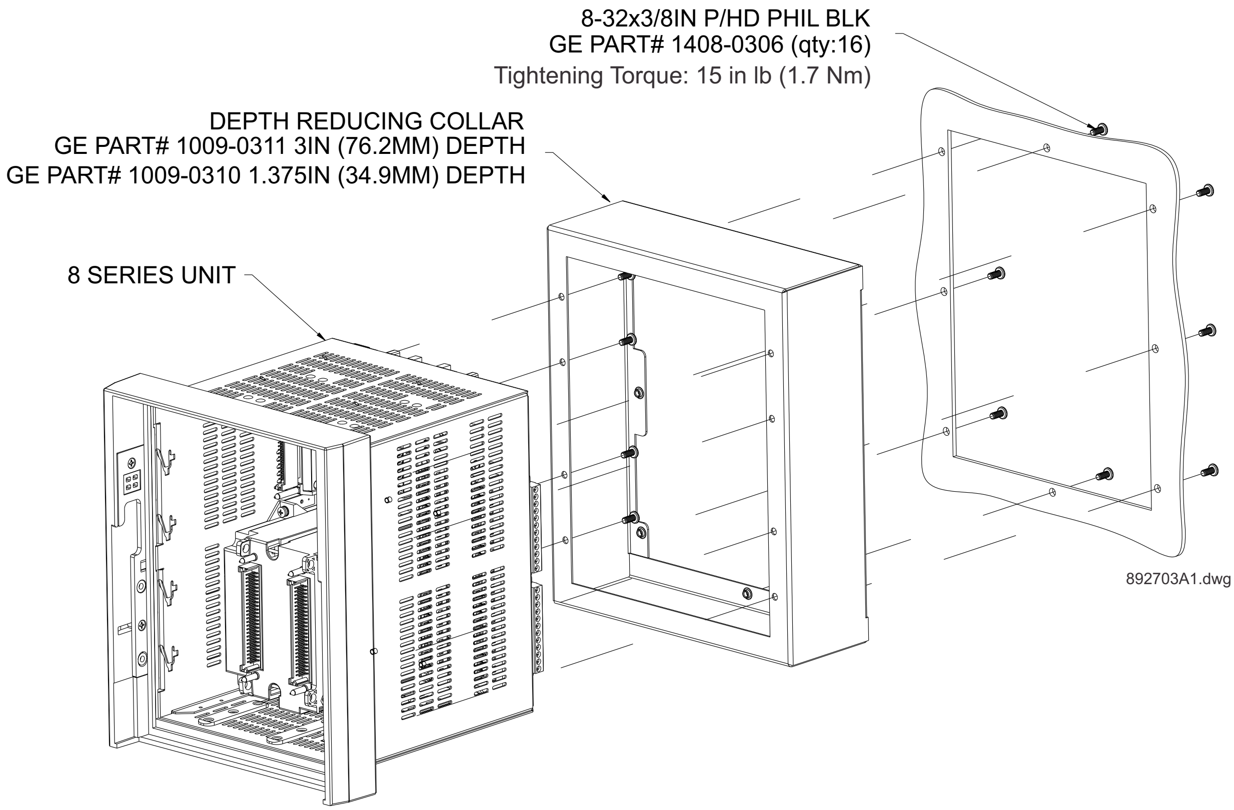


Figure 2-8: Depth reducing collar installation



To mount an 8 Series relay with a depth reducing collar, follow these steps:

1. Drill mounting holes as shown on the panel cutout drawing (Figure 2-7:Depth reducing collar panel cutout).
2. Mount the required collar (depth 1.375" or 3") on the captive unit using eight screws as shown.
3. Mount the combined unit and collar on the panel using eight screws as shown.

Draw-out Unit Withdrawal and Insertion

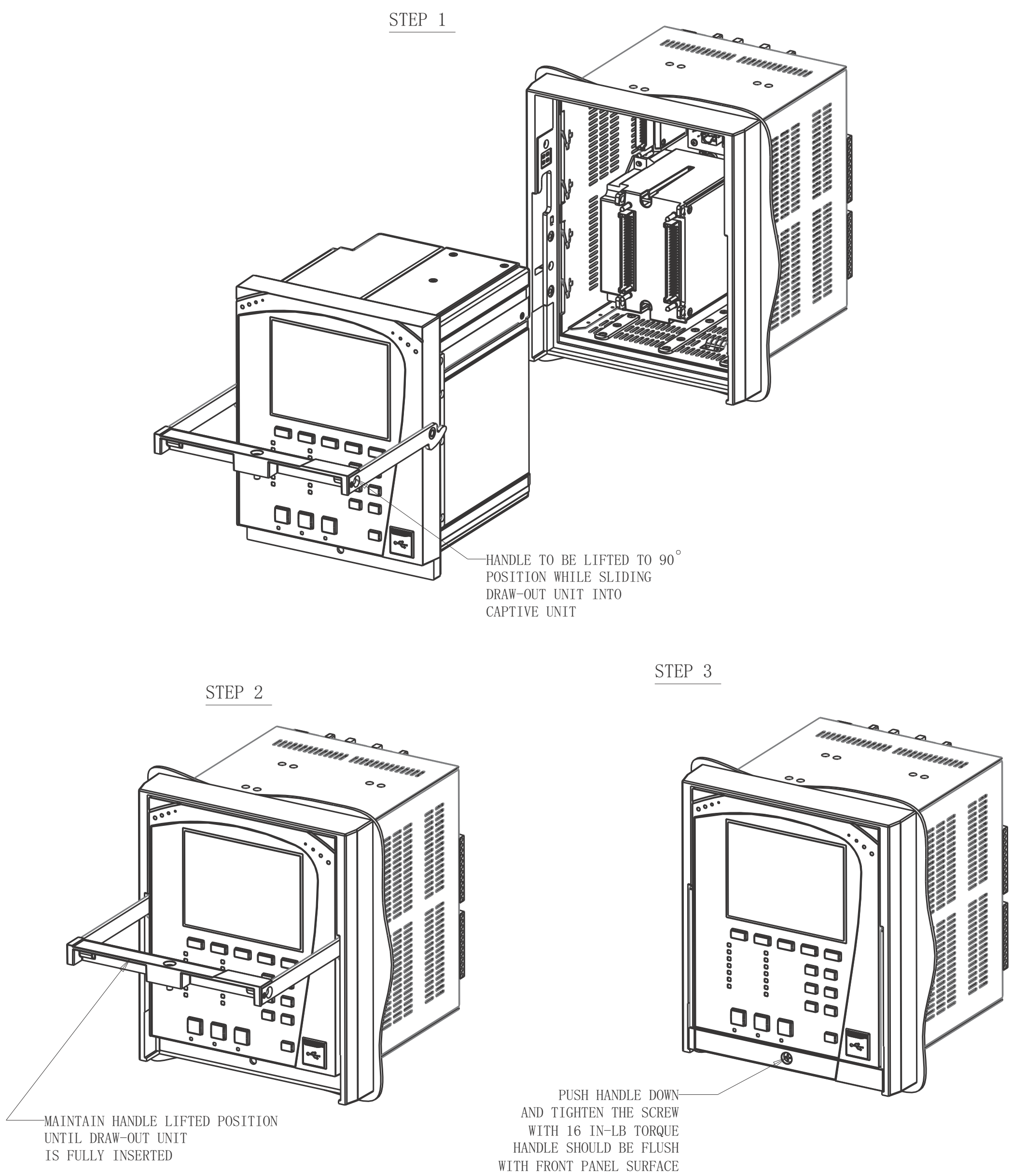
Unit withdrawal and insertion may only be performed when control power has been removed from the unit.

NOTICE

Turn off control power before drawing out or re-inserting the relay to prevent mal-operation.

Follow the steps outlined in the diagrams below to insert and withdraw the Draw-out unit.

Figure 2-9: Unit withdrawal and insertion diagram



Removable Power Supply

Follow the steps outlined in the *Insert or Remove Power Supply* diagram to insert (#1) or remove (#2) the power supply from the unit.

Figure 2-10: Insert or Remove the Power Supply

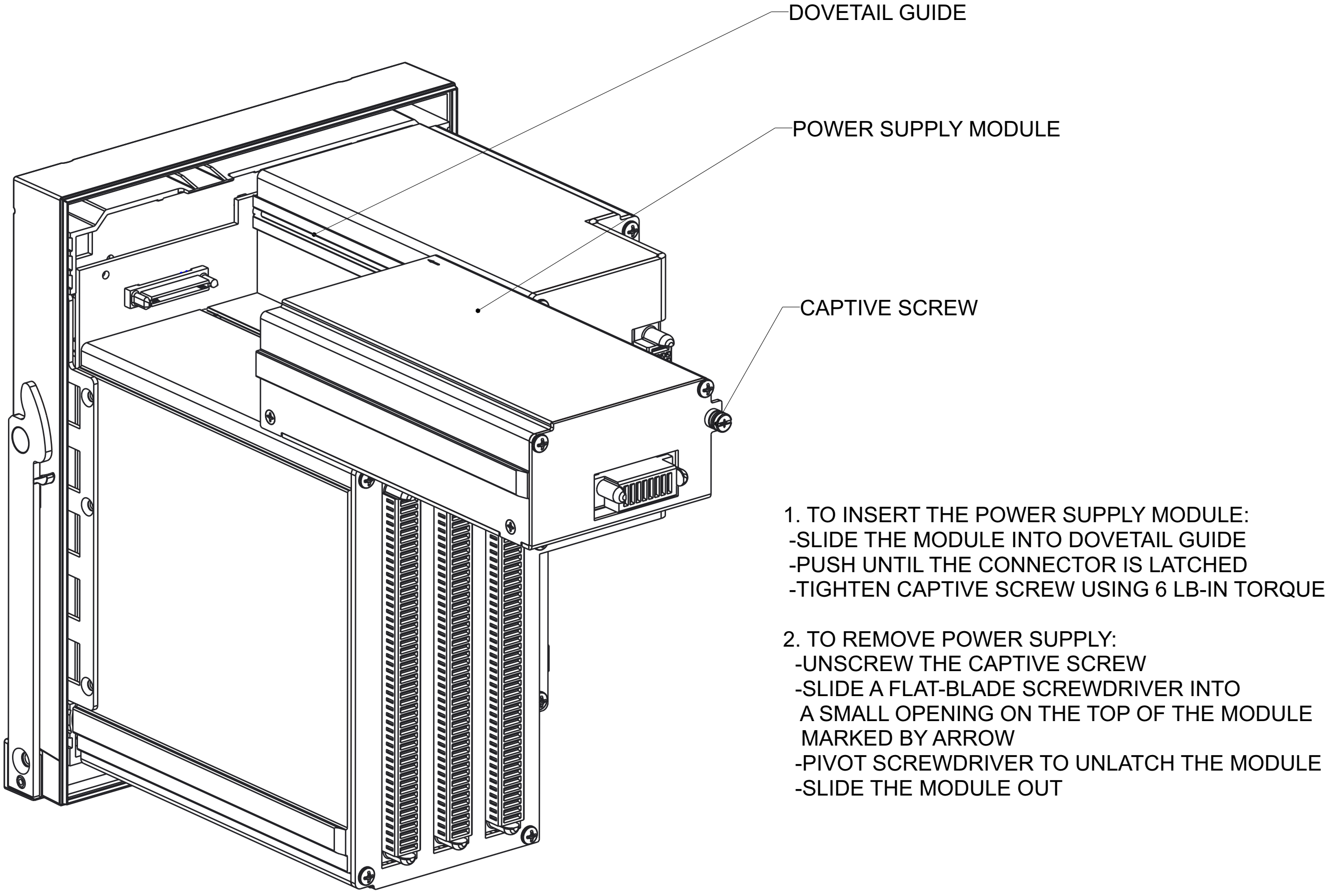
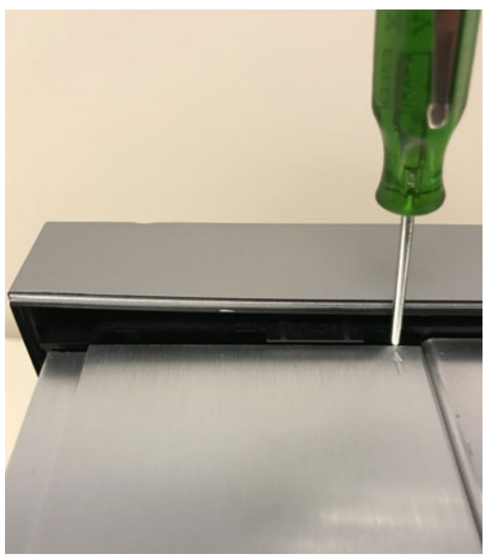


Figure 2-11: Unlatch Module (location is marked by arrow)



Removable Magnetic Module

⚠WARNING **Prior to the removal of the CT/VT magnetic module, all preparation steps below shall be adhered to in order to prevent injury.**

All current and voltage sources connected to the 8 Series relay must be identified before starting the removal process.

Removal of the magnetic module from a relay installed in a power system shall only be performed by suitably-qualified personnel.

Appropriate PPE is required based on the arc flash calculations.

⚠CAUTION **LOTO (Lockout Tag Out) of the system is required prior to module removal/ replacement.**

Follow the procedures outlined below to remove or replace the CT/VT magnetic module.

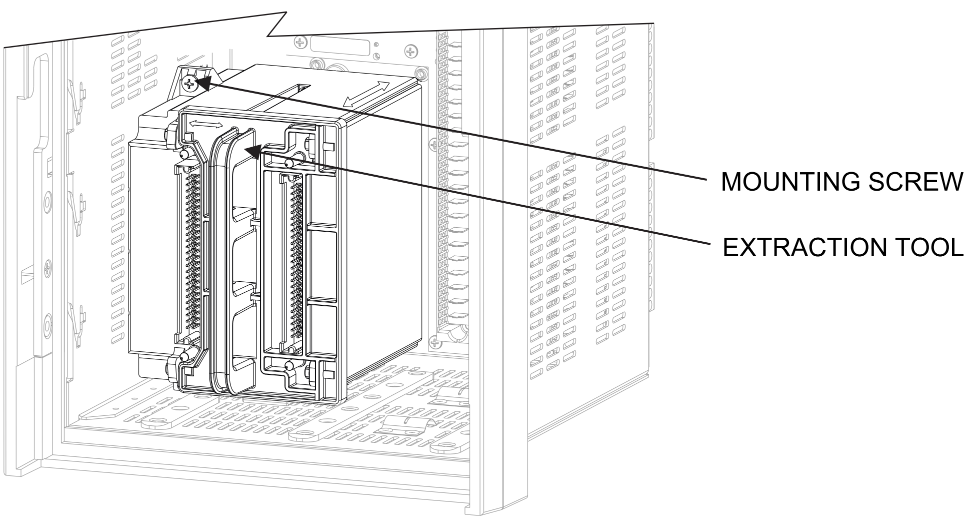
PREPARATION

1. Shut down and de-energize all systems connected to the 8 Series relay
2. Review all points in the section Cautions and Warnings.

⚠WARNING **An 8 Series relay, with the magnetic module removed, does NOT have an internal automatic CT shorting mechanism.**

⚠CAUTION **Hazardous voltages can exist when opening the secondary circuits of live current transformers. Make sure that in-field current transformer secondary circuits are shorted out before making or removing any connection to the current transformer (CT) input terminals of the device (i.e disconnection/connection of 8 Series CT Input terminals or the internal CT /VT magnetic module).**

Figure 2-12: Removing/replacing the CT/VT Magnetic Module



REMOVAL

⚠CAUTION

LOTO (Lockout Tag Out) of the system is required prior to module removal/ replacement.

1. Remove the 8 Series draw-out unit from the chassis (see the section Draw-out Unit Withdrawal and Insertion). Carefully set aside.
2. Within the captive chassis, unscrew the mounting screw (as indicated in the following figure).
3. Insert the magnetic module extractor tool as shown in the following figure, without engaging the pins.
4. Slide the tool to the left, engaging the pins fully (see arrow in figure).
5. Pull the tool handle towards the operator to disengage the module, and carefully remove the module from the chassis..
6. Remove the tool from the module, and save for future use

REPLACEMENT

⚠CAUTION

LOTO (Lockout Tag Out) of the system is required prior to module removal/ replacement.

Ensure the replacement CT /VT module is the same type as the removed module. Alternate models and configurations may be unsafe for use.

1. Insert the extractor tool into the front of the module, then slide the tool to the left to engage the tool pins.
2. Place the module/tool at the front of the chassis so that it is flush with the left and bottom sides.
3. Slide the module/tool into the back of the chassis as far as it will go, making sure the connectors mate while keeping the module flush to the left and bottom sides of the chassis.
4. Tighten the captive mounting screw using a torque of 6 in-lbs.
5. Remove the tool from the magnetics module and save for future use.
6. Insert the 8 Series draw-out unit (see the section Draw-out Unit Withdrawal and Insertion).
7. Re-energize the 8 series relay system.
8. Remove the external shorting equipment from the CT inputs.
9. Ensure the In Service LED on the relay front panel is green.
10. Navigate to the Target message screen (press **Home** and then **Targets**) and check that the Target screen does not show any Self-Test errors.

    (Self-Test errors may indicate that the module has not been mounted properly.)
11. Verify through the 8 Series relay that CTs and VTs, digital inputs and other circuits are all metering correctly.

Remote Module I/O (RMIO)

If using the Remote RTD module, follow these installation steps.

Figure 2-13: RMIO - DIN rail mounting - Base & Expansion units

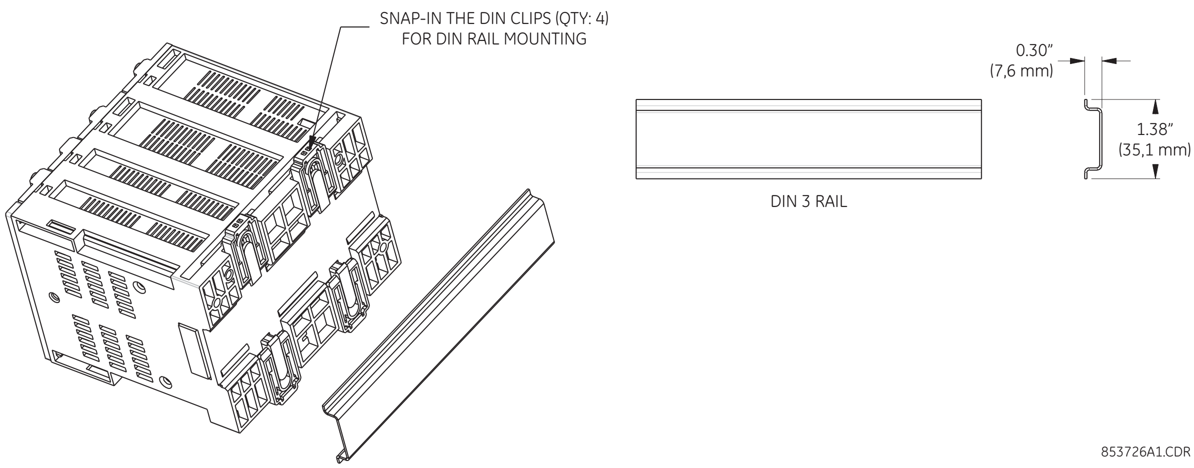


Figure 2-14: RMIO - Base Unit screw mounting

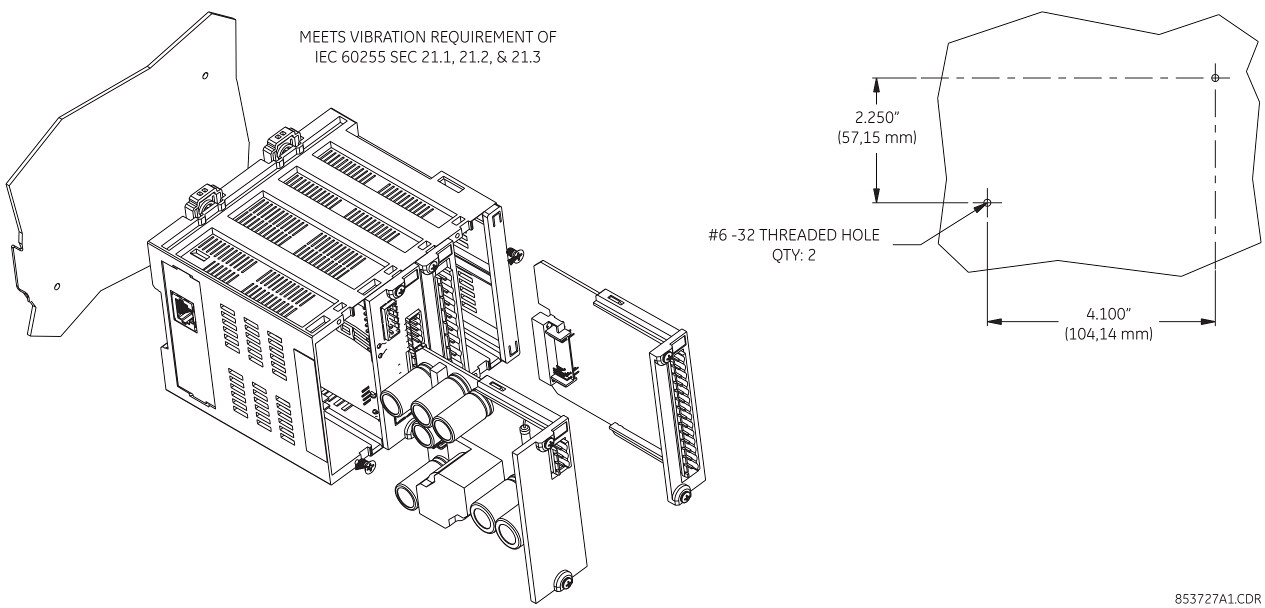
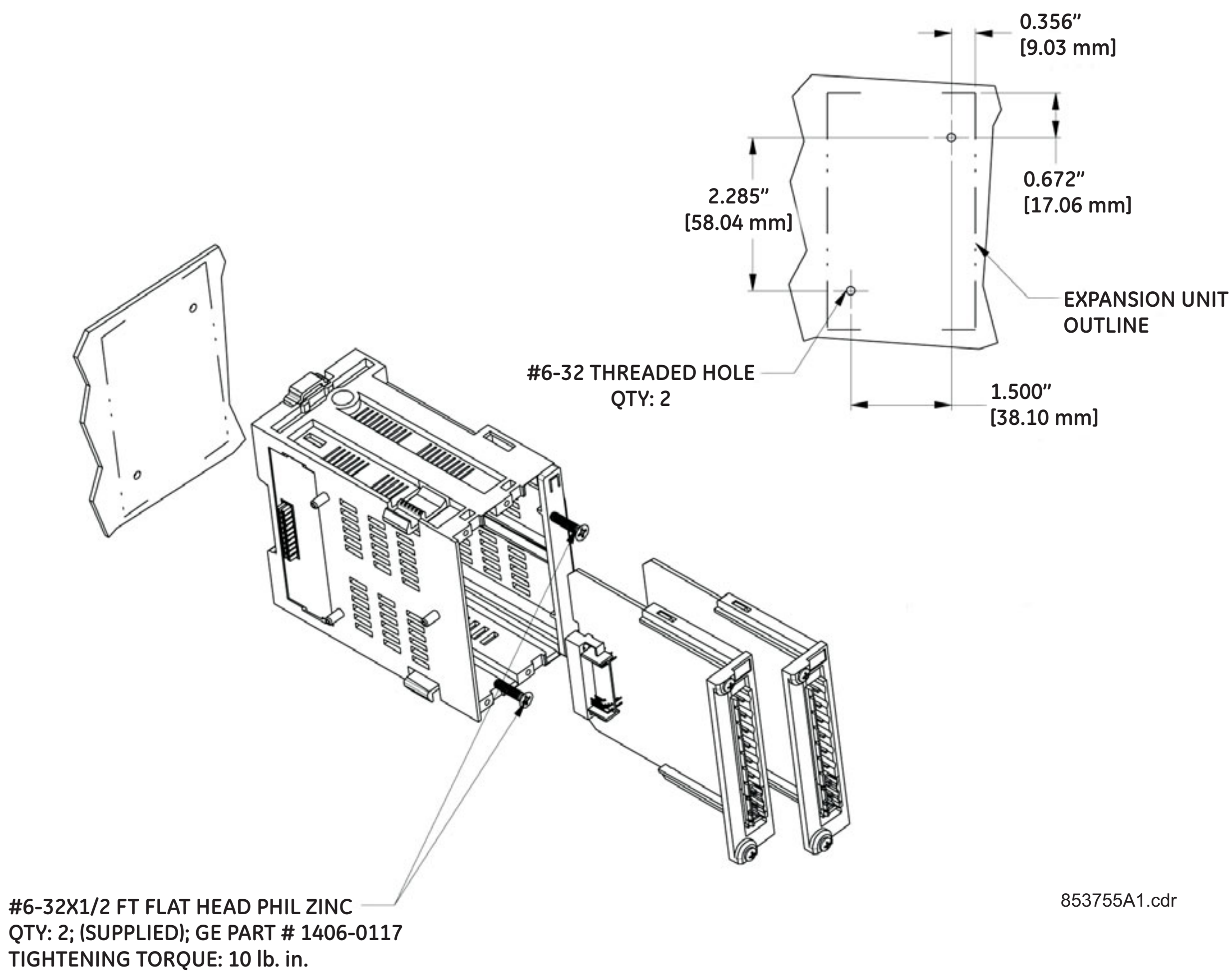


Figure 2-15: RMIO - Expansion Unit screw mounting

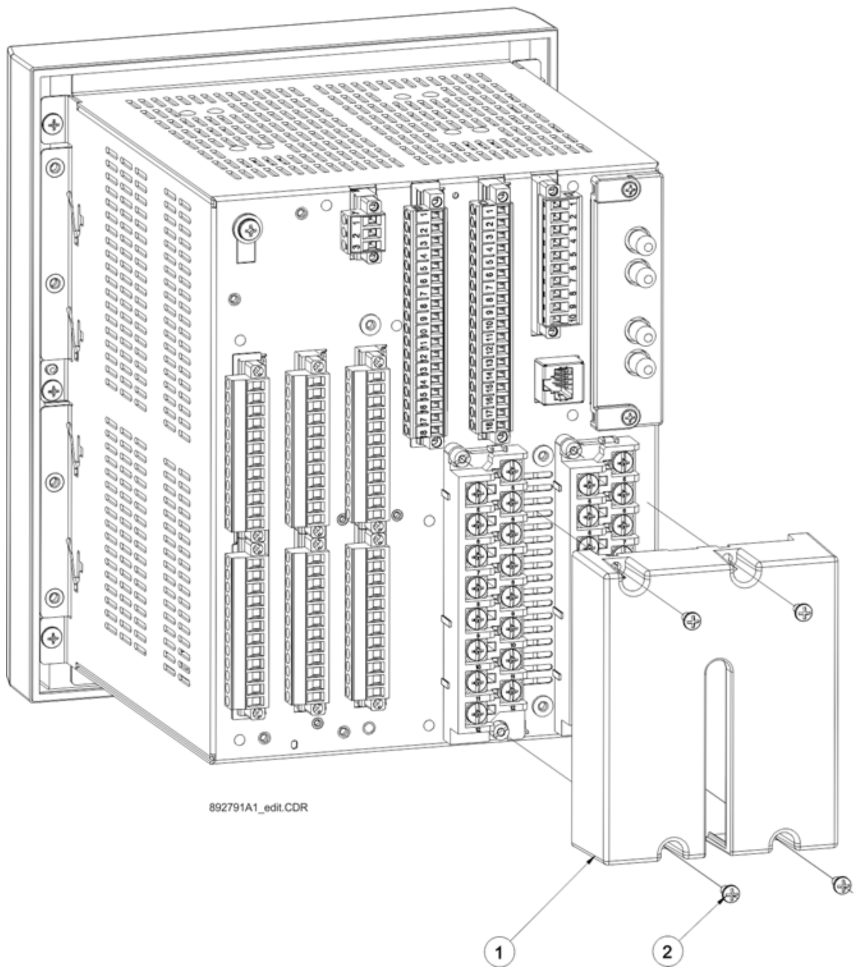


IP20 Back Cover

If using the IP20 back cover, follow these installation steps.

1. Place the IP20 cover in the orientation shown over the CT/VT terminal blocks, routing wiring through the cover slots.
2. Secure the cover with the 4 screws provided. Suggested tightening torque is 8 lb-in.

Figure 2-16: IP20 Back Cover installation



Arc Flash Sensor

The Arc Flash sensor houses the fiber optics and membrane that are used to detect the arc flash. Two mounting screw holes are provided to affix the sensors to the panel.

⚠CAUTION

If the 8 Series is used in the computation for reducing the Hazard Reduction Category code, operands for sensor failures must be assigned to an auxiliary output relay which must be connected into the control logic of the breaker equipment to ensure safe operations when the output relay is asserted. In the event of this assertion, the Hazard Reduction Category code cannot be maintained unless backup protection is continuing to maintain it.

Sensor Fiber Handling & Storage

⚠CAUTION

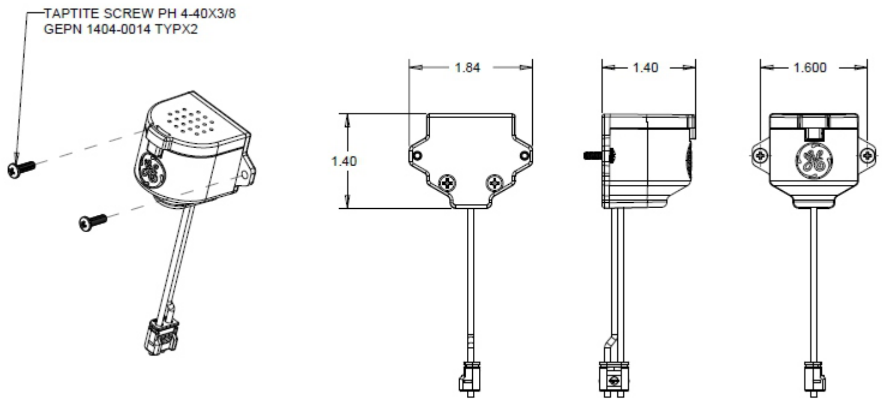
Arc Flash sensor fiber is pressure sensitive and must be handled carefully to avoid damage. Read the following guidelines fully before proceeding.

Care must be taken when handling the Arc Flash sensor fiber, which can be damaged if twisted, bent, or clamped tightly during installation.

- Do not bend sensor fiber sharply, or with a radius of less than 25 mm (1 inch). Sharp bends can damage the fiber. Do not pull or tug loops of sensor fiber, as sharp bends may result.
- Do not clamp sensor fiber tightly during installation. Sensor fiber should be held in place loosely for the best long-term performance. Avoid over-tightening ties which may deform or break the sensor fiber.
- Do not pull or tug sensor fiber with force, as this may cause internal damage or separate the fiber from the cable connector.
- Do not twist the sensor fiber, as twisting can damage the fiber resulting in substandard performance.
- Do not attach sensor fiber directly to the bus.
- Avoid surface temperatures above 70 °C or 158 °F to prolong the life of the fiber.
- Secure all sensor fibers (loosely but securely) away from any moving parts.
- Use the factory-provided dust caps on all Arc Flash sensor fiber and connectors when not in use, to avoid dust contamination in the transceiver and sensor plugs.

Sensor Installation

Figure 2-17: AF Sensor - front, side and top view



NOTICE

Review the sensor fiber handling guidelines above.

Sensor fiber should be held in place loosely for the best long-term performance. Avoid over-tightening ties which may deform or break the sensor fiber.

Before installing the AF sensor unit, ensure that all other drilling and installation is complete to minimize possible damage to the sensitive unit.

To install the AF sensor and route the sensor fiber, follow these steps:

1. Choose a location for the sensor clear of any obstructions that could shield the sensor from arc flash light.
2. Mount the sensor securely, using the mounting screw holes.
3. Once the sensor is securely mounted, carefully route the sensor fiber from the AFS sensor to the base unit, minimizing loops and curves for the strongest possible signal.
4. Secure all sensor fibers (loosely but securely) away from any moving parts.

NOTICE

Both the AF sensor connections (CH 1 through CH 4) and the sensor cables are shipped with dust caps in place to avoid dust contamination. The small rubber dust caps must be removed before operation.

Electrical Installation

Typical Wiring Diagrams

The following illustrates the electrical wiring of the Draw-out unit.

Figure 2-18: Typical Wiring for a 2-Winding Transformer with VTs on HV Side (892841A3)

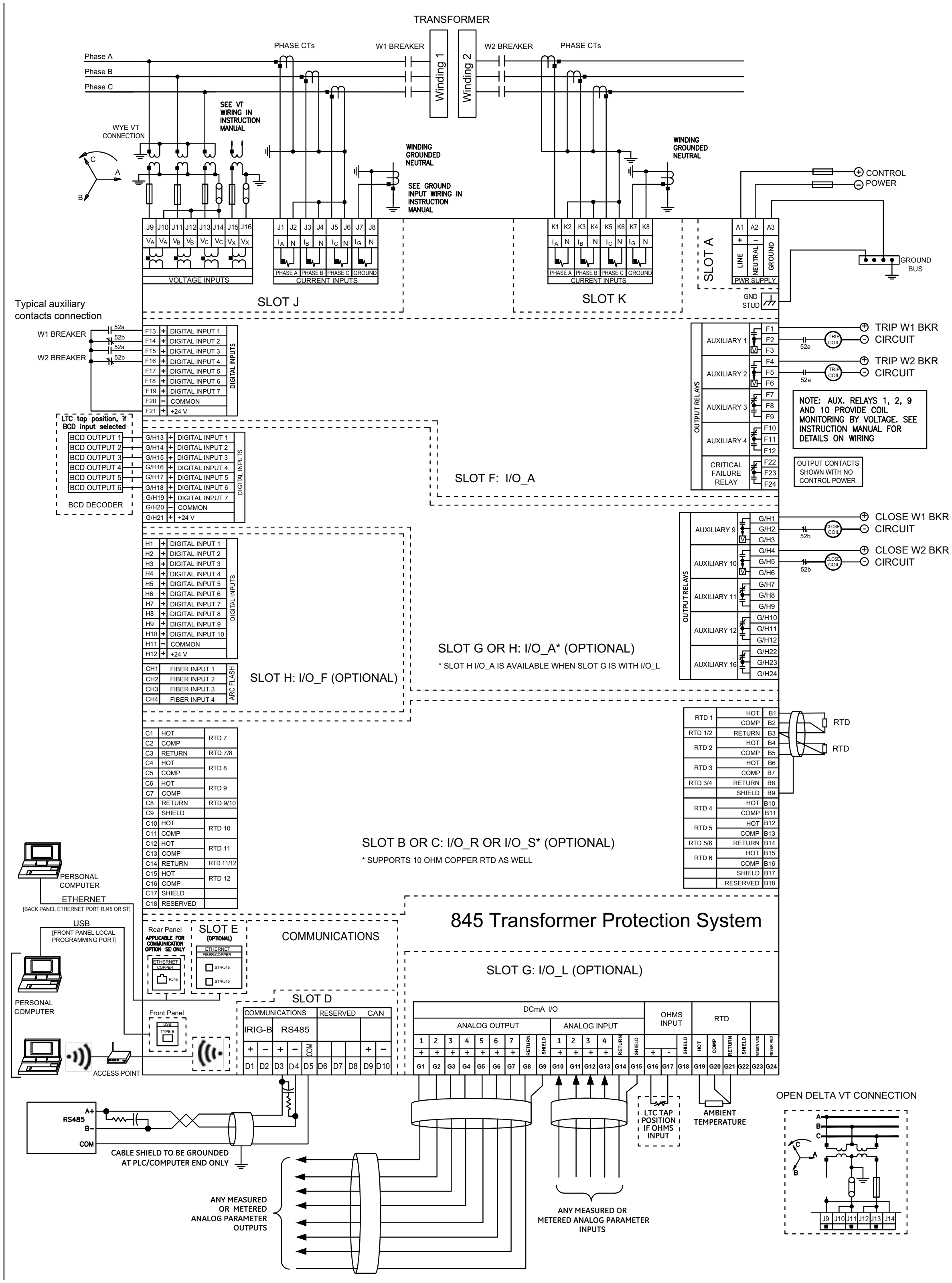


Figure 2-19: Typical Wiring for a 2-Winding Transformer without VTs (892842A3)

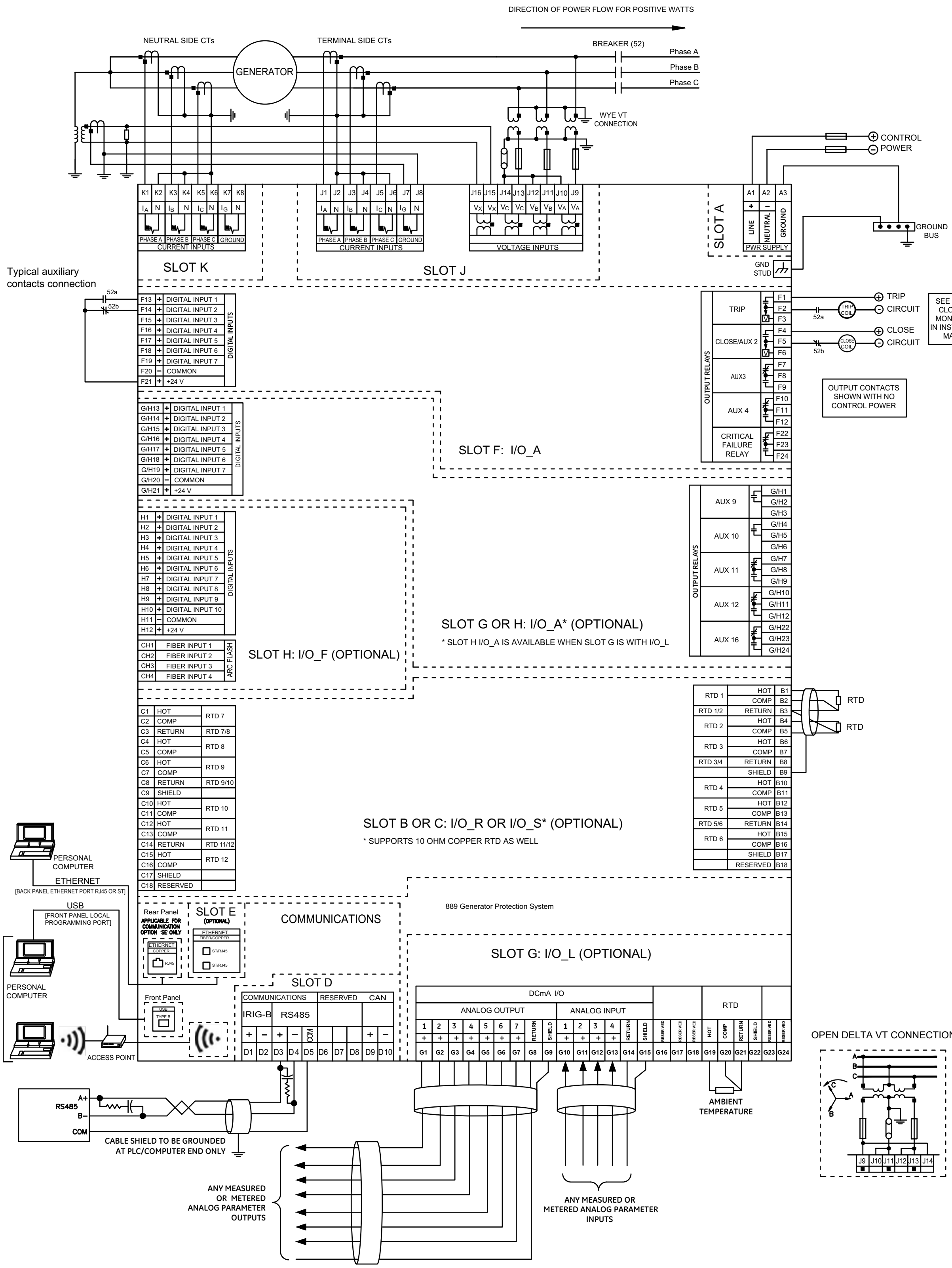
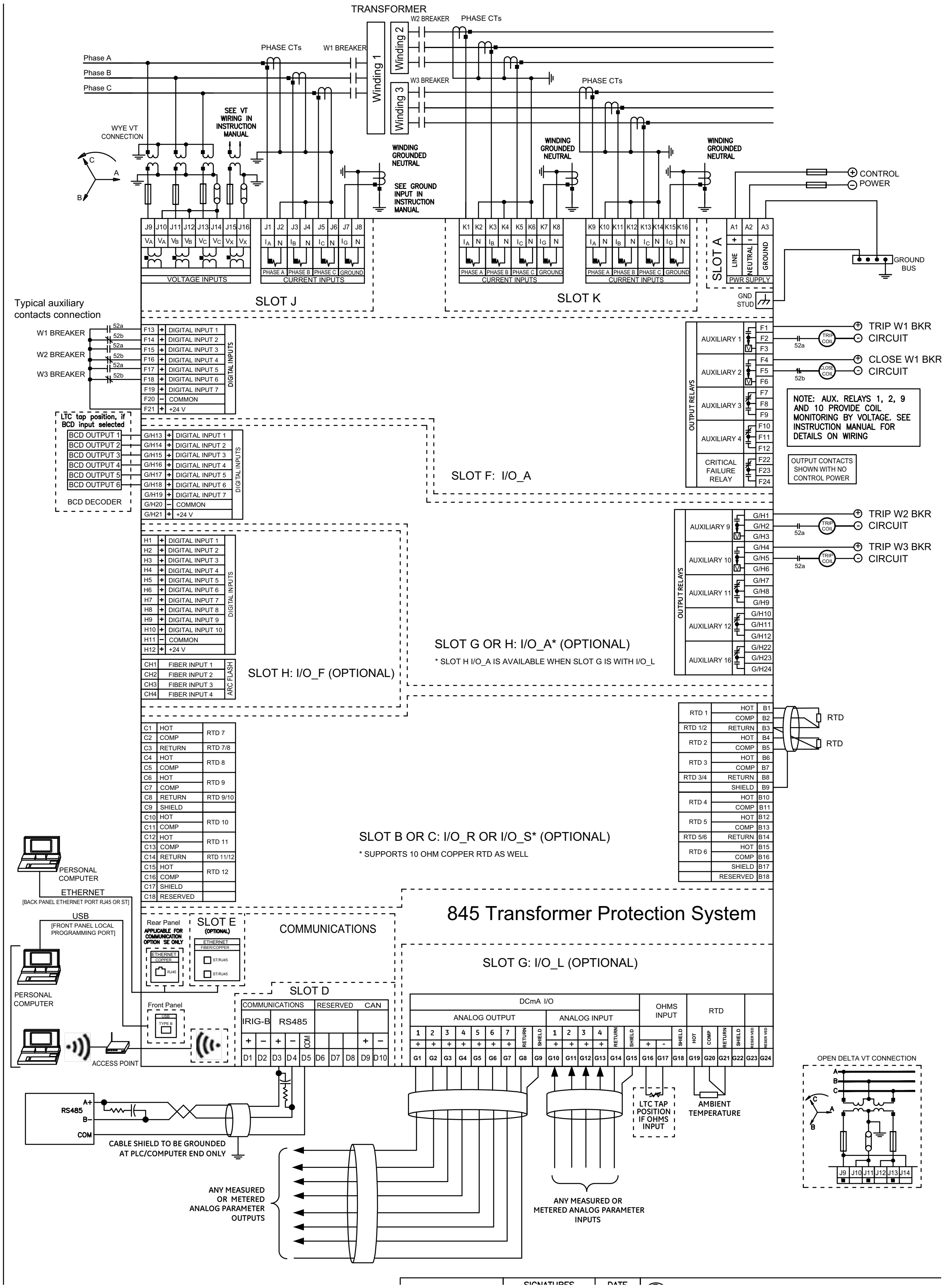


Figure 2-20: Typical Wiring for a 3-Winding Transformer (892789A3)



Terminal Identification

All the terminal strips are labeled with a slot letter to identify the module slot position and numbers to identify the terminals within the module.

CAUTION

Make sure that the first letter on the terminal strip corresponds to the slot location identified on the chassis silkscreen.

Terminal Connections

NOTE

When installing two lugs on one terminal, both lugs must be "right side up" as shown in the picture below. This is to ensure the adjacent lower terminal block does not interfere with the lug body.

Figure 2-21: Orient the Lugs Correctly

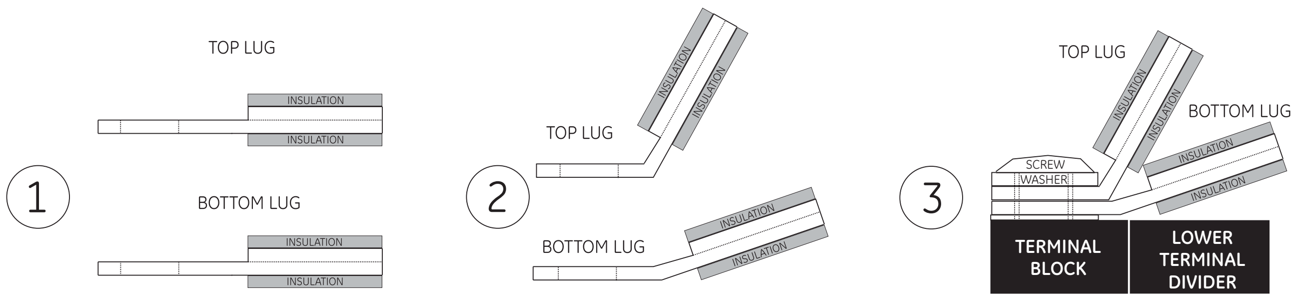


Figure 2-22: Correct Installation Method

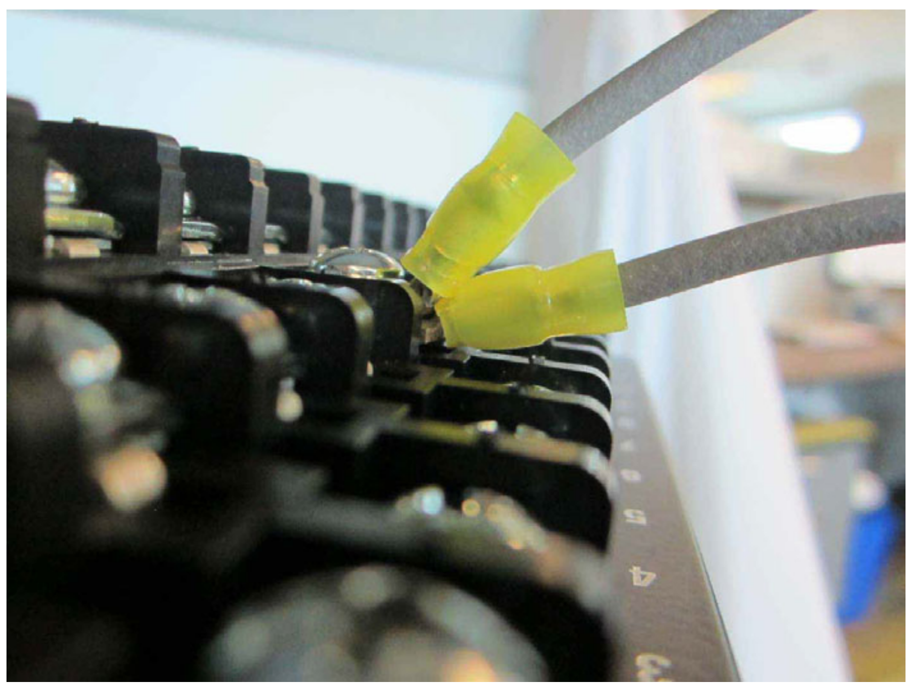
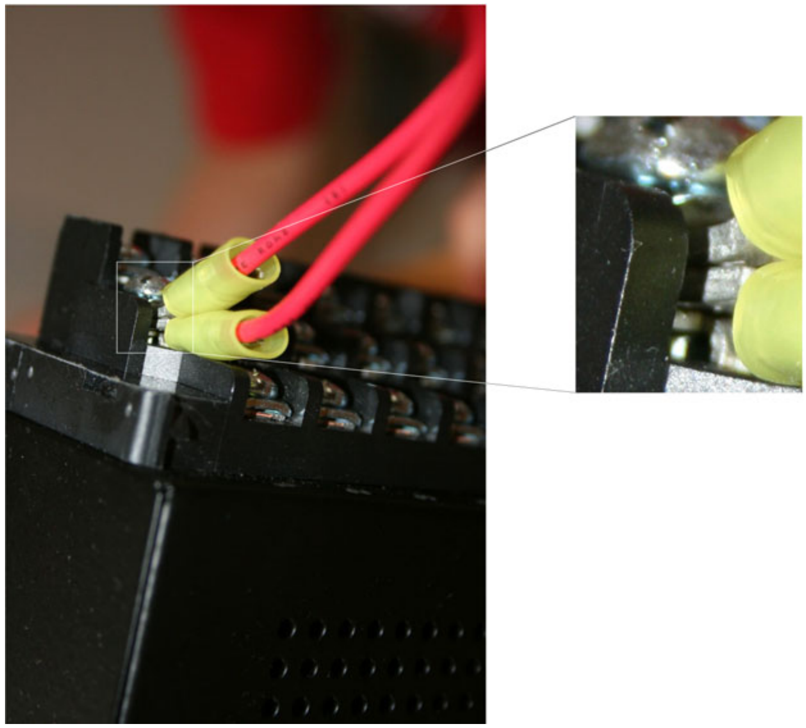


Figure 2-23: INCORRECT INSTALLATION METHOD (lower lug reversed)



A broad range of applications are available for the 845 relays. As such, it is not possible to present typical connections for all possible schemes. The information in this section covers the important aspects of interconnections, in the general areas of instrument transformer inputs, other inputs, outputs, communications and grounding. The figure below shows the rear terminal layout of the 845 Platform.

Figure 2-24: Rear Terminal Layout of the 8 Series Platform

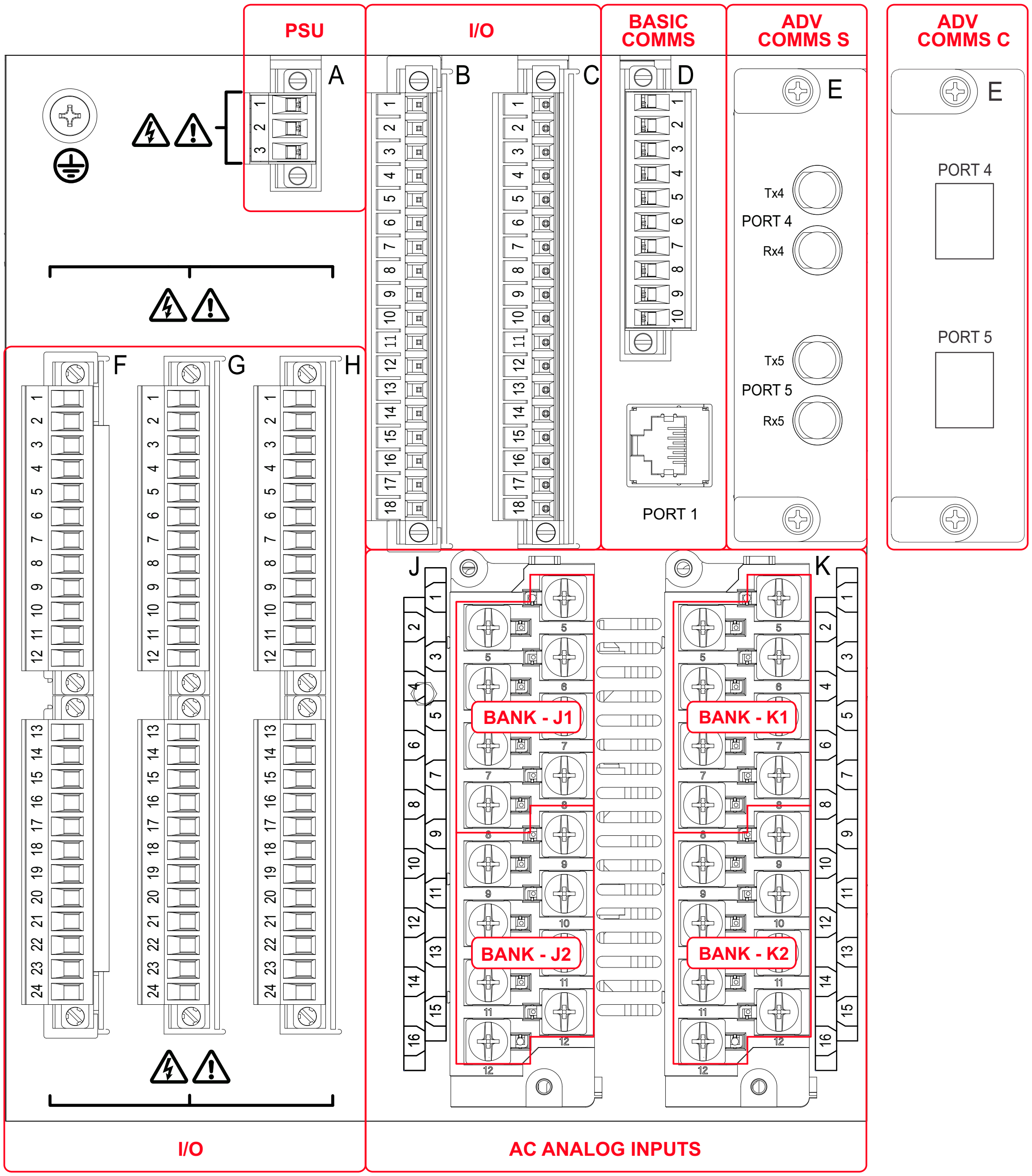

PSU
I/O
BASIC COMMS
ADV COMMS S
ADV COMMS C
A
B
C
D
E
F
G
H
J
K
Tx4
PORT 4
Rx4
Tx5
PORT 5
Rx5
PORT 1
PORT 4
PORT 5
BANK - J1
BANK - J2
BANK - K1
BANK - K2
I/O
AC ANALOG INPUTS

Table 2-1: Power Supply

H - HV Power Supply	
Terminal	**Description**
1	Line
2	Neutral
3	Ground

Table 2-2: Power Supply

L - LV Power Supply	
Terminal	**Description (DC Voltage input polarity)**
1	+ve (positive)
2	-ve (negative)
3	Ground

Table 2-3: Comms

SE - Comms - Basic Ethernet		1E/1P/3E/3A - Comms - Advanced Ethernet	
Terminal	**Description**	**Terminal**	**Description**
1	IRIG-B (+)	1	IRIG-B (+)
2	IRIG-B (-)	2	IRIG-B (-)
3	RS485_1 (+)	3	RS485_1 (+)
4	RS485_1 (-)	4	RS485_1 (-)
5	RS485_1 COM	5	RS485_1 COM
6	RESERVED	6	RESERVED
7	RESERVED	7	RESERVED
8	optional RMIO COM	8	optional RMIO COM
9	optional RMIO +	9	optional RMIO +
10	optional RMIO -	10	optional RMIO -
RJ45	ETHERNET	RJ45	NOT USED

Figure 2-25: Optional I/O card terminal mappings

Optional I/O Card A, slot F, G, or H

F/G/H1		NO	TRIP	OUTPUT RELAYS
F/G/H2		COMMON	TRIP	OUTPUT RELAYS
F/G/H3		OPT/V	TRIP	OUTPUT RELAYS
F/G/H4		NO	CLOSE /AUX	OUTPUT RELAYS
F/G/H5		COMMON	CLOSE /AUX	OUTPUT RELAYS
F/G/H6		OPT/V	CLOSE /AUX	OUTPUT RELAYS
F/G/H7		NC	AUX	OUTPUT RELAYS
F/G/H8		COMMON	AUX	OUTPUT RELAYS
F/G/H9		NO	AUX	OUTPUT RELAYS
F/G/H10		NC	AUX	OUTPUT RELAYS
F/G/H11		COMMON	AUX	OUTPUT RELAYS
F/G/H12		NO	AUX	OUTPUT RELAYS
F/G/H13	+	DIGITAL INPUT 1	THRESHOLD SETTING GROUP 1	DIGITAL INPUTS
F/G/H14	+	DIGITAL INPUT 2	THRESHOLD SETTING GROUP 1	DIGITAL INPUTS
F/G/H15	+	DIGITAL INPUT 3	THRESHOLD SETTING GROUP 1	DIGITAL INPUTS
F/G/H16	+	DIGITAL INPUT 4	THRESHOLD SETTING GROUP 1	DIGITAL INPUTS
F/G/H17	+	DIGITAL INPUT 5	THRESHOLD SETTING GROUP 1	DIGITAL INPUTS
F/G/H18	+	DIGITAL INPUT 6	THRESHOLD SETTING GROUP 1	DIGITAL INPUTS
F/G/H19	+	DIGITAL INPUT 7	THRESHOLD SETTING GROUP 1	DIGITAL INPUTS
F/G/H20	−	COMMON		DIGITAL INPUTS
F/G/H21	+	DC +24V		DIGITAL INPUTS
F/G/H22		NC	AUX*	
F/G/H23		COMMON	AUX*	
F/G/H24		NO	AUX*	

Optional I/O Card M, slot F, G, or H

F/G/H1		COMMON	HSHB 1 (with Vmon)	OUTPUT RELAYS
F/G/H2		NO	HSHB 1 (with Vmon)	OUTPUT RELAYS
F/G/H3		RESERVED		OUTPUT RELAYS
F/G/H4		COMMON	HSHB 2 (with Vmon)	OUTPUT RELAYS
F/G/H5		NO	HSHB 2 (with Vmon)	OUTPUT RELAYS
F/G/H6		RESERVED		OUTPUT RELAYS
F/G/H7		COMMON	HSHB 3 (w/o Vmon)	OUTPUT RELAYS
F/G/H8		NO	HSHB 3 (w/o Vmon)	OUTPUT RELAYS
F/G/H9		RESERVED		OUTPUT RELAYS
F/G/H10		COMMON	HSHB 4 (w/o Vmon)	OUTPUT RELAYS
F/G/H11		NO	HSHB 4 (w/o Vmon)	OUTPUT RELAYS
F/G/H12		RESERVED		OUTPUT RELAYS
F/G/H13	+	DIGITAL INPUT 1	THRESHOLD SETTING GROUP 1	DIGITAL INPUTS
F/G/H14	+	DIGITAL INPUT 2	THRESHOLD SETTING GROUP 1	DIGITAL INPUTS
F/G/H15	+	DIGITAL INPUT 3	THRESHOLD SETTING GROUP 1	DIGITAL INPUTS
F/G/H16	+	DIGITAL INPUT 4	THRESHOLD SETTING GROUP 1	DIGITAL INPUTS
F/G/H17	+	DIGITAL INPUT 5	THRESHOLD SETTING GROUP 1	DIGITAL INPUTS
F/G/H18	+	DIGITAL INPUT 6	THRESHOLD SETTING GROUP 1	DIGITAL INPUTS
F/G/H19	+	DIGITAL INPUT 7	THRESHOLD SETTING GROUP 1	DIGITAL INPUTS
F/G/H20	−	COMMON		DIGITAL INPUTS
F/G/H21	+	DC +24V		DIGITAL INPUTS
F/G/H22		NC	FORM C CFR*	
F/G/H23		COM	FORM C CFR*	
F/G/H24		NO	FORM C CFR*	

Optional I/O Card L, slot G

G1	+	ANALOG OUTPUT 1	ANALOG OUTPUTS
G2	+	ANALOG OUTPUT 2	ANALOG OUTPUTS
G3	+	ANALOG OUTPUT 3	ANALOG OUTPUTS
G4	+	ANALOG OUTPUT 4	ANALOG OUTPUTS
G5	+	ANALOG OUTPUT 5	ANALOG OUTPUTS
G6	+	ANALOG OUTPUT 6	ANALOG OUTPUTS
G7	+	ANALOG OUTPUT 7	ANALOG OUTPUTS
G8	−	RETURN	ANALOG OUTPUTS
G9	−	SHIELD	ANALOG OUTPUTS
G10	+	ANALOG INPUT 1	ANALOG INPUTS
G11	+	ANALOG INPUT 2	ANALOG INPUTS
G12	+	ANALOG INPUT 3	ANALOG INPUTS
G13	+	ANALOG INPUT 4	ANALOG INPUTS
G14	−	RETURN	ANALOG INPUTS
G15	−	SHIELD	ANALOG INPUTS
G16		RESERVED	
G17		RESERVED	
G18		RESERVED	
G19	+	HOT	RTD
G20	+	COMP	RTD
G21	−	RETURN	RTD
G22	−	SHIELD	RTD
G23		RESERVED	
G24		RESERVED	

Optional I/O Card R or S, slot B or C**

B1/C1		HOT	RTD 1
B2/C2		COMP	RTD 1
B3/C3		RETURN	RTD 1/2
B4/C4		HOT	RTD 2
B5/C5		COMP	RTD 2
B6/C6		HOT	RTD 3
B7/C7		COMP	RTD 3
B8/C8		RETURN	RTD 3/4
B9/C9		SHIELD	
B10/C10		HOT	RTD 4
B11/C11		COMP	RTD 4
B12/C12		HOT	RTD 5
B13/C13		COMP	RTD 5
B14/C14		RETURN	RTD 5/6
B15/C15		HOT	RTD 6
B16/C16		COMP	RTD 6
B17/C17		SHIELD	
B18/C18		RESERVED	

Optional I/O Card F, slot H

H1	+	DIGITAL INPUT 1	DIGITAL INPUTS
H2	+	DIGITAL INPUT 2	DIGITAL INPUTS
H3	+	DIGITAL INPUT 3	DIGITAL INPUTS
H4	+	DIGITAL INPUT 4	DIGITAL INPUTS
H5	+	DIGITAL INPUT 5	DIGITAL INPUTS
H6	+	DIGITAL INPUT 6	DIGITAL INPUTS
H7	+	DIGITAL INPUT 7	DIGITAL INPUTS
H8	+	DIGITAL INPUT 8	DIGITAL INPUTS
H9	+	DIGITAL INPUT 9	DIGITAL INPUTS
H10	+	DIGITAL INPUT 10	DIGITAL INPUTS
H11	−	COMMON	DIGITAL INPUTS
H12	+	+24 V	DIGITAL INPUTS

CH1	FIBER INPUT 1	ARC FLASH
CH2	FIBER INPUT 2	ARC FLASH
CH3	FIBER INPUT 3	ARC FLASH
CH4	FIBER INPUT 4	ARC FLASH

894213A1.CDR

NOTES:
- Digital Input/Output numbering is sequential starting with Slot F.
- RTD numbering is sequential starting with Slot B.

* This output is the Critical Fail Relay (CFR) when used in Slot F only

** Card S also supports 10 Ohm Copper RTD

Table 2-4: AC Analog

AC Inputs - 1 X 3-Phase 1/5A CT, 4 VT	
Terminal	**Description**
1	CT1 PhA
2	CT1 PhA RETURN
3	CT1 PhB
4	CT1 PhB RETURN
5	CT1 PhC
6	CT1 PhC RETURN
7	CT1 N/G
8	CT1 N/G RETURN
9	VT1A IN
10	VT1A RETURN
11	VT1B IN
12	VT1B RETURN
13	VT1C IN
14	VT1C RETURN
15	VT1N IN
16	VT1N RETURN

Terminal Strip Types

There are two types of removable terminal strips as shown: right-angle plugs with side screw connections, and straight plugs with front screw connections.

Figure 2-26: Right-angle plugs with side screw connections

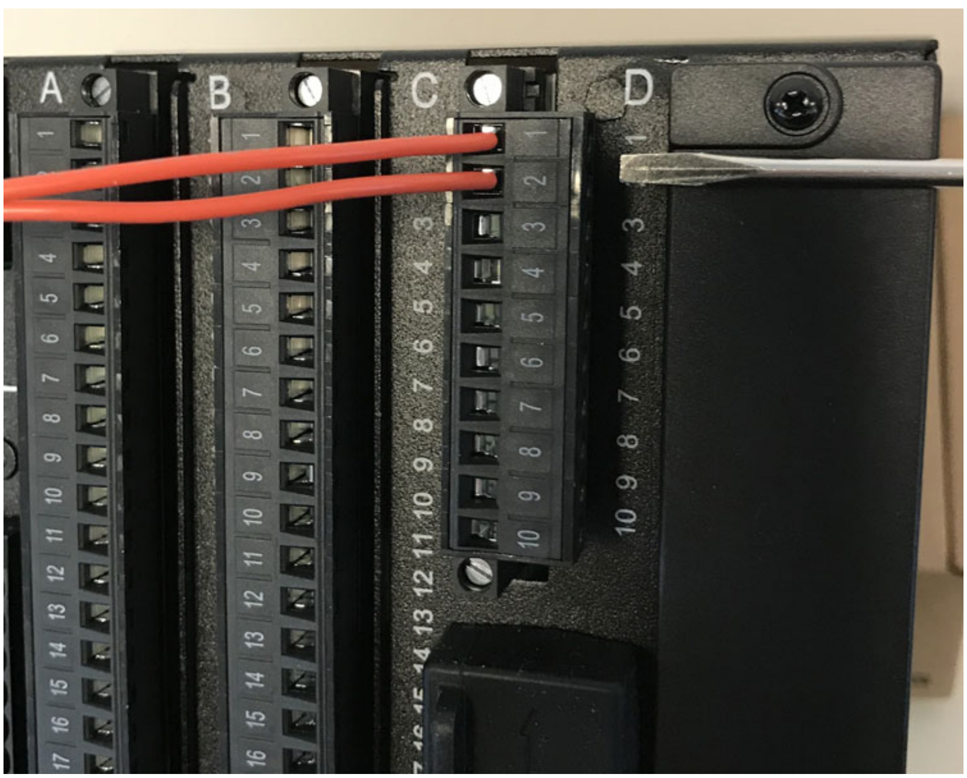
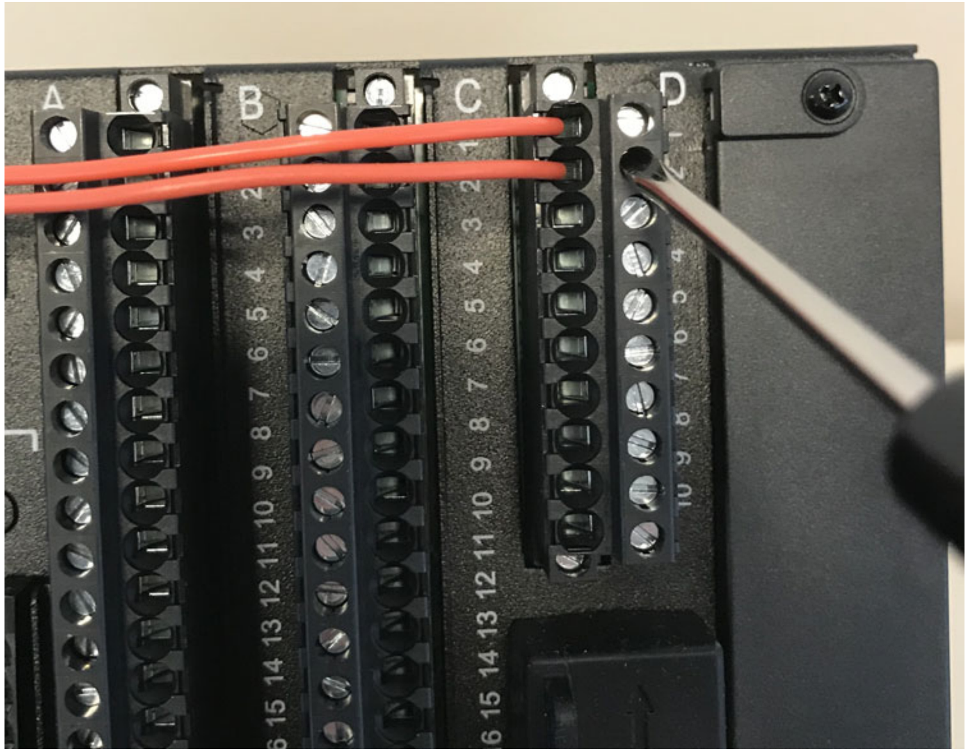


Figure 2-27: Straight plugs with front screw connections



Wire Size

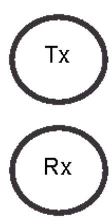
Use the following guideline for wiring to terminal strips A, B, C, D, F, G, H:

- 12 AWG to 24 AWG
- Suggested wiring screw tightening torque: 4.5 in-lbs (0.5 N-m)
- Wire stripping length:
  - Right-angle connection type plug: 7 to 8mm
  - Front connection type plug: 9 to 10mm

Use the following guideline for wiring to terminal blocks J, K:

- 12 AWG to 22 AWG (3.3 mm2 to 0.3 mm2): Single wire termination with/without 9.53 mm (0.375”) maximum diameter ring terminals.
- 14 AWG to 22 AWG (2.1 mm2 to 0.3 mm2): Multiple wire termination with 9.53 mm (0.375”) maximum diameter ring terminals. Two ring terminals maximum per circuit.
- Suggested wiring screw tightening torque: 15 in-lb (1.7 N-m)
- Suggested mounting screw tightening torque (to attach terminal block to chassis): 8 in-lb (0.9 N-m)

Figure 2-28: Fiber Connector Types (S - ST)



RMIO Module Installation

The optional remote module (RMIO) is designed to be mounted near the motor. This eliminates the need for multiple RTD cables to run back from the motor, which may be in a remote location, to the switchgear.

Although the RMIO is internally shielded to minimize noise pickup and interference, it should be mounted away from high current conductors or sources of strong magnetic fields.

Figure 2-29: RMIO unit showing 2 IO_G modules

Figure 2-30: RMIO terminal identification with 4 IO_G modules

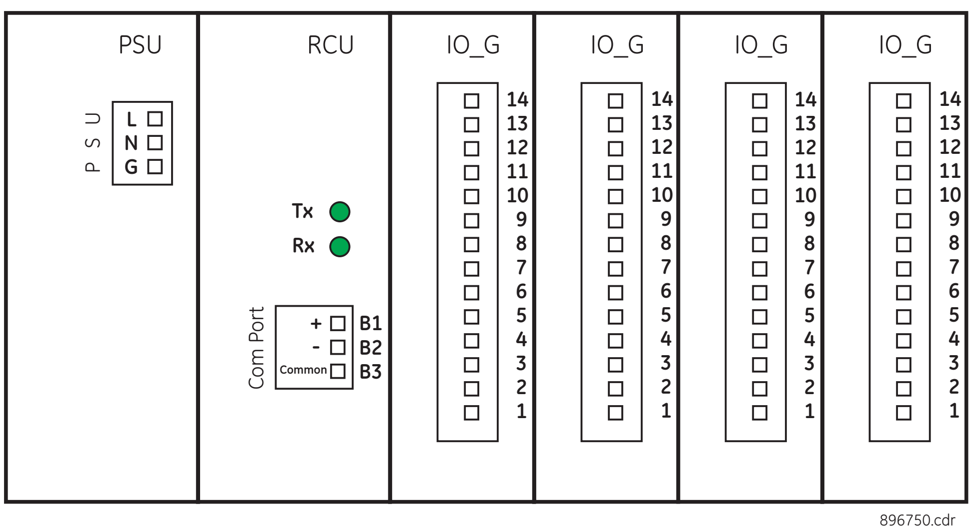
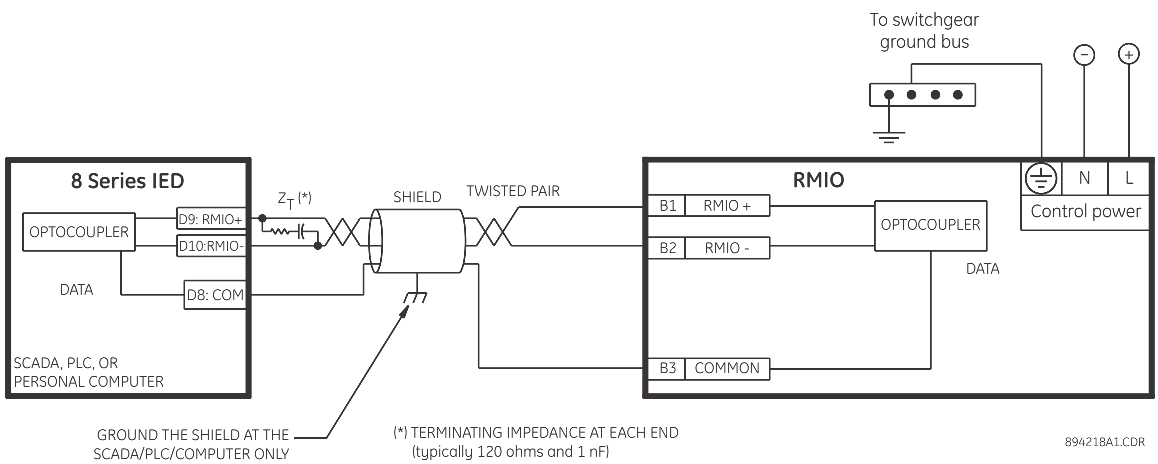


Figure 2-31: RMIO wiring diagram



NOTE

D8, D9, and D10 refer to terminals shown on the 8 Series Terminal Identification diagrams.

Phase Sequence and Transformer Polarity

For correct operation of the relay features, follow the instrument transformer polarities, shown in the *Typical Wiring Diagram* above. Note the solid square markings that are shown with all instrument transformer connections. When the connections adhere to the drawing, the arrow shows the direction of power flow for positive watts and the positive direction of vars. The phase sequence is user-programmable for either ABC or ACB rotation.

Depending on order code, the 845 relay can have up to four (4) current inputs in each J slot and K slot. Three of them are used for connecting to the phase CT phases A, B, and C. The fourth input is a ground input that can be connected to either a ground CT placed on the neutral from a Wye connected transformer winding, or to a “donut” type CT measuring the zero sequence current from a grounded system. The relay CTs are placed in a packet mounted to the chassis of the 845 relay. There are no internal ground connections on the current inputs. Current transformers with 1 to 12000 A primaries may be used.

⚠CAUTION

Verify that the relay’s nominal input current of 1 A or 5 A matches the secondary rating of the connected CTs. Unmatched CTs may result in equipment damage or inadequate protection.

⚠CAUTION

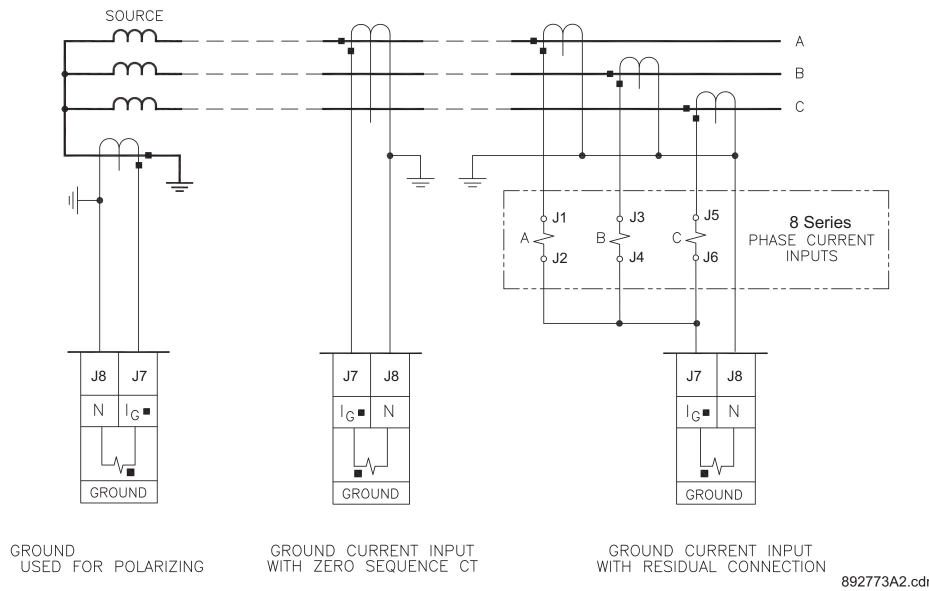
IMPORTANT: The phase and ground current inputs correctly measure up to 46 times the current input’s nominal rating. Time overcurrent curves become horizontal lines for currents above 20 × PKP.

Ground CT Inputs

Before making ground connections, be aware that the relay automatically calculates the neutral (residual) current from the sum of the three phase current phasors. The following figures show three possible ground connections using the ground current input (Terminals J7 and J8).

The ground input (Terminals J7 and J8) is used in conjunction with a Zero Sequence CT as source, or in the neutral of wye-connected source CTs. The ground current input can be used to polarize the neutral. When using the residual connection, set the **GROUND CT PRIMARY** setpoint to a value equal to the **PHASE CT PRIMARY** setpoint.

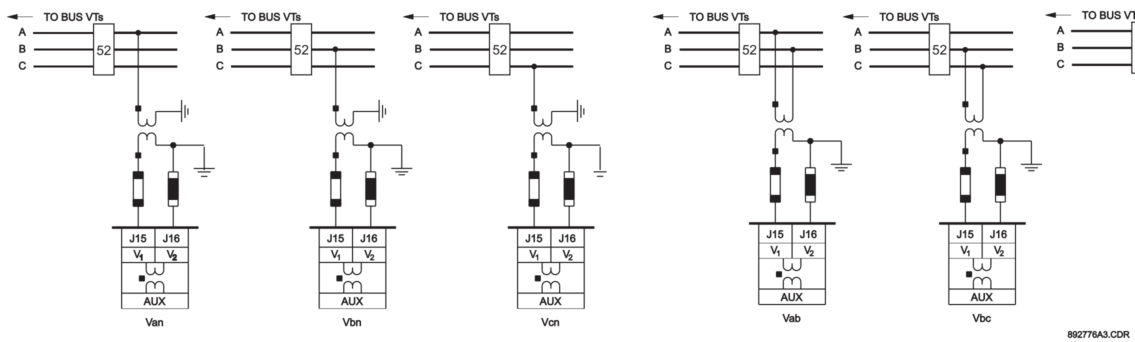
Figure 2-32: Ground Inputs



Voltage Inputs

The 845 relays have four channels for AC voltage inputs, each with an isolating transformer in each J and K slot. Voltage transformers up to a maximum 5000:1 ratio may be used. The nominal secondary voltage must be in the 10 to 240 V range. The Bus VT connections most commonly used, wye and delta (or open delta), are shown in the typical wiring diagram. The single Auxiliary voltage input is commonly used as the “line voltage”. For LEA inputs, the “line voltage” connection is line to neutral voltages. The line VT input channel, used for the synchrocheck feature, can be connected for phase-neutral voltages V_{an}, V_{bn}, or V_{cn}; or for phase-phase voltages V_{ab}, V_{bc}, or V_{ca} as shown.

Figure 2-33: Line VT Connections



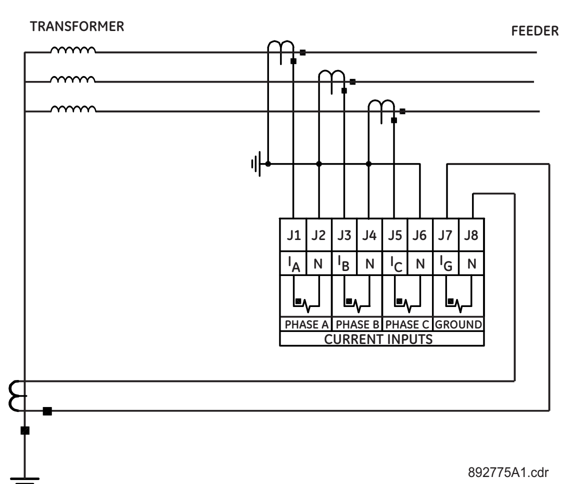
CAUTION **If Delta VTs are used for three-phase voltages, the zero sequence voltage (V0) and neutral ground polarizing voltage (–V0) are zero. Also, with the Delta VT connection, the phase-neutral voltage cannot be measured and is not displayed.**

Restricted Ground Fault Inputs

Restricted Ground Fault protection, (also referred to as Restricted Earth Fault protection,) is often applied to transformers having grounded Wye windings to provide ground fault detection for faults near the transformer neutral. Each current bank on the relay has 3 phase current inputs and one ground input. Any of the available inputs on the relay current banks can be selected as a signal input for an RGF element.

The phase and ground input CT connections to the relay are shown below:

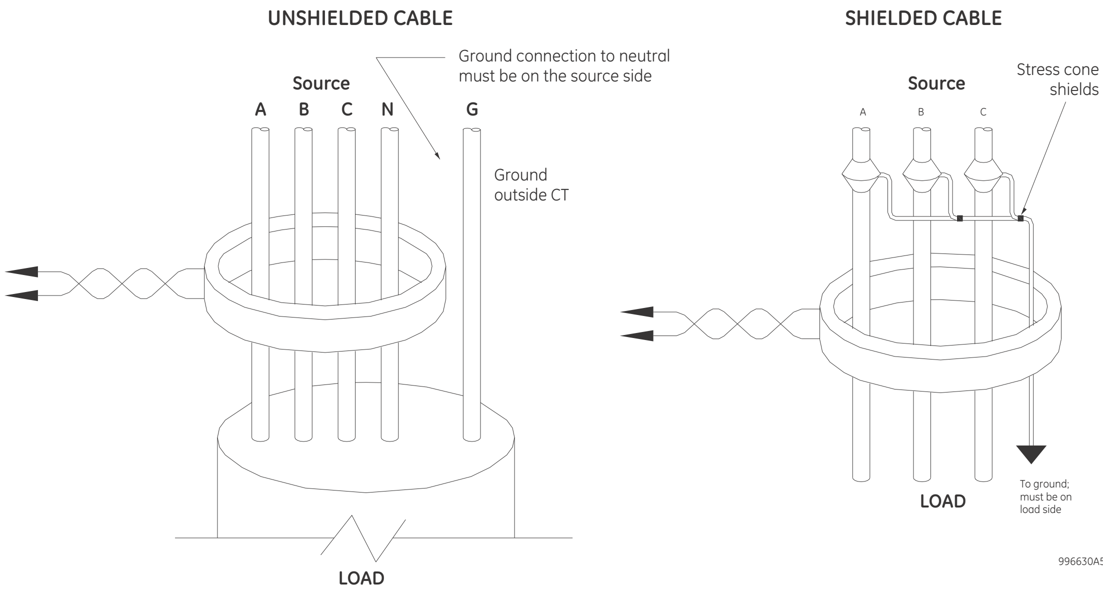
Figure 2-34: Restricted Ground Fault Inputs



Zero-Sequence CT Installation

The figure below shows the various CT connections and the exact placement of a Zero Sequence current CT, so that ground fault current can be detected. Twisted pair cabling on the Zero Sequence CT is recommended.

Figure 2-35: Zero Sequence (Core Balance) CT Installation



Control Power

Control power is supplied to the relay such that it matches the relay's installed power supply range.

⚠CAUTION

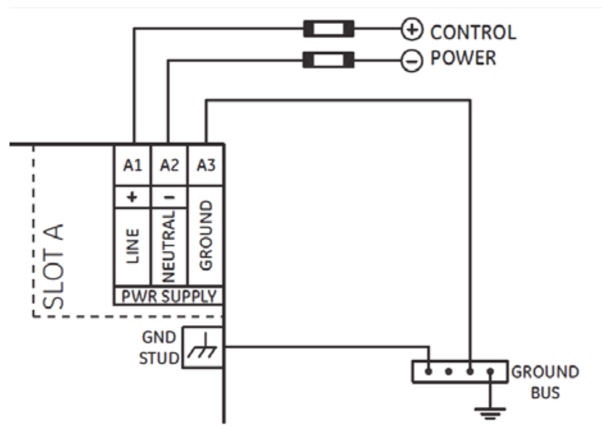
Control power supplied to the relay must match the installed power supply range. If the applied voltage does not match, damage to the unit may occur. All grounds MUST be connected for normal operation regardless of control power supply type.

For more details, please refer to the Power Supply subsection located in the Introduction chapter.

⚠CAUTION

The relay should be connected directly to the ground bus, using the shortest practical path. A tinned copper, braided, shielding and bonding cable should be used. As a minimum, 96 strands of number 34 AWG should be used. Belden catalog number 8660 is suitable.

Figure 2-36: Control Power Connection



Contact Inputs

Depending on the order code, the 845 relay has a different number of contact inputs which can be used to operate a variety of logic functions for circuit switching device control, external trips, blocking of protection elements, etc. The relay has 'contact inputs' and 'virtual inputs' that are combined in a form of programmable logic to facilitate the implementation of various schemes.

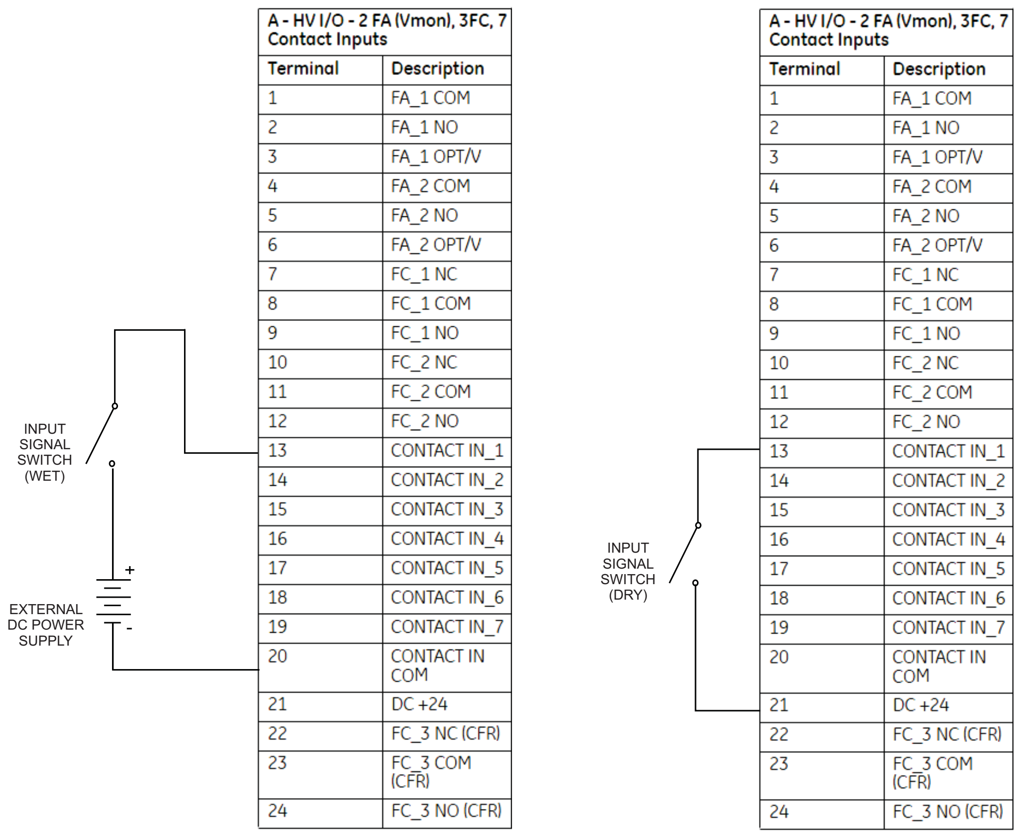
The voltage threshold at which the contact inputs detect a closed contact input is programmable as 17 V DC for 24 V sources, 33 V DC for 48 V sources, 84 V DC for 110 to 125 V sources, and 166 V DC for 250 V sources.

Wet or Dry input signal types can be connected to contact input terminals as shown in the figure: Wet and Dry Contact Input Wiring Examples.

Dry inputs use an internal +24V that is supplied by the 845. The voltage threshold must be set to 17V for the inputs to be recognized using the internal +24V.

NOTICE The same type of input signal must be connected to all contact inputs on the same contact input card.

Figure 2-37: Wet and Dry Contact Input Wiring Examples



A - HV I/O - 2 FA (Vmon), 3FC, 7 Contact Inputs	
Terminal	**Description**
1	FA_1 COM
2	FA_1 NO
3	FA_1 OPT/V
4	FA_2 COM
5	FA_2 NO
6	FA_2 OPT/V
7	FC_1 NC
8	FC_1 COM
9	FC_1 NO
10	FC_2 NC
11	FC_2 COM
12	FC_2 NO
13	CONTACT IN_1
14	CONTACT IN_2
15	CONTACT IN_3
16	CONTACT IN_4
17	CONTACT IN_5
18	CONTACT IN_6
19	CONTACT IN_7
20	CONTACT IN COM
21	DC +24
22	FC_3 NC (CFR)
23	FC_3 COM (CFR)
24	FC_3 NO (CFR)

A - HV I/O - 2 FA (Vmon), 3FC, 7 Contact Inputs	
Terminal	**Description**
1	FA_1 COM
2	FA_1 NO
3	FA_1 OPT/V
4	FA_2 COM
5	FA_2 NO
6	FA_2 OPT/V
7	FC_1 NC
8	FC_1 COM
9	FC_1 NO
10	FC_2 NC
11	FC_2 COM
12	FC_2 NO
13	CONTACT IN_1
14	CONTACT IN_2
15	CONTACT IN_3
16	CONTACT IN_4
17	CONTACT IN_5
18	CONTACT IN_6
19	CONTACT IN_7
20	CONTACT IN COM
21	DC +24
22	FC_3 NC (CFR)
23	FC_3 COM (CFR)
24	FC_3 NO (CFR)

Output Relays

The locations of the output relays have a fixed assignment for the platform called the master identifier. I/O options that include inputs occupy the fixed assigned output locations so in these cases the relay assignment maps to the master identifier.

The output relays for the 845 relay are fully programmable, and can be assigned in the transformer breakers menu for breaker tripping or closing. The output relays assigned for breaker closing, are automatically excluded from the menus for output selection for the rest of the elements.

The critical failure output relay is reserved as Relay_8 and it is omitted and is not programmable.

Table 2-5: Slots F,G,H Terminal Master Identifier (left) and I/O options M, L, F (right)

Slots F, G, H Terminal Master Identifier					Slots F, G, H with I/O options M, L, F			
Terminal #	**SLOT F**	**SLOT G**	**SLOT H**		**Terminal #**	**SLOT F**	**SLOT G**	**SLOT H**
1	RELAY_1	RELAY_9	RELAY_17		1	RELAY_1	Analog Out_1	Digital In_8
2	RELAY_1	RELAY_9	RELAY_17		2	RELAY_1	Analog Out_2	Digital In_9
3	RELAY_1	RELAY_9	RELAY_17		3	Reserved	Analog Out_3	Digital In_10
4	RELAY_2	RELAY_10	RELAY_18		4	RELAY_2	Analog Out_4	Digital In_11
5	RELAY_2	RELAY_10	RELAY_18		5	RELAY_2	Analog Out_5	Digital In_12
6	RELAY_2	RELAY_10	RELAY_18		6	Reserved	Analog Out_6	Digital In_13
7	RELAY_3	RELAY_11	RELAY_19		7	RELAY_3	Analog Out_7	Digital In_14
8	RELAY_3	RELAY_11	RELAY_19		8	RELAY_3	Return	Digital In_15
9	RELAY_3	RELAY_11	RELAY_19		9	Reserved	Shield	Digital In_16
10	RELAY_4	RELAY_12	RELAY_20		10	RELAY_4	Analog In_1	Digital In_17
11	RELAY_4	RELAY_12	RELAY_20		11	RELAY_4	Analog In_2	Common
12	RELAY_4	RELAY_12	RELAY_20		12	Reserved	Analog In_3	+24V
13	RELAY_5	RELAY_13	RELAY_21		13	Digital In_1	Analog In_4	ARC FLASH Sensor 1 Sensor 2 Sensor 3 Sensor 4
14	RELAY_5	RELAY_13	RELAY_21		14	Digital In_2	Return	
15	RELAY_5	RELAY_13	RELAY_21		15	Digital In_3	Shield	
16	RELAY_6	RELAY_14	RELAY_22		16	Digital In_4	Reserved	
17	RELAY_6	RELAY_14	RELAY_22		17	Digital In_5	Reserved	
18	RELAY_6	RELAY_14	RELAY_22		18	Digital In_6	Reserved	
19	RELAY_7	RELAY_15	RELAY_23		19	Digital In_7	RTD_Hot	
20	RELAY_7	RELAY_15	RELAY_23		20	Common	RTD_Comp	
21	RELAY_7	RELAY_15	RELAY_23		21	+24V	RTD_Return	
22	RELAY_8	RELAY_16	RELAY_24		22	RELAY_8	Shield	
23	RELAY_8	RELAY_16	RELAY_24		23	RELAY_8	Reserved	
24	RELAY_8	RELAY_16	RELAY_24		24	RELAY_8	Reserved	

Table 2-6: Slots F, G, H with I/O options A, A, A (left) and I/O options A, L, A (right)

Slots F,G,H with I/O options A, A, A					Slots F,G,H with I/O options A, L, A			
Terminal #	**SLOT F**	**SLOT G**	**SLOT H**		**Terminal #**	**SLOT F**	**SLOT G**	**SLOT H**
1	RELAY_1	RELAY_9	RELAY_17		1	RELAY_1	Analog Out_1	RELAY_9
2	RELAY_1	RELAY_9	RELAY_17		2	RELAY_1	Analog Out_2	RELAY_9
3	RELAY_1	RELAY_9	RELAY_17		3	RELAY_1	Analog Out_3	RELAY_9
4	RELAY_2	RELAY_10	RELAY_18		4	RELAY_2	Analog Out_4	RELAY_10
5	RELAY_2	RELAY_10	RELAY_18		5	RELAY_2	Analog Out_5	RELAY_10
6	RELAY_2	RELAY_10	RELAY_18		6	RELAY_2	Analog Out_6	RELAY_10
7	RELAY_3	RELAY_11	RELAY_19		7	RELAY_3	Analog Out_7	RELAY_11

Slots F,G,H with I/O options A, A, A					Slots F,G,H with I/O options A, L, A			
Terminal #	SLOT F	SLOT G	SLOT H		Terminal #	SLOT F	SLOT G	SLOT H
8	RELAY_3	RELAY_11	RELAY_19		8	RELAY_3	Return	RELAY_11
9	RELAY_3	RELAY_11	RELAY_19		9	RELAY_3	Shield	RELAY_11
10	RELAY_4	RELAY_12	RELAY_20		10	RELAY_4	Analog In_1	RELAY_12
11	RELAY_4	RELAY_12	RELAY_20		11	RELAY_4	Analog In_2	RELAY_12
12	RELAY_4	RELAY_12	RELAY_20		12	RELAY_4	Analog In_3	RELAY_12
13	Digital In_1	Digital In_8	Digital In_15		13	Digital In_1	Analog In_4	Digital In_8
14	Digital In_2	Digital In_9	Digital In_16		14	Digital In_2	Return	Digital In_9
15	Digital In_3	Digital In_10	Digital In_17		15	Digital In_3	Shield	Digital In_10
16	Digital In_4	Digital In_11	Digital In_18		16	Digital In_4	Reserved	Digital In_11
17	Digital In_5	Digital In_12	Digital In_19		17	Digital In_5	Reserved	Digital In_12
18	Digital In_6	Digital In_13	Digital In_20		18	Digital In_6	Reserved	Digital In_13
19	Digital In_7	Digital In_14	Digital In_21		19	Digital In_7	RTD_Hot	Digital In_14
20	Common	Common	Common		20	Common	RTD_Comp	Common
21	+24V	+24V	+24V		21	+24V	RTD_Return	+24V
22	RELAY_8	RELAY_16	RELAY_24		22	RELAY_8	Shield	RELAY_16
23	RELAY_8	RELAY_16	RELAY_24		23	RELAY_8	Reserved	RELAY_16
24	RELAY_8	RELAY_16	RELAY_24		24	RELAY_8	Reserved	RELAY_16

Table 2-7: Slots F,G,H with I/O options A, A, F (left) and I/O options A, N, F (right)

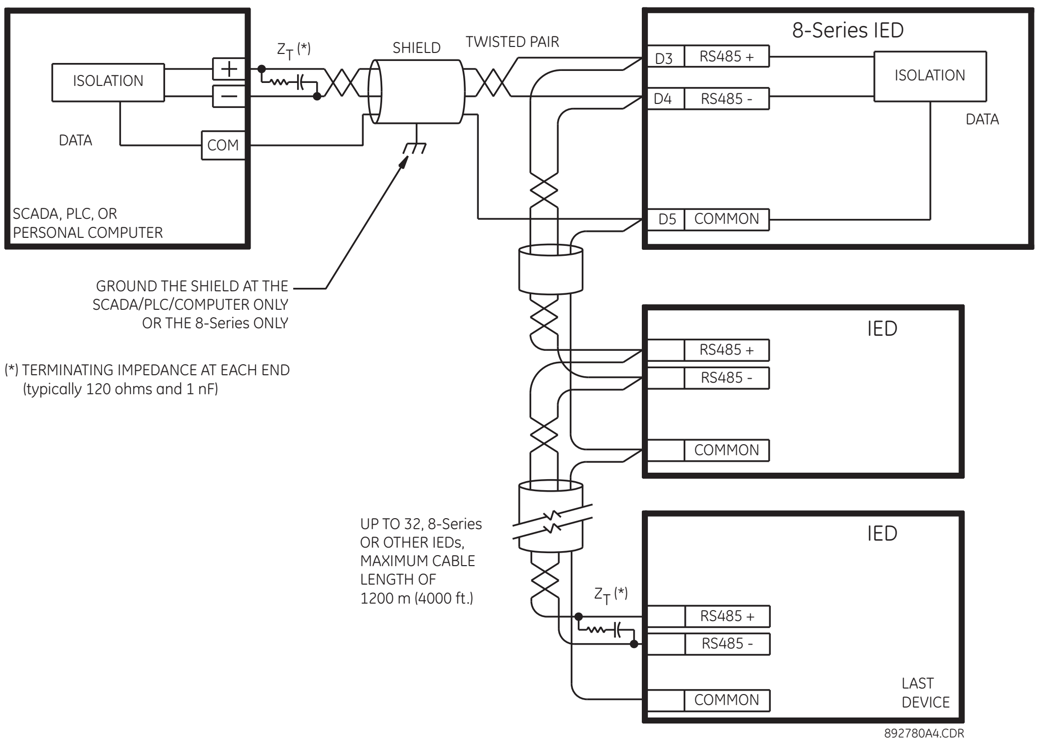
Slots F,G,H with I/O options A, A, F					Slots F, G, H with I/O options A, N, F		
Terminal #	SLOT F	SLOT G	SLOT H		Terminal #	SLOT F	SLOT H
1	RELAY_1	RELAY_9	Digital In_15		1	RELAY_1	Digital In_8
2	RELAY_1	RELAY_9	Digital In_16		2	RELAY_1	Digital In_9
3	RELAY_1	RELAY_9	Digital In_17		3	RELAY_1	Digital In_10
4	RELAY_2	RELAY_10	Digital In_18		4	RELAY_2	Digital In_11
5	RELAY_2	RELAY_10	Digital In_19		5	RELAY_2	Digital In_12
6	RELAY_2	RELAY_10	Digital In_20		6	RELAY_2	Digital In_13
7	RELAY_3	RELAY_11	Digital In_21		7	RELAY_3	Digital In_14
8	RELAY_3	RELAY_11	Digital In_22		8	RELAY_3	Digital In_15
9	RELAY_3	RELAY_11	Digital In_23		9	RELAY_3	Digital In_16
10	RELAY_4	RELAY_12	Digital In_24		10	RELAY_4	Digital In_17
11	RELAY_4	RELAY_12	Common		11	RELAY_4	Common
12	RELAY_4	RELAY_12	+24V		12	RELAY_4	+24V
13	Digital In_1	Digital In_8	ARC FLASH Sensor 1 Sensor 2 Sensor 3 Sensor 4		13	Digital In_1	ARC FLASH Sensor 1 Sensor 2 Sensor 3 Sensor 4
14	Digital In_2	Digital In_9			14	Digital In_2	
15	Digital In_3	Digital In_10			15	Digital In_3	
16	Digital In_4	Digital In_11			16	Digital In_4	
17	Digital In_5	Digital In_12			17	Digital In_5	
18	Digital In_6	Digital In_13			18	Digital In_6	
19	Digital In_7	Digital In_14			19	Digital In_7	
20	Common	Common			20	Common	
21	+24V	+24V			21	+24V	
22	RELAY_8	RELAY_16			22	RELAY_8	
23	RELAY_8	RELAY_16			23	RELAY_8	
24	RELAY_8	RELAY_16			24	RELAY_8	

Serial Communications

One two-wire RS485 port is provided. Up to thirty-two 8 Series IEDs can be daisy-chained together on a communication channel without exceeding the driver capability. For larger systems, additional serial channels must be added. Commercially available repeaters can also be used to add more than 32 relays on a single channel. Suitable cable should have a characteristic impedance of 120 ohms and total wire length should not exceed 1200 meters (4000 ft).

Voltage differences between remote ends of the communication link are not uncommon. For this reason, surge protection devices are internally installed across all RS485 terminals.Internally, an isolated power supply with an opto-coupled data interface is used to prevent noise coupling.

Figure 2-38: RS485 wiring diagram



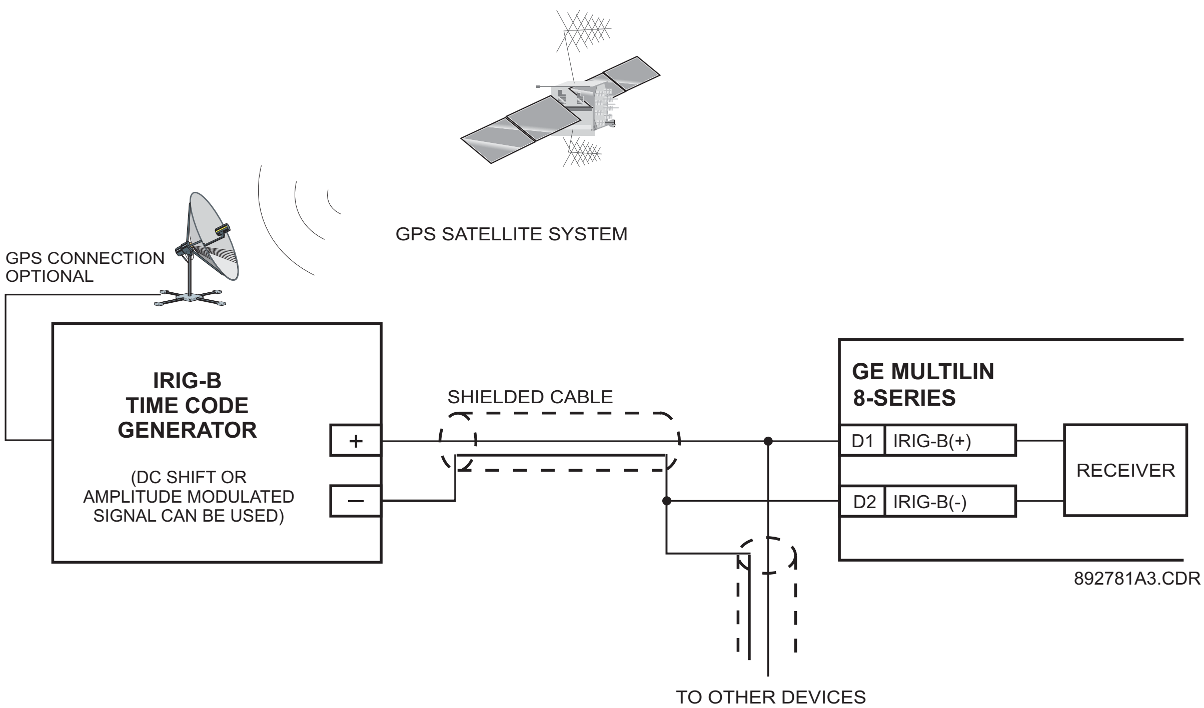
CAUTION **To ensure that all devices in a daisy-chain are at the same potential, it is imperative that the common terminals of each RS485 port are tied together and grounded only once, at the master or at the 845. Failure to do so may result in intermittent or failed communications.**

The source computer/PLC/SCADA system should have similar transient protection devices installed, either internally or externally. Ground the shield at one point only, as shown in the figure above, to avoid ground loops. Correct polarity is also essential. The 845 IEDs must be wired with all the positive (+) terminals connected together and all the negative (–) terminals connected together. Each relay must be daisy-chained to the next one. Avoid star or stub connected configurations. The last device at each end of the daisy-chain should be terminated with a 120 ohm ¼ watt resistor in series with a 1 nF capacitor across the positive and negative terminals. Some systems allow the shield (drain wire) to be used as a common wire and to connect directly to the COM terminal; others function correctly only if the common wire is connected to the COM terminal, but insulated from the shield. Observing these guidelines ensure a reliable communication system immune to system transients.

IRIG-B

IRIG-B is a standard time code format that allows time stamping of events to be synchronized among connected devices within 1 millisecond. The IRIG-B time code formats are serial, width-modulated codes which can be either DC level shift or amplitude modulated (AM) form. The type of form is auto-detected by the 845 relay. Third party equipment is available for generating the IRIG-B signal; this equipment may use a GPS satellite system to obtain the time reference so that devices at different geographic locations can also be synchronized.

Figure 2-39: IRIG-B connection



845 Transformer Protection System

Chapter 3: Interfaces

There are two methods of interfacing with the 845.

- Interfacing via the relay keypad and display.
- Interfacing via the EnerVista 8 Series Setup software.

This section provides an overview of the interfacing methods available with the 845 using the relay control panel and EnerVista 8 Series Setup software. For additional details on interface parameters (for example, settings, actual values, etc.), refer to the individual chapters.

FIRST ACCESSING THE RELAY

When first accessing the relay, log in as Administrator either through the front panel or through EnerVista connected serially (so that no IP address is required). Use the default password (the default password is "0").

Basic Security

If the relay is in the commissioning phase and you want to bypass authentication, switch the "Setpoint access" setting on or assign it to a contact input. Once the setting is on, you have complete administrator access from the front panel. If a contact input is chosen, the access is also conditional on the activation of the respective contact input.

For more information on setpoint access and other security features available with basic security, refer to the Basic Security section in the Setpoints chapter.

CyberSentry

If logging in through EnerVista, choose Device authentication and login as Administrator.

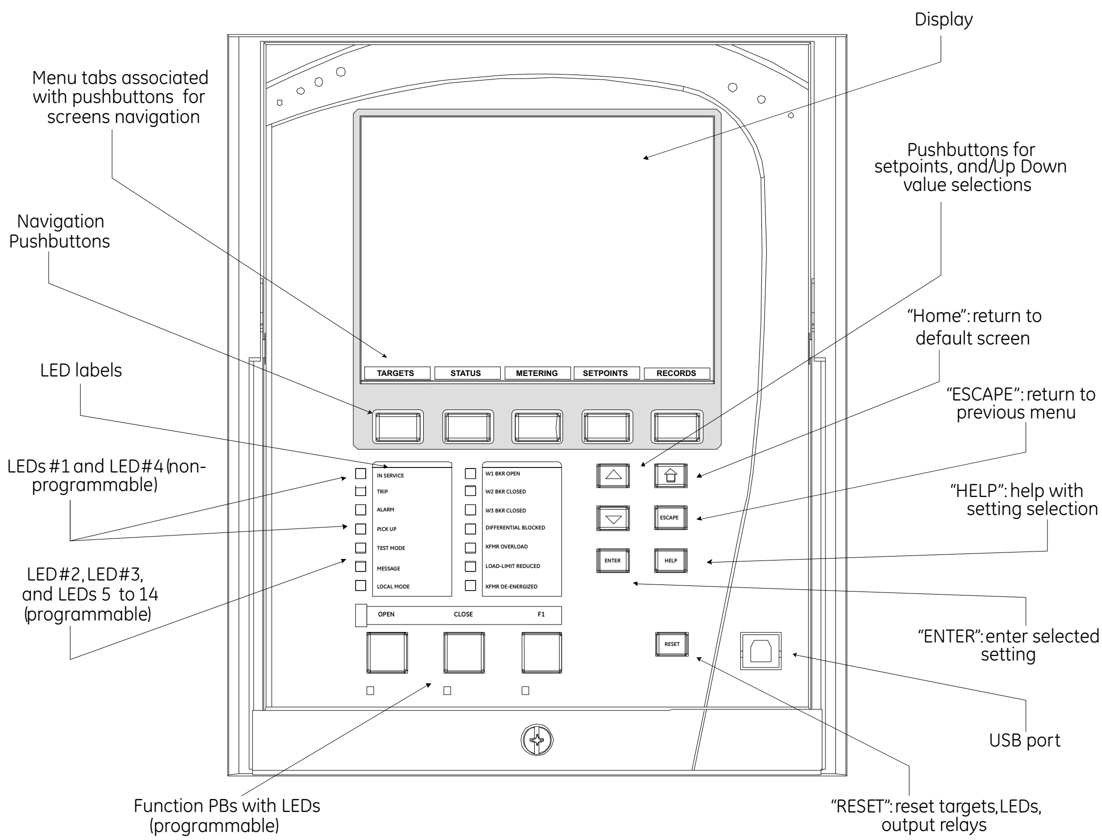
Note: If the relay is in the commissioning phase, to bypass authentication use the setpoint access feature to gain administrative access to the front panel in the same way as with basic security (see the "Basic Security" section).

For more information on security features available with CyberSentry, refer to the CyberSentry security section in the Setpoints chapter.

Front Control Panel Interface

The 845 relay provides an easy to use faceplate for menu navigation using 5 navigation pushbuttons and a high quality graphical display. Conveniently located on the panel is a group of 7 pushbuttons for Up/Down value selection, Enter, Home, Escape, Help, and Reset functions. The faceplate also includes 3 programmable function pushbuttons with LEDs. Fourteen other status LEDs are available, 12 of which are programmable.

Figure 3-1: 845 Front Control Panel)



The USB port is intended for connection to a portable computer.

845 Graphical Display Pages

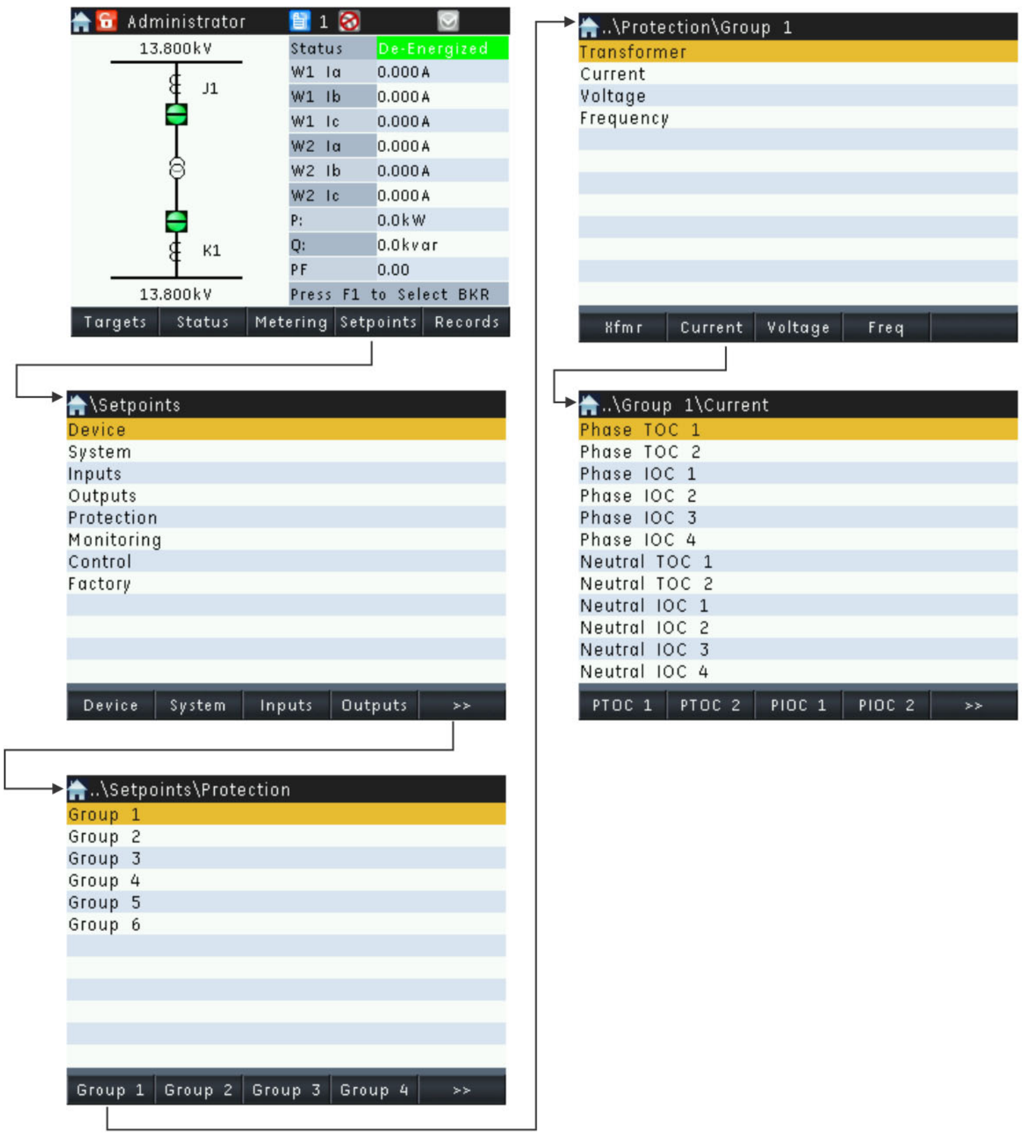
The front panel liquid crystal display (LCD) allows visibility under varied lighting conditions. When the keypad and display are not being used, system information is displayed after a user-defined period of inactivity. Pressing the Menu key during the display of the default message, returns the display to the last message shown before the default message appeared. Any Trip, Alarm, or Pickup is displayed immediately, automatically overriding the default message.

Figure 3-2: 845 Display Page Hierarchy

Working with Graphical Display Pages

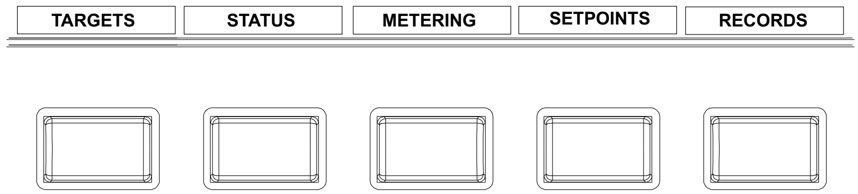
The 845 display contains five main menu items labeled Targets, Status, Metering, Setpoints, and Records located at the bottom of the screen. Choosing each main menu item displays the corresponding sub-menu.

Figure 3-3: Typical paging operation from the Main Menu



There are two ways to navigate throughout the 845 menu: using the pushbuttons corresponding to the soft tabs from the screen, or by selecting the item from the list of items on the screen using the "Up" and "Down" pushbuttons to move the yellow highlighted line, and pressing the pushbutton "Enter".

Figure 3-4: Tab Pushbuttons



The tab pushbuttons are used to enter the menu corresponding to the label on the tabs. If more than 5 tabs exist, the first and the last tab are labelled with arrows to allow you to scroll to the other tabs.

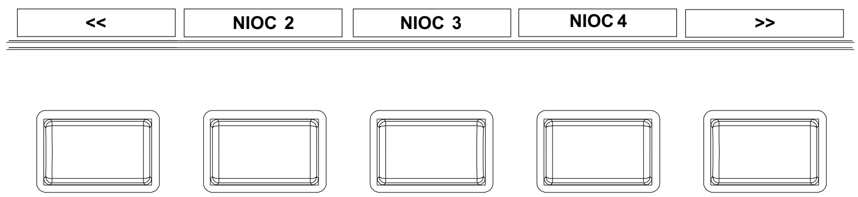
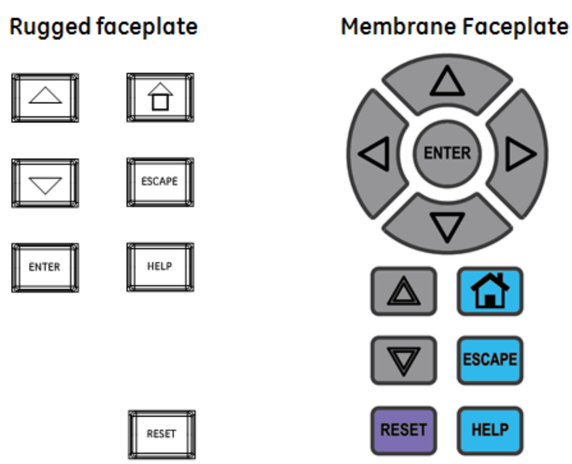
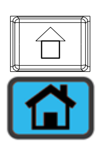


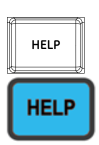
Figure 3-5: Keypad Pushbuttons



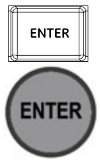
Each Keypad pushbutton serves the following function:



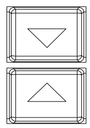
The **Home** pushbutton is used to display the home screen, and all screens defined under the Front Panel/Screens menu as *default* screens.



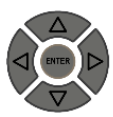
The **Help** pushbutton is used to provide the Modbus address corresponding to the present location when in the Actual Values menu.



The **Enter** pushbutton has a dual function. It is used to display a sub-menu when an item is highlighted. It is also used to save the desired value for any selected setpoint.

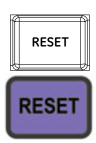


The **Up,** and **Down** pushbuttons are used to select/highlight an item from a menu, as well as select a value from the list of values for a chosen item.



The **Up, Down, Left,** and **Right** pushbuttons on the membrane faceplate are used to move the yellow highlight. These pushbuttons are also used on special screens to navigate to multiple objects.

The **Escape** pushbutton is used to display the previous menu. This pushbutton can also be used to cancel a setpoint change.



The **Reset** pushbutton clears all latched LED indications, target messages, and latched output relays, providing the conditions causing these events are not present.

To change (or view) an item on (or from) the 845 menus:

1. Use the pushbuttons that correspond to the tabs (Targets, Status, Metering, Setpoints, Records) on the screen to select a menu.
2. Use the **Up** and **Down** pushbuttons to highlight an item.
3. Press **Enter** to view a list of values for the chosen item. (Some items are view-only.)
4. Use the **Up** and **Down** pushbuttons to highlight a value.
5. Press **Enter** to assign the highlighted value to the item.

Single Line Diagram

BKR1 LED setting for Breaker symbol color configuration

In all 8 Series devices the Breaker symbol color is configurable as per the color scheme setting in **Setpoints > Device > Front Panel > Display Properties > Color Scheme**.

Single Line Diagram for 845 and Breaker/Transformer status color

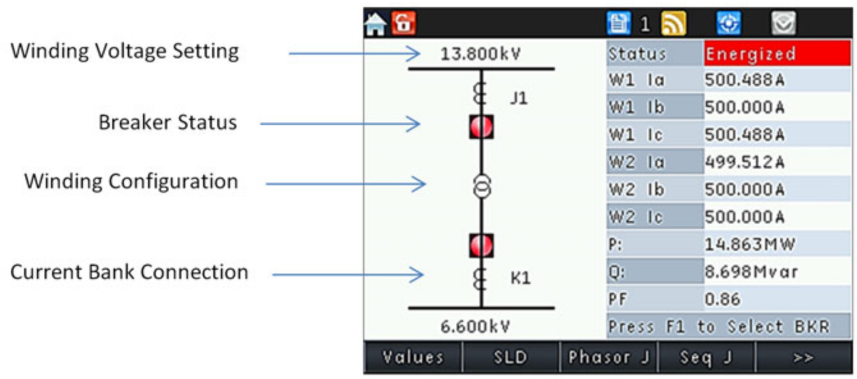
The 845 has a single line diagram (SLD) that represents the power system. The single line diagram provided is pre-configured to show:

- Breaker status
- AC input connection
- Rated Winding voltage

Accompanying the single line diagram are typical metered values associated with the power system.

The single line diagram is configured as the default menu but this can be changed under **Setpoints > Device > Front Panel > Default Screen**.

Figure 3-6: SLD and typical metered values screen



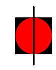
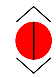
The breaker status icon changes state according to the breaker status input and the color scheme setting (**Setpoints > Device > Front Panel > Display Properties > Color Scheme**) to show Breaker status.

The winding voltage setting for each breaker is displayed on the associated branch. The winding configuration icon will display either a 2-winding or 3-winding transformer based on the order code.

The transformer status is indicated in the top right of the display.

	SLD Breaker Symbol Color				Transformer Status		
Color Scheme	Open Color	Close Color	Not Configured	Unknown	De-Energized	Energized	Not Configured
Red (Open)			?	?	Red	Green	Orange
Green (Open)			?	?	Green	Red	Orange

When breaker detection Connected/Disconnected (Racked-In/Racked-Out) is configured, the symbols change with respect to the Connected/Disconnected state of the breaker. The following table further illustrates this with an example of the switching device 'Close' state when the color scheme is set to Green (Open).

Connected/Disconnected Detection	Breaker State	Symbol
Not Configured*	Connected*	
Configured	Connected	
Configured	Disconnected	

*845 considers the breaker state Connected when detection of the Connected/ Disconnected state of the breaker is not configured. Connected/Disconnected detection is not configured when setpoint Connected (under **Setpoints > System > Breaker**) is set to OFF.

The parameters displayed in the Front panel screen example are as follows for a 2-Winding Transformer with VT:

Parameter	Input for the value
W1 Ia	Metering\ CT Bank 1 -J1\ J1 Ia
W1 Ib	Metering\ CT Bank 1 -J1\ J1 Ib
W1 Ic	Metering\ CT Bank 1 -J1\ J1 Ic
W2 Ia	Metering\ CT Bank 2 -K1\ K1 Ia
W2 Ib	Metering\ CT Bank 2 -K1\ K1 Ib
W2 Ic	Metering\ CT Bank 2 -K1\ K1 Ic
P:	Metering\ Power 1\ Pwr1 Real
Q:	Metering\ Power 1\ Pwr1 Reactive
PF	Metering\ Power 1\ Pwr1 PF

The parameters displayed in the Front panel screen example are as follows for a 2-Winding Transformer without VT:

Parameter	Input for the value
W1 Ia	Metering\ CT Bank 2 -K1\ K1 Ia
W1 Ib	Metering\ CT Bank 2 -K1\ K1 Ib
W1 Ic	Metering\ CT Bank 2 -K1\ K1 Ic
W2 Ia	Metering\ CT Bank 3 -K2\ K2 Ia
W2 Ib	Metering\ CT Bank 3 -K2\ K2 Ib
W2 Ic	Metering\ CT Bank 3 -K2\ K2 Ic
P:	Metering\ Power 1\ Pwr1 Real
Q:	Metering\ Power 1\ Pwr1 Reactive
PF	Metering\ Power 1\ Pwr1 PF

The parameters displayed in the Front panel screen example are as follows for 3-Winding Transformer:

Parameter	Input for the value
W1 Ia	Metering\ CT Bank 1 -J1\ J1 Ia
W1 Ib	Metering\ CT Bank 1 -J1\ J1 Ib
W1 Ic	Metering\ CT Bank 1 -J1\ J1 Ic
W2 Ia	Metering\ CT Bank 2 -K1\ K1 Ia
W2 Ib	Metering\ CT Bank 2 -K1\ K1 Ib
W2 Ic	Metering\ CT Bank 2 -K1\ K1 Ic
W3 Ia	Metering\ CT Bank 3 -K2\ K2 Ia
W3 Ib	Metering\ CT Bank 3 -K2\ K2 Ib
W3 Ic	Metering\ CT Bank 3 -K2\ K2 Ic

Rugged and Membrane (3 PB) Front Panel LEDs

Front panel LED details:

- Number of LEDs: 17
- Programmability: Any FlexLogic operand
- Reset mode: self-reset or latched

The 845 front panel provides two columns of 7 LED indicators each, and 3 LED pushbutton indicators. The “IN-SERVICE” (LED 1) and the “PICKUP” (LED 4) indicators from the first LED column are non-programmable LEDs. The bottom 3 LED indicators from the first column, and the 7 LED indicators from the second LED column are fully programmable. The indicators “TRIP” (LED 2), and “ALARM” (LED 3), are also programmable, and can be triggered by either a selection of FlexLogic operand assigned in their own menu, or by the operation of any protection, control or monitoring element with function selected as Trip, Alarm, or Latched Alarm.

The RESET key is used to reset any latched LED indicator or Target Message once the condition has been cleared (latched conditions can also be reset via the RESETTING menu).

Figure 3-7: LED numbering

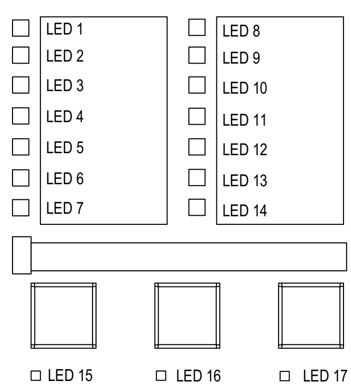


Figure 3-8: LEDs for 845 relay protecting 2W Xfmr

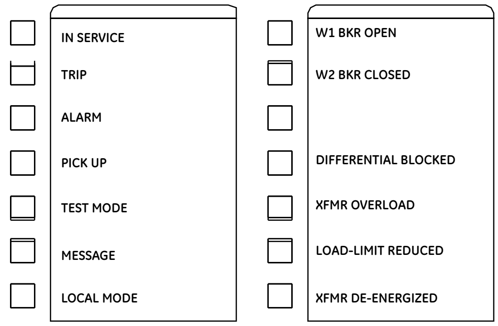
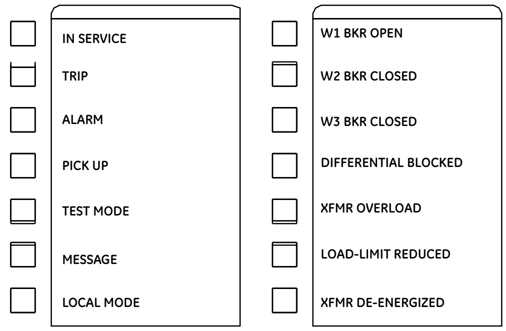


Figure 3-9: LEDs for 845 relay protecting 3W Xfmr



Some status indicators are common while some are feature specific which depend on the availability in the order code. The common status indicators in the first column are described below.

- **IN SERVICE**
  - Green color = Relay powered up, passed self-test has been programmed, and ready to serve. This LED indicates that control power is applied, all monitored inputs, outputs, and internal systems are OK, and that the device has been programmed.
  - Red color = Relay failed self test, has not been programmed, or out of service
- **TRIP**

  This LED indicates that the element selected to produce a trip has operated. This indicator always latches; as such, a Reset command must be initiated to allow the latch to be reset.
- **ALARM**

  This LED indicates that the FlexLogic™ operand serving as an Alarm switch has operated. Latching of the indicator depends on the selected protection function. A Reset command must be initiated to allow the latch to be reset.
- **PICKUP**

  This LED indicates that at least one element is picked up. This indicator is never latched.
- **TEST MODE**

  This LED indicates that the relay has been set into Test Mode.
- **MESSAGE**

  This LED indicates the presence of Target Messages detected by the relay.
- **LOCAL MODE**

  This LED indicates that the relay is operating in local mode.

Breaker status indication is based on the breaker's 52a and 52b contacts. With both contacts wired to the relay and configured, closed breaker status is determined by closed 52a contact and opened 52b contact. Vice-versa the open breaker status is determined by opened 52a contact and closed 52b contact. If both 52a and 52b contacts are open, due to a breaker being racked out from the switchgear, both the Breaker Open and Breaker Closed LED Indicators will be off.

The Event Cause indicators in the first column are described as follows:

Events Cause LEDs are turned ON or OFF by protection elements that have their respective target settings selected as either "Self-Reset" or "Latched". If a protection element target setting is "Self-Reset", then the corresponding Event Cause LEDs remain ON as long as the operate operand associated with the element remains asserted. If a protection element target setting is "Latched", then the corresponding Event Cause LEDs turn ON when the operate operand associated with the element is asserted and will remain ON until the RESET button on the front panel is pressed after the operand is reset.

Default labels are shipped in the package of every 845, together with custom templates. A custom LED template is available for editing and printing, refer to publication GET-20035 from http://www.gegridsolutions.com/multilin. The default labels can be replaced by user-printed labels. Customization of LED operation is of maximum benefit in installations where languages other than English are used to communicate with operators.

NOTICE

For LED and Pushbutton programming details, please refer to Front Panel.

Home Screen Icons

The next figure shows the icons available on the front screen. For descriptions of these screen icons see the following tables.

Figure 3-10: Home Screen Icons

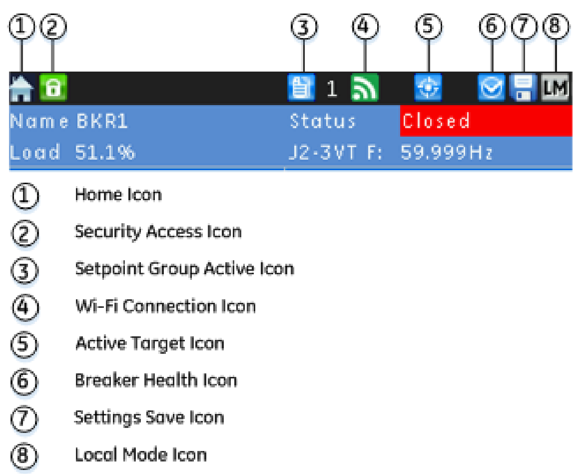


Table 3-1: Security Icon

Security State	Security Icon Color
User not logged in	Icon is green and locked
User logged in	Icon is red and unlocked

NOTE

The security icon only represents the security access level through the front panel.

Table 3-2: Setpoint Group Icon

Description
Identifies the active setpoint group

Table 3-3: Wifi Icon

Wifi State	Wifi Icon Color
Disabled	Icon is grey and crossed by a red line
Disconnected	Grey
Connecting	Orange
Connected	Green

Table 3-4: Active Target Icon

Description
When the target auto navigation setting is disabled, the message LED and the Active Target icon are the only indication of active target messages.

Table 3-5: Breaker Health Icon

Description
The Breaker Health icon is blue when the setting for the breaker health function is not disabled. When the setting is disabled the icon is grey.

Table 3-6: Settings Save Icon

Description
Indicates that a setting is being saved on the relay (i.e., when changing one of relay settings). Icon is ON (relay is saving to flash memory) Icon is OFF (relay is not saving to flash memory)

NOTE

Do not remove power from the relay whenever the Settings Save icon is ON. When power is removed the data being saved can also be lost.

Table 3-7: Local Mode Icon

Description
Indicates that Local Mode is active. During Local Mode, the control for the breakers and disconnect switches can be performed only by the relay front panel.

Relay Messages

Target Messages

Target Messages are displayed in order of their activation, whereas in cases of simultaneous activation, they are displayed in the order outlined below (from highest to lowest priority):

1. Targets generated by pressing programmable pushbutton
2. Targets generated by Contact inputs
3. Targets generated by Protection, Control and Monitoring elements
4. Targets generated by communications.

In cases where the Pickup and Operate flags from an element are detected at the same time, the Pickup flag is not displayed. The Operate flag is displayed instead.

LED #6, from the first column of LEDs, is factory configured to be triggered by the FlexLogic operand ANY TARGET, to indicate the presence of at least one target message. This LED is labeled as “MESSAGE”. The LED can be programmed to any other FlexLogic operand by choice.

MESSAGE TIMEOUT:

The timeout applies to each screen other than the default screen. Examples include viewing, metering, or navigating to a screen with setting, etc. If no further navigation is performed, no pushbutton is touched, and/or no target is initiated for the time specified in the message timeout setpoint, the display goes back to the default screen (the metering summary screen).

The target message interrupts the message timeout. It overrides it. The message timeout starts timing after each target message, and if no more activity is recorded for the specified time, the display goes back to the default screen.

Pressing a programmable pushbutton activates a new screen with a Target Message corresponding to the programmed PB action. The PB Target Message is displayed for 10 seconds then defaults to the screen that was displayed before pressing the pushbutton. The PB Target Message is recorded in the list with other generated Target Messages.

Target Messages can be cleared either by pressing the PB corresponding to the tab “CLEAR”, or by initiating a RESET command. The “CLEAR” command clears only the Target Messages, while initiating a RESET clears not only the Target Messages, but also any latched LEDs and output relays.

Self-Test Errors

The relay performs self-diagnostics at initialization (after power up), and continuously as a background task to ensure that the hardware and software are functioning correctly. There are two types of self-test warnings indicating either a minor or major problem. Minor errors indicate a problem with the relay that does not compromise protection and control functionality of the relay. Major errors indicate a problem with the relay which takes it out of service.

CAUTION

Self-Test Warnings may indicate a serious problem with the relay hardware!

Upon detection of a minor problem, the relay does the following:

- Displays a detailed description of the error on the relay display as a target message
- Records the minor self-test error in the Event Recorder
- Flashes the “ALARM” LED

Upon detection of a major problem, the relay does the following:

- De-energizes critical failure relay
- De-energizes all output relays
- Blocks protection and control elements
- Turns the "IN SERVICE" LED to red
- Flashes the "ALARM" LED
- Displays “Major Self-test error” with the error code as a target message
- Records the major self-test failure in the Event Recorder

NOTE

The Critical Failure Relay (Output Relay 8) is energized when the relay is in-service, and no major error is present

Under both conditions, the targets cannot be cleared if the error is still active.

Figure 3-11: Minor Errors

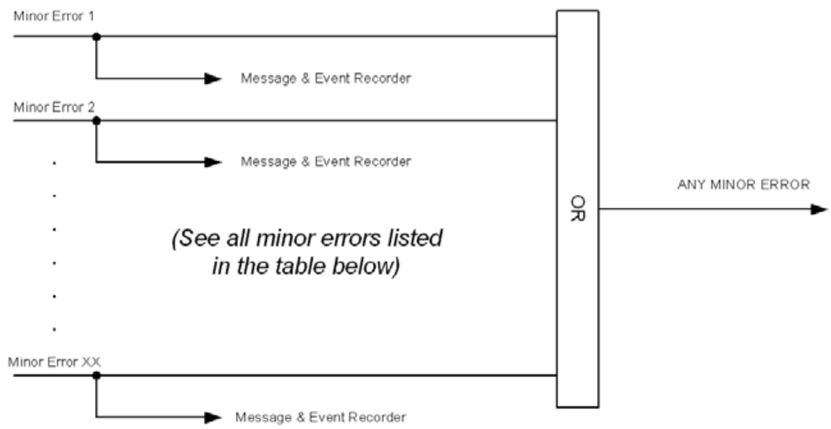


Figure 3-12: Major Errors

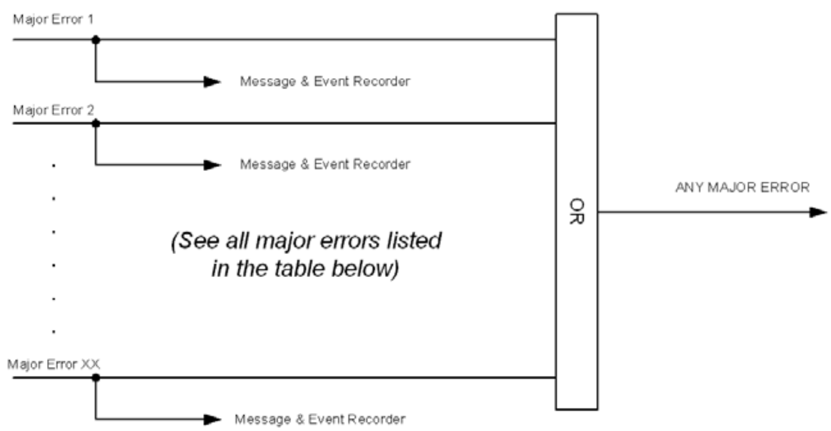


Table 3-8: Minor Self-test Errors

Self-test Error Message[1]	Description of Problem	How Often the Test is Performed	What to do
Order Code Error	Hardware doesn't match order code	Every 1 second	If alert doesn't self-reset then contact factory. Otherwise monitor re-occurrences as errors are detected and self-reset
CPU S/N Invalid	CPU card doesn't have valid data to match the order code.	Every 1 second	
Slot"$" IO S/N Invalid[2]	IO card located in slot $ doesn't have valid data to match the order code.	Every 1 second	
Comms S/N Invalid	Comms card doesn't have valid data to match the order code.	Every 1 second	
CPanel S/N Invalid	Control Panel doesn't have valid data to match the order code.	Every 1 second	
PSU S/N Invalid	Power Supply Unit doesn't have valid data to match the order code.	Every 1 second	
RTC Error	The CPU cannot read the time from the real time clock	Every 1 second	
Product Serial Invalid	The product serial number doesn't match the product type	Every 1 second	
Comm Alert #1	Communication error between CPU and Comms board	Every 1 second	
Comm Alert #2		Every 1 second	
Comm Alert #3		Every 1 second	
FLASH Error	The permanent storage memory has been corrupted	Every 1 second	
SPI Error	Communication error between CPU and LEDs, Keypad or peripheral memory devices	Every 1 second	
Invalid MAC Address	MAC address is not in the product range	Every 1 second	
Calibration Error	Unit has default calibration values	Boot-up and Every 1 second	
WiFi Default Settings	SSID and Passphrase is the factory default	Every 1 second	Set SSID and Passphrase
Link Error Primary[3]	Port 1 or Port 4 (depending on order code) is not connected	Every 1 second	Ensure Ethernet cable is connected, check cable functionality (i.e. physical damage or perform continuity test), and ensure master or peer device is functioning. If none of these apply, contact the factory.
Link Error Secondary	Port 5 is not connected	Every 1 second	Ensure Ethernet cable is connected, check cable functionality (i.e. physical damage or perform continuity test), and ensure master or peer device is functioning. If none of these apply, contact the factory.

Self-test Error Message[1]	Description of Problem	How Often the Test is Performed	What to do
Traffic Error Primary	Abnormally high amount of Broadcast and Uni-cast traffic on port 1 or port 4	Every 1 second	Contact site IT department to check network for malfunctioning devices
Traffic Error Secondary	Abnormally high amount of Broadcast and Uni-cast traffic on port 5	Every 1 second	Contact site IT department to check network for malfunctioning devices
Ambient Temperature >80C	The ambient temperature surrounding the product has exceeded 80C	Every 1 second	Inspect mounting enclosure for unexpected heat sources (i.e loose primary cables) and remove accordingly
Event Rate High	Abnormally high amounts of events have been generated so the relay has stopped logging to prevent further issues	Every 1 second	Ensure settings are not set close to nominal ratings. Ensure FlexLogic equations do not have impractical timing for status events
IRIG-B Failure	A bad IRIG-B input signal has been detected	Every 1 second	Ensure IRIG-B cable is connected, check cable functionality (i.e. physical damage or perform continuity test), ensure IRIG-B receiver is functioning, and check input signal level (it may be less than specification). If none of these apply, contact the factory.
Version Mismatch	CPU and Comms do not have the same revision on firmware	Boot-up and Every 1 second	Ensure that both the CPU and Comms FW was uploaded during the upgrade process
SelfTestFWUpdate	The updating of the firmware failed	Every 1 second	Re-try uploading firmware. If the upload doesn't work a second time contact factory
Remote CAN IO Mismatch	The value of the cards in the slots detected by the Remote IO does not match the value validated by the user configuration	Every 1 second. A failure is declared after 60 consecutive failures	Fix the remote CANBUS IO mismatch.

1. – Failure is logged after the detection of 5 consecutive failures

2. $ – is the slot ID (i.e., F, G, H etc.)

3.To disable Link Error Primary target when not in-use with SE order code, change IP address to 127.0.0.1

Table 3-9: Major Self-test Errors

Self-test Error Message	Latched Target Message	Description of Problem	How Often the Test is Performed	What to do
Relay Not Ready	No	PRODUCT SETUP INSTALLATION setting indicates relay is not in a programmed state.	On power up and whenever the PRODUCT SETUP INSTALLATION setting is altered.	Program all required settings and then set the PRODUCT SETUP INSTALLATION setting to "Ready".
Major Self-Test (error code)	Yes	Unit hardware failure detected	Every 1 second	Contact the factory and supply the failure code as noted on the display.

NOTE

When a total loss of power is present, the Critical Failure Relay (Output Relay 8) is de-energized.

Out of Service

When the relay is shipped from the factory, the DEVICE IN SERVICE is set to “Not Ready”. The IN SERVICE LED will be orange and the critical fail relay will be de-energized but this will not be classified as a major self-test. An out of service event will be generated in the event recorder.

Flash Messages

Flash messages are warning, error, or general information messages displayed in response to pressing certain keys. The factory default flash message time is 2 seconds.

Label Removal

The 3 Pushbutton (Rugged and Membrane) front panels come with a label removal tool for removing the LED label and user-programmable pushbutton label.

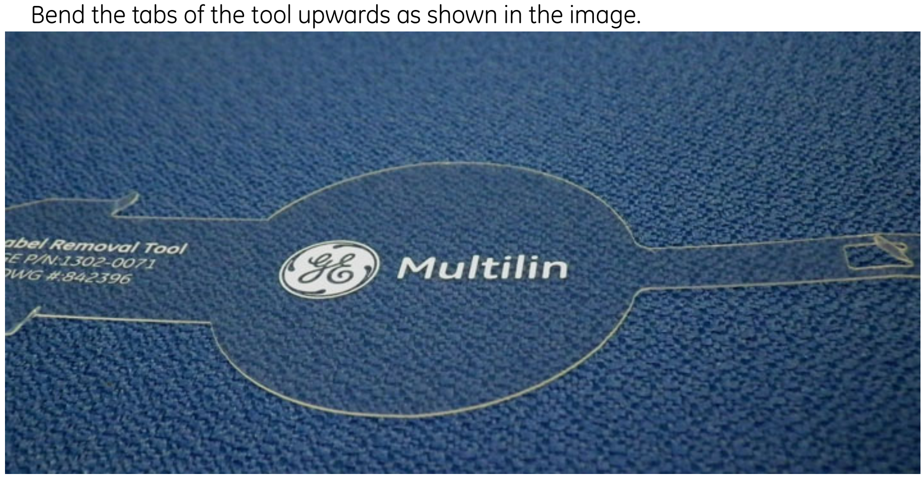
NOTE

Templates for printing custom LED labels are available online at:

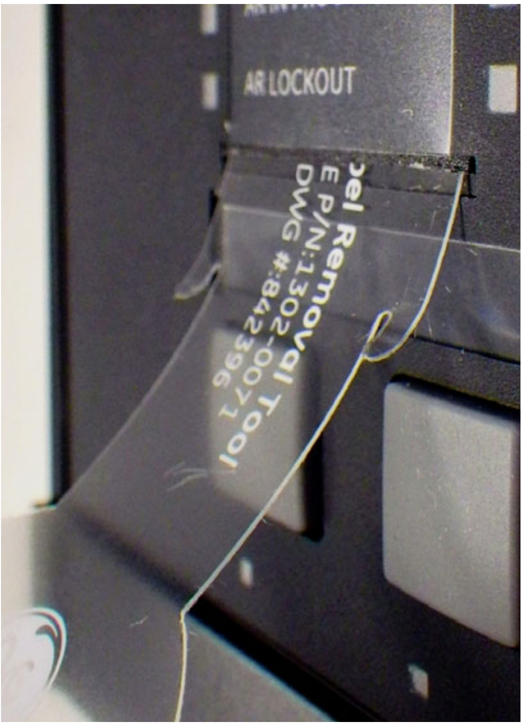
http://www.gegridsolutions.com/app/ViewFiles.aspx?prod=845&type=9.

The following procedures describes how to use the label removal tool.

1. Bend the tabs of the tool upwards as shown in the image.



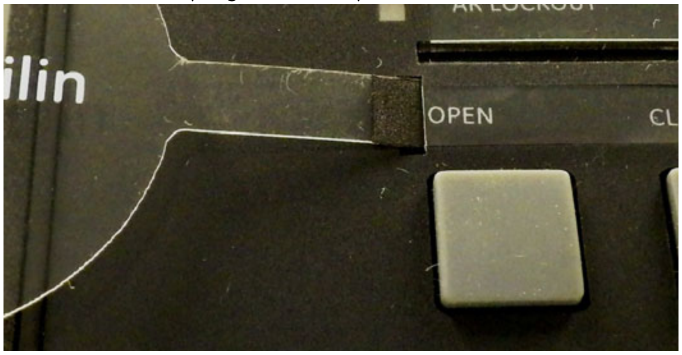
2. Slide the label removal tool under the LED label as shown in the next image. Make sure the bent tabs are pointing away from the relay. Move the tool inside until the tabs enter the pocket.



3. Remove the tool with the LED label.

The following describes how to remove the user-programmable pushbutton label from the 845 front panel.

1. Slide the label tool under the user-programmable pushbutton label as shown in the next image. Make sure the bent tab is pointing away from the relay.
2. Remove the tool and user-programmable pushbutton label as shown in image.



Software Interface

EnerVista 8 Series Setup Software

Although settings can be entered manually using the control panel keys, a PC can be used to download setpoints through the communications port. The EnerVista 8 Series Setup software is available from GE Multilin to make this as convenient as possible. With EnerVista 8 Series Setup software running, it is possible to:

- Program and modify settings
- Load and save setting files to and from a disk
- Read actual values
- Monitor status
- Read pre-trip data and event records
- Get help on any topic
- Upgrade the 845 firmware

The EnerVista 8 Series Setup software allows immediate access to all 845 features with easy to use pull down menus in the familiar Windows environment. This section provides the necessary information to install EnerVista 8 Series Setup software, upgrade the relay firmware, and write and edit setting files.

The EnerVista 8 Series Setup software can run without a 845 connected to the computer. In this case, settings may be saved to a file for future use. If a 845 is connected to a PC and communications are enabled, the 845 can be programmed from the setting screens. In addition, measured values, status and trip messages can be displayed with the actual value screens.

Hardware & Software Requirements

The following requirements must be met for the EnerVista 8 Series Setup software.

- Dual-core processor
- Microsoft Windows™ 7 or 8.1; 32-bit or 64-bit is installed and running properly.
- At least 1 GB of free hard disk space is available.
- At least 2 GB of RAM is installed.
- 1280 x 800 display screen

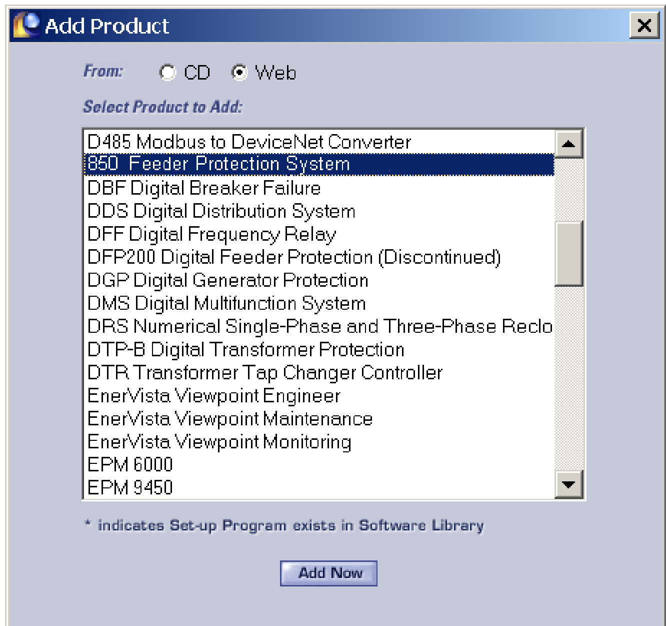
The EnerVista 8 Series Setup software can be installed from either the GE EnerVista CD or the GE Multilin website at http://www.gegridsolutions.com/.

Installing the EnerVista 8 Series Setup Software

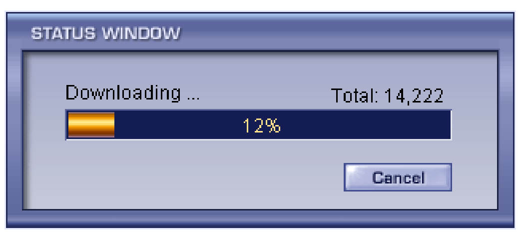
After ensuring the minimum requirements indicated earlier, use the following procedure to install the EnerVista 8 Series Setup software from the enclosed GE EnerVista CD.

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 on the local PC.
3. When installation is complete, start the EnerVista Launchpad application.
4. Click the **IED Setup** section of the LaunchPad toolbar.

5. In the EnerVista Launchpad window, click the **Add Product** button and select the 845 Protection System 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 845.



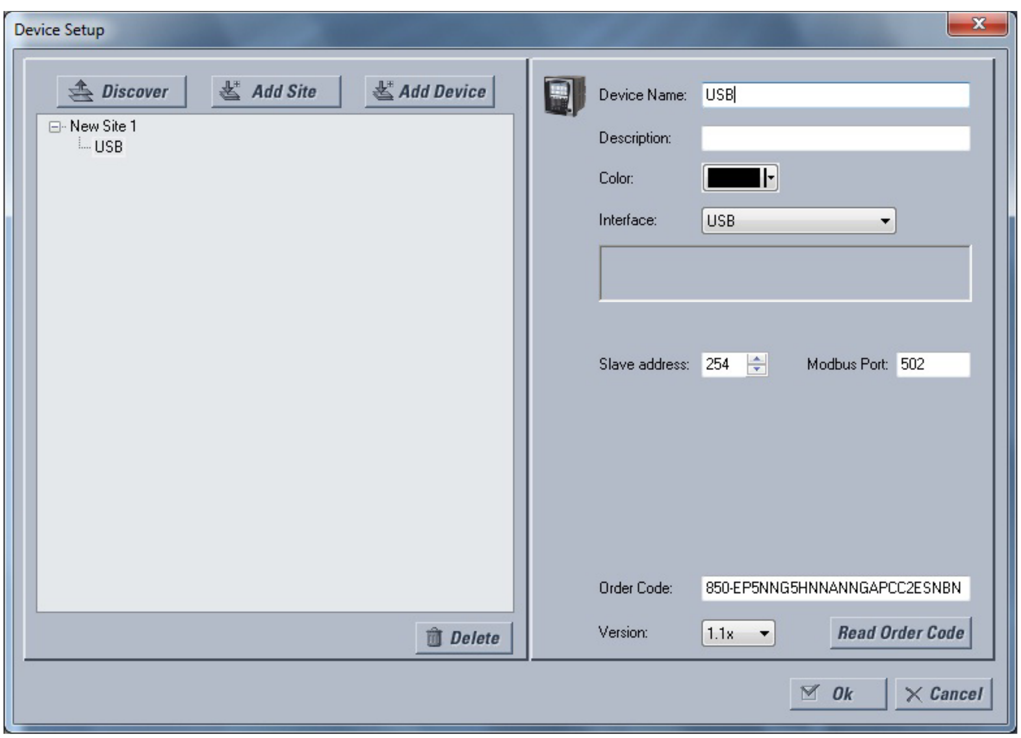
6. EnerVista Launchpad obtains the latest installation software from the Web or CD and automatically starts the installation process. A status window with a progress bar is shown during the downloading process.



7. Select the complete path, including the new directory name, where the EnerVista 8 Series Setup software is being installed.
8. Click on **Next** to begin the installation. The files are installed in the directory indicated, the USB driver is loaded into the computer, and the installation program automatically creates icons and adds the EnerVista 8 Series Setup software to the Windows start menu.
9. The 845 device is added to the list of installed IEDs in the EnerVista Launchpad window, as shown below.

If you are going to communicate from your computer to the 845 Relay using the USB port:

10. Plug the USB cable into the USB port on the 845 Relay then into the USB port on your computer.
11. Launch EnerVista 8 Series Setup software from LaunchPad.
12. In **EnerVista > Device Setup**:



13. Select **USB** as the Interface type.
14. Select the Read Order Code button.

Upgrading the Software

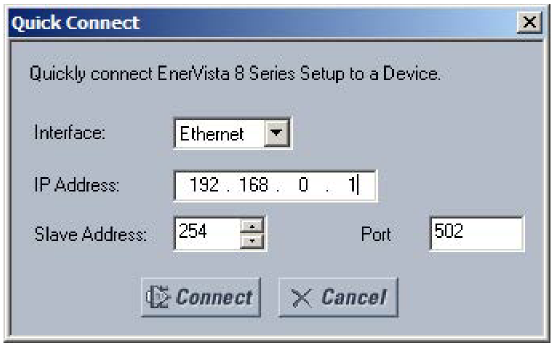
The latest EnerVista software and firmware can be downloaded from:
https://www.gegridsolutions.com/
After upgrading, check the version number under **Help > About**. If the new version does not display, try uninstalling the software and reinstalling the new versions.

Connecting EnerVista 8 Series Setup software to the Relay

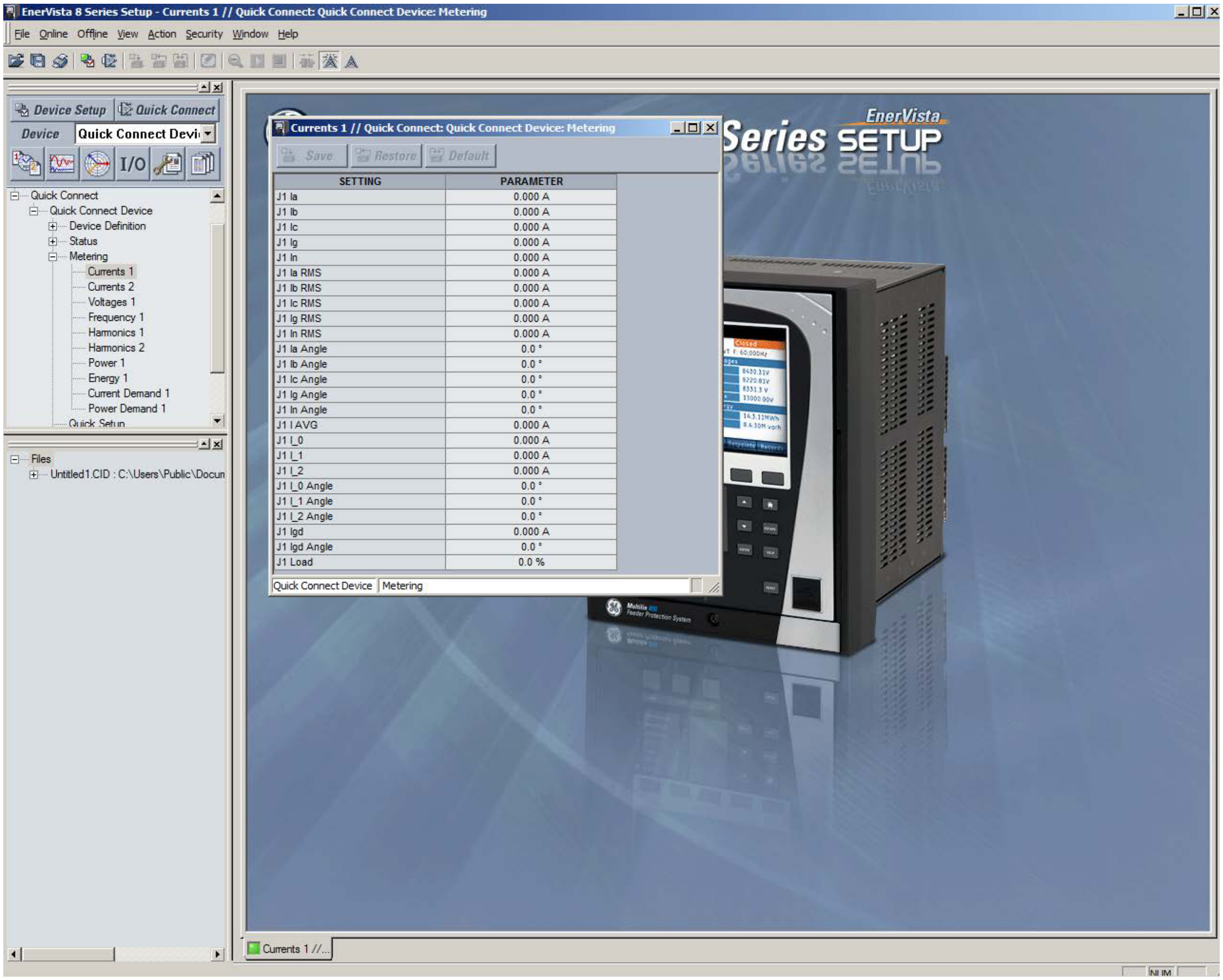
Using the Quick Connect Feature

The **Quick Connect** button can be used to establish a fast connection through the front panel USB port of a 845 relay, or through the Ethernet port. The following window appears when the **QuickConnect** button is pressed:

As indicated by the window, the "Quick Connect" feature can quickly connect the EnerVista 8 Series Setup software to a 845 front port if the USB is selected in the interface drop-down list. Select “USB” and press the **Connect** button. Ethernet or WiFi can also be used as the interface for Quick Connect as shown next.



When connected, a new Site called "Quick Connect" appears in the Site List window.



The 845 Site Device has now been configured via the Quick Connect feature for either USB or Ethernet communications. Proceed to *Connecting to the Relay* next, to begin communications.

Configuring Ethernet Communications

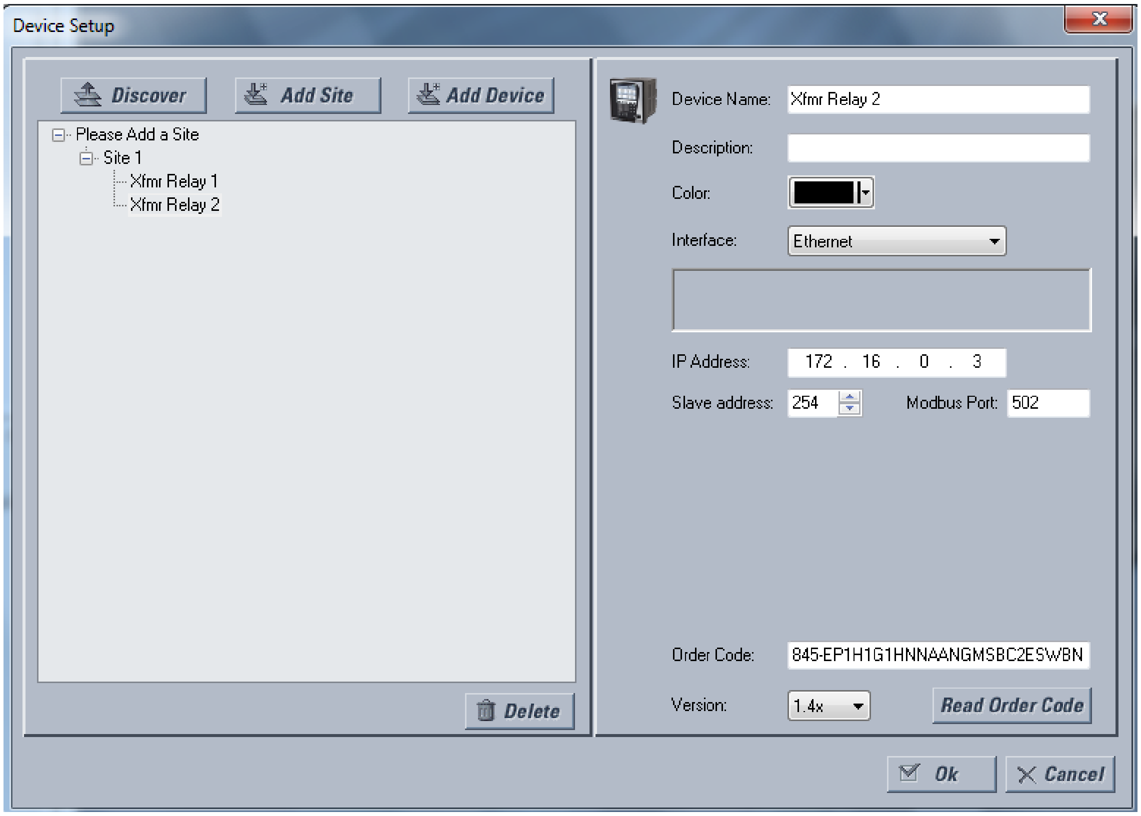
Before starting, verify that the Ethernet cable is properly connected to the RJ-45 Ethernet port.

NOTICE

845 supports a maximum of 3 TCP/IP sessions.

1. Install and start the latest version of the EnerVista 8 Series Setup software (available from the GE EnerVista CD or Website). See the previous section for the installation procedure.
2. Click on the **Device Setup** button to open the Device Setup window and click the **Add Site** button to define a new site.
3. Enter the desired site name in the "Site Name" field. If desired, a short description of the site can also be entered. In this example, we will use "Substation 1" as the site name.
4. The new site appears in the upper-left list.
5. Click the **Add Device** button to define the new device.
6. Enter the desired name in the "Device Name" field, and a description (optional).

7. Select “Ethernet” from the Interface drop-down list. This displays a number of interface parameters that must be entered for proper Ethernet functionality.



8. Enter the IP address, slave address, and Modbus port values assigned to the 845 relay (from the **Setpoints > Device > Communications** menu).
9. Click the **Read Order Code** button to connect to the 845 and upload the order code. If a communications error occurs, ensure that the Ethernet communication values correspond to the relay setting values.
10. Click **OK** when the relay order code has been received. The new device will be added to the Site List window (or Online window) located in the top left corner of the main EnerVista 8 Series Setup software window.

The 845 Site Device has now been configured for Ethernet communications. Proceed to the following section to begin communications.

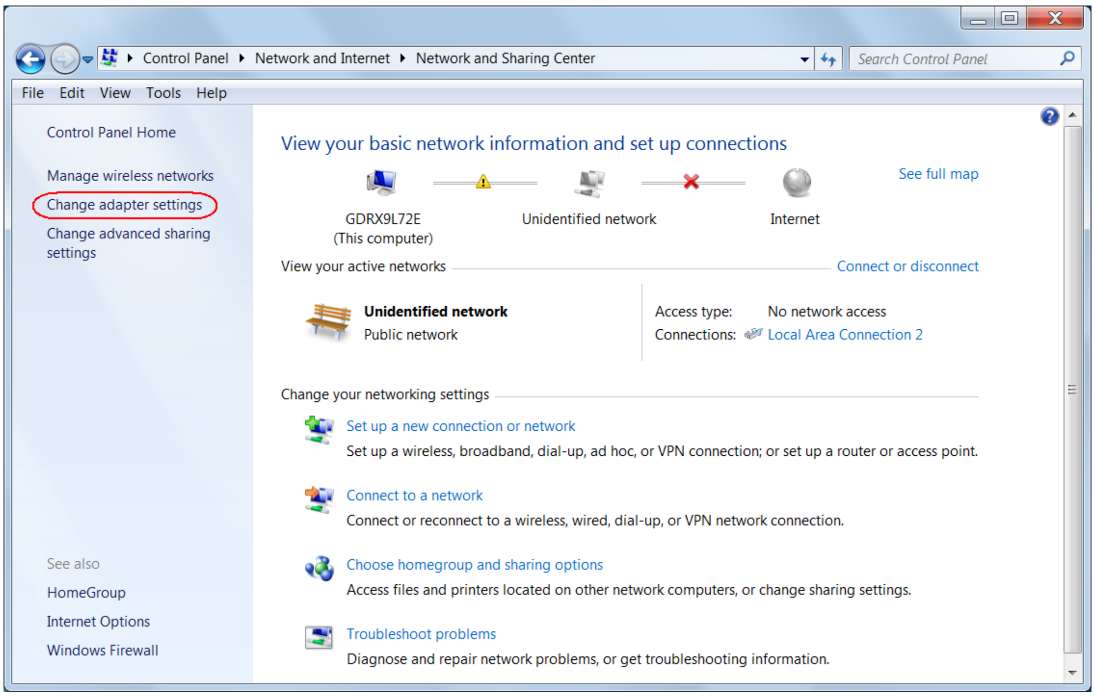
Configuring USB Address

By default, the relay USB port uses the network address 172.16.0.2. In some cases this IP is part of the corporate network for the computer and conflicts with existing computers or other devices on that network. To resolve this conflict, change the USB address to be in a different network. This change must be made to the computer settings, the relay settings, and the EnerVista 8 Series Setup software settings in order to connect to the relay through the USB port.

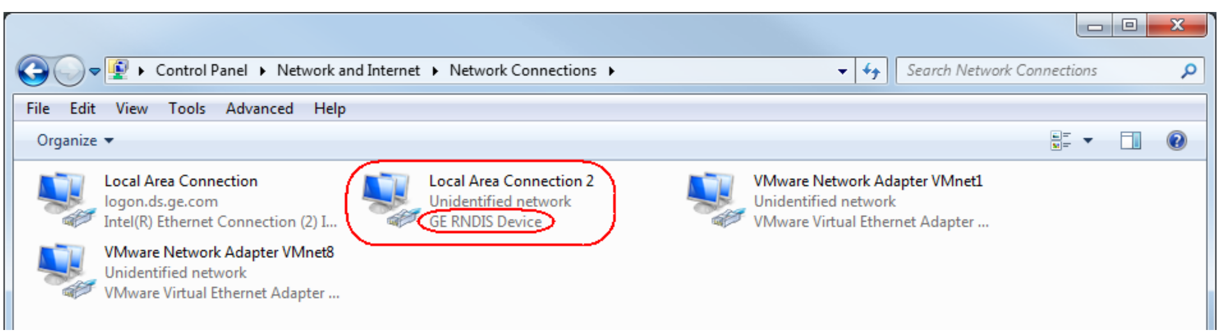
1. Open the Windows Control Panel and select **Network and Internet > Network Sharing**.

NOTE

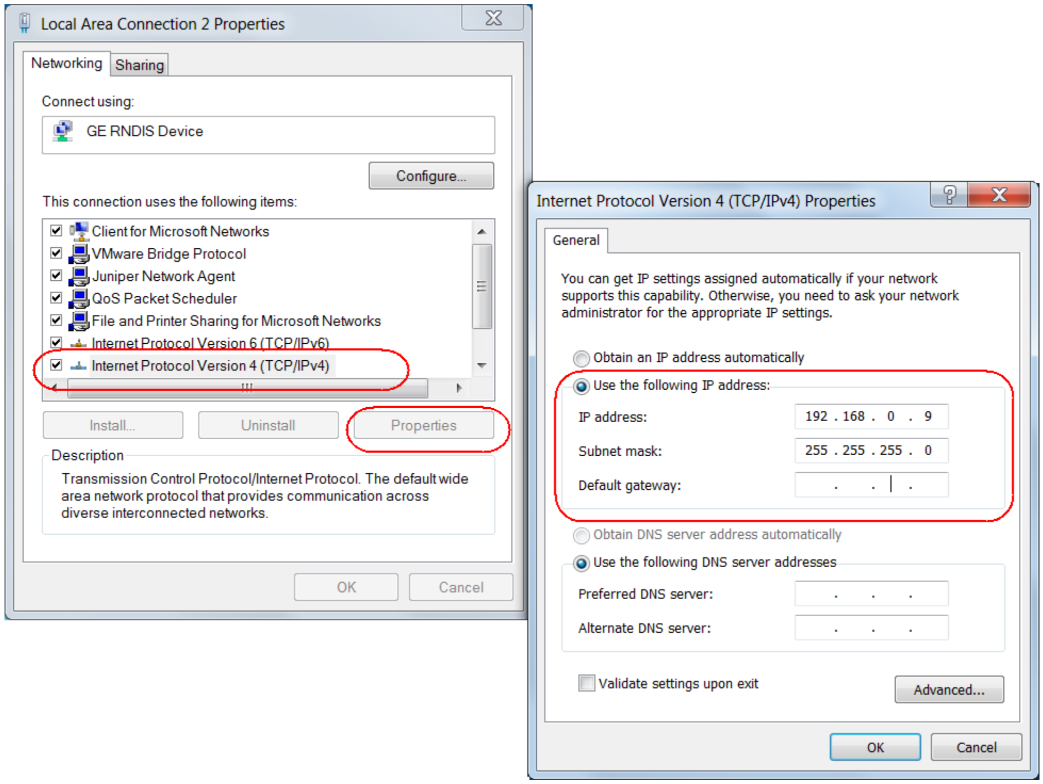
The exact path may vary depending on the version of Windows.



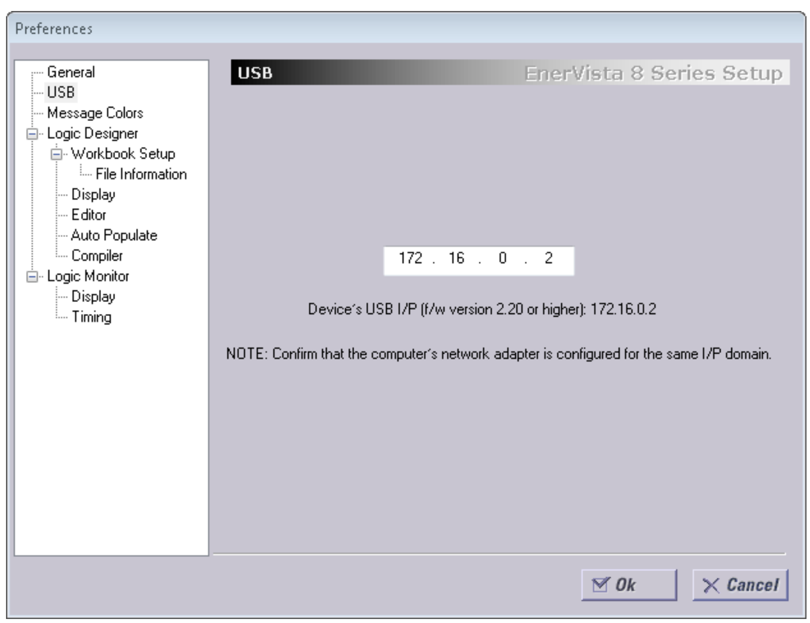
2. Click **Change adapter settings**.



3. Find the **GE RNDIS Device** (or **GE RNDIS Device #2**) and right-click the network it is on to open the **Properties** window.
4. Select **Internet Protocol Version 4 (TCP/IPv4)** and click **Properties**.



5. In the Internet Protocol Version 4 (TCP/IPv4) Properties window, ensure that **Use the following IP Address** is selected, and enter an appropriate IP address.
6. Click **OK** to save the new settings.
7. In the EnerVista 8 Series Setup software, navigate to **File > Preferences > USB** and change the IP address to match. This address will now be used by the EnerVista 8 Series Setup software when the interface selected is USB.



8. Click **OK** to save the new settings.
9. On the front panel of the relay, navigate to **Setpoint > Device > Communications > USB**.

10. Change both the **USB IP Address** and **USB GWY IP Address** setpoints to match the IP address the computer is now using.

The relay should now communicate with the computer through the USB port.

Connecting to the Relay

Now that the communications parameters have been properly configured, communications with the relay can be initiated.

1. Expand the Site list by double clicking on the site name or clicking on the «**+**» box to list the available devices for the given site.
2. Desired device trees can be expanded by clicking the «**+**» box. The following list of headers is shown for each device:

   Device Definition
   Status
   Metering
   Quick Setup
   Setpoints
   Records
   Maintenance.
3. Expand the **Setpoints > Device > Front Panel** list item and double click on **Display Properties** or **Default Screens** to open the settings window as shown:

4. The settings window opens with a corresponding status indicator on the lower left of the EnerVista 8 Series Setup window.

5. If the status indicator is red, verify that the serial, USB, or Ethernet cable is properly connected to the relay, and that the relay has been properly configured for communications (steps described earlier).

The settings can now be edited, printed, or changed. Other setpoint and command windows can be displayed and edited in a similar manner. "Actual Values" windows are also available for display. These windows can be arranged, and resized, if desired.

Working with Setpoints & Setpoints Files

NOTICE

When a settings file is being uploaded to a device, the DEVICE IN SERVICE state (Setpoints > Device > Installation) switches to "Not Ready" for the duration of the upload. This ensures that all new settings are applied before the device is operational. Settings file upload operations include the following:

- Enervista 8 Series Setup software menu option **Write Settings File to Device**
- Logic Designer changes saved online
- SLD configuration saved online
- IEC 61850 configuration saved online
- FlexLogic configuration saved online
- CID file uploaded to device

Individual setting changes from the device front panel or Enervista 8 Series Setup software Online Window do not change the DEVICE IN SERVICE state.

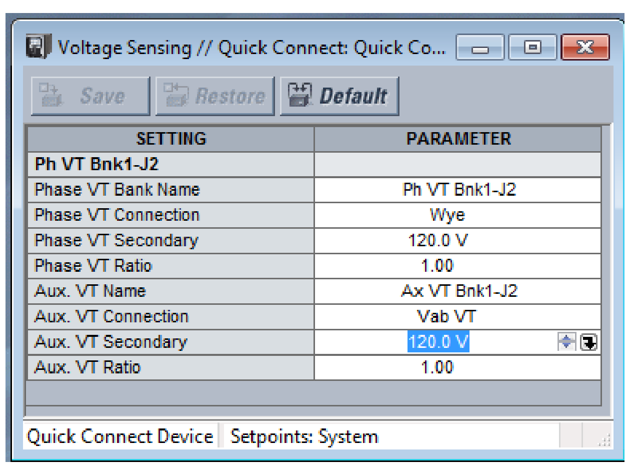
Engaging a Device

The EnerVista 8 Series Setup software may be used in on-line mode (relay connected) to directly communicate with a relay. Communicating relays are organized and grouped by communication interfaces and into sites. Sites may contain any number of relays selected from the product series.

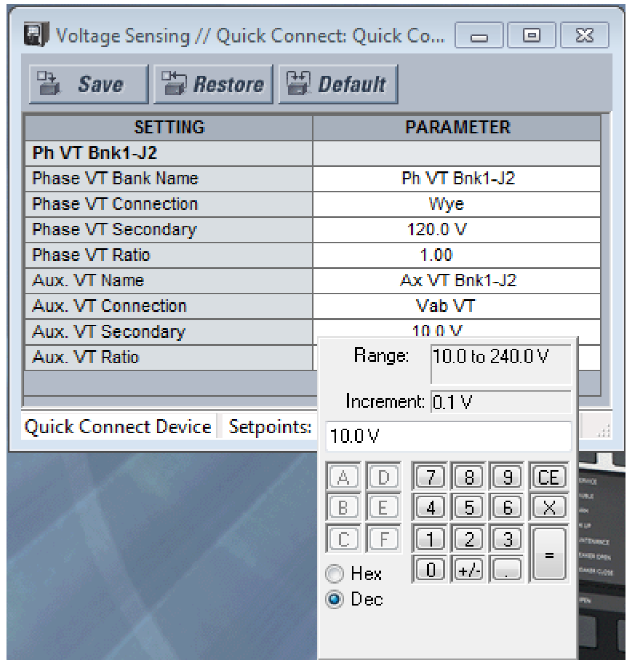
Entering Setpoints

The System Setup page is used as an example to illustrate entering setpoints. In this example, we are changing the voltage sensing setpoints.

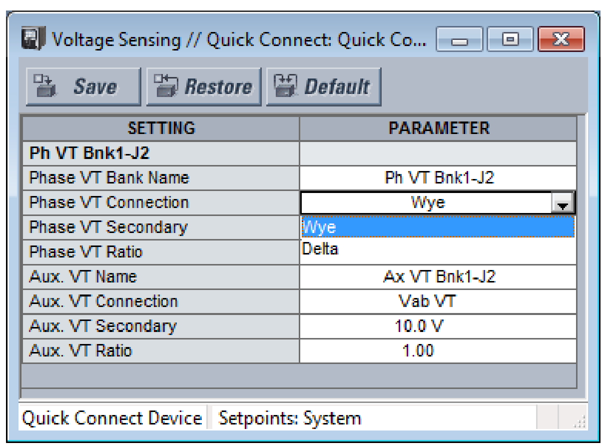
1. Establish communications with the relay.
2. Select the **Setpoint > System > Voltage Sensing** menu item.
3. Select the Aux. VT Secondary setpoint by clicking anywhere in the parameter box. This displays three arrows: two to increment/decrement the value and another to launch the numerical keypad.



4. Clicking the arrow at the end of the box displays a numerical keypad interface used to enter values within the setpoint range displayed near the top of the keypad: Click **=** to exit from the keypad and keep the new value. Click on **X** to exit from the keypad and retain the old value.



5. For setpoints requiring non-numerical pre-set values (e.g. **Phase VT Connection** below), clicking anywhere within the setpoint value box displays a drop-down selection menu arrow. Select the desired value from this list.



6. In the **Setpoints > System Setup > Voltage Sensing** dialog box, click on **Save** to save the values into the 845. Click **YES** to accept any changes and exit the window. Click **Restore** to retain previous values. Click **Default** to restore Default values.
7. For setpoints requiring an alphanumeric text string (e.g. "relay name"), the value may be entered directly within the setpoint value box.

NOTE

When using Setpoint Groups, an element from one group can be dragged and dropped on the same element in another group, copying all settings.

File Support

Opening any EnerVista 8 Series Setup file automatically launches the application or provides focus to the already opened application.

New files are automatically added to the tree.

Using Setpoints Files

The EnerVista 8 Series Setup software interface supports three ways of handling changes to relay settings:

- In off-line mode (relay disconnected) to create or edit relay settings files for later download to communicating relays.
- Directly modifying relay settings while connected to a communicating relay, then saving the settings when complete.
- Creating/editing settings files while connected to a communicating relay, then saving them to the relay when complete.

Settings files are organized on the basis of file names assigned by the user. A settings file contains data pertaining to the following types of relay settings:

- Device Definition
- Relay Setup
- System Setup
- Protection
- Control
- Inputs/Outputs
- Monitoring
- FlexLogic
- Quick setup
- Protection summary
- IEC 61850 configurator
- Modbus user map

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

The 845 displays relay setpoints with the same hierarchy as the front panel display.

Downloading & Saving Setpoints Files

Back up a copy of the in-service settings for each commissioned unit, so as to revert to the commissioned settings after inadvertent, unauthorized, or temporary setting changes are made, after the settings default due to firmware upgrade, or when the unit has to be replaced. This section describes how to backup settings to a file and how to use that file to restore settings to the original relay or to a replacement relay.

Setpoints must be saved to a file on the local PC before performing any firmware upgrades. Saving setpoints is also highly recommended before making any setpoint changes or creating new setpoint files.

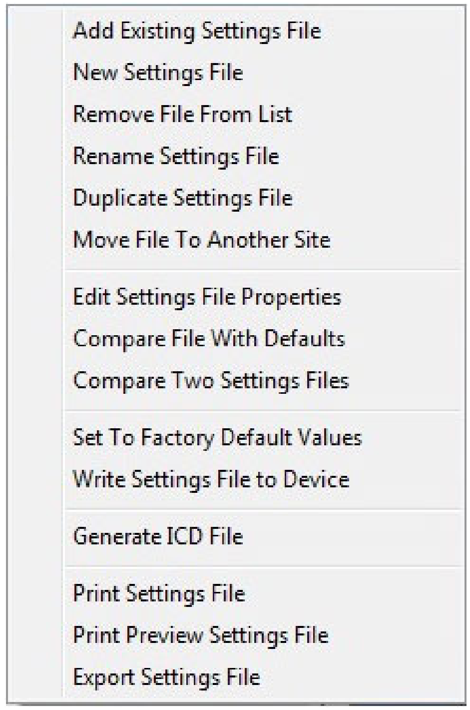
The setpoint files in the EnerVista 8 Series Setup window are accessed in the Files Window. Use the following procedure to download and save setpoint files to a local PC.

1. Ensure that the site and corresponding device(s) have been properly defined and configured as shown in *Connecting EnerVista 8 Series Setup to the Relay*, above.
2. Select the desired device from the site list.
3. Select the **Read Device Settings** from the online menu item, or right-click on the device and select **Read Device Settings** to obtain settings information from the device.
4. After a few seconds of data retrieval, the software requests the name and destination path of the setpoint file. The corresponding file extension is automatically assigned. Press **Receive** to complete the process. A new entry is added to the tree, in the File pane, showing path and file name for the setpoint file.

Adding Setpoints Files to the Environment

The EnerVista 8 Series Setup software provides the capability to review and manage a large group of setpoint files. Use the following procedure to add an existing file to the list.

1. In the offline pane, right-click on **Files** and select the **Add Existing Settings File** item as shown:

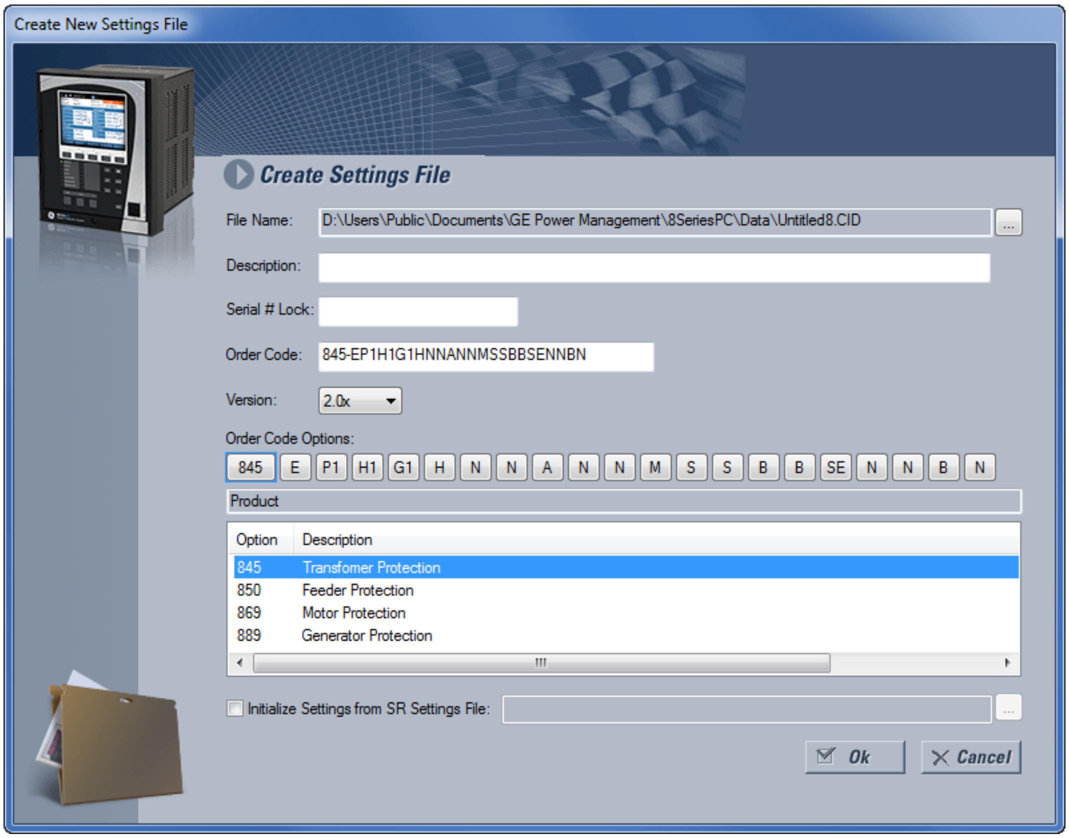


2. The Open dialog box is displayed, prompting to select a previously saved setpoint file. As for any other MS Windows® application, browse for the file to be added then click **Open**. The new file and complete path will be added to the file list.

Creating a New Setpoints File

The EnerVista 8 Series Setup software allows the creation of new setpoint files independent of a connected device. These can be uploaded to a relay at a later date. The following procedure illustrates how to create new setpoint files.

1. In the Offline pane, right click and select the **New Settings File** item. The following box appears, allowing for the configuration of the setpoint file for the correct firmware version. It is important to define the correct firmware version to ensure that setpoints not available in a particular version are not downloaded into the relay.



2. Select the Firmware Version, and Order Code options for the new setpoint file.
3. For future reference, enter some useful information in the **Description** box to facilitate the identification of the device and the purpose of the file.
4. To select a file name and path for the new file, click the button beside the File Name box.
5. Select the file name and path to store the file, or select any displayed file name to replace an existing file. All 845 setpoint files should have the extension '.cid' (for example, '845 1.cid').
6. Click **OK** to complete the process. Once this step is completed, the new file, with a complete path, is added to the 845 software environment.

NOTE

Offline settings files can be created for invalid order codes in order to support file conversion from different products, upgrades, and special orders. To validate an order code, visit the GE Multilin online store.

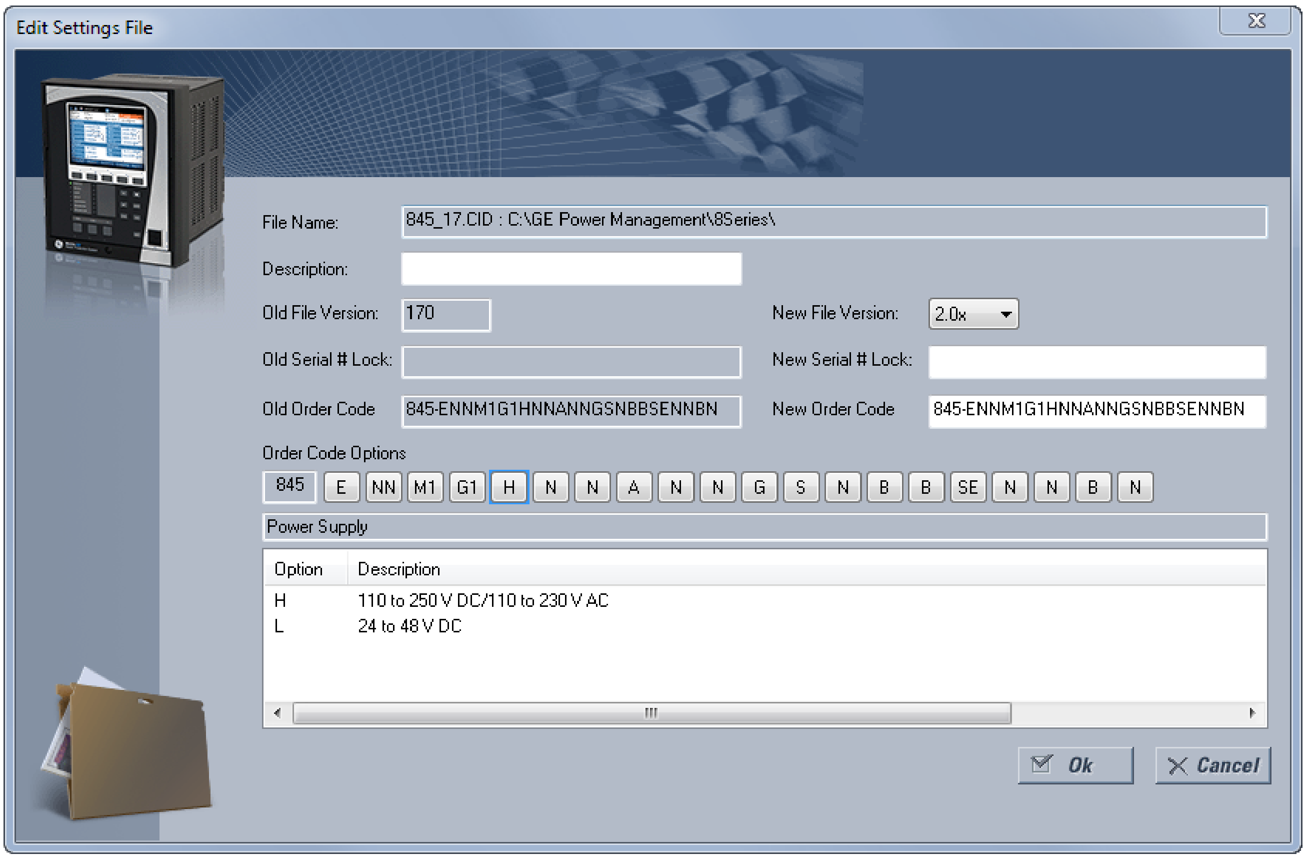
NOTE

File names for setting files cannot have a decimal point other than the one that is added in front of CID.

Upgrading Setpoints Files to a New Revision

It is often necessary to upgrade the revision for a previously saved setpoint file after the 845 firmware has been upgraded. This is illustrated in the following procedure:

1. Establish communications with the 845 relay.
2. Select the **Status > Information > Main CPU** menu item and record the Firmware Version.
3. Load the setpoint file to be upgraded into the EnerVista 8 Series Setup software environment as described in the section, *Adding Setpoints Files to the Environment*.
4. In the File pane, select the saved setpoint file.
5. From the main window menu bar, select the **Offline > Edit Settings File Properties** menu item and note the File Version of the setpoint file. If this version is different from the Firmware Revision noted in step 2, select a New File Version that matches the Firmware Revision from the pull-down menu.
6. For example, if the firmware revision is J0J08AA150.SFD (Firmware Revision 1.50) and the current setpoint file revision is 1.10, change the New File Version to “1.5x”.

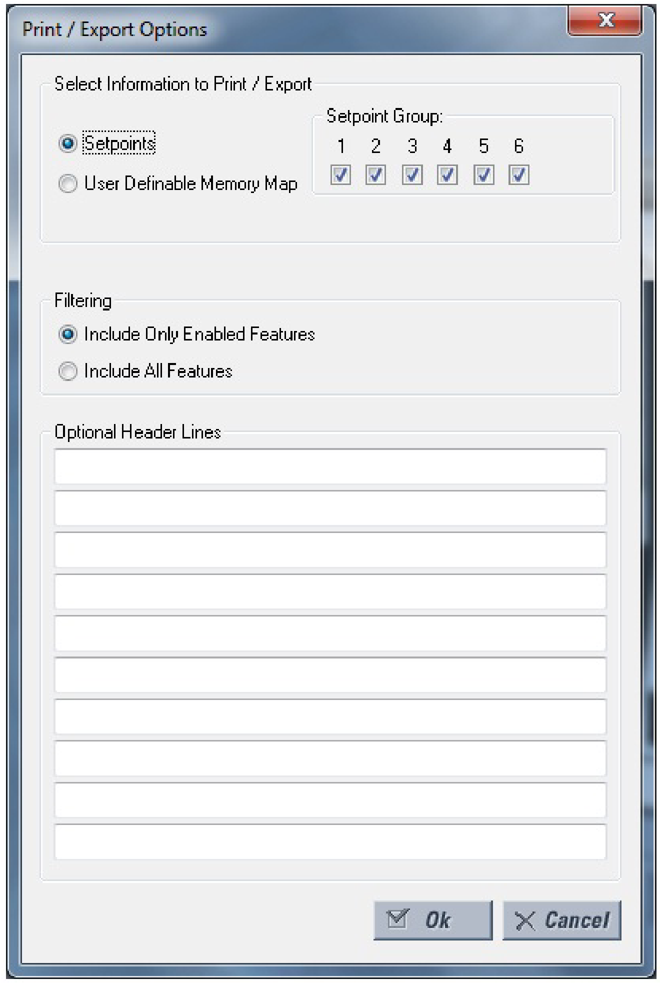


7. Enter any special comments about the setpoint file in the "Description" field.
8. Select the desired firmware version from the "New File Version" field.
9. When complete, click **OK** to convert the setpoint file to the desired revision. See *Loading Setpoints from a File* below, for instructions on loading this setpoint file into the 845.

Printing Setpoints

The EnerVista 8 Series Setup software allows printing of partial or complete lists of setpoints. Use the following procedure to print a list of setpoints:

1. Select a previously saved setpoints file in the File pane or establish communications with a 845 device.
2. If printing from an online device, select the **Online > Print Device Information** menu item. If printing from a previously saved setpoints file, select the **Offline > Print Settings File** menu item.
3. The Print/Export Options dialog box appears. Select **Setpoints** in the upper section and select either **Include All Features** (for a complete list) or **Include Only Enabled Features** (for a list of only those features which are currently used) in the filtering section and click **OK**.



4. Setpoint lists can be printed in the same manner by right clicking on the desired file (in the file list) or device (in the device list) and selecting the **Print Device Information** or **Print Settings File** options.

Printing Values from a Connected Device

A complete list of actual values can also be printed from a connected device with the following procedure:

1. Establish communications with the desired 845 device.
2. From the main window, select the **Online > Print Device Information** menu item
3. The Print/Export Options dialog box will appear. Select **Actual Values** in the upper section and select either **Include All Features** (for a complete list) or **Include Only Enabled Features** (for a list of only those features which are currently used) in the filtering section and click **OK**.

Actual values lists can be printed in the same manner by right clicking on the desired device (in the device list) and selecting the **Print Device Information** option.

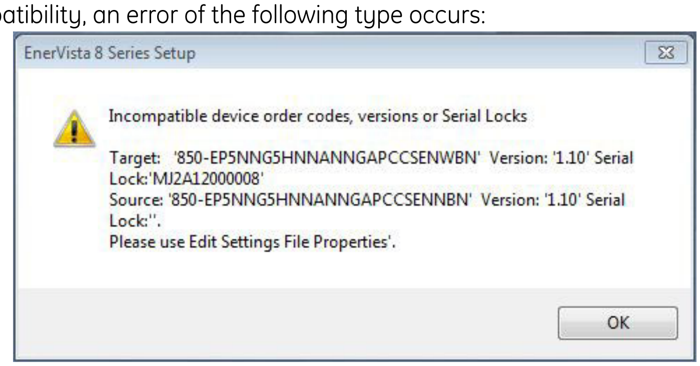
Loading Setpoints from a File

⚠CAUTION

An error message occurs when attempting to upload a setpoint file with a revision number that does not match the relay firmware. If the firmware has been upgraded since saving the setpoint file, see Upgrading Setpoints Files to a New Revision for instructions on changing the revision number of a setpoint file.

The following procedure illustrates how to load setpoints from a file. Before loading a setpoints file, it must first be added to the 845 environment as described in the section, *Adding Setpoints Files to the Environment*.

1. Select the previously saved setpoints file from the File pane of the 845 software main window.
2. Select the **Offline > Edit Settings File Properties** menu item and verify that the corresponding file is fully compatible with the hardware and firmware version of the target relay. If the versions are not identical, see *Upgrading Setpoint Files to a New Revision* for details on changing the setpoints file version.
3. Right-click on the selected file and select the **Write Settings File to Device** item.
4. Select the target relay from the list of devices shown and click **Send**. If there is an incompatibility, an error of the following type occurs:



If there are no incompatibilities between the target device and the settings file, the data is transferred to the relay. An indication of the percentage completed is shown in the bottom of the main window.

Uninstalling Files and Clearing Data

The unit can be decommissioned by turning off the power to the unit and disconnecting the wires to it. Files can be cleared after uninstalling the EnerVista software or the relay, for example to comply with data security regulations. On the computer, settings files can be identified by the .cid extension.

To clear the current settings file do the following:

1. Create a default settings file.
2. Write the default settings file to the relay.
3. Delete all other files with the .cid extension.
4. Delete any other data files, which can be in standard formats, such as COMTRADE or .csv.

You cannot directly erase the flash memory, but all records and settings in that memory can be deleted. Do this from the front panel or EnerVista software using:

RECORDS > CLEAR RECORDS

Quick Setup

The Quick Setup item is accessed from the EnerVista software from different screens. Online and offline settings changes are made from the corresponding Quick Setup screen.

Figure 3-13: 845 Quick Setup (Online) tree position

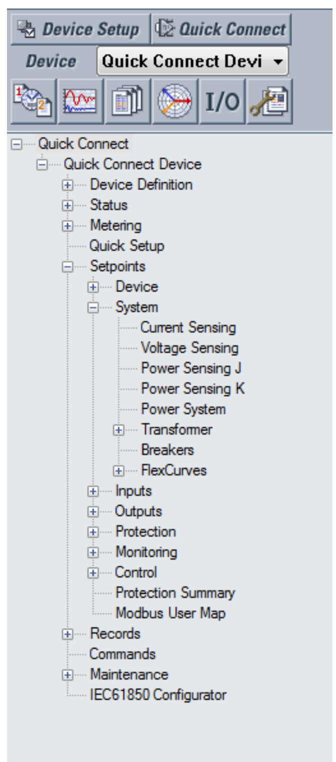
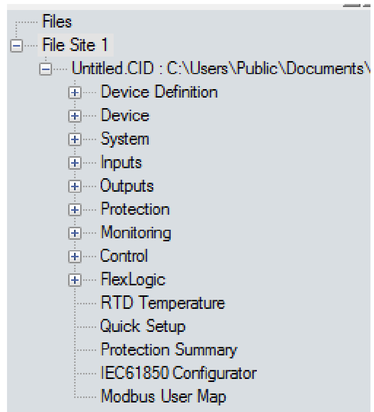
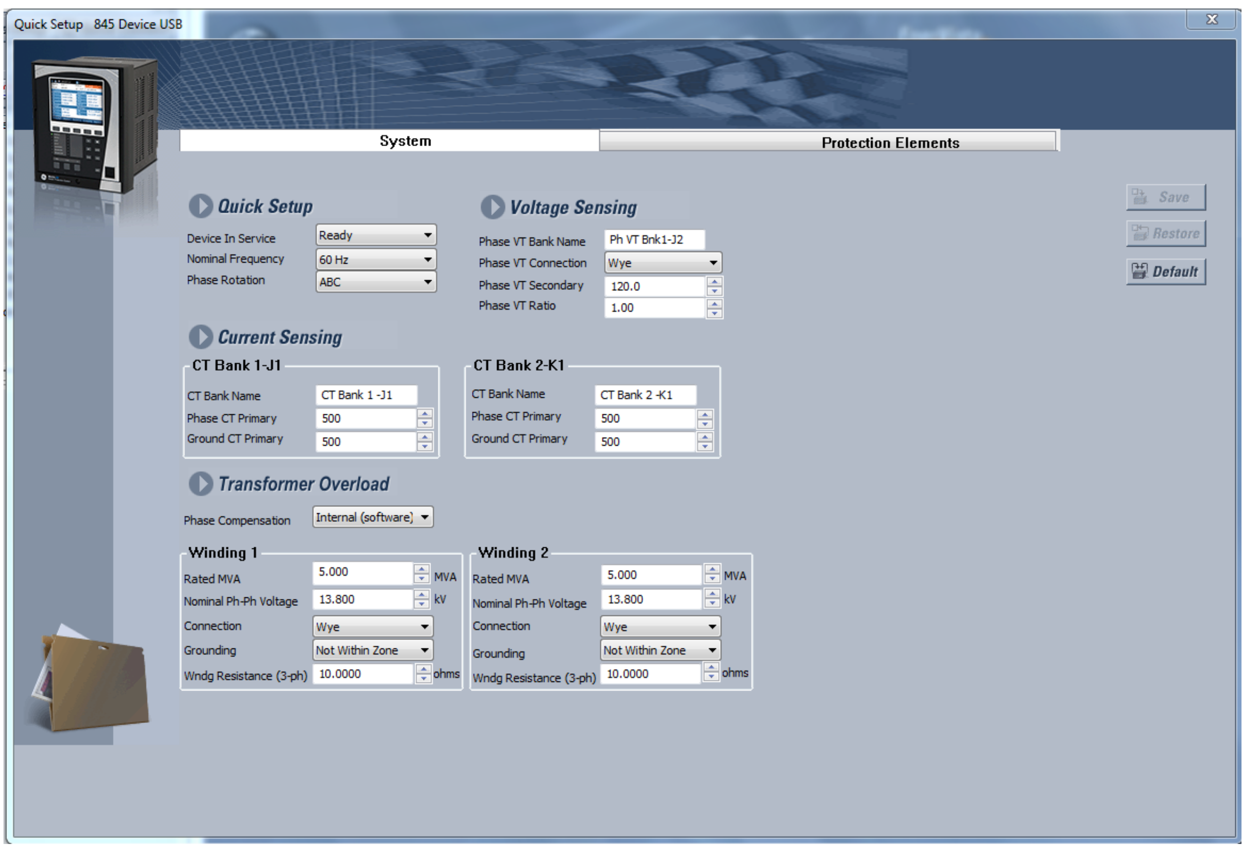


Figure 3-14: 845 Quick Setup (Offline) tree position



Quick Setup is designed for quick and easy user programming. Power system parameters, and settings for some simple overcurrent elements are easily set. The Quick Setup screen is shown as follows:

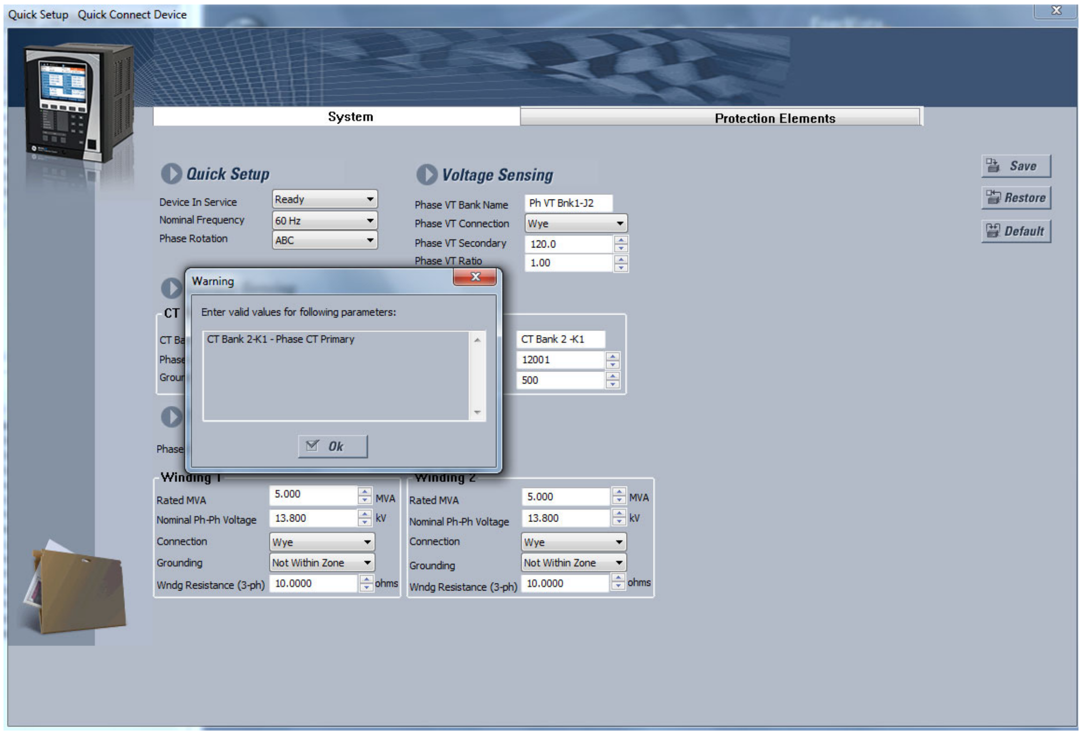
Figure 3-15: Quick Setup window



- Settings names and units can be viewed at this screen. To view the range of the settings, hover the cursor over the setpoint value field.
- Configure and save the settings as required.
- The Save, Restore and Default buttons function the same as in the individual setting setup screens.

- Attempting to enter and save a setting value which exceeds the range gives a warning dialog box. (note the value is not replaced with the maximum value of the setting). Correct the setting value and save to proceed.

Example: The Phase CT Primary value has a setting range of 1 to 12000, but the user enters 12001 and tries to save it. Quick Setup displays a warning dialog. Pressing OK leaves the setting value at 12001, but not 12000 (max. value) as is the case with other views.



Upgrading Relay Firmware

To upgrade the 845 firmware, follow the procedures listed in this section. Upon successful completion of this procedure, the 845 will have new firmware installed with the factory default setpoints.The latest firmware files are available from the GE Grid Solutions website at http://www.gegridsolutions.com.

NOTICE

EnerVista 8 Series Setup software prevents incompatible firmware from being loaded into an 845 relay.

NOTICE

Note that uploading firmware on a Wi-Fi interface is not allowed.

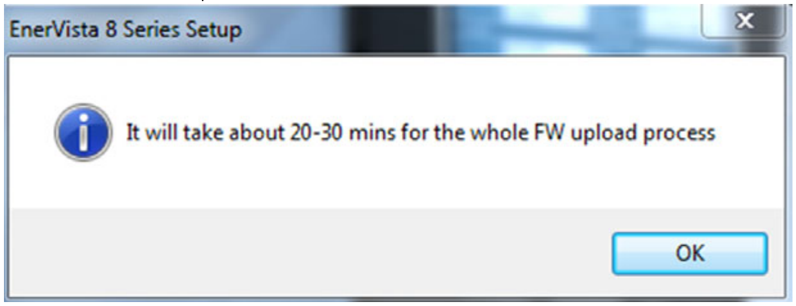
NOTICE

Before upgrading firmware, it is very important to save the current 845 settings to a file on your PC. After the firmware has been upgraded, it will be necessary to load this file back into the 845. Refer to *Downloading and Saving Setpoints Files* for details on saving relay setpoints to a file.

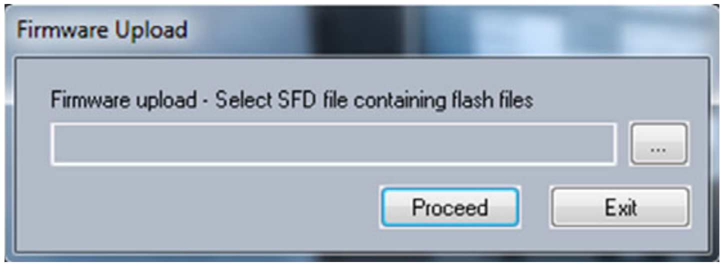
Loading New Relay Firmware

Loading new firmware into the 845 flash memory is accomplished as follows:

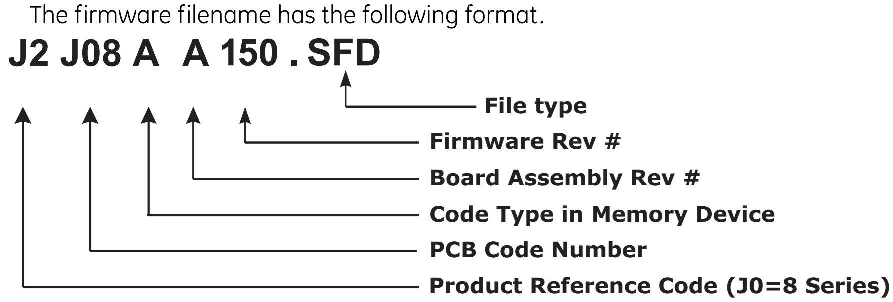
1. Connect the relay to the local PC and save the setpoints to a file as shown in *Downloading and Saving Setpoints Files*.
2. Select the **Maintenance > Update Firmware** menu item. The following screen appears. Select OK to proceed.



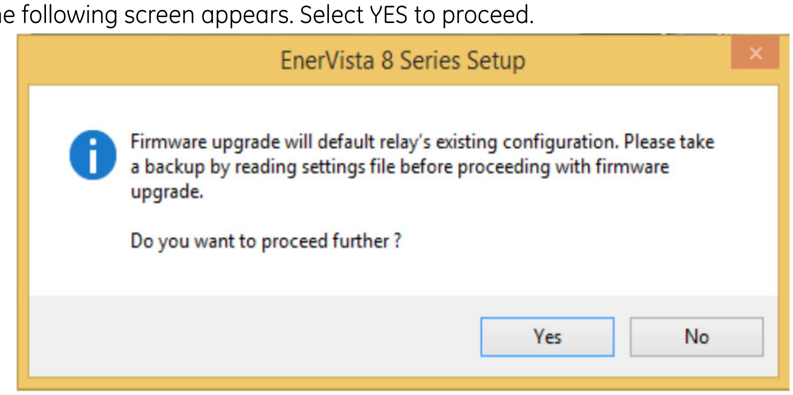
3. The EnerVista 8 Series Setup software requests the new firmware file. Locate the folder that contains the firmware file to load into the 845.



The firmware filename has the following format.

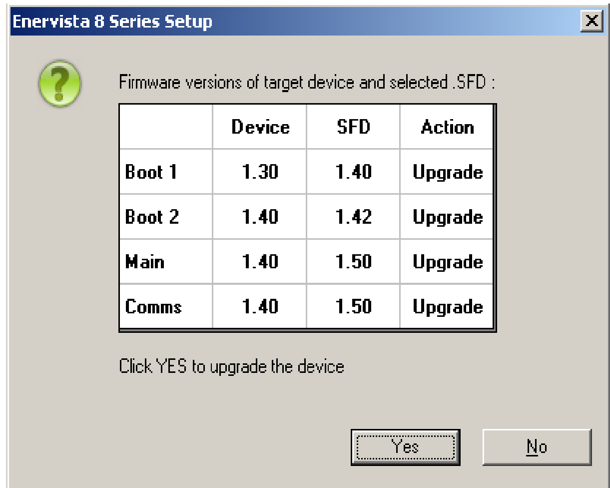


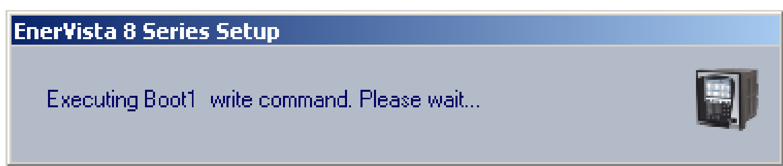
The following screen appears. Select YES to proceed.

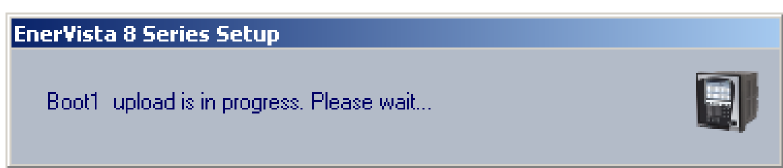


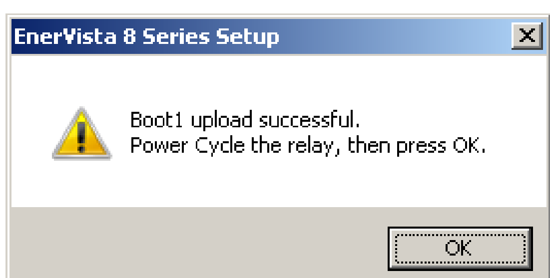
4. EnerVista 8 Series Setup software now prepares the 845 to receive the new firmware file. The 845 front panel momentarily displays "Upload Mode", indicating that it is in upload mode.

5. The following screen appears, click YES to proceed with the firmware loading process.







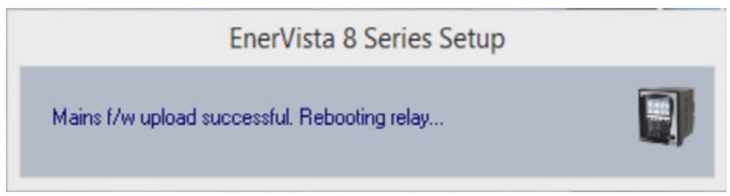


6. After the Boot 2 upload is completed, the EnerVista 8 Series Setup software requests that the user reboot the relay. After the Boot 1 upload is completed, the EnerVista 8 Series Setup software again requests that the user to reboot the relay.

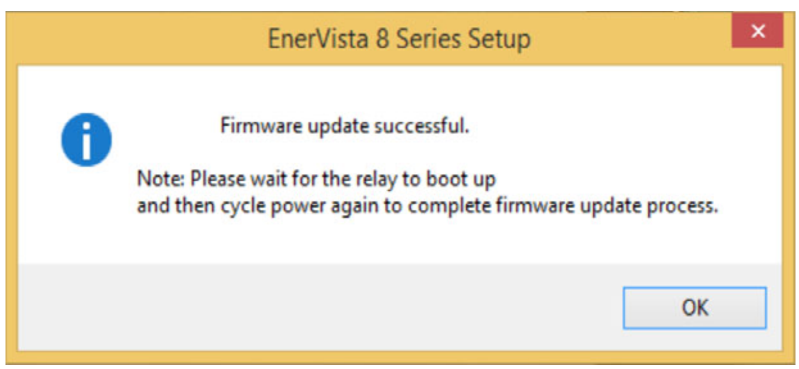
⚠CAUTION

Make sure to reboot the relay first and then press the OK. Not the other way around.

7. Wait for the Comms upload process to complete.



8. Wait for the Mains upload process to complete.
9. The EnerVista 8 Series Setup software notifies the user when the 845 has finished loading. Wait for the relay to boot, and then **Cycle power to the relay to complete firmware update.**



After successfully updating the 845 firmware, the relay is not in service and requires setpoint programming. To communicate with the relay, the communication settings may have to be manually reprogrammed.

When communications is established, the saved setpoints must be reloaded back into the relay. See *Loading Setpoints from a File* for details.

Modbus addresses assigned to features, settings, and corresponding data items (i.e. default values, min/max values, data type, and item size) may change slightly from version to version of firmware.

The addresses are rearranged when new features are added or existing features are enhanced or modified.

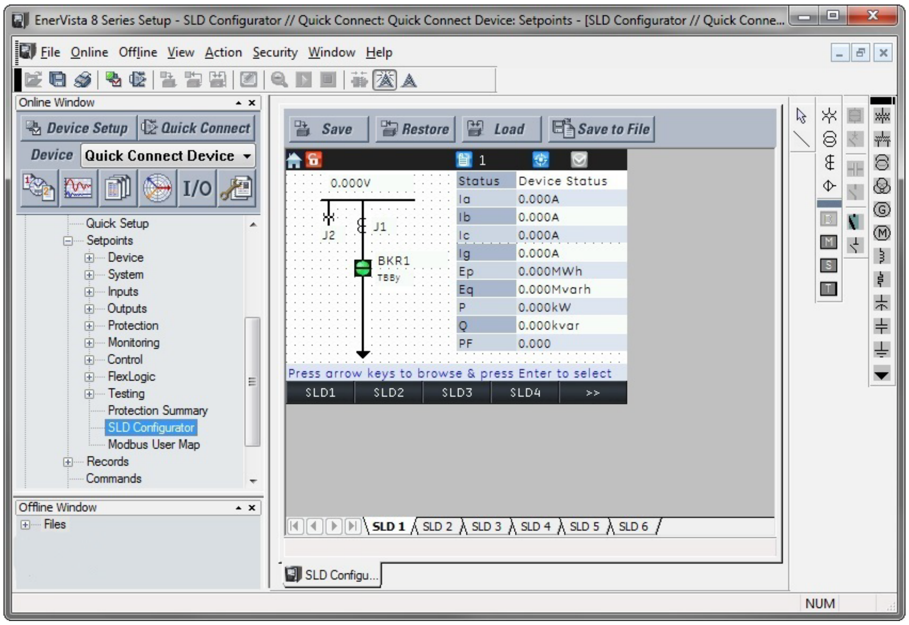
Advanced EnerVista 8 Series Setup Software Features

SLD Configurator

The SLD Configurator allows users to create customized single line diagrams (SLD) for the front panel display. The SLDs must be configured from the SLD Configurator in the EnerVista 8 Series Setup software, located under **Setpoints > SLD Configurator**. The SLD Configurator allows breakers, switches, metering, and status items on the SLD.

Single line diagrams (SLD) are viewed from the relay front panel and individual SLD pages can be selected for the default home screen pages. The 8 Series provides six (6) SLD pages. Each page can have a combination of active and passive objects. Status, metering, and control objects are active while the static images for bus, generator, motor, transformer, ground, etc. are passive objects.

Figure 3-16: SLD Page



For optimum use, the first SLD page can be used for the overall single line diagram and the subsequent pages can be used for breaker/switch specific CT/VT placement, metering and status. Once the configurable SLDs are programmed, they are saved within the relay settings file. The SLD pages can also be saved individually as local XML files. The locally stored XML files can then be reloaded to generate another diagram. SLDs represent objects using GE symbols (similar to ANSI).

The following figure shows the objects that are available for design in the SLD Configurator and their maximum usage limits [X]. The maximum limit reflects the maximum possible order code.

Figure 3-17: SLD Configurator Component Library

Column1	Column2	Column3	Column4
Select	VT (GE) [12]	Breaker (GE) [3]	Transformer 2W (GE) [2]
Line [50]	VT (IEC) [12]	Breaker (IEC) [3]	Transformer 3W (GE) [2]
Separator	CT (GE) [12]	Separator	Transformer 2W (IEC) [2]
	CT (IEC) [12]		Transformer 3W (IEC) [2]
	Separator		Generator [2]
	Device Status [1]	Separator	Motor [2]
	Metering Object [15]	Disconnect Switch (GE) [9]	Reactor (for grounding) [5]
	Status Object [15]	Disconnect Switch (IEC) [9]	Resistor (for grounding) [5]
	Text Object [20]	Separator	Capacitor (polarity) [5]
	Remote Breaker (GE) [3] Remote Breaker (IEC) [3]		Capacitor (non-polarity) [5]
	Separator		Ground [10]
			Load [5]
			Separator

Control Objects

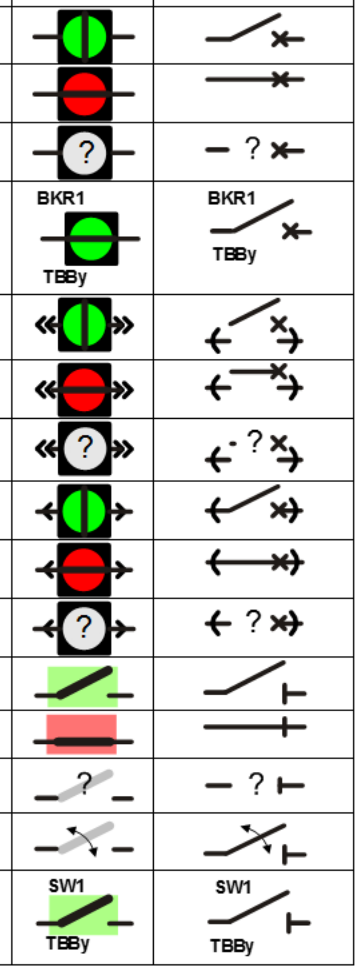
The control objects consist of selectable breakers and disconnect switches. The following figure shows the different symbols in the GE Standard style and IEC style. If the switching element is tagged, blocked, or bypassed, indicators with the letters "T", "B", and "By" appear on the lower right corner of the element. Additionally, the breaker/switch name is displayed on top of the object.

NOTE

The displayed breaker name is configured in the setpoint **Setpoints > System > Breakers > Breaker[X] > Name**. This setpoint has a 13-character limit. The name should be kept to a minimum so that it appears properly on the SLD.

Figure 3-18: Control Object Symbols

Component		Symbols GE	Symbols IEC
Breaker	BKR Open		
	BKR Closed		
	BKR Bad Status	?	?
	BKR Tagged (**T**) /Blocked (**B**) /Bypassed (**By**)	BKR1 TBBy	BKR1 TBBy
Breaker (Truck)	BKR Racked Out & Open		
	BKR Racked Out & Closed		
	BKR Racked Out & Bad Status	?	?
	BKR Racked In & Open		
	BKR Racked In & Closed		
	BKR Racked In & Bad Status	?	?
Disconnect Switch	SW Open		
	SW Closed		
	SW Unknown Status	?	?
	SW Intermediate		
	SW Tagged (**T**) /Blocked (**B**) /Bypassed (**By**)	SW1 TBBy	SW1 TBBy



NOTE

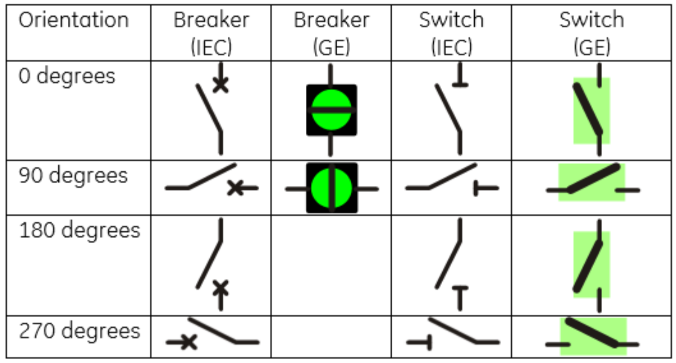
GE symbols are color-coded ANSI symbols.

The control objects status follows the color scheme from the **Setpoints > Device > Front Panel > Display Properties > Color Scheme** setting. By default, this setting is set to "Green (open)". If set to "Red (open)", the status colors are reversed.

If the setting is used, the breaker symbols automatically change to the Truck CB symbols. The SLD assumes that if the Breaker Racked-In/Racked-Out input is used (any setting other than "Off"), the appropriate Truck CB symbol will be used.

The following figure shows the orientation available for the control objects. The default position for the control objects is 0 degrees. Orientation in multiple directions allows for configuration of the single line diagram according to the existing drawings and ensure the correct side for the fixed/moving contacts.

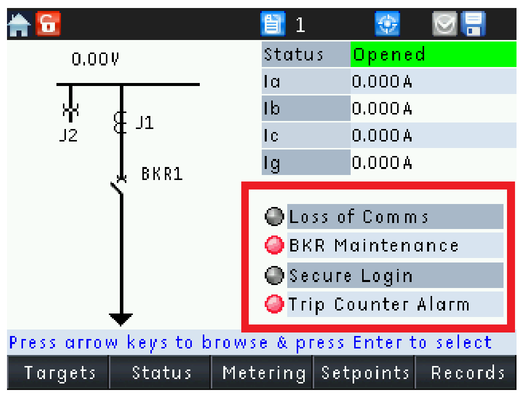
Figure 3-19: Orientation for Breakers and Switches



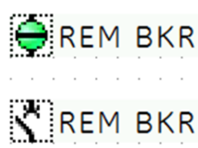
Status Objects

The status objects consist of digital operands. Up to 15 digital status elements can be configured per SLD page. The status object acts as an LED on the screen. If the diagram shows a circle with no color, it means the assigned input is low. If it shows a circle with red color in it, the assigned input is high. The following figure shows an example of "Reclose Blocked" signal in both On and Off state.

Figure 3-20: Reclose Blocked signal



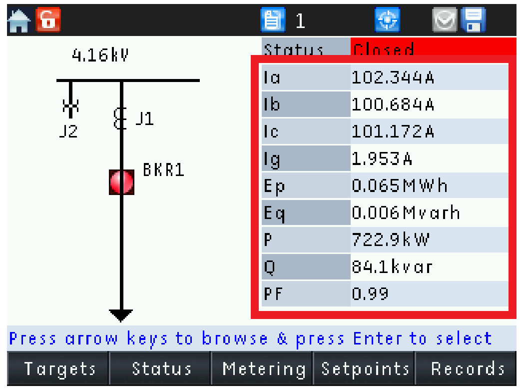
In addition, Remote Breaker status objects are added for GE and IEC style. Remote breaker status allows monitoring of three distant breakers. These objects are not controllable and hence cannot be used for selection and operation.



Metering Objects

The metering objects consist of metering elements. Up to 15 metering elements can be configured per SLD page. The metering object has an input for all the available FlexAnalog values. The units for these values are dynamically scaled as per the defaults. The following figure shows the metering element on a configured SLD.

Figure 3-21: Metering Element on configured SLD



Device Status Object

The configurable SLD feature in the 8 Series allows only one device status object per SLD page. The device status does not have any properties. It is simply shown as "Status: [device status]". This object shows if the transformer is energized/de-energized.

Static Objects

Static objects are used as simple bitmap images or text/drawing blocks to complete the single line diagram. There is no control associated with these static objects. The static objects consist of drawing tools, text object, and power system components.

Front Panel Interaction

8 Series relays use the Select-Before-Operate (SBO) mechanism for local control of breakers and switches [IEC 61850-7-2]. Initially, the diagram can be browsed through all available breakers and switches by using the navigation keys. After navigation, selection must be made for the breaker or switch object by pressing the Enter key. After selecting the desired switch or breaker, control operations can then be carried out on the selected switch or breaker. The 8 Series allows local opening, closing, tagging, blocking, and bypassing. Front panel control is only allowed when the relay is in Local Mode.

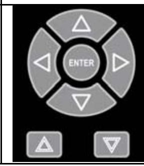
Navigation

The Single Line Diagram can be accessed in two ways from the front panel of the relay. The original location for the SLD pages is under **Status > Summary > Single Line Diagram > SLD [X]**. However, a more convenient way to access an SLD page is by setting it as a default home screen at **Setpoints > Device > Front Panel > Home Screens > Home Screen1**. Pressing home button more than once rotates through the configured home screens. If the desired SLD is set to home screen 2 through home screen 10, it can be activated by pressing home button until it appears on the screen. If no home screen is configured, the default screens become active. If the default screens are disabled, **Status > Summary > Values** screen is shown.

Breaker/Switch Browsing and Selection

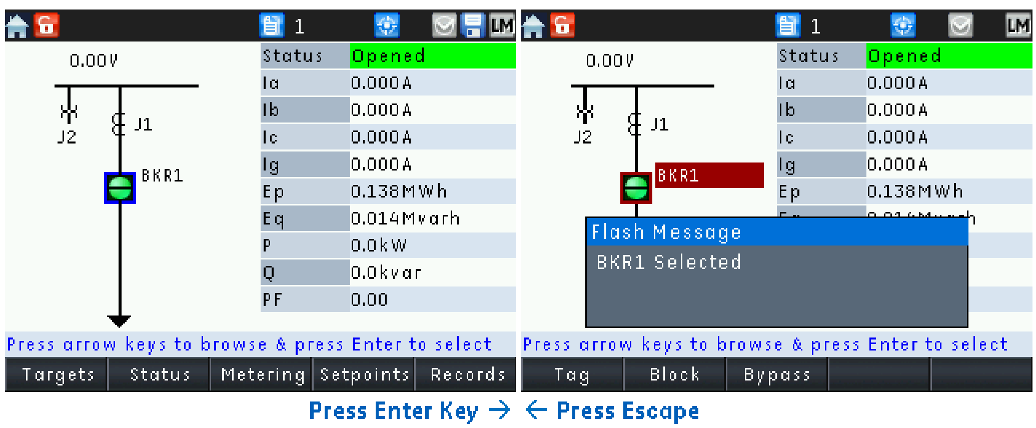
While in the SLD screen, only one page is active at any point of time. If SLD1 is active, only breakers and switches on SLD1 can be operated and controlled. By default, when entering the SLD menu, the screen displays SLD1. SLD2 through SLD6 can be accessed through the navigation pushbuttons as shown in the following figure: Active element selection with flash message.

To browse through the control elements on the SLD page, the navigation keys can be used. On the rugged front panel, the up and down keys can be pressed for navigation and on the membrane front panel, up, down, left, and right keys can be pressed. With the rugged front panel navigation, pressing down sequentially rotates through all the available breakers and switches on the screen. Pressing up key rotates through in a reverse order. With the membrane front panel, the up, down, left, and right keys can navigate to the closest breaker/switch depending on the key press direction.

Rugged Front Panel	Membrane Front Panel
	

While browsing through switches/breakers the active element is shown with a **blue** colored border around it. To select a breaker/switch, the browsing indicator border must be around the desired breaker or switch. The breaker or switch can then be selected by pressing the Enter key. As the breaker or switch is being selected, a flash message appears indicating that the breaker or switch has been selected as shown in the following figure. Once the element is selected for operation, the SLD control pushbuttons appear and the color of the highlighter will change to **maroon** indicating that the breaker or switch is selected. By default, the control pushbuttons are programmed for Tag, Block, and Bypass. For each control action, a flash message is displayed. Refer to section Local Control Mode (breakers and switches).

Figure 3-22: Active element selection with flash message



NOTE

Browsing and selection is allowed only when the relay is in Local Mode and the user has at least an operator level of security access. To check if the relay is in local mode, look for an "LM" symbol on the task pane at the top of the screen. Pressing navigation keys on SLD pages while in remote mode does nothing.

NOTE

Control pushbuttons appearing on the SLD page are only active while a control object is selected.

NOTE

The control object is deselected if the user navigates to any screen other than SLD or by pressing escape key. If no action is taken after selection, the object is automatically deselected after the Bkr/Sw Select timeout setting (**Setpoints > Control > Control Mode > Bkr/Sw Select Timeout**). Once deselected, the control pushbutton labels return to the SLD page navigation labels and the color of the box around the object changes back to blue for browsing. Pressing escape once more removes the browsing highlight around the objects. If inactive during browsing for the timeout setting (**Setpoints > Device > Front Panel > Message Timeout**), the browsing highlight around the object disappears. If an object is selected, Home button operation will be prohibited. The object must be de-selected by pressing escape in order for the home button to function.

NOTE

Upgrading from firmware versions1.3x to 1.7x, the breaker operations from the front panel now follow select-before-operate mechanism. The breaker must be first selected by browsing and pressing Enter key for selection. Once selected, the breaker can be opened or closed with the open and close pushbuttons. Upgrades from firmware versions below 1.3x are not supported.

Control Operations

The control operations carried out through the front panel of the relay are done only in Local Mode (**Setpoints > Control > Local Control Mode > Local Mode**). Opening and closing operations can be carried out by pressing the Open and Close pushbuttons on the relay front panel. Other operations such as tagging, blocking and bypassing can be carried out by pressing the control pushbuttons that appear after the control object selection.

NOTE

Remote operations are allowed for opening, closing, blocking, and bypassing. Tagging must be done locally.

NOTE

It is recommended to use tagging for maintenance purposes only. When a breaker or a switch is tagged, it cannot be bypassed although the letters "By" may appear below the element on SLD.

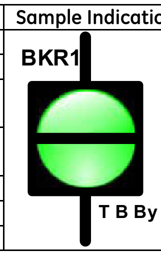
NOTE

If breaker is selected and relay status is changed to Out-of-Service, the breaker control actions, such as tag, blocked, bypass and open/close are blocked. The breaker may remain in the selected state, but no action can be executed.

Once the selected breaker or switch is tagged, a letter "T" appears below the associated element. Similarly, for blocking, letter "B" appears and for bypassing, letters "By" appear below the associated breaker or switch as shown in the last column of the following figure. The blocking and bypassing letters also appear if the breakers/switches are blocked or bypassed remotely. These are linked to their respective breaker/switch in the SLD Configurator window so that when that breaker/switch is deleted, the letters also get deleted.

Permitted breaker/switch operations are described in the following figure below when various letter indications are present under the control element.

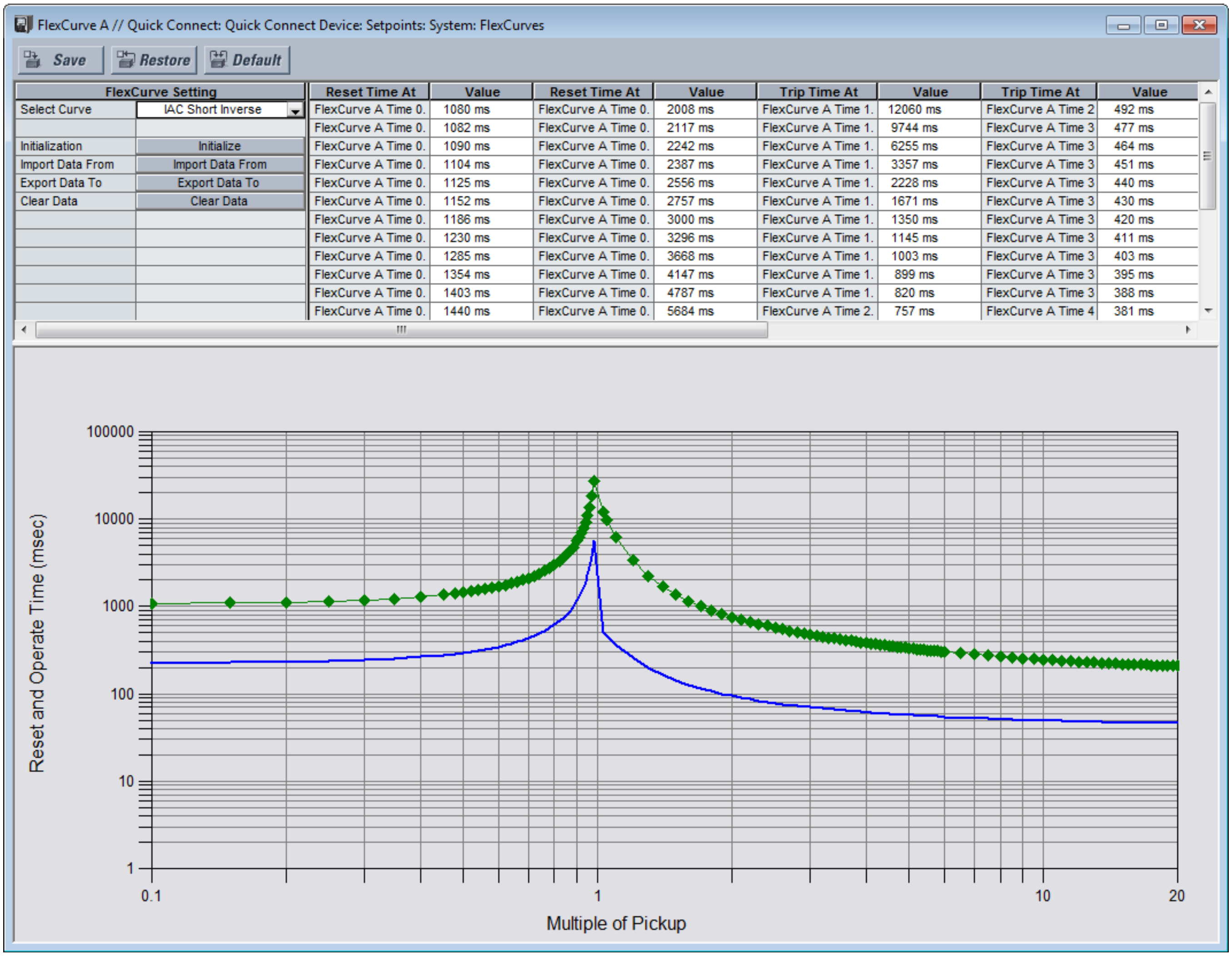
Figure 3-23: Letter Indications for breaker/switch operations

Breaker/Switch Position	Letter Indication	Operation	Sample Indication
Open	B	Closing is blocked.	
Closed	B	Opening is blocked.	
Open	B By	Closing is blocked but bypassing is allowed. Closing is permitted.	
Closed	B By	Opening is blocked but bypassing is allowed. Opening is permitted.	
Open or Closed	T	Tagged by operator. No operation allowed.	
Open or Closed	T By	Tagged by operator. No operation allowed.	
Open or Closed	T B By	Tagged by operator. No operation allowed.	

For detailed tagging, blocking and bypassing operations, refer to the section Local Control Mode (breakers and switches).

FlexCurve Editor

The FlexCurve Editor is designed to graphically view and edit the FlexCurve. The FlexCurve Editor screen is shown as follows for FlexCurves A, B, C, and D:



- The Operate Curves are displayed, which can be edited by dragging the tips of the curves
- A Base curve can be plotted for reference, to customize the operating curve. The Blue colored curve in the picture is a reference curve. It can be Extremely Inverse, Definite Time, etc.
- The Trip (Reset and Operate) Times in the tables and curves work interactively i.e., changing the table value affects the curve shape and vice versa.
- Save Configured Trip Times.
- Export Configured Trip Times to a CSV file
- Load Trip Times from a CSV File
- The screen above shows the model followed by 845 for viewing FlexCurves. Select **Initialize** to copy the trip times from the selected curve to the FlexCurve.

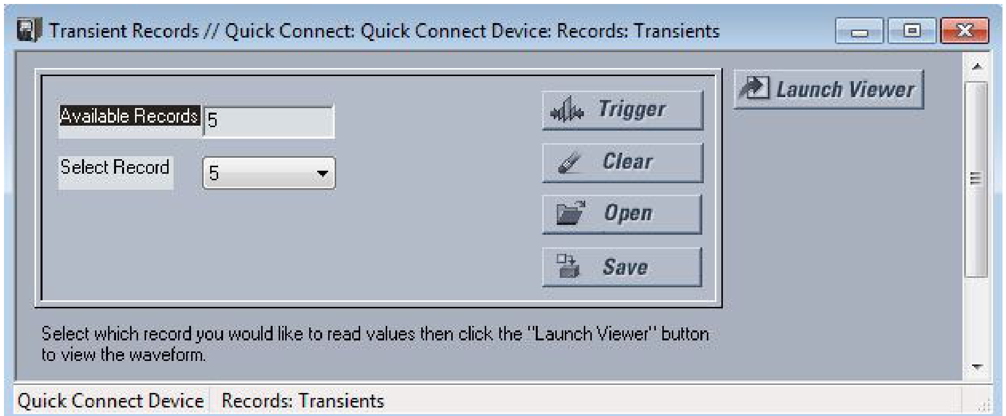
Transient Recorder (Waveform Capture)

The EnerVista 8 Series Setup software can be used to capture waveforms (or view trace memory) from the relay at the instance of a pickup, trip, alarm, or other condition.

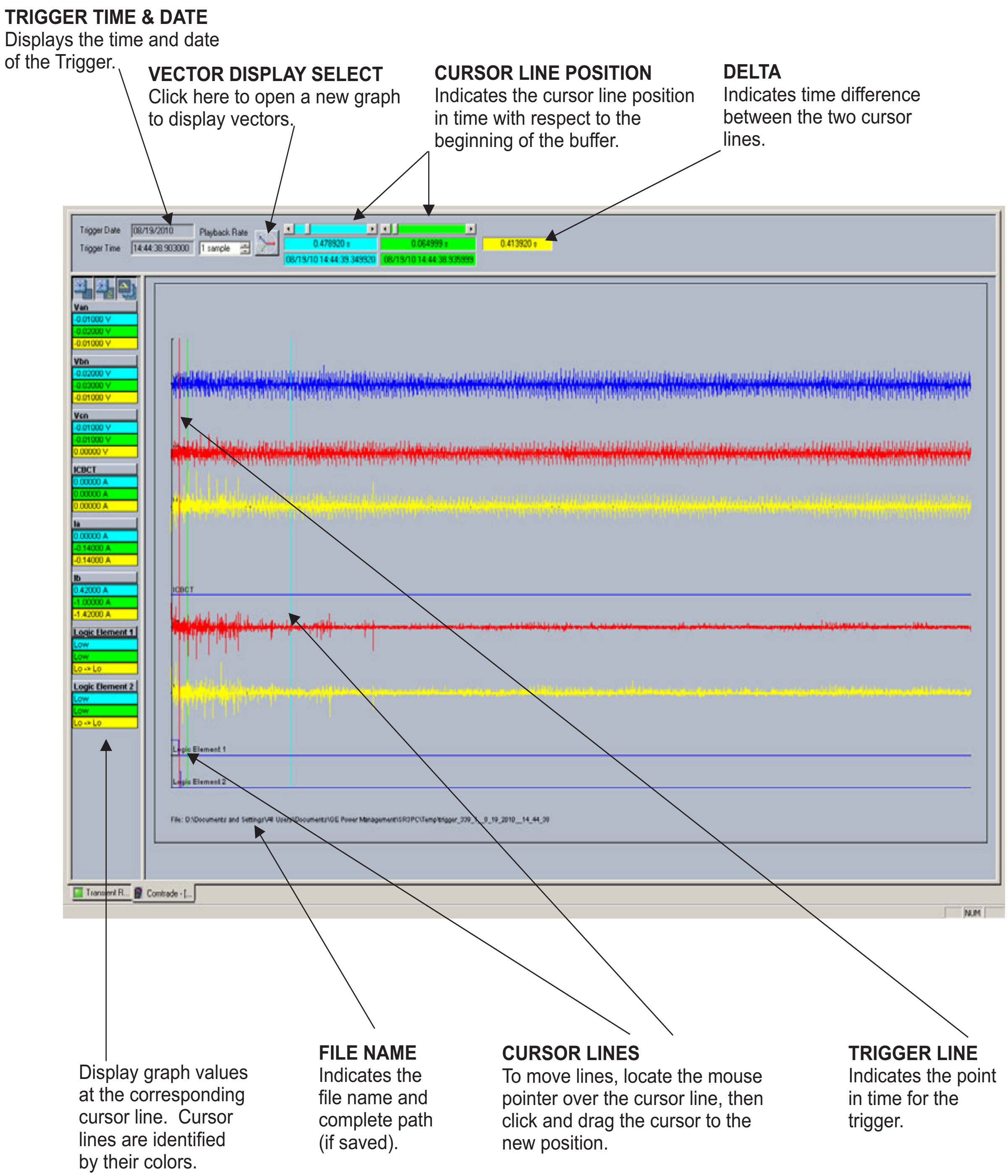
NOTE

The COMTRADE Version used on 8 Series relays is C37.111-1999.

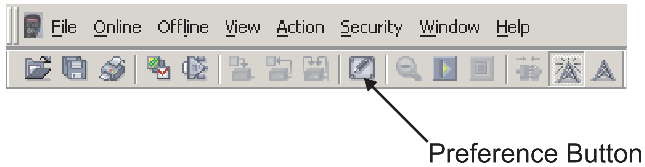
- With EnerVista 8 Series Setup software running and communications established, select the **Records > Transients > Transient Records** menu item to open the Transient Recorder Viewer window.



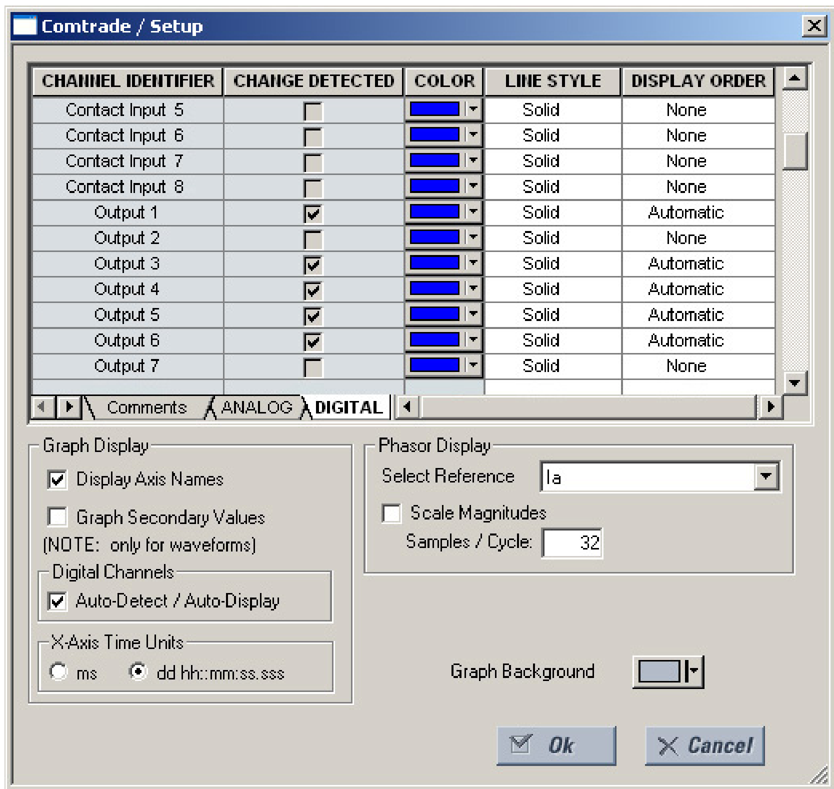
- Click on **Trigger Waveform** to trigger a waveform capture.
- To view the captured waveforms, click on the **Launch Viewer** button. A detailed Waveform Capture window appears as shown below.
- Click on the **Save** button to save the selected waveform to the local PC. A new window appears, requesting the file name and path. One file is saved as a COMTRADE file, with the extension "CFG" The other file is a "DAT" file, required by the COMTRADE file for proper display of waveforms.
- To view a previously saved COMTRADE file, click the **Open** button and select the corresponding COMTRADE file.



- The red vertical line indicates the trigger point.
- The date and time of the trigger are displayed at the top left corner of the window. To match the captured waveform with the event that triggered it, make note of the time and date shown in the graph, then find the event that matches the same time in the event recorder. The event record provides additional information on the cause and system conditions at the time of the event.
- From the window main menu bar, press the **Preference** button to open the COMTRADE Setup page, in order to change the graph attributes.

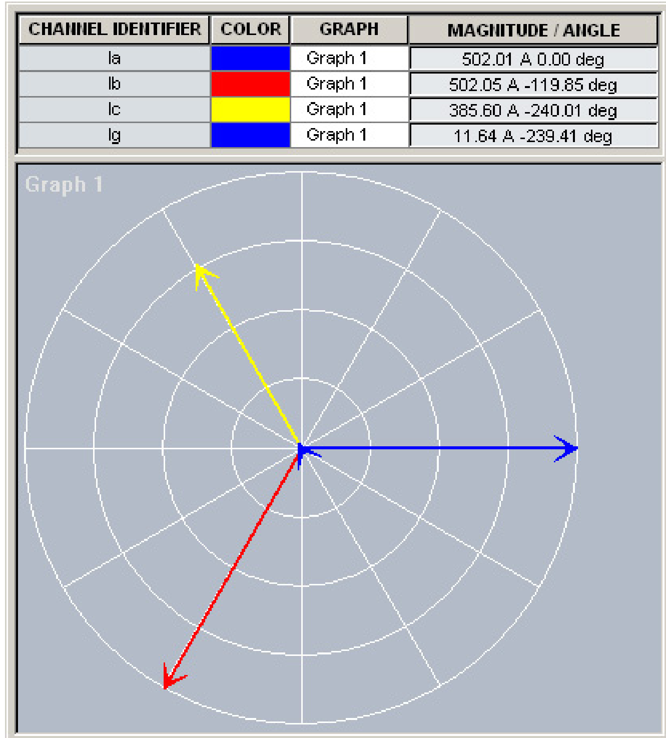


The following window appears:



Change the color of each graph as desired, and select other options as required, by checking the appropriate boxes. Click **OK** to store these graph attributes, and to close the window. The Waveform Capture window reappears based on the selected graph attributes.

To view a vector graph of the quantities contained in the waveform capture, press the **View Phasors** button to display the following window:



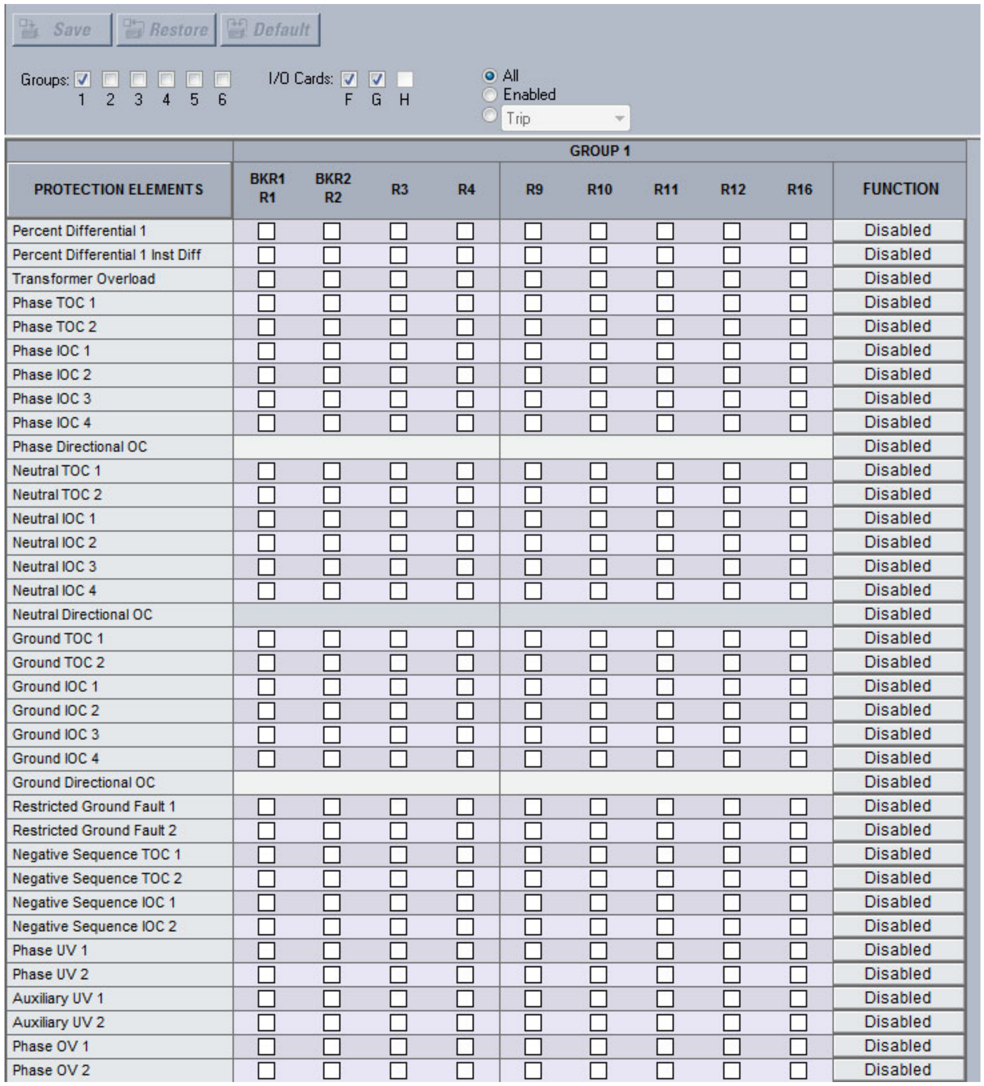
Protection Summary

Protection Summary is a single screen which holds the summarized information of different settings from Grouped Elements and Monitoring Elements.

The Protection Summary Screen allows the user to:

- view the output relay (R3, R4) assignments for the elements
- modify the output relay assignments for the elements
- view the Function status for the elements
- navigate to the respective element screen on a button click.

With the EnerVista 8 Series Setup software running and communications established, select the **Setpoints > Protection Summary** menu item to open the Protection Summary window. The Protection Summary screen is as follows:



Offline Settings File Conversion

The EnerVista 8 Series Setup software supports conversion of offline settings files created in the SR Series platform. This feature allows the conversion of existing offline settings files to 8 Series files for 845 devices.

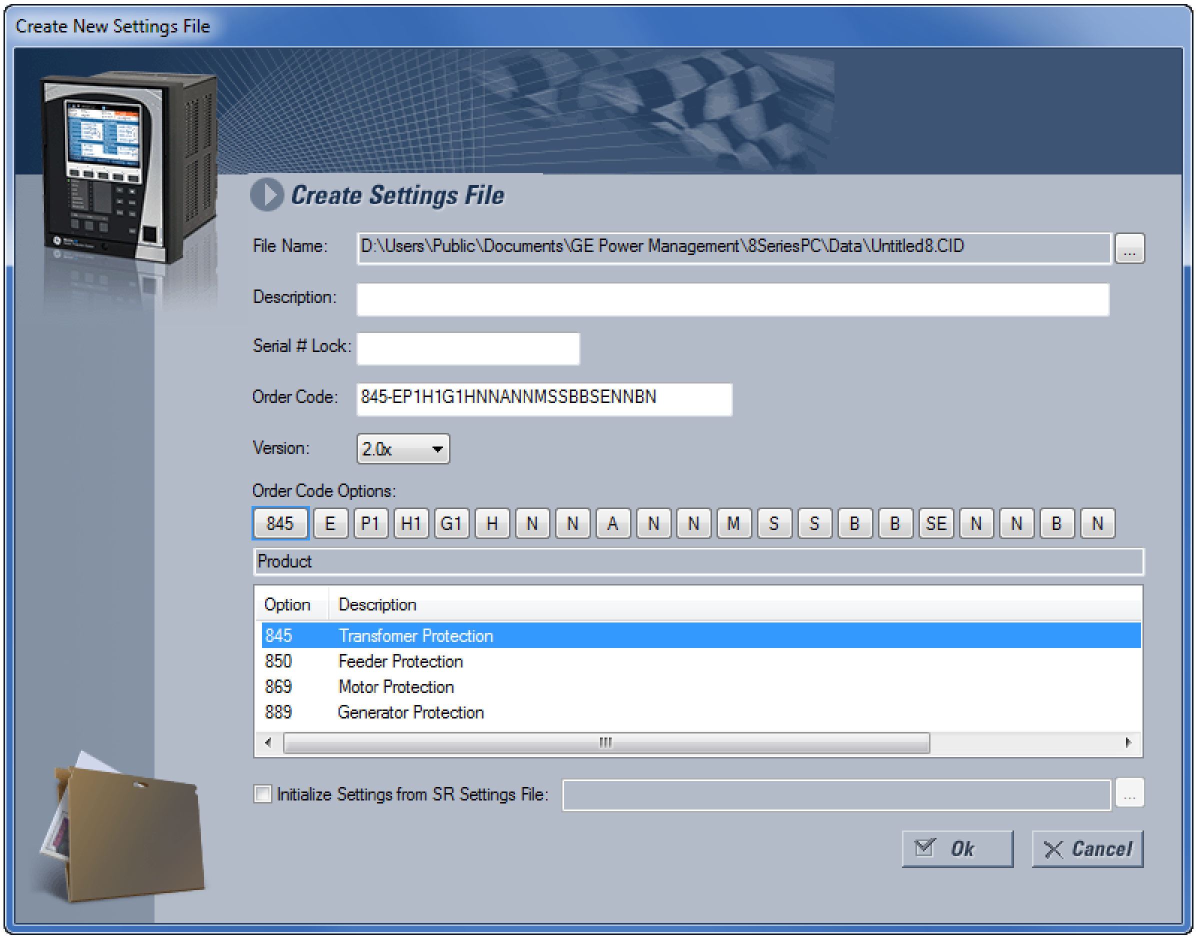
The EnerVista 8 Series Setup software reduces the manual effort required when moving from an older product to the 845. The settings file conversion feature takes an existing settings file and generates a new settings file compatible with the 8 Series order code specified. After the import is complete, the results are displayed in an interactive results window.

Convert SR 745 Files

EnerVista 8 Series Setup software version 1.4x and above supports conversion of SR 745 files to 845 settings files.

The conversion can only be initialized with EnerVista from the Offline/New Settings File commands located in the taskbar.

1. In the menu taskbar, click on **Offline** and select the **New Settings File** item. The following Create New Setting s File dialog box appears, which allows for the setpoint file conversion.



2. Select the Firmware Version and Order Code option for the new setpoint file.
3. For future reference, enter some useful information in the **Description** box to facilitate the identification of the device and purpose for the file.
4. To select the file name and path for the new file, click the button beside the **File Name** box.
5. To select the SR settings file used for initialization, click the **Initialize Settings from SR Settings File** button.
6. To locate and select the file to convert, click the button beside the **Initialize Settings from SR Settings File** box.

⚠CAUTION

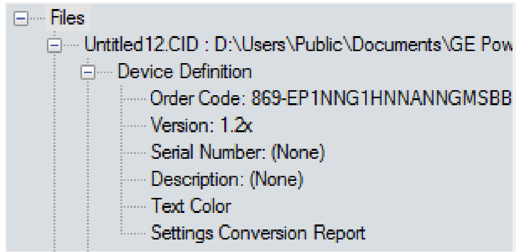
EnerVista 8 Series Setup version 1.4x and above supports conversion of 5.0, 5.1 and 5.2 files. If the file version is less than 5.0 it must be converted to 5.2 using the latest 745 EnerVista Setup before doing the 845 conversion.

7. Click **OK** to begin the conversion and complete the process. Once this step is completed, the new file, with a complete path, is added to the EnerVista 8 Series Setup software environment.

Conversion Summary Report

At the end of the conversion process, the results are summarized in a conversion report. The report is found under Device Definition in the offline file window.

Figure 3-24: Conversion Report in Offline Window

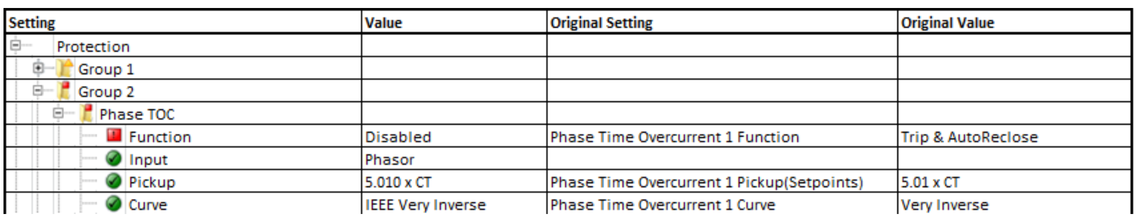


⚠CAUTION **For future reference, make a printout of the conversion report immediately after the conversion in case conversion reports are removed or settings modified from the 8 Series Setup Software.**

Results Window

The following figure shows an example conversion summary results window.

Figure 3-25: Results Window



Setting	Value	Original Setting	Original Value
Protection			
Group 1			
Group 2			
Phase TOC			
Function	Disabled	Phase Time Overcurrent 1 Function	Trip & AutoReclose
Input	Phasor		
Pickup	5.010 x CT	Phase Time Overcurrent 1 Pickup(Setpoints)	5.01 x CT
Curve	IEEE Very Inverse	Phase Time Overcurrent 1 Curve	Very Inverse

The results window has the following columns:

- **Name**: the same tree structure as in the offline window, but with status icons

NOTE: Settings in the results window are linked to setting screens. Click in the results window to navigate to the corresponding 8 Series settings window.

- **Value**: the converted value for the 8 Series settings file
- **Original Name**: setting name of the input file
- **Original Value**: setting value of the input file

⚠CAUTION **All other settings available (not shown in the conversion report) in the 8 Series file are set to default and must be verified before putting the relay into service.**

Status Icons

The status icon shows the conversion results:

Manual configuration required

Successful conversion

Value is not supported

Print Report If desired, the conversion summary report can be printed using the File/Print command in the EnerVista taskbar or it can be printed from the "GUI" print button.

NOTE: Although the report shows successful conversion (green checkbox), the settings must still be verified before putting the relay in service.

GE
Grid Solutions

845 Transformer Protection System

Chapter 4: About Setpoints

The 845 has a considerable number of programmable setpoints, all of which make the relay extremely flexible. These setpoints have been grouped into a variety of menus which are available from the paths shown below. Each setpoints menu has sub-sections that describe in detail the setpoints found on that menu.

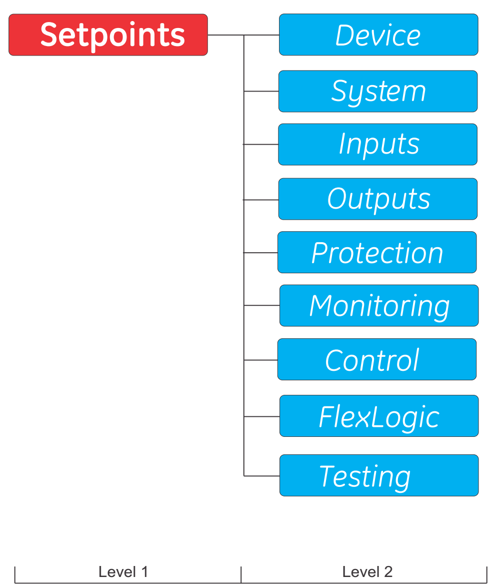
NOTE

Use the path provided to access the menus from the front panel and from the EnerVista 8 Series Setup software.

NOTE

Certain named settings allow custom names. Do not create 13-character long names using the largest width characters (i.e. WWWWWWWWWWWWW). Doing so can cause the last 3 characters to overlap the setting name when viewed from the HMI or the EnerVista 8 Series Setup software.

Figure 4-1: Main Setpoints Display Hierarchy



Protection and Trip Breaker Selection

Depending on order code, the 845 relay provides protection for either two-winding, or three-winding transformers. Based on this, either two or three breakers can be configured for status monitoring, tripping and closing. Each breaker menu provides a selection of trip output and/or close output relay. Depending on the selected output relays, and the function setting for the protection, control and monitoring elements, some conditions apply.

- All ouputs selected for “BKR # Trip Output Select” under Breaker setup menu are available for selection in the menus of all elements, except in the outputs selection for “BKR# Close Output Select”.
- For all elements, the default value for the trip selected outputs under Breaker setup shows “Do Not Operate”. The user can select these relays from the menu of the element.
- All outputs selected for “BKR# Close Output Select”, are automatically excluded from the list of outputs available under the menus of all elements including the list of output selection for “BKR# Trip Output Select setpoint. The close output relays can be used for closing the breakers Remotely or Locally as part of teh Breaker Control feature.
- By default the form-A circuit monitoring outputs Aux Relay 1 is selected for tripping Breaker 1, Aux Relay 2 is selected for tripping Breaker 2, and Aux Relay 9 for tripping Breaker 3. Outputs for closing of the breakers are not selected.

NOTE

If the output selected under “BKR # Close Breaker Select” is replaced by another output, the old output which is no longer used for closing, will automatically show up in the menu of the elements with the default value “Do Not Operate”. The newly selected output is automatically excluded from the list of outputs for selection under all element menus. When excluded from the list of outputs for element menus, the output is inactive for any element.

Programming Output Relays for breaker tripping and closing the breakers

The programming of the output relays for tripping individual breakers is performed once, when selected under setpoint **BKR 1(2,3) Trip Relay Select**, and **BKR 1(2,3) Close Relay Select** from the Setpoints/System/Breakers/Breaker 1(2,3) menu as shown:

PATH: SETPOINTS > SYSTEM > BREAKER 1 (2, 3)

From these screens, **Relay 1**, **Relay 2**, and **Relay 9** are selected as default outputs for tripping Breaker 1, Breaker 2, and Breaker 3 respectively. Output relays for closing the breakers are not selected. The user can program any output relay from the list of output relays for breaker tripping, or closing.

PROTECTION ELEMENT TRIP SELECTIONS

Selective tripping of the transformer breakers from the protection element can be programmed from two places:

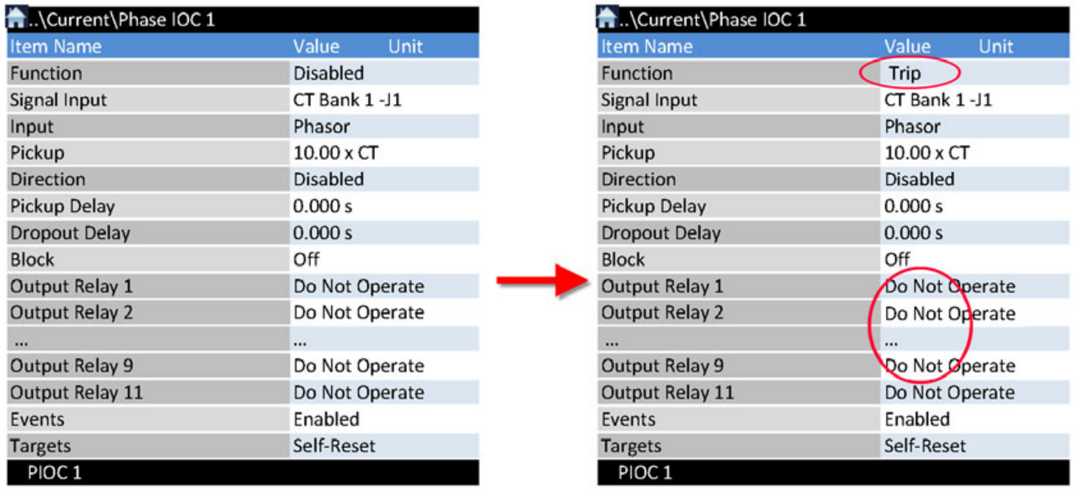
- From the Relay HMI: Protection Element Menu
- From the 845 PC program: Element’s Menu or Protection Summary

From the Relay HMI: Protection Element Menu

If **Trip** is selected as a “Function” for an element, and upon operation of that element, the LED “TRIP” will turn on. Similarly when Alarm, or Latched Alarm is selected, upon element operation, the LED “ALARM” will turn on. Selecting the “Configurable” setting is not associated with an LED.

Example 1: Programming an IOC1 element as a Trip function

1. Select **Trip** from the list of selections available for the setpoint “Function”



2. Select the output relays for tripping the breakers, and any other aux relays if necessary.

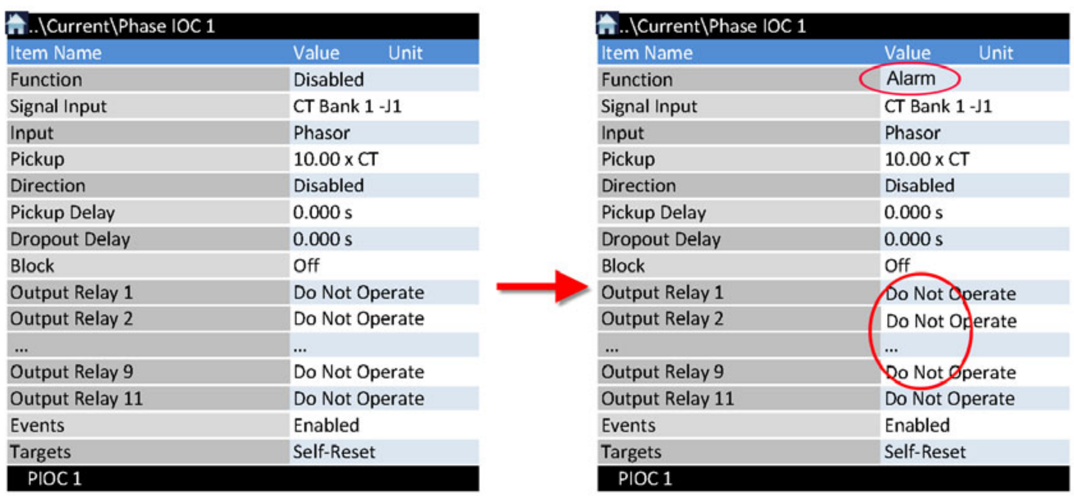
NOTE

Selecting **Trip** as a function, does not automatically change the values of the breaker trip selected output relays to “Operate” from the menus of the protection, control or monitoring elements. Regardless of the selected element function, the values for all output relays from the menu elements will show “Do Not Operate”. The user must select the desired output relays to be energized upon element operation.

Example 2: Programming an IOC1 element to “Alarm”

These same steps also apply if the element is programmed to “Latched Alarm” or “Configurable”.

1. Select **Alarm** from the list of selections available for the setpoint “Function”



2. If necessary, select the output relays to operate as an Alarm upon IOC1 operation.
   To distinguish the element functionality upon function selection, and to prevent the user from making programming mistakes, a mechanism affecting the output relays selected for breaker tripping is implemented and will activate upon changing the function from Disabled to Alarm, Latched Alarm, or Configurable.

- The output relays selected for tripping of the breakers will be de-activated in the IOC1 element menu. The rest of the outputs are fully programmable and operational.
- The setting for these trip selected output relays can be changed, i.e. from "Do Not Operate" to "Operate", but the physical relay will not be energized. This is to prevent the user to operate the trip output relay by mistake, when the function is used as Alarm, or Configurable.

Changing the function back to be fully “Trip”, will enable the breaker trip selected output relays from the IOC1 menu to be programmable.

From 845 PC Program: Element Menu or Protection Summary

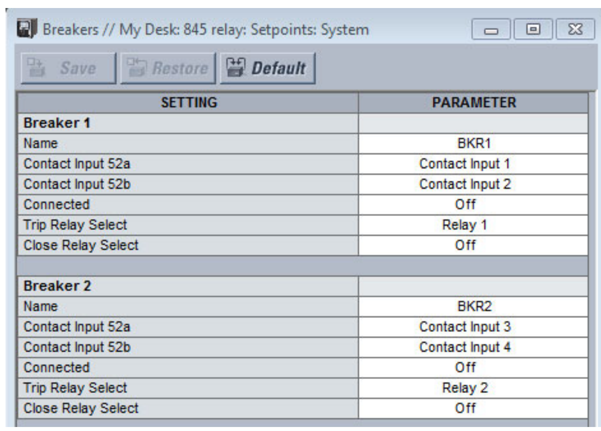
Using the 845 PC program, there are two places where the menu of each protection, control, or monitoring element can be accessed: The element’s individual menu, and the Protection Summary menu.

Element Menu - The element function can be set as Trip, Alarm, Latched Alarm, or Configurable. Depending on the selected function, the relay applies the following rules:

Example 1: Programming an IOC1 element as a Trip function

1. Select **Output Relays 1** and **2** to trip breaker 1 and 2 respectively.

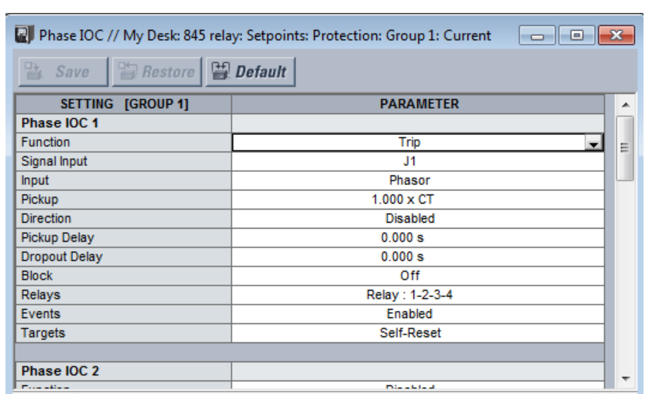
Figure 4-2: Transformer Breakers setup



SETTING	PARAMETER
Breaker 1	
Name	BKR1
Contact Input 52a	Contact Input 1
Contact Input 52b	Contact Input 2
Connected	Off
Trip Relay Select	Relay 1
Close Relay Select	Off
Breaker 2	
Name	BKR2
Contact Input 52a	Contact Input 3
Contact Input 52b	Contact Input 4
Connected	Off
Trip Relay Select	Relay 2
Close Relay Select	Off

2. Select **Trip** as the setpoint “Function”.
   When Trip is selected as a Function, all output relays are accessible for Operate/Do Not Operate programming.

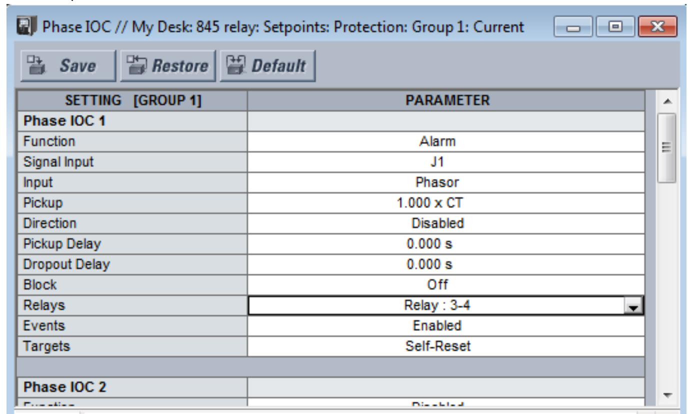
Figure 4-3: Function setpoint for Phase IOC 1 selected as Trip



SETTING [GROUP 1]	PARAMETER
Phase IOC 1	
Function	Trip
Signal Input	J1
Input	Phasor
Pickup	1.000 x CT
Direction	Disabled
Pickup Delay	0.000 s
Dropout Delay	0.000 s
Block	Off
Relays	Relay : 1-2-3-4
Events	Enabled
Targets	Self-Reset
Phase IOC 2	

Example 2: Programming an IOC1 element as an Alarm, Latched Alarm, or Configurable function

1. Select **Alarm**, **Latched Alarm**, or **Configurable** as the setpoint "Function".
   When Alarm, Latched Alarm or Configurable is selected as a Function, the Output Relays 1 and 2, which have been assigned to trip Breaker 1 and 2 respectively, are de-activated for operation.

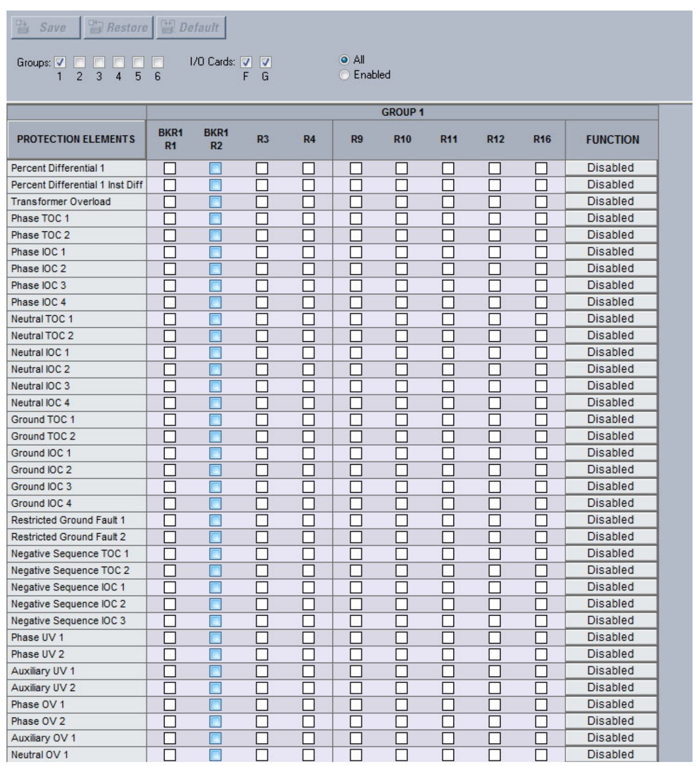


SETTING [GROUP 1]	PARAMETER
Phase IOC 1	
Function	Alarm
Signal Input	J1
Input	Phasor
Pickup	1.000 x CT
Direction	Disabled
Pickup Delay	0.000 s
Dropout Delay	0.000 s
Block	Off
Relays	Relay : 3-4
Events	Enabled
Targets	Self-Reset
Phase IOC 2	

Protection Summary - The selections of Function, and the selection of output relays for "Operate"/"Do Not Operate" for each element are reflected in the Protection Summary window as shown.

Once the Protection Summary window is open, the user can change the setting "Operate"/"Do Not Operate" for any output relay, except the ones selected for breaker close, by checking/unchecking the appropriate box. The user can also access the individual menu for any of the listed elements, and make changes.

Figure 4-4: Protection Summary screen



PROTECTION ELEMENTS	BKR1 R1	BKR1 R2	R3	R4	R9	R10	R11	R12	R16	FUNCTION
Percent Differential 1										Disabled
Percent Differential 1 Inst Diff										Disabled
Transformer Overload										Disabled
Phase TOC 1										Disabled
Phase TOC 2										Disabled
Phase IOC 1										Disabled
Phase IOC 2										Disabled
Phase IOC 3										Disabled
Phase IOC 4										Disabled
Neutral TOC 1										Disabled
Neutral TOC 2										Disabled
Neutral IOC 1										Disabled
Neutral IOC 2										Disabled
Neutral IOC 3										Disabled
Neutral IOC 4										Disabled
Ground TOC 1										Disabled
Ground TOC 2										Disabled
Ground IOC 1										Disabled
Ground IOC 2										Disabled
Ground IOC 3										Disabled
Ground IOC 4										Disabled
Restricted Ground Fault 1										Disabled
Restricted Ground Fault 2										Disabled
Negative Sequence TOC 1										Disabled
Negative Sequence TOC 2										Disabled
Negative Sequence IOC 1										Disabled
Negative Sequence IOC 2										Disabled
Negative Sequence IOC 3										Disabled
Phase UV 1										Disabled
Phase UV 2										Disabled
Auxiliary UV 1										Disabled
Auxiliary UV 2										Disabled
Phase OV 1										Disabled
Phase OV 2										Disabled
Auxiliary OV 1										Disabled
Neutral OV 1										Disabled

NOTE

Use the protection summary window for programming all of the elements and output relays needed for the application. Please note, that the output relays selected for breaker closing are excluded from the menus of all elements, and they are made inactive (cannot be selected) in the Protection Summary menu. The check boxes related to these outputs automatically become inactive, and they cannot be checked/unchecked by the user.

NOTE

The check boxes for the relay outputs assigned for breaker tripping will automatically become inactive (non-selectable), if the function of an element is set to Alarm, Latched Alarm, or Configurable. In all other cases, the check boxes corresponding to those output relays will be active, and available for selection.

Setpoints Entry Methods

Before placing the relay in operation, setpoints defining system characteristics, inputs, relay outputs, and protection settings must be entered, using one of the following methods:

- Front panel, using the keypad and the display.
- Front USB port, connected to a portable computer running the EnerVista 8 Series Setup software.
- Rear Ethernet (copper or fiber port connected to portable computer running the EnerVista 8 Series Setup software.
- Wi-Fi wireless connection to a portable computer running the EnerVista 8 Series Setup software.
- Rear RS485 port and a SCADA system running user-written software.

Any of these methods can be used to enter the same information. A computer, however, makes entry much easier. Files can be stored and downloaded for fast, error free entry when a computer is used. To facilitate this process, the GE EnerVista CD with the EnerVista 8 Series Setup software is supplied with the relay. The relay leaves the factory with setpoints programmed to default values, and it is these values that are shown in all the setpoint message illustrations.

At a minimum, the **Setpoints > System** setpoints must be entered for the system to function correctly. To safeguard against the installation of a relay whose setpoints have not been entered, the **Out-Of-Service** self-test warning is displayed. In addition, the Critical Failure relay is de-energized. Once the relay has been programmed for the intended application, the **Setpoints > Device > Installation > Device In Service** setpoint should be changed from "Not Ready" (the default) to "Ready".Before putting the relay in "Ready" state, each page of setpoint messages should be worked through, entering values either by keypad or computer.

Common Setpoints

To make the application of this device as simple as possible, similar methods of operation and similar types of setpoints are incorporated in various features. Rather than repeat operation descriptions for this class of setpoint throughout the manual, a general description is presented in this overview. Details that are specific to a particular feature are included in the discussion of the feature. The form and nature of these setpoints is described below.

- **FUNCTION setpoint**: The **<ELEMENT_NAME> FUNCTION** setpoint determines the operational characteristic of each feature. The range for this setpoint is: “Disabled”, “Trip”, “Alarm”, “Latched Alarm”, and “Configurable”.

  If the **FUNCTION setpoint** is selected as “Disabled”, then the feature is not operational.

  If the **FUNCTION setpoint** is selected as “Trip”, then the feature is operational. When the “Trip” function is selected and the feature operates, the output relay #1 “Trip” operates, and the LED “TRIP” is lit.

  If the **FUNCTION setpoint** is selected as “Alarm” or “Latched Alarm”, then the feature is operational. When this function is selected, and the feature operates, the LED “ALARM” is lit, and any assigned auxiliary output relay operates. The “Trip” output relay does not operate, and the LED “TRIP” is not lit.

  When **Alarm** function is selected and the feature operates, the LED “ALARM” flashes, and it self-resets when the operating conditions are cleared.

  When **Latched Alarm** function is selected, and the feature operates, the LED “ALARM” will flash during the operating condition, and will be steady lit after the conditions are cleared. The LED “ALARM” can be reset by issuing reset command.

  If the **FUNCTION setpoint** is selected as “Configurable”, the feature is fully operational but outputs are not driving any action, such as output relay #1, Alarm LED or anything else. Operands from this element must be programmed to a desirable action which may be as simple as the auxiliary output relay from the list of available relays in the element itself, FlexLogic, Trip Bus etc.

NOTE

The FlexLogic operands generated by the operation of each feature are active, and available to assign to outputs, or use in FlexLogic equations, regardless of the selected function, except when the function is set to “Disabled”.

- **PICKUP**: The setpoint selects the threshold equal to or above (for over elements) or equal to or below (for under elements) which the measured parameter causes an output from the measuring element.
- **PICKUP DELAY**: The setpoint selects a fixed time interval to delay an input signal from appearing as an output.
- **DROPOUT DELAY**: The setpoint selects a fixed time interval to delay dropping out the output signal after being generated.
- **TDM**: The setting provides a selection for Time Dial Multiplier which modifies the operating times per the selected inverse curve. For example, if an IEEE Extremely Inverse curve is selected with TDM=2, and the fault current is 5 times bigger than the PKP level, operation of the element can not occur before an elapsed time of 2.59 s from Pickup.
- **OUTPUT RELAYS**: The **<ELEMENT_NAME> RELAYS** setpoint selects the relays required to operate when the feature generates an output. The range is “Operate” or “Do Not Operate”, and can be applied to any combination of the auxiliary output relays. The default setting is “Do Not Operate”.

  The available auxiliary relays vary depending on the order code.

- **DIRECTION**: The **<ELEMENT_NAME> DIRECTION** setpoint is available for overcurrent features which are subject to control from a directional element. The range is "Disabled", "Forward", and "Reverse". If set to "Disabled", the element is allowed to operate for current flow in any direction. There is no supervision from the directional element. If set to "Forward", the OC element is allowed to operate when the fault is detected by the directional element in forward direction. In this mode, the OC element does not operate for fault in reverse direction. If set to "Reverse", the OC element is allowed to operate when the fault is detected in reverse direction, and does not operate in forward direction.
- **RESET**: Selection of an Instantaneous or a Timed reset is provided by this setting. If Instantaneous reset is selected, the element resets instantaneously providing the quantity drops below 97 to 98% of the PKP level before the time for operation is reached. If Timed reset is selected, the time to reset is calculated based on the reset equation for the selected inverse curve.
- **BLOCK**: The **<ELEMENT_NAME> BLOCK** setpoint selects an operand from the list of FlexLogic operands, which when active, blocks the feature from running. When set to 'On' the feature is always blocked; when set to 'Off', block is disabled.
- **EVENTS**: The **<ELEMENT_NAME> EVENTS** setpoint can be set to "Enabled", or "Disabled". If set to "Enabled", the events associated with the pickup, operation, or other conditions of the feature are recorded in the Event Recorder.
- **TARGETS**: The **<ELEMENT_NAME> TARGETS** setpoint can be set to "Disabled", "Self-Reset", or "Latched". If set to "Self-Reset", or "Latched", the targets associated with the pickup, operation, or another condition of the feature are displayed on the screen of the 845 relay. The targets disappear from the screen when "Self-Reset" is selected, and the conditions are cleared. The targets stay on the screen, when "Latched" is selected, and the conditions are cleared.

CAUTION **To ensure the settings file inside the relay is updated, wait 30 seconds after a setpoint change before cycling power.**

NOTICE When IP addresses are changed and sent as a Settings file the unit reboots twice.

Logic Diagrams

Refer to the logic diagrams provided for a complete understanding of the operation of each feature. These sequential logic diagrams illustrate how each setpoint, input parameter, and internal logic is used in a feature to obtain an output. In addition to these logic diagrams, the Setpoints chapter provides written descriptions for each feature.

- **Setpoints**: Shown as a block with a heading labeled 'SETPOINT'. The exact wording of the displayed setpoint message identifies the setpoint. Major functional setpoint selections are listed below the name and are incorporated in the logic.
- **Comparator Blocks**: Shown as a block with an inset box labeled 'RUN' with the associated pickup/dropout setpoint shown directly above. Element operation of the detector is controlled by the signal entering the 'RUN' inset. The measurement/ comparison can only be performed if a logic '1' is provided at the 'RUN' input. The relationship between a setpoint and input parameter is indicated by the following symbols: "<" (less than), ">" (greater than), etc.
- **Pickup and Dropout Time Delays**: Shown as a block with indication of two timers – the t_{PKP} (Pickup Delay), and t_{DPO} (Dropout Delay).
- **LED Indicators**: Shown as the following schematic symbol **(X)**.
- **Logic**: Described with basic logic gates (AND, OR, XOR, NAND, NOR). The inverter (logical NOT), is shown as a circle: **O**
- **FlexLogic operands**: Shown as a block with a heading labeled 'FLEXLOGIC OPERANDS'. Each feature produces output flags (operands) which can be used further for creating logic in the FlexLogic equation editor, or Trip Bus, or can be directly assigned to trigger an output. The operands from all relay features constitute the list of FlexLogic operands.

Setpoints Text Abbreviations

The following abbreviations are used in the setpoints pages.

- A: amperes
- kA: kiloamperes
- V: volts
- kV: kilovolts
- kW: kilowatts
- kvar: kilovars
- kVA: kilo-volt-amperes
- AUX: auxiliary
- COM, Comms: communications
- CT: current transformer
- GND: ground
- Hz: Hertz
- MAX: maximum
- MIN: minimum
- SEC, s: seconds
- UV: undervoltage
- OV: overvoltage
- VT: voltage transformer
- Ctrl: control
- Hr & hr: hour
- O/L: overload

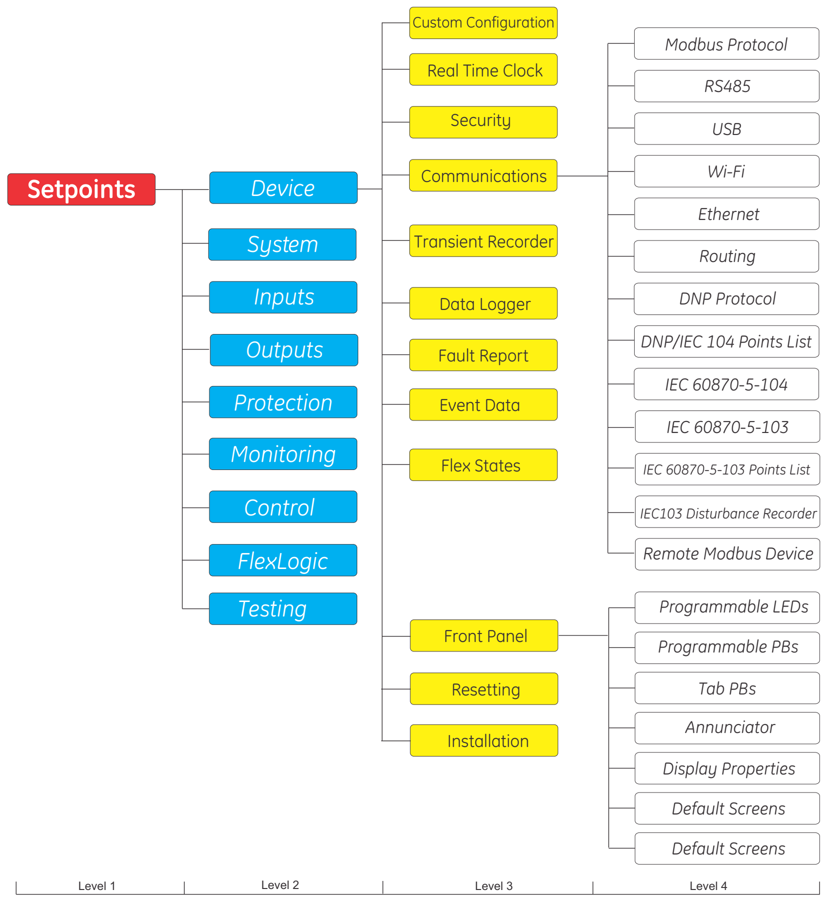
845 Transformer Protection System

Chapter 5: Device, System, Input and Output Setpoints

This chapter describes the Device, System, Input and Output setpoint menu settings in detail.

Device

Figure 5-1: Device Display Hierarchy



Custom Configuration

The custom configuration features allow customization of the 8 Series configurations in such a way that the user experience of the 8 Series platform is further enhanced.

Configuration Mode

Modern multifunctional Intelligent Electronic Devices (IEDs), such as the 8 Series platform, support a multitude of functions and features which include: Protection and Control (P&C), Asset Monitoring, Flexible Logic Engine (FlexLogic), Records and Reporting, Time Synchronization, Testing/Simulation, etc. Taking into consideration user experience, configuration mode controls how the “Setpoints” are presented by only displaying settings that are typically used, or settings that are important to configure.

There are two configuration modes supported: Simplified, and Regular.

- In Simplified configuration mode, some of the advanced functions/features or a few settings under a function are hidden or made read-only (greyed out).
- In Regular configuration mode, all function/features and setpoints of the device are editable and nothing is hidden or greyed out.

Simplified configuration mode does not remove any functionality or setting from the device. It only controls the view or display of the settings. All the settings made in Regular configuration mode are still applied during simplified mode (they are either hidden or read-only). Therefore, simplified configuration mode can also be viewed as locking advanced setpoints.

Configuration mode is applicable to the “Setpoints” items only and does not control view/presentation to other Main menu items, such as Device Definition, Status, Metering, Records, Commands and Maintenance. The configuration mode setting is available to be changed by the “Administrator” role. The configuration mode control is applicable to device HMI and setup software, as well as online and offline setting files.

NOTE

Configuration mode does not disable the device functionality or settings. It only controls the view or presentation on the HMI and setup software screens. Therefore, settings which are hidden or Read-only are preserved and applied within the device.

The homepage shows the home icon which changes color according to the configuration mode. When in Simplified configuration mode, the home icon color changes to green.

When in Regular mode, the home icon color stays blue.

Example 1: More about the setting items view control

The Phase TOC 1 function in Regular mode has 14 setpoints made available to edit (read-write). In the case of Simplified mode this function has only 6 out of the 14 setpoints made available to edit (read-write), 5 setpoints are hidden, and 3 setpoints are read/view-only.

NOTE

All setpoints under Regular mode are still applied and used by the device. For example the “Input” is hidden but configured as “Phasor” during Regular mode, therefore Phase TOC 1 still applies “Phasor” as an input. Similarly, “Reset” is read-only, and Phase TOC 1 still applies “Instantaneous” for resetting. The read-only settings are greyed out.

Figure 5-2: Comparing the setpoints for Regular and Simplified mode

Regular

..\Current\Phase TOC 1		
Item Name	Value	Unit
Function	Disabled	
Signal Input	CT Bank 1 -J1	
Input	Phasor	
Pickup	1.000	x CT
Curve	IEEE Mod Inverse	
TDM	1.00	
Reset	Instantaneous	
Direction	Disabled	
Voltage Restraint	Disabled	
Volt Lower Limit	0.1	p.u.
Block	Off	
Relays	Do Not Operate	
Events	Enabled	
Targets	Self-Reset	
PTOC 1		

Simplified

..\Current\Phase TOC 1		
Item Name	Value	Unit
Function	Disabled	
Signal Input	CT Bank 1 -J1	
Pickup	1.000	x CT
Curve	IEEE Mod Inverse	
TDM	1.00	
Reset	Instantaneous	
Direction	Disabled	
Voltage Restraint	Disabled	
Relays	Do Not Operate	
PTOC 1		

Example 2: More about the Function/Feature view control

The differences in the Input setpoints screens for Regular and Simplified mode are shown below. Under Simplified mode, the *Virtual Inputs* and *Remote Inputs* are hidden for any configuration change. However, the device will still accept and process virtual and remote inputs based on what is configured during Regular mode. This way, Simplified configuration mode does not change the behavior of the device.

Figure 5-3: Comparing the Inputs screens for Regular and Simplified mode

Regular

..\Setpoints\Inputs			
Item Name			
Contact Inputs			
Virtual Inputs			
Analog Inputs			
Remote Inputs			
Inputs	V Inputs	MA In	Rem In

Simplified

..\Setpoints\Inputs	
Item Name	
Contact Inputs	
Analog Inputs	
Inputs	MA In

Path: Setpoints > Device > Config Mode

CONFIG MODE

Range: Simplified, Regular

Default: Regular

This setting allows selection of the configuration mode while the device is accessed by the “Administrator” role. In Regular configuration mode, all values in settings/functions can be edited. In Simplified configuration mode, selected settings/functions are hidden or the values are read-only to enhance user experience with minimum setpoint changes.

Real-time Clock

Path: **Setpoints > Device > Real Time Clock**

The 845 is capable of receiving a time reference from several time sources in addition to its own internal clock for the purpose of time-stamping events, transient recorders and other occurrences within the relay. The accuracy of the time stamp is based on the time reference that is used. The 845 supports an internal clock, SNTP, IRIG-B, and PTP IEEE 1588 (version 2)as potential time references.

If two or more time sources are available, the time source with the higher priority shown in Time Sources table is used where 1 is considered to be the highest priority. Please note that the time source priority of PTP and IRIG-B can be swapped. If both PTP and IRIG-B are available to the 845, by default the 845 clock syncs to PTP over IRIG-B. If PTP is not available the 845 CPU syncs the internal clock to IRIG-B.

Table 5-1: Time Sources

Time Source	Priority
PTP (IEEE1588)	1*
IRIG-B	2*
SNTP	3
Internal Clock	4

* The priority of IRIG-B and PTP can be swapped.

NOTICE

Synchronization by IEC103, DNP, Modbus and IEC104 is not going to be issued if there is a sync source from IRIG-B, SNTP or PTP.

Clock

Path: **Setpoints > Device > Real Time Clock > Clock**

DATE

Format: Month/Day/Year
Range: Month: 1 to 12; Day: 1 to 31; Year: 2008 to 2094
Default: 01/01/2008

TIME

Range: 0 to 23: 0 to 59:0 to 59
Default: 00:00:00

LOCAL TIME OFFSET FROM UTC

Range: –24.0 to 24.0 hrs in steps of 0.5 hrs
Default: 0.0 hrs

REAL TIME CLOCK EVENTS

Range: Disabled, Enabled
Default: Enabled

IRIG-B

Range: Disabled, Enabled
Default: Disabled

DAYLIGHT SAVINGS TIME

Range: Disabled, Enabled
Default: Disabled

DST START MONTH

Range: January to December (all months)
Default: Not Set

DST START DAY

Range: SUN to SAT (all days of the week)
Default: Not Set

DST START WEEK

Range: 1st, 2nd, 3rd, 4th, Last
Default: Not Set

DST START HOUR

Range: 0 to 23
Default: 2

DST END MONTH

Range: January to December (all months)
Default: Not Set

DST END WEEK

Range: 1st, 2nd, 3rd, 4th, Last
Default: Not Set

DST END DAY

Range: SUN to SAT (all days of the week)
Default: Not Set

DST END HOUR

Range: 0 to 23
Default: 2

IRIG-B

IRIG-B is available in all 8 Series relays. A failure on IRIG-B triggers an event and a target message.

NOTICE

Note that IRIG-B is auto detected. The signal type is detected in the hardware, so there are no configurable options.

PTP Configuration

Path: Setpoints > Device > Real Time Clock > Precision Time

PORT 4(5) PTP FUNCTION

Range: Disabled, Enabled
Default: Enabled

When the port setting is selected as "Disabled," PTP is disabled on the port. The relay does not generate, or listen to, PTP messages on the port.

PORT 4(5) PATH DELAY ADDER

Range: 0 to 60000 ns in steps of 1 ns
Default: 0 ns

The time delivered by PTP is advanced by the time value in the setting prior to the time being used to synchronize the relay's real time clock. This is to compensate for time delivery delays not compensated for in the network. In a fully compliant Power Profile (PP) network, the peer delay and the processing delay mechanisms compensate for all the delays between the grandmaster and the relay. In such networks, the setting is zero.

In networks containing one or more switches and/or clocks that do not implement both of these mechanisms, not all delays are compensated, so the time of message arrival at the relay is later than the time indicated in the message. The setting can be used to approximately compensate for the delay. Since the relay is not aware of network switching that dynamically changes the amount of uncompensated delay, there is no setting that always completely corrects for uncompensated delay. A setting can be chosen that reduces worst-case error to half of the range between minimum and maximum uncompensated delay if these values are known.

PORT 4(5) PATH DELAY ASYMMETRY

Range: -1000 to +1000 ns in steps of 1 ns

Default: 0 ns

The setting corresponds to "Delay Asymmetry" in PTP, which is used by the peer delay mechanism to compensate for any difference in the propagation delay between the two directions of a link. Except in unusual cases, the two fibers are of essentially identical length and composition, so the setting is set to zero.

In unusual cases where the length of link is different in different directions, the setting is to be set to the number of nanoseconds longer the Ethernet propagation delay is to the relay compared with the mean of path propagation delays to and from the relay. For instance, if it is known say from the physical length of the fibers and the propagation speed in the fibers that the delay from the relay to the Ethernet switch it is connected to is 9000 ns and that the delay from the switch to the relay is 11000 ns, then the mean delay is 10000 ns, and the path delay asymmetry is +1000 ns.

STRICT POWER PROFILE

Range: Enabled, Disabled

Default: Enabled

Power profile (IEEE Std C37.238™ 2011) requires that the grandmaster clock be power profile compliant, that the delivered time have a worst-case error of ±1 µs, and that the peer delay mechanism be implemented. With the strict power profile setting enabled, the relay selects as master only clocks displaying the IEEE_C37_238 identification codes. It uses a port only when the peer delay mechanism is operational. With the strict power profile setting disabled, the relay uses clocks without the power profile identification when no power profile clocks are present, and uses ports even if the peer delay mechanism is non-operational.

The setting applies to all of the relay's PTP-capable ports.

PTP DOMAIN NUMBER

Range: 0 to 255

Default: 0

The setting is set to the domain number of the grandmaster-capable clock(s) to which they can be synchronized. A network may support multiple time distribution domains, each distinguished with a unique domain number. More commonly, there is a single domain using the default domain number zero.

The setting applies to all of the relay's PTP-capable ports.

PTP VLAN PRIORITY

Range: 0 to 7

Default: 4

The setting selects the value of the priority field in the 802.1Q VLAN tag in request messages issued by the relay's peer delay mechanism. In compliance with PP (Power Profile) the default VLAN priority is 4, but it is recommended that in accordance with PTP it be set to 7.

Depending on the characteristics of the device to which the relay is directly linked, VLAN Priority may have no effect.

The setting applies to all of the relay's PTP-capable ports.

PTP VLAN ID

Range: 0 to 4095

Default: 0

The setting selects the value of the ID field in the 802.1Q VLAN tag in request messages issued by the relay's peer delay mechanism. It is provided in compliance with PP (Power Profile). As these messages have a destination address that indicates they are not to be bridged, their VLAN ID serves no function, and so may be left at its default value.

Depending on the characteristics of the device to which the relay is directly linked, VLAN ID may have no effect.

The setting applies to all of the relay's PTP-capable ports.

PTP PRIORITY

Range: 1, 2

Default: 1

The setting sets the priority of PTP time for the relay. If set to 1 and IRIG-B is available, the relay syncs the relay's time reference to the PTP time. If set to 2 and IRIG-B is available, the relay syncs its reference to IRIG-B time.

SNTP Protocol

845 Transformer Protection System relays accept time synchronization from up to two different SNTP servers. In order to define number of SNTP servers to be used, different settings for each SNTP server must be configured.

- If one SNTP server is used to synchronize the relay, the SNTP Server and UDP port settings must be configured with the corresponding settings.
- If two SNTP servers are used to synchronize the relay, the SNTP Server IP and UDP port for the main server must be configured, along with the SNP Server 2 IP and UDP port for the back-up server.

NOTE

845 Transformer Protection System relays only support SNTP unicast.

It may take 2-3 minutes for the relay to synchronize with the SNTP server.

Path: Setpoints > Device > Real Time Clock > SNTP

SNTP FUNCTION

Range: Disabled, Enabled

Default: Disabled

SNTP SERVER IP ADDRESS

Range: Standard IP Address Format

Default: 0.0.0.0

SNTP UDP PORT NUMBER

Range: 0 to 65535 in steps of 1

Default: 123

SNTP SERVER 2 IP ADDRESS

Range: Standard IP Address Format

Default: 0.0.0.0

SNTP 2 UDP PORT NUMBER

Range: 0 to 65535 in steps of 1

Default: 123

NOTICE

The SNTP and PTP settings take effect after rebooting the relay.

Security

The following security features are available:

- **Basic Security** – The basic security feature present in the default offering of the product.
- **CyberSentry** – The feature refers to the advanced security options available as a software option. When this option is purchased, it is automatically enabled and Basic Security is disabled.

GENERAL RULES FOR ROLES

- All the roles are password protected, except for the Observer role which is user-defined on the device. A user with Observer capability defined on the Radius is password protected.
- All the roles, except for the Observer role, support only one session at one time.
- The Observer role has read-only access to all values in the relay except for one service command which is described in the Password Recovery Procedure section.
- All the roles, except for the Observer, have access to a "log out" setting, which has the effect of switching to Observer role.
- A Setpoint access setting for bypassing security is available. If this feature is used, the user gains total access to any operations / configuration changes executed either from the front panel or from EnerVista.
- The setpoint access setting may be either switched directly on or assigned to a digital input.
- If the setpoint access setting is assigned to a digital input, the digital input needs to be activated through a physical key (jumper).
- The setpoint access setting may be set only by an Administrator.

PASSWORD COMPLEXITY

The password complexity is available on both Basic Security and CyberSentry.

If password complexity is enabled, a user account requires an alpha-numeric password that meets the following requirements:

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

PASSWORD RECOVERY PROCEDURE

In the event of losing all passwords, the 845 can be reset to factory defaults by following the procedure below:

1. Send an email to the customer support department providing a valid serial number and using a recognizable corporate email account. (Worldwide e-mail: multilin.tech@ge.com)
2. Customer support provides the code to reset the relay to factory defaults.
3. Enter the code provided from the front panel, under the menu **Setpoints > Device > Installation > Service Command** to reset the relay to factory defaults.

NOTE

Note that even an Observer may execute this operation.

NOTE

- The current limitation for the maximum number of Observer sessions from EnerVista is three when the Communications card is present.
- When the communications card is not present, a maximum of two Observer sessions may be initiated through EnerVista. If two Observers are connected, a third connection is only allowed for an Administrator. No Operator has access. However, if an Operator is first connected, before any other user, only one Observer is allowed and not two, so that an Administrator may always be able to connect. This is because the maximum number of TCP connections from EnerVista, when the Communications card is not present, is only three. (With a Communications card, the maximum number of TCP connections is five.)

Basic Security

The 8 Series Basic Security supports three roles: Administrator, Operator and Observer.

The Main Settings Structure is available from **Path:** **Setpoints > Device > Security.**

LOGIN

The setting allows a user to login with a specific role.

1. Whenever a new role is logged in, the user is prompted to enter a password.
2. If the wrong password is entered, an "Authentication Failed!" message is displayed
3. If the maximum failed authentications occur an "Account Blocked!" message is displayed.
4. The Observer is the default choice and it does not require a password.

LOGOUT

This setting logs out the current user and logs in as Observer. If the user is already an Observer, this setting does not apply. When logging out, a switch to Observer role is performed.

CHANGE PASSWORDS

1. The Change local passwords menu is shown on the front panel and EnerVista on a successful login of Administrator role.
2. If password complexity is enabled, the rules as defined in the Password Complexity section must be obeyed. If password complexity is disabled this setting accepts 1 to 20 alphanumeric characters.
   See **Path:** **Setpoints > Device > Security > Change Local Passwords**.
3. The default password is "0", which is programmed from the factory.
4. The "login setting" in this menu is similar to that in the parent security settings.
5. The Observer does not have password associated with it. So there is no need to show it in the list of password changing roles.

LOAD FACTORY DEFAULTS

The Administrator role can change this setting. This setting resets all the settings, communication and Security passwords, and all records.

ACCESS LOCKOUT

Access lockout is the number of failed authentications (the default is 3 and the maximum is 99) before the device blocks subsequent authentication attempts for the lockout period. A value of 0 shall mean Lockout is disabled.

ACCESS LOCKOUT PERIOD

Access lockout period is the period of time in minutes of a lockout (the default is 3 and the maximum is 9999). A value of "0" means that there is no lockout period.

ACCESS TIMEOUT

Access timeout is the time of idleness before a logged in user is automatically logged out. This timeout applies to all users, independent of the communication channel (serial, Ethernet or direct access).

PASSWORD COMPLEXITY

This setting is available so that the option of selecting between simple passwords and complex ones is provided.

- The setting is only available to Administrator.
- By default password complexity is disabled.
- When password complexity is enabled, it follows the rules defined in the Password Complexity section.

OPERATOR PIN PASSWORD

This setting allows a numeric password for the Operator even when Password Complexity is enabled. When the Operator PIN password is enabled, a virtual numeric keypad is shown instead of a virtual keyboard. By default, Operator PIN password is disabled. Changing this setting changes the Operator password to the default "0".

SETPOINT ACCESS

This setting is only available to Administrator. The setpoint access is used for the purpose of bypassing security. It can be either switched on or assigned to a digital input. If assigned to a digital input, the digital input needs to be activated through a physical key.

Event Record	Description
FAILED AUTH	A failed authentication has occurred. Time stamp in UTC when it occurred is provided.
AUTH LOCKOUT	The authentication lockout has occurred because of too many failed authentication attempts.
LOGIN	An event meant to indicate when a certain role logged in.
LOGOUT	An event meant to indicate when a certain role logged out or timed out.

NOTE

If the maximum number of Observer roles already logged in on the relay has been reached, you must log in on the Security screen within one minute of making the connection otherwise your session is terminated.

FACTORY SERVICE MODE

When the factory service mode feature is enabled, the device may go into factory service mode. The default value is Disabled.

REQUIRE PW FOR RESET KEY

This setting is only available to the Administrator. The Require PW for Reset Key is used for the purpose of bypassing security. If this setting is enabled and an alarm or trip occurs on the relay, the Reset button is not available to the Operator. Only the Administrator can reset the relay with their password.

REQUIRE PW FOR D/T CHANGE

The date/time can be set by any role, if this setting is disabled. If this setting is enabled the date/time can only be set by the Administrator.

REQUIRE PW FOR CONTROL

If this setting is disabled, Operator controls do not require a password. If this setting is enabled, the Operator password is required. By default Require PW for Control is enabled.

CyberSentry

The following features are supported in the CyberSentry feature:

- CyberSentry provides secure tunneling of MODBUS communications between itself and the EnerVista setup software, using SSH.
- All the roles supported in the Basic Security are supported.
- Server authentication using RADIUS is added.

SECURE TUNNELING

The following items are supported in the feature:

- Under the CyberSentry option, the 8 Series supports SSH secure tunneling of MODBUS communications between itself and EnerVista setup software.
- SSH secure tunneling is supported on Ethernet only.
- If bypass security is set (through setpoint access), the communications over Ethernet is not encrypted.

ROLE ACCESS MAP

The detailed role access map is defined in the following figure.

Figure 5-4: Role Access Map

Roles	Administrator	Operator	Observer
	Complete Access	Command Menu	Role active by default.
Targets	R	R	R
Targets – Clear	Yes	Yes	No
Status	R	R	R
Metering	R	R	R
Setpoints – Device – Real Time Clock	RW	RW	R
Setpoints – Device – Security	RW	R	R
Setpoints – Device – Communications	RW	R	R
Records – Clear	Yes	Yes	No
Maintenance – Modbus Analyzer	NA	NA	NA
Maintenance – Update Firmware	Yes	No	No
Maintenance – Retrieve File	Yes	Yes	Yes events, oscillography, diagnostic

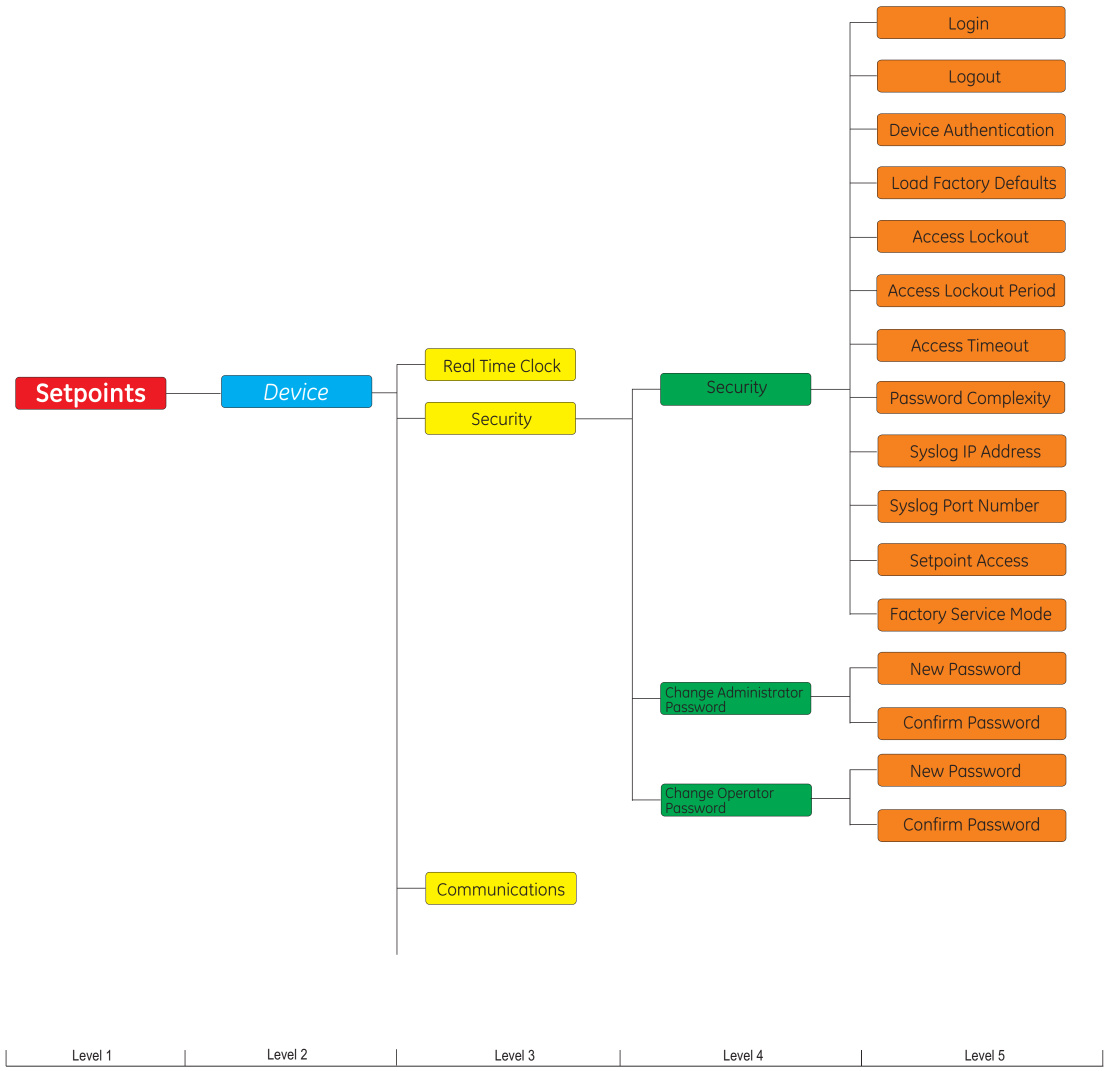
NOTICE

Commands may be issued freely through protocols other than Modbus (e.g., DNP, IEC 104, and, IEC 61850) without user-authentication or encryption of data taking place, even if the relay has the advanced security feature enabled.

SECURITY SETTINGS STRUCTURE

The figure below shows the location of the Security settings in the device display hierarchy.

Figure 5-5: Security Settings Structure



SECURITY SETTINGS

LOGIN

Range: Administrator, Operator, Observer

Default: Observer

The setting allows a user to login with a specific role.

- Whenever a new role is logged in, the user is prompted to enter a password.
- If the wrong password is entered, an “Authentication Failed!” message is displayed.
- If the maximum failed authentications occur, the “Account Blocked!” message is displayed.
- The Observer is the default choice and it does not require a password.

LOGOUT

Range: Yes, No

Default: No

This setting logs out the current user. When logging out from the panel, a switch to the Observer role is performed.

DEVICE AUTHENTICATION

Range: Yes, No

Default: Yes

Device authentication setting offers the option to disable or enable this type of authentication. By default device authentication is on, but the option to turn it off is provided and may be chosen when a RADIUS server is accessible and will be used exclusively.

Only an administrator role may change this setting. If administrator disables it, the role remains logged in, but it is not allowed to write any other settings. In EnerVista a popup window warns that such changes are not going to be saved.

If device authentication is disabled, EnerVista still displays both radio buttons for choosing between device and server authentication. See the EnerVista setup section. However the drop down menu, when local is selected, has only the Administrator option. Once logged in, this role is only able to switch on device authentication. After switching on the device authentication, the Administrator gains write access to all the other settings without the need to logout and login again.

LOAD FACTORY DEFAULTS

Range: Yes, No

Default: No

An Administrator role is able to change this setting. This resets all the settings, communication and security passwords, and all records.

ACCESS LOCKOUT

Range: 0-99

Default: 3

The Access lockout is the set number of failed authentications (the default is 3 and the maximum is 99) before the device blocks subsequent authentication attempts for the lockout period. A value of “0” means Lockout is disabled.

ACCESS LOCKOUT PERIOD

Range: 0-9999 minutes

Default: 3 minutes

The Access lockout period is the set period of time in minutes of a lockout (the default is 3 and the maximum is 9999). A value of “0” means that there is no lockout period.

NOTE

Note that the lockout period is measured from the moment the maximum number of failed authentications has been reached. Additional attempts to login during the lockout period do not extend this time.

ACCESS TIMEOUT

Range: 2-999 minutes

Default: 5 minutes

The Access timeout is the time of idleness before a logged in user is automatically logged out. This timeout setting applies to all users, independent of the communication channel (serial, Ethernet or direct access).

ENABLE PASSWORD COMPLEXITY

Range: Disabled, Enabled

Default: Disabled

This setting is available to provide the option of selecting between simple passwords and complex ones. The following conditions apply:

- The setting is only available to Administrator
- By default password complexity is disabled
- When password complexity is enabled, it follows the rules defined in the *Password Complexity* section.

SYSLOG IP ADDRESS

Range: 0.0.0.0 to 223.255.255.254

Default: 0.0.0.0

This is the IP address of the target Syslog server all security events are transmitted to.

SYSLOG PORT NUMBER

Range: 1 to 65535

Default: 514

This sets the UDP port number of the target Syslog server all security events are transmitted to.

SETPOINT ACCESS

Range: Off, On, Digital Input

Default: Off

- The setting is only available to Administrator.
- The setpoint access setting may be assigned to a digital input.
- When the digital input is activated, the user gets Administrator access to the front panel.

FACTORY SERVICE MODE

Range: Disabled, Enabled

Default: Disabled

- When the feature is enabled, the Factory role is accessible and the device may go into factory service mode.
- The setting may be changed only by an Administrator.
- The default value is Disabled.

NOTE

The factory role password may not be changed.

REQUIRE PW FOR RESET KEY

Range: Disabled, Enabled

Default: Disabled

If this setting is enabled and an alarm or trip occurs on the relay, the Reset button is not available to the Operator. Only the Administrator can reset the relay with their password.

REQUIRE PW FOR D/T CHANGE

Range: Disabled, Enabled

Default: Disabled

The date/time can be set by any role, if this setting is disabled. If this setting is enabled the date/time can only be set by the Administrator.

CHANGE PASSWORDS SETTINGS

- The two menu items: Change Administrator Password, and Change Operator Password are available only to Administrator, which is the only role that has permissions to change passwords for itself and the other local roles.

- Each password change menu has two settings: New Password and Confirm Password.
- With password complexity enabled, each setting may take 6 to 20 alphanumeric characters. With password complexity disabled, each setting takes 1 to 20 alphanumeric characters.
- If password complexity is enabled, its rules, as defined in the section *Password Complexity*, must be obeyed.
- The default password is “0”.
- The Observer does not have a password associated with it. So there is no need to show it in the list of password changing roles.

ENERVISTA SETUP

For the software setup the following applies:

- Some Security Settings (such as Radius configuration) are only accessible and configurable through the EnerVista setup program.
- The EnerVista software only allows for changes that are permitted by the user’s logged in role. For example, the Observer role cannot write to any settings, but can only view.
- If the settings file is modified off line, EnerVista checks for the role of the user trying to download it and allows the download only if the role is Administrator (see table below). If the role is different, EnerVista notifies the user that this operation is allowed only for Administrators (e.g., via a pop-up window).
- The EnerVista Login Screen has two radio buttons to choose between device and server authentication.
  - If server authentication is chosen, the screen provides “User Name:” and “Password:” fields
  - If device authentication is chosen the “User Name:” field changes to a drop down menu.
    If device authentication is enabled internally, the drop down menu contains all predefined roles on the 8 Series.
    If device authentication is disabled, the drop down menu has only the Administrator option. This is to allow for switching on the device authentication. Once logged in, the Administrator is only able to turn on the device authentication, but once the device authentication is enabled, access to all the other settings is granted.
- A file download may be performed only from EnerVista.

Table 5-2: Role and File Access Table

Role:		Administrator	Operator	Observer
File access:				
Read (Download from 845)	All files	Yes	Yes	Yes
Write (Upload to 845)	Settings file	Yes	No	No
	Firmware	Yes	No	No

NOTE

In special cases security settings, such as RADIUS IP address and port, if modified offline, can result in interruption of service when applied online, if the user is not aware of the change having been made. For this reason, if these settings have been modified, offline, they will not be written during the file write operation.

RADIUS SETTINGS

The following are settings that need to be configured through EnerVista, in order to set up communication with a Radius server on 845. For configuring the RADIUS server itself, consult the RADIUS documentation. An example is provided, see *Communications Guide*.

Table 5-3: Radius Settings

Setting Name	Description	Min	Max	Default	Units	Minimum Permissions
Primary Radius IP Address	IP address of primary Radius server. Default value indicates no Primary Radius server is configured, and so Radius is disabled.	0.0.0.0	223.255.255.254	0.0.0.0	-	Administrator
Primary Authentication Port	Radius authentication port	1	65535	1812	-	Administrator
Vendor ID	An identifier that specifies Radius vendor specific attributes used with the protocol.	1	65535	Value that represents General Electric (2910)	-	Administrator
Radius Authentication Method	Authentication method used by Radius server. Currently fixed to EAP-TTLS.	EAP-TTLS	EAP-TTLS	EAP-TTLS	-	Administrator
Timeout	Timeout in seconds in between re-transmission requests	0	9999	10	sec	Administrator
Retries	Number of retries before giving up	0	9999	3	-	Administrator
Radius Authentication (Shared) Secret	Shared Secret used in authentication. It is only displayed as asterisks. This setting must meet the CyberSentry password requirements.	See password section for requirements	245 characters	N/A	-	Administrator
Confirm Radius Authentication (Shared) Secret	Confirmation of the shared secret. Only display as asterisks.	See password section for requirements	245 characters	N/A	-	Administrator

SECURITY EVENTS

- The event recorder records the events described in the table Security Events.

Table 5-4: Security Events

Event Record	Level	Description
FAILED_AUTH, ORIGIN, TIMESTAMP	Warning (4)	A failed authentication with time stamp in UTC time when it occurred.
USER_LOCKOUT, ORIGIN, TIMESTAMP:	Error (3)	The user lockout has occurred because of too many failed authentication attempts.
SETTING_CHG, ORIGIN, TIMESTAMP:	Notice (5)	An event to indicate setting change(s).
LOGIN, ORIGIN, TIMESTAMP:	Warning (4)	An event to indicate when a certain role logged in.

Event Record	Level	Description
LOGOUT, ORIGIN, TIMESTAMP:	Warning (4)	An event to indicate when a certain role logged out or timed out.
RADIUS_UNREACH, ORIGIN, TIMESTAMP:	Critical (2)	RADIUS server is unreachable. Origin: RADIUS server IP address and port number.
CLEAR_EVENT_RECORDS, ORIGIN, TIMESTAMP:	Warning (4)	Clear event records command was issued.
CLEAR_TRANSIENT_RECORDS, ORIGIN, TIMESTAMP:	Notice (5)	Clear transient records command was issued.
CLEAR_FAULT_REPORTS, ORIGIN, TIMESTAMP:	Notice (5)	Clear fault reports command was issued.

FLEXLOGIC OPERANDS

The following operands are added for CyberSentry.

CyberSentry FlexLogic Operand	Description
AUTHENTICATION FAIL	Operand set for Failed Authentication self test and alarm
UNAUTH SETTING CHANGE ATTEMPT	Operand set for unauthorized setting change action
RADIUS SRV UNAVAILABLE	Operand set for RADIUS servers unavailable self test

Communications

8 Series relays have a two-stage communications capability. The base CPU supports Modbus protocol through the Ethernet, USB, serial and WiFi port. In addition, the base CPU also supports IEC 103, DNP serial, DNP TCP/IP, and TFTP protocol. Once the communications module option is added to the base, the base Ethernet port becomes disabled but the two Ethernet ports on the communications module have enhanced communications capabilities such as IEC61850 Ed.2, IEC62439 parallel redundancy protocol (PRP) and IEEE 1588 Precision Time Protocol (PTP version 2). The communications CPU also supports Modbus TCP, IEC 104, DNP TCP, TFTP, SFTP, and SNTP protocol.

Modbus Protocol

All Ethernet ports and serial communication ports support the Modbus protocol. The only exception is if the serial port has been configured for DNP or IEC 60870-5-103 operation (see descriptions below). This allows the EnerVista 8 Series Setup software (which is a Modbus master application) to communicate to the 845.

The 845 implements a subset of the Modicon Modbus RTU serial communication standard. The Modbus protocol is hardware-independent. That is, the physical layer can be any of a variety of standard hardware configurations. This includes USB, RS485, fiber optics, etc. Modbus is a single master / multiple slave type of protocol suitable for a multi-drop configuration.

The 845 is always a Modbus slave with a valid slave address range 1 to 254.

DATA FRAME FORMAT AND DATA RATE

One data frame of an asynchronous transmission to or from an 845 typically consists of 1 start bit, 8 data bits, and 1 stop bit. This produces a 10-bit data frame. This is important for transmission through modems at high bit rates. Modbus protocol can be implemented at any standard communication speed. The 845 supports operation at 9600, 19200, 38400, 57600, and 115200 bps baud rate. The USB interface supports ModBus TCP/IP.

FUNCTION CODE SUPPORTED

The following functions are supported by the 845:

- FUNCTION CODE 03H - Read Setpoints
- FUNCTION CODE 04H - Read Actual Values

- FUNCTION CODE 05H - Execute Operation
- FUNCTION CODE 06H - Store Single Setpoint
- FUNCTION CODE 07H - Read Device Status
- FUNCTION CODE 08H - Loopback Test
- FUNCTION CODE 10H - Store Multiple Setpoints
- FUNCTION CODE 42H - Group Settings Read
- FUNCTION CODE 43H - Group Settings Write

When a ModBus master such as the EnerVista 8 Series Setup software communicates to the 845 over Ethernet, the 845 slave address, TCP port number and the 845 IP address for the associated port must be configured and are also configured within the Master for this device. The default ModBus TCP port number is 502.

The following ModBus parameters are configurable:

Path: **Setpoints > Device > Communications > Modbus Protocol**

MODBUS SLAVE ADDRESS

Range: 1 to 254 in steps of 1

Default: 254

For the RS485 ports each 845 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, otherwise conflicts resulting in errors occur. Generally, each device added to the link uses the next higher address starting at 1.

MODBUS TCP PORT NUMBER

Range: 1 to 65535 in steps of 1

Default: 502

The TCP port number used with Modbus over Ethernet. Note that the maximum number of simultaneous Modbus connections supported over Ethernet is:

- three for an 845 without the communications card,
- five for an 845 with the communications card.

MODBUS 485 READ ACTUALS

Range: Function Code 03h, Function Code 04h

Default: Function Code 04h

The Modbus 485 Read Actuals setting configures the Function Code that the relay responds to from a Modbus Master when Actual Values are requested. Use this setting in scenarios where the Modbus Master can only communicate using Function Code 03h for requesting Actual Values.

NOTE

This setting applies only to the RS485 connection.

NOTE

When this setting is changed to Function Code 03h, retrieving configuration settings through the RS485 port is not possible.

MODBUS ACTIVITY TIMEOUT

Range: 0 to 3600 s in steps of 1 s

Default: 0 s

The Modbus Activity Timeout specifies the minimum time without Modbus communication. This timeout is used to declare the Modbus 'Loss of Communication' state.

The Modbus state is always Active if the Modbus Activity Timeout is 0 s.

MODBUS ERROR RESPONSES

The following exception response codes are implemented.

Error ID	Exception	Description
01	ILLEGAL FUNCTION	The function code transmitted is not one of the functions supported by the 845.
02	ILLEGAL DATA ADDRESS	The address referenced in the data field transmitted by the master is not an allowable address for the 845.
03	ILLEGAL DATA VALUE	The value referenced in the data field transmitted by the master is not within range for the selected data address.

RS485

On the rear card 8 Series relays are equipped with one RS485 serial communication port and one 10/100 Mbps Ethernet 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 connected to this port. A maximum of 32 relays can be daisy-chained and connected to a DCS, PLC or a PC using the RS485 port.

Path: **Setpoints > Device > Communications > RS485**

BAUD RATE

Range: 9600, 19200, 38400, 57600, 115200
Default: 115200

PARITY

Range: None, Odd, Even
Default: None

PORT PROTOCOL

Range: Modbus, DNP 3.0, IEC 60870-5-103
Default: Modbus

WiFi

WiFi refers to Wireless Local Area Networks (WLANs) that are based on the 802.11 set of standards. WLANs are essentially providing Local Area Network (LAN) type of connectivity but without the need of cables, which makes them more convenient for use in limited spaces. WiFi works on top of the TCP/IP stack, the same as Ethernet. The signal strength and its range is determined by the wireless device's antenna technology and standard, the best being IEEE 802.11n.

WiFi defines two modes of operation, namely ad-hoc, used for small deployments, and infrastructure mode, which supports more robust types of security and better capabilities for centralized management. The infrastructure mode requires an access point (AP). Devices operating in this mode pass all data through the AP.

The WiFi module integrated on the 8 Series products conforms to IEEE 802.11b/g/n standards. The 8 Series devices operate in infrastructure mode. Security is optional, but enabled by default and it is advisable that it is left on, as wireless traffic is very susceptible to cyber-attacks.

The security technology used is WPA2 (Wireless Protected Access version 2), based on the IEEE 802.11i standard for data encryption. WPA2 is a second version of WPA technology, designed to solve known security limitations found in one of the encryption algorithms used by WPA, namely TKIP (Temporal Key Integrity Protocol). WPA2 uses CCMP (Counter Mode with Cipher Block Chaining Message Authentication Code Protocol), which provides an enhanced data cryptographic encapsulation mechanism based on AES (Advanced Encryption Standard). CCMP makes WPA2 much stronger and secure than its predecessors, WPA and WEP.

Several forms of WPA2 security keys exist. The 8 Series supports WPA2 PSK (Pre-Shared Key), which utilizes 64 hexadecimal digits. The key may actually be entered as a string of 64 hexadecimal digits or as a passphrase of 8 to 32 printable ASCII characters. For user convenience, the settings accept the key in the form of a passphrase. Internally the ASCII passphrase is used for deriving a 256-bit key.

The following are the WiFi network settings for the 8 Series product. Only an Administrator has the rights to change them.

Path: Setpoints > Device > Communications > WiFi

WiFi Enable

This setting switches WiFi functionality on/off. By default WiFi is enabled in the basic offering, but it is disabled in software options that offer CyberSentry.

WiFi IP Address / Subnet Mask

The default IP address is 192.168.0.x, where x is calculated as:

X = (modulo 242 of the last 3 digits of the serial number) + 12
Example: A unit has a serial number of MJ3A16000405, the default IP address would be 192.168.0.175 (where 405 mod 242 = 163 + 12 = 175).

This is to ensure uniqueness of the default IP address for all 8 Series devices present on one wireless network and it creates a usable address space from 192.168.0.12 to 192.168.0.253 for 8 Series devices.

NOTE

From the remaining range of unicast addresses 192.168.0.1 to 192.168.0.253, at least two are going to be used for the AP and a laptop installed with the EnerVista software, which will be used to configure the 8 Series devices. The AP should be configured with the address 192.168.0.1 and mask 255.255.255.0 and have DHCP enabled with a DHCP range from 192.168.0.2 to 192.168.0.253. This allows laptops, iPads and any other devices to connect to the local network without the need to statically configure their own IP address and mask.

WiFi GWY IP Address

The setting specifies the address of the access point AP which the 8 Series device uses for communicating over WiFi.

WiFi Security

The setting enables WiFi security. If set to "None", there is no security and all traffic is open. By default WiFi Security is set to WPA2-PSK.

WiFi SSID

The SSID is the public name of a wireless network. All of the wireless devices on a WLAN must use the same SSID in order to communicate with each other. The default for the SSID is provided by the vendor with the shipment of any new 8 Series device. It is recommended that the customer modifies this name as needed after initial startup, to ensure unique SSIDs if several WLANs are configured.

NOTE

SSID broadcast should be disabled on AP. This provides some extra protection by requiring an SSID before connecting to the device and making it harder for casual outsiders looking for wireless networks to find the device and attempt to connect.

WiFi WPA2 Passphrase

The WPA2 Passphrase is used for generating the encryption key. The same passphrase must be set on AP and on all devices communicating on the same WLAN. The 8 Series device supports a string of up to 14 printable ASCII characters. Internally a 256-bit key is calculated by applying the PBKDF2 key derivation function to this passphrase, using the SSID as the salt and 4096 iterations of HMAC-SHA1.

The 8 Series devices are configured with a default passphrase, which is provided by the vendor with the shipment of any new 8 Series device.

When choosing a new passphrase, the password complexity rules of CyberSentry must be used (see CyberSentry details in the relay Instruction manual).

This field is visible only if the security is set to WPA2-PSK.

NOTE

Ideally the passphrase should be set through EnerVista and not directly from the Keypad, where there are limitations in terms of space and types of characters supported. However, for convenience, the passcode setting is available from the Keypad as well.

WiFi Status

A WiFi symbol is displayed in the caption area of the 8 Series product front panel. The following table lists all possibilities for this icon:

WiFi State	WiFi Icon Color
Disabled	Icon is grey and crossed by a red line
Disconnected	Grey
Connecting	Yellow
Connected	Green

WiFi Events

Event	Description
WiFi Connected	This event is recorded to indicate a network connect.
WiFi Disconnected	This event is recorded to indicate a network disconnect.

NOTE

If the relay is in service mode and the settings are default a minor error is triggered.

WiFi Quick Start Procedure

The following provides the settings information and instructions to quickly setup WiFi.

Required Equipment

- 8 Series Relay with WiFi functionality
- PC with WiFi
- Access Point

Quick Start Procedure

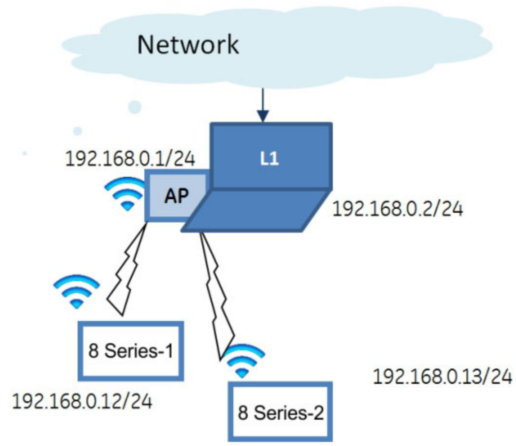
1. The PC WiFi Network Settings are as follows:
   Passphrase: provided with the 8 Series relay
2. The Access Point Settings are given below:

IP address:	192.168.0.1
Subnet Mask:	255.255.255.0
SSID:	same as entered on the PC (SSID provided with the 8 Series relay)
Broadcast	disabled
Security type:	WPA2-PSK (WPA2-Personal)
Encryption:	AES
Passphrase:	same as entered on the PC (Passphrase provided with the 8 Series relay)
DHCP enabled	range of 192.168.0.12 to 192.168.0.253

3. Any 8 Series relays in range are automatically connect to the configured Access Point.
4. Start EnerVista on a PC and use the Discover function, all relays within range appear and are populated in EnerVista for initial configuration and commissioning.

5. Once the relay is configured, change the 8 Series relay default WiFi SSID and Passphrase settings before the relay goes into service.

Figure 5-6: Example of WiFi Deployment



USB

The USB parameters are as follows:

IP Address: 172.16.0.2

IP Subnet Mask: 255.255.255.0

IP GWY IP Address: 172.16.0.1

NOTICE Whenever the device is rebooted, the USB cable needs to be unplugged and plugged in again for proper communication to be established over USB.

NOTICE Connecting multiple 8 Series relays over USB to a single PC is not possible because in the case of USB, the IP address of the device 172.16.0.2 is constant.

Ethernet Ports

The following communication offerings are available.

Base Offering

Modes: 10/100 Mbps

One Port: RJ45

Protocol: Modbus TCP

Communications Card Option "C" - 2x Copper (RJ45) Ports

Modes: 10/100 MB

Two Ports: RJ45 (with this option both enabled ports are on the communications card; the Ethernet port located on the base CPU is disabled)

Protocols: Modbus TCP, DNP 3.0, IEC 60870-5-104, IEC 61850 GOOSE, IEEE 1588, SNTP, IEC 62439-3 clause 4 (PRP)

Communications Card Option "S" - 2x ST Fiber Ports

Modes: 100 MB

Two Ports: ST (with this option both enabled ports are on the communications card; the Ethernet port located on the base CPU is disabled)

Protocols: Modbus TCP, DNP 3.0, IEC 60870-5-104, IEC 61850 GOOSE, IEEE 1588, SNTP, IEC 62439-3 clause 4 (PRP)

Wavelength: 1310 nm

Typical link distance: 4 km

Network Settings Menu

The following are the network settings menu of the 845 to accommodate the features of the 845 product. If the communications card is installed network port 1 is no longer available. When using more than one Ethernet port, configure each to belong to a different network or subnet using the IP addresses and mask, else communication becomes unpredictable when more than one port is configured to the same subnet.

NOTE

The softkeys and Down/Up key can be used to enter an IP address. When entering an IP address you must press the “Back” key first to switch between softkey mode and the Down/Up key mode.

NETWORK 1, 4, 5, PRT1(4,5) IP ADDRESS

Range: Standard IPV4 Address format
Default: 169.254.3.3 (Port 1)
Default: 127.0.0.1 (Port 4, 5)

The setting sets the port’s IPV4 address in standard IPV4 format.

NOTE

The setting is valid on port 1 if the optional communications card is not present.

The setting is valid on port 5 if port 4’s OPERATION is set to INDEPENDENT.

PRT1(4,5) SUBNET IP MASK

Range: Standard IPV4 mask format
Default: 255.255.255.0 (Port 1)
Default: 0.0.0.0 (Port 4, 5)

This setting specifies the IPv4 mask associated with the corresponding port IP address.

PRT1 GWY ADDRESS

This setting sets the ports IPv4 GATEWAY address in standard IPv4 format.

This setting is only valid on port 1.

This setting is not present on port 4 and 5, which are available on the communications card.

NOTE

The communications card comes with the capability of setting a number of static routes and one default route, which is used instead of default gateways.

Notes:

- The fiber optic ports support only 100 Mbps.
- Changes to the Ethernet communications settings take effect only after rebooting the relay.
- All Ethernet ports have flex operands associated with them. A failure of one of the Ethernet ports will trigger an event, a target message and the corresponding operand set.

PRT4 OPERATION

Range: Independent, LLA, PRP

Default: Independent

This setting determines the mode of operation for ports 4 and 5: INDEPENDENT, LLA or PRP.

INDEPENDENT operation: ports 4 and 5 operate independently with their own MAC and IP address.

LLA operation: the operation of ports 4 and 5 are as follows:

Ports 4 and 5 use port 4's MAC and IP address settings while port 5 is in standby mode in that it does not actively communicate on the Ethernet network but monitors its link. If Port 4 is active and the link loss problem is detected, communications is switched to Port 5 immediately. Port 5 is, in effect, acting as a redundant or backup link to the network for port 4.

LLA (Link Loss Alert) is a proprietary feature supported by the 8 Series relay fiber optic ports. When enabled on an 8 Series fiber optic port, this feature is able to detect a failure of the fiber link. If port 4's OPERATION is set to LLA, the detection of a link failure by this feature triggers the transfer of communications from port 4 to port 5. If LLA is enabled on a port with a non-fiber SFP, the target message "LLA not supported by Prt (4 or 5)" is displayed on the keypad and an event is logged.

PRP (Parallel Redundancy Protocol) operation: ports 4 and 5 use the same MAC address and combine information at the link layer. It is intended to only be used if the two ports are connected to separate parallel LAN's. In this mode of operation both ports cannot be connected to the same LAN. The receiving devices (845) process the first frame received and discard the duplicate through a link redundancy entity (LRE) or similar service that operates below layer 2. Aside from LRE, PRP uses conventional Ethernet hardware but both ports must know they are in PRP. Ports of PRP devices operating with the same Internet Protocol (IP) addresses for traffic that uses IP Management protocols such as Address Resolution Protocol (ARP) must operate correctly.

Duplicate Discard mode (only mode supported by the 8 Series). This is the normal setting for PRP operation and once set it allows the sender LRE to append a six-octet field that contains a sequence number, the Redundancy Control Trailer (RCT) to both frames it sends. The receiver LRE uses the sequence number of the RCT and the source MAC address to detect duplicates. It forwards only the first frame of a pair to its upper layers.

Routing

When the configuration card is present, a default route and a maximum number of 6 static routes can be configured. The default route is used as the last choice, if no other route towards a given destination is found.

Path: Setpoints > Device > Communications > Routing > Default Route

GATEWAY ADDRESS

Range: Standard IPV4 unicast address format (0.0.0.1 to 223.255.255.254)

Default: 127.0.0.1

This setting sets the gateway of the default route to be used by IP traffic sent from the relay, if no other route towards a given IP destination is found.

This setting is available only if the communications card is present.

Path: Setpoints > Device > Communications > Routing > Static RT1 (2 to 6)

RT1 (2,3,4,5,6) DESTINATION

Range: Standard IPV4 network address format (0.0.0.1 to 223.255.255.254)

Default: 127.0.0.1

This setting sets the destination IPv4 route. This setting is available only if the communications card is present.

RT1 (2,3,4,5,6) MASK

Range: Standard IPV4 network mask format

Default: 255.0.0.0

This setting sets the IP mask associated with the route. This setting is available only if the communications card is present.

RT1 (2,3,4,5,6) GATEWAY

Range: Standard IPV4 unicast address format (0.0.0.1 to 223.255.255.254)

Default: 127.0.0.1

This setting sets the destination IP route. This setting is available only if the communications card is present.

ADDING AND DELETING STATIC ROUTES

Defaults:

Rule #1.
By default, the value of the destination field is 127.0.0.1 for all static routes (1 to 6). This is equivalent to saying that the static routes are not configured. When the destination address is 127.0.0.1, the mask and gateway must also be kept as default values.Rule #2.
By default, the value of the default route gateway address is 127.0.0.1. This means the default route is not configured.

Adding a route:

Rule #3.
Use any of the static network route entries numbered 1 to 6 to configure a static network route. Once a route destination is configured for any of the entries 1 to 6, that entry becomes a static route and it must meet all the rules listed in the following section under "Important Notes".

Rule #4.
To configure the default route, enter a default gateway address. A default gateway address configured must be validated against Rule #5, the next rule.

Deleting a route:

Rule #5.
Routes are deleted by replacing the route destination with the default address (127.0.0.1). When deleting a route, the mask and gateway must also be put back to their default values.

Rule #6.
The default route is deleted by replacing the default gateway with the default value 127.0.0.1.

Important Notes:

1. Host routes are not supported at present.
2. The route mask has IPv4 mask format. In binary this is a set of contiguous bits of 1 from left to right, followed by one or more contiguous bits of 0.
3. The route destination and mask must match.
4. Item #3, above, can be verified by checking that RtDestination & RtMask == RtDestination
5. This is an example of a good configuration: RtDestination= 10.1.1.0; Rt Mask= 255.255.255.0
6. This is an example of a bad configuration: RtDestination = 10.1.1.1; Rt Mask= 255.255.255.0
7. The route destination must not be a connected network.
8. The route gateway must be on a connected network. This rule applies to the gateway address of the default route as well.

9. Item #8, above, can be verified by checking that:
   RtGwy & Prt4Mask) == (Prt4IP & Prt4Mask) || (RtGwy & Prt5Mask) == (Prt5IP & Prt5Mask)

TARGETS

WRONG ROUTE CONFIG

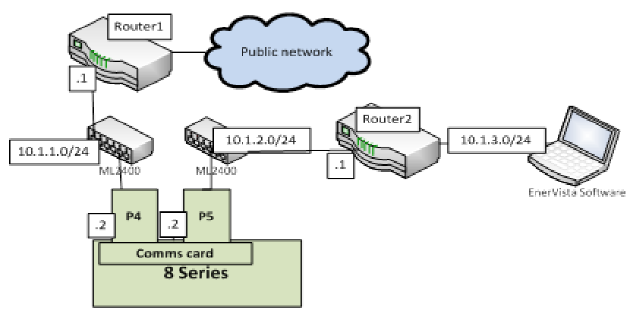
Description: A route with mismatched destination and mask has been configured.

Message: "Wrong route configuration.

"What to do: Rectify the IP address and mask of the mis-configured route.

TOPOLOGY EXAMPLE

Figure 5-7: Topology Example



In the above figure: Topology Example, the 8 Series device is connected through the two Ethernet ports available on the communications card.

- Port 4 (IP address 10.1.1.2) connects to LAN 10.1.1.0/24 and to the Internet through Router1. Router 1 has an interface on 10.1.1.0/24 and the IP address of this interface is 10.1.1.1.
- Port 5 (IP address 10.1.2.2) connects to LAN 10.1.2.0/24 and to EnerVista setup program through Router 2. Router 2 has an interface on 10.1.2.0/24 and the IP address of this interface is 10.1.2.1.

Configuration

Network addresses:

PRT54IP ADDRESS = 10.1.1.2PRT4 SUBNET IP MASK = 255.255.255.0PRT5 IP ADDRESS = 10.1.2.2PRT5 SUBNET IP MASK = 255.255.255.0

Routing Settings:

IPV4 DEFAULT ROUTE: GATEWAY ADDRESS = 10.1.1.1

STATIC NETWORK ROUTE 1:

- RT1 DESTINATION = 10.1.3.0/24RT1 NET MASK = 255.255.255.0RT1 GATEWAY = 10.1.2.1

Behavior: One static network route was added to the destination 10.1.3.0/24, where a laptop running EnerVista is located. This static route uses a different gateway (10.1.2.1) than the default route. This gateway is the address of Router 2, which is "aware" of destination 10.1.3.0 and is able to route packets coming from the 8 Series device and destined to EnerVista.

DNP Protocol

Path: Setpoints > Device > Communications > DNP protocol

DNP Channel 1(2) Port

Range: NONE, NETWORK - TCP, NETWORK - UDP

Default: NONE

The **DNP Channel 1 Port** and **DNP Channel 2 Port** settings select the communications port assigned to the DNP protocol for each channel. 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.

DNP Address

Range: 0 to 65519 in steps of 1

Default: 65519

The DNP address sets the DNP slave address. This number identifies the 845 on a DNP communications link. Each DNP slave must be assigned a unique address.

DNP Client Address 1(2)

Range: standard IP address

Default: 0.0.0.0

The DNP Client Address settings can force the 845 to respond to a maximum of two specific DNP masters.

DNP TCP/UDP Port 1(2)

Range: 1 to 65535 in steps of 1

Default: 2000

NOTE

"DNP Channel 1 Port" will take the "**DNP TCP/UDP Port 1**" and "**DNP Client Address 1**" to allow/reject connections. The same relation is used by channel 2.

DNP Unsol Resp Function

Range: Enabled, Disabled

Default: Disabled

This setting will take effect for Ethernet communication only if the main card is present or a comms card is available in the device. This setting enables/disables the unsolicited response functionality. It is disabled for RS485 applications since there is no collision avoidance mechanism.

DNP Unsol Resp Timeout

Range: 0 to 60 s in steps of 1

Default: 5 s

Sets the time the 845 waits for a DNP master to confirm an unsolicited response.

Unsol Resp Max Retries

Range: 1 to 255 in steps of 1

Default: 10

Sets the number of times the 845 retransmits an unsolicited response without receiving confirmation from the master; a value of "255" allows infinite re-tries.

DNP Unsol Resp Dest Addr

Range: 1 to 65519 in steps of 1

Default: 1

Sets the DNP address to which all unsolicited responses are sent. The IP address to which unsolicited responses are sent is determined by the 845 from the current TCP connection or the most recent UDP message.

DNP Time Sync IIN Period

Range: 1 to 10080 min. in steps of 1

Default: 1440 min

This setting determines how often the Need Time Internal Indication (IIN) bit is set by the 845. Changing this time allows the DNP master to send time synchronization commands more or less often, as required.

NOTE

If the requirement for synchronization is more than a couple of seconds, consider synchronization via other means such as IRIGB or 1588. Given network asymmetry, the consistency of the network latency, clock drift, and additional delays due to routers located between the client and the 845 all contribute error.

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(32) Default Variation

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

TCP Connection Timeout

Range: 10 to 300 s in steps of 1

Default: 120 s

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 will be aborted by the 845. This frees up the connection to be re-used by a client.

DNP / IEC104 Point Lists

The menu path for the DNP/IEC104 point lists is shown below.

Path: **Setpoints > Device > Communications > DNP/IEC104 Point Lists**

Binary Input / MSP Points
Analog Input / MME Points
Binary Outp / CSC / CDC Pnts

Binary input points (DNP) or MSP points (IEC 60870-5-104)

The binary inputs points for the DNP protocol, or the MSP points for IEC 60870-5-104 protocol, can be configured to a maximum of 96 points. The data source for each point is user-programmable and can be configured by assigning FlexLogic operands. For a complete list, see Format Code FC142.

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

Path: **Setpoints > Device > Communications > DNP/IEC104 Point Lists > Binary Input/MSP Points**

Point 0 Entry
...
Point 255 Entry

Analog input points (DNP) or MME points (IEC 60870-5-104)

Up to 255 analog input points can be configured for the DNP or IEC 60870-5-104 protocols. The menu path for the analog input point (DNP) or MME points (IEC 60870-5-104) is shown below.

Path: Setpoints > Device > Communications > DNP/IEC104 Point Lists > Analog Input / MME Points

Analog IP Point 0 Entry
Point 0 Scale Factor
Point 0 Deadband

DNP ANALOG INPUT POINT 0(255) SCALE FACTOR

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

Default: /1

These are numbers used to scale analog input point values. Each setting represents the scale factor for the analog input point. For example, if the DNP PHASE A VOLTAGE SCALE FACTOR setting is set to "/ 1000", and the Phase A voltage is 72000 V, the Phase A voltage sent on to the 845 is 72 V. The settings are useful when analog input values must be adjusted to fit within certain ranges in DNP masters.

NOTICE

Note that a scale factor of "/ 0.1" is equivalent to a multiplier of 10.

DNP ANALOG INPUT POINT 0(255) DEADBAND

Range: 1 to 100000000 in steps of 1

Default: 30000

The setting is the threshold value to define the condition to trigger unsolicited responses containing analog input data. Each setting represents the default deadband value for the associated analog input. For example, to trigger unsolicited responses from the 845 when phase A current changes by 15 A, the DNP CURRENT DEADBAND for Phase A current should be set to "15". Note that these settings are the deadband default values. DNP object 34 points can be used to change deadband values from the default for each individual DNP analog input point. Whenever power is removed and re-applied to the 845 the new deadbands are in effect.

Binary output points (DNP) or CSC/CDC points (IEC 60870-5-104)

The binary output points for the DNP protocol, or the CSC/CDC points for IEC 60870-5-104 protocol, can be configured to a maximum of 16 points. The data source for each point is user-programmable and can be configured by assigning FlexLogic operands. The menu path for the binary output points (DNP) or CSC/CDC points (IEC 60870-5-104) is shown below.

Path: Setpoints > Device > Communications > DNP/IEC104 Point Lists > Binary Output / CSC/CDC Points

Binary Output Point 0 ON
Binary Output Point 0 OFF
...
Binary Output Point 31 ON
Binary Output Point 31 OFF

NOTICE

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

BINARY INPUT POINTS

The DNP binary input data points are configured through the **DNP / IEC104 POINT LISTS BINARY INPUT / MSP POINTS** menu. When a freeze function is performed on a binary counter point, the frozen value is available in the corresponding frozen counter point.

BINARY INPUT POINTS

Static (Steady-State) Object Number: **1**
Change Event Object Number: **2**
Request Function Codes supported: **1 (read), 22 (assign class)**

Static Variation reported when variation 0 requested: **2 (Binary Input with status), Configurable**

Change Event Variation reported when variation 0 requested: **2 (Binary Input Change with Time), Configurable**

Change Event Scan Rate: **8 times per power system cycle**

Change Event Buffer Size: **1024**

Default Class for All Points: **1**

POINT NAME/DESCRIPTION COUNTERS

The following details lists both Binary Counters (Object 20) and Frozen Counters (Object 21). When a freeze function is performed on a Binary Counter point, the frozen value is available in the corresponding Frozen Counter point. 845 Digital Counter values are represented as 16 or 32-bit integers. The DNP 3.0 protocol defines counters to be unsigned integers. Care should be taken when interpreting negative counter values.

BINARY COUNTERS

Static (Steady-State) Object Number: **20**

Change Event Object Number: **22**

Request Function Codes supported: **1 (read), 7 (freeze), 8 (freeze noack), 9 (freeze and clear), 10 (freeze and clear, noack), 22 (assign class)**

Static Variation reported when variation 0 requested: **1 (32-Bit Binary Counter with Flag)**

Change Event Variation reported when variation 0 requested: **1 (32-Bit Counter Change Event without time)**

Change Event Buffer Size: **10**

Default Class for all points: **3**

FROZEN COUNTERS

Static (Steady-State) Object Number: **21**

Change Event Object Number: **23**

Request Function Codes supported: **1 (read)**

Static Variation reported when variation 0 requested: **1 (32-Bit Frozen Counter with Flag)**

Change Event Variation reported when variation 0 requested: **1 (32-Bit Counter Change Event without time)**

Change Event Buffer Size: **10**

Default Class for all points: **3**

BINARY AND FROZEN COUNTERS POINT INDEX NAME/DESCRIPTION

0 Digital Counter 1
1 Digital Counter 2
2 Digital Counter 3
3 Digital Counter 4
4 Digital Counter 5
5 Digital Counter 6
6 Digital Counter 7
7 Digital Counter 8
8 Digital Counter 9
9 Digital Counter 10
10 Digital Counter 11
11 Digital Counter 12
12 Digital Counter 13
13 Digital Counter 14

14 Digital Counter 15
15 Digital Counter 16

ANALOG INPUTS

It is important to note that 16-bit and 32-bit variations of analog inputs are transmitted through DNP as signed numbers. Even for analog input points that are not valid as negative values, the maximum positive representation is 32767 for 16-bit values and 2147483647 for 32-bit values. This is a DNP requirement. The deadbands for all Analog Input points are in the same units as the Analog Input quantity. For example, an Analog Input quantity measured in volts has a corresponding deadband in units of volts. Relay settings are available to set default deadband values according to data type. Deadbands for individual Analog Input Points can be set using DNP Object 34.

NOTICE

1. A default variation refers to the variation response when variation 0 is requested and/or in class 0, 1, 2, or 3 scans. The default variations for object types 1, 2, 20, 21, 22, 23, 30, and 32 are selected via relay settings. This optimizes the class 0 poll data size.
2. For static (non-change-event) objects, qualifiers 17 or 28 are only responded when a request is sent with qualifiers 17 or 28, respectively. Otherwise, static object requests sent with qualifiers 00, 01, 06, 07, or 08, are responded with qualifiers 00 or 01. For change event objects, qualifiers 17 or 28 are always responded.

Cold restarts are implemented the same as warm restarts – the 845 is not restarted, but the DNP process is restarted.

IEC 60870-5-104

The IEC 60870-5-104 communications protocol is supported on Ethernet ports 4 and 5 only. Setting changes become active after rebooting.

NOTICE

In 845 both DNP and IEC104 protocol can work at the same time, but consider that there is only one point map. So, the two protocols use the same data mapping, i.e., same point index and same point source.

NOTICE

The 845 supports up to two IEC104 client connections simultaneously.

Path: **Setpoints > Device > Communications > IEC 60870-5-104**

Channel 1 Port
Channel 2 Port
Common Address of ASDU
Client Address 1
Client Address 2
TCP Port Number 1
TCP Port Number 2
Cyclic Data Period
Object Info Addrs Bnry
Object Info Addrs Analog
Object Info Addrs Countrs
Object Info Addrs Cmnd
Object Info Analog Param

By default the Object Information Address for the different data is as follows:

M_SP (Single Points) = 1000
M_ME (Measured value) = 2000
M_IT (Integrated Totals) = 3000
C_SC or C_DC (Single or Double Command) = 4000
P_ME_NB (Parameter of measured value) = 5000

Each Measured value has a Parameter of measured value (P_ME_NB) associated to its threshold.

The IEC 60870-5-104 Deadbands settings are used to determine when to trigger spontaneous responses containing M_ME_NB_1 analog data. Each setting represents the threshold value for each M_ME_NB_1 analog point.

For example, to trigger spontaneous responses from the 845 when a current value changes by 15 A, the "Analog Point xx Deadband" setting should be set to 15. Note that these settings are the default values of the deadbands. P_ME_NB_1 (parameter of measured value, scaled value) points can be used to change threshold values, from the default, for each individual M_ME_NB_1 analog point. There are three ways to send the measurands to the Master station. The measurands are part of the General Group and Group 2, so when a general interrogation or group 2 interrogation takes place all the measurands are included in the response. Also, there is a cyclic data period setting where it is configured in the scan period to send the measurands to the Master. And the last way, is by sending spontaneously when a deadband overflow takes place. The IEC104 Channels sub-menu information is shown below.

Commands are executed over the Binary Outputs. The first 8 Binary Outputs are configured to receive Select/Operate Commands and the next 8 Binary Outputs are configured to receive Direct Execute Commands.

The **IEC104 CHANNEL 1 PORT** and **IEC104 CHANNEL 2 PORT** settings select the communications port assigned to the IEC104 protocol for each channel. When this setting is set to "Network - TCP", the IEC104 protocol can be used over TCP/IP on channels 1 or 2. The **IEC104 NETWORK CLIENT ADDRESS** settings can force the 845 to respond to a maximum of two specific IEC104 masters which own the configured IP Addresses. The settings in this sub-menu are shown below.

NOTICE

"IEC104 Channel 1 Port" takes the "Port Number 1" and "Client Address 1" to allow or reject connections. The same method is used by channel 2.

GROUPS OF DATA

The data is organized into groups in order to provide values when the controlling station requests them by a general or group interrogation.

Group 1 is set by the 96 Single Points (M_SP).
Group 2 is set by the 32 Measured values (M_ME).
Group 3 is set by the 32 Measured thresholds (P_ME).

These 96 Single Points and 32 Measured Values are also sent as a response to a General Interrogation.

The Integrated Totals (M_IT) has its own Counter Group 1, and it is sent as a response to a General Request Counter.

IEC 60870-5-103

The point map for the 103 is different from the one shared by the IEC104 and DNP protocols. IEC 60870-5-103 serial communications protocol is supported on the rear RS485 port only.

The DNP, IEC 103 and Modbus cannot be enabled simultaneously. Only one instance of DNP 3.0, IEC 103 or Modbus can run on the RS485 serial port.

PATH: SETPOINTS > DEVICE > COMMUNICATIONS > IEC 60870-5-103 PROTOCOL

IEC103 Common ASDU Addrs

Range: 0 to 254 in steps of 1
Default: 0

IEC103 Sync Timeout

Range: 0 to 1440 minutes in steps of 1 min
Default: 0 min

All binary inputs are configured from FlexLogic operands. For a complete list, see Format Code FC142.

NOTICE

Pay attention when configuring the function type and information number of the different points, because they must be unique. There is no mechanism in the EnerVista 8 Series Setup software or the front panel HMI to detect duplication of the information index.

NOTICE

The IEC 60870-5-103 point lists always begin with point 0 and end at the first “Off” value. Since IEC 60870-5-103 point lists must be in one continuous block, any points assigned after the first “Off” point are ignored.

IEC 61850

The optional communications processor supports both the IEC61850 GOOSE and IEC 61850 MMS Server service as per IEC 61850 standard Ed. 2. The GOOSE messaging service provides the 845 unit the ability to Publish/Subscribe Digital Input and other element statuses and its Quality and Timestamp to/from other IEDs with supporting GOOSE messaging service. Server support allows remote control center, RTU/Gateway, local HMI or other client role devices access to the relay for monitoring and control. The configuration of IEC61850 services is accomplished using the 845 configuration software, EnerVista 8 Series Setup software.

The IEC 61850 Configurator

The 845 supports the IEC 61850 protocol which is identified by order code option “**2A**” or “**2E**”.

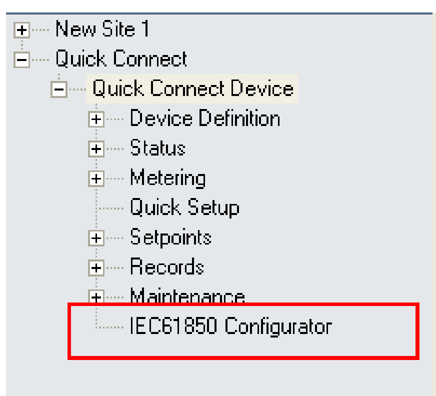
The IEC 61850 configurator is found in both the online and offline section of the EnerVista 8 Series Setup software for configuring the online 845 and offline 845 settings file respectively.

Online and Offline Setup

ONLINE SETTINGS FILE

Two options are available to configure the relay’s online settings file.

1. Configuration
   - Configure the 845 (having order code option: IEC 61850) through the Device Setup or Quick connect screen.
   - The IEC 61850 Configurator “tree” item is displayed after Maintenance. See figure below.

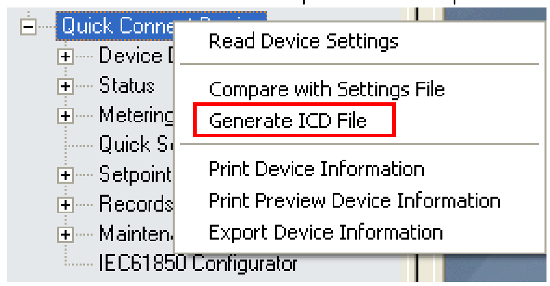


   - Launch the online IEC 61850 configurator screen, by double-clicking on the **IEC61850 Configurator** “tree” item.
   - Select the required settings from the different tab displays (in the configurator screen) to complete the IEC 61850 configuration.
2. Online right-click option

– Select any online relay and right click on the selected "tree" item. More options become available for selection, as shown in the next examples.

Example of Additional Options

Generate ICD file: The menu option generates a default ICD file with the respective order code option and saves the file to the path selected previously.



Read Device Settings: The menu option reads all the settings from the relay by TFTP and creates an 845 file with extension *.CID. The created *.CID file consists of two sections. A private section where all non IEC 61850 settings are available, and a public section in which IEC 61850 related settings are implemented.

NOTICE

When creating a CID file using a 3rd party ICT/SCL tool, ensure the following:

– The order code in the CID file must match the device order code if writing the CID file directly into the relay (without using the EnerVista software). The "Desc" value in communication settings of the CID file must match the relay's order code.

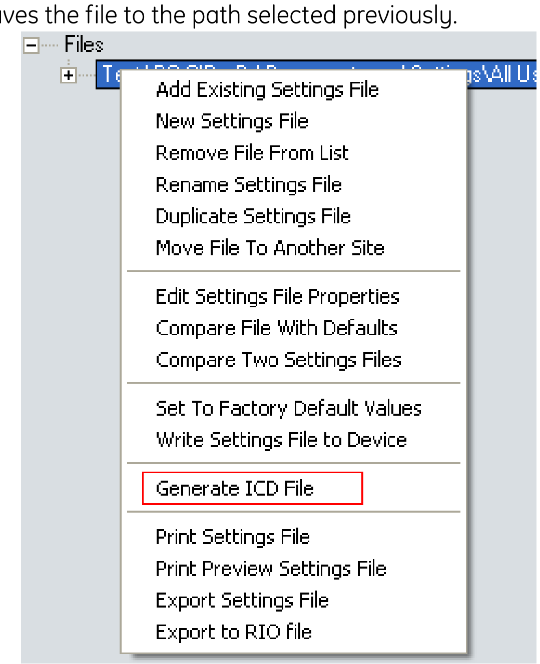
– The maximum allowed services must be equal or below the specified limits as in ICD/CID.

– Configure Datasets only in "LLN0" logical node.

– Creating new LD, LN, and communication-AP settings is not recommended.

OFFLINE SETTINGS FILE

The Generate ICD file menu option generates a default ICD file with the respective order code option and saves the file to the path selected previously.



IEC 61850 Configurator Details

The IEC61850 Configurator allows editing of all sections of the IEC61850 CID and ICD file. No other operations can be performed in the EnerVista 8 Series Setup software if the IEC 61850 Configurator is open. Close the IEC61850 session to perform other operations in the EnerVista software.

NOTICE

When the IEC 61850 configuration is saved while online, the DEVICE IN SERVICE state (Setpoints > Device > Installation) switches to "Not Ready" for the duration of the upload. This ensures that all new settings are applied before the device is operational.

The IEC 61850 configurator consists of five sections:

- ICD/CID
- Settings
- Reports
- GOOSE Reception
- GOOSE Transmission

Remote Modbus Device

The Remote Modbus Device describes a device within the same network as the 8 Series device and the poll mode of operation for retrieving the data. The 8 Series device acts as a Modbus Master and initiates Modbus requests to the Modbus slave at a defined poll interval or per trigger.

Path: Device > Communications > Remote Modbus Device > Device 1

DEVICE NAME

Range: 13 Alphanumeric Characters
Default: BSG3

The Remote Modbus Device Name defaults to the Powell BriteSpot Thermal Monitoring device (BSG3).

DEVICE PROFILE

Range: 13 Alphanumeric Characters
Default: BSG3

The Remote Modbus Device default profile is for the Powell BriteSpot Thermal Monitoring device (BSG3). The 27 analog and 27 digital operands that are available in the device are supported and are pre-configured in the default settings file. The data defined for BSG3 are described in the 8 Series Protection Relay Platform Communications guide.

Other device profiles can be configured as described in the following section.

IP ADDRESS

Range: Standard IPV4 network address format
Default: 0.0.0.0

SLAVE ADDRESS

Range: 1 to 254 in steps of 1
Default: 254

MODBUS PORT

Range: 0 to 10000 in steps of 1
Default: 502

POLL RATE

Range: OFF, 3 to 120 minutes in steps of 1
Default: 3 minutes

TRIGGER

Range: Any FlexLogic operand

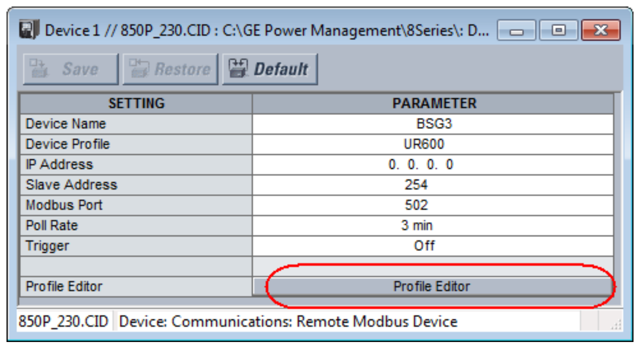
fault: Off

Remote Modbus Device Editor

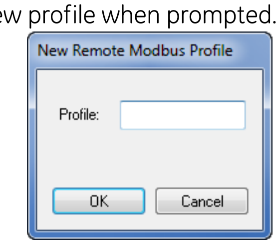
The Remote Modbus Device Editor allows customization of the generic Modbus device. Using this feature, data can be read from another device on the network. The data retrieved is mapped from Digital Points to FlexLogic operands, and from Analog Points to FlexAnalog values for use in relay logic operations.

To use the Remote Modbus Device Editor, follow these steps:

1. In the EnerVista 8 Series Setup navigate to **Device > Communications > Remote Modbus Device > Device 1.**
2. To edit or replace the default BSG3 profile, click the **Profile Editor** button.



3. If required, create a new profile and add it to the profile list by clicking **New** and entering a name for the new profile when prompted.

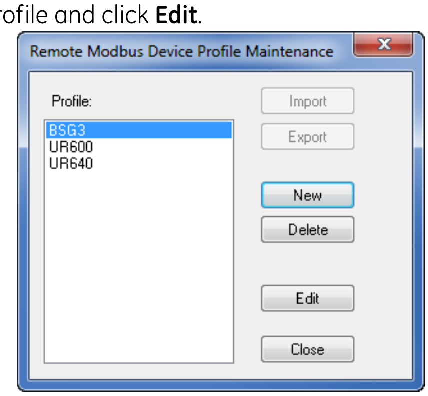


   Click **OK** to create the new profile.

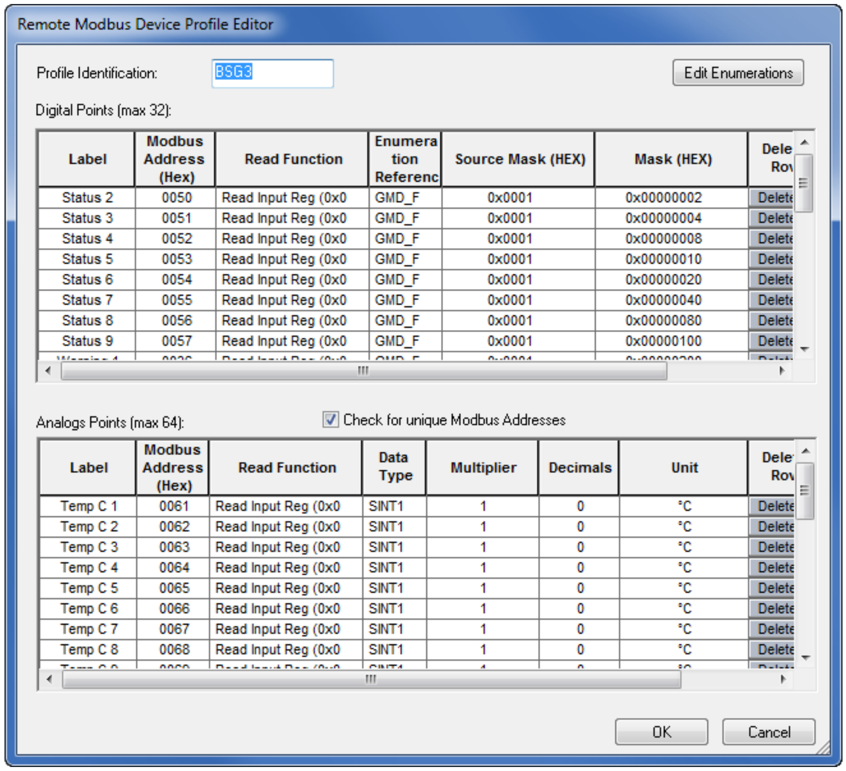
   – Profiles are stored in the directory C:\Users\Public\Documents\GE Power Management\8SeriesPC\RMD_Profiles for a default installation, or in a similar path corresponding to the EnerVista 8 Series Setup installation path.

   – Profile files have the extension .8gmd, and are XML files.

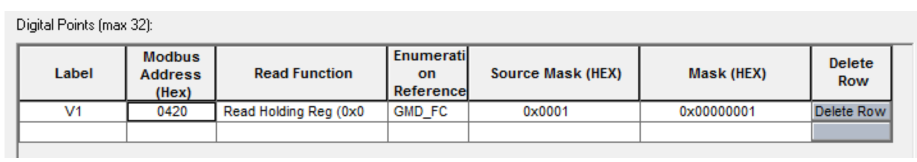
4. Select an existing profile and click **Edit**.



The profile opens in the Remote Modbus Device Profile Editor window, with all configured points listed.



5. To add a Digital Point enter a name in the **Label** column and an address in the **Modbus Address** column. The remaining columns fill with default values that can be edited as needed. Use the **Delete Row** button to delete entries.



The following fields are available for each Digital Point:

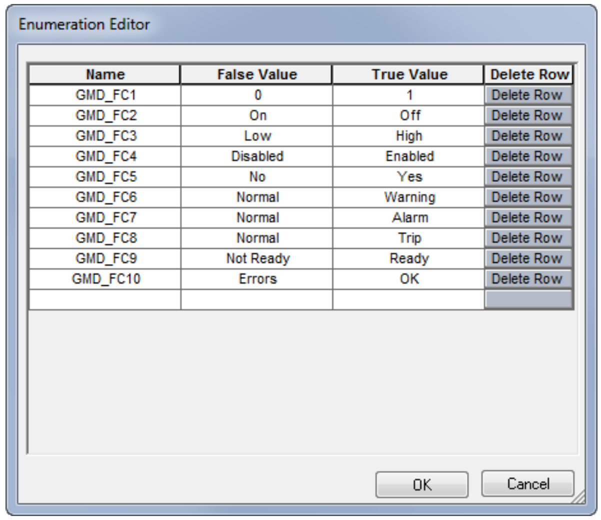
- **Label:** The name for the point, to a maximum of 13 characters
- **Modbus Address (Hex)**: The Modbus Address for the point, in hexadecimal
- **Read Function**: The Modbus function to be used for reading the point (function 3 or function 4).
- **Enumeration Reference**: Selects the enumeration to apply to this point.
- **Source Mask**: The bit from the source to use as a source for the point. For example, if the Source Mask is 16, bit 4 will be used. (Bits are numbered 0 to 15.)

```
0000   0000   0000   0000   0000   0000   0001   0000
31                          15                      0
```

- **Mask**: The specific position in a 32 bit value to pack the bit read from the source. For example, if Mask is 8198, the source bit is placed in the 13th position. (Bits are numbered from 0 to 31.)

```
0000   0000   0000   0000   0010   0000   0000   0000
31                          15                      0
```

6. To manage the enumerations used by Digital Points, click the **Edit Enumeration** button. Enumerations are used to display user-friendly text for the true/false settings of each point. A maximum of 10 enumerations are permitted.

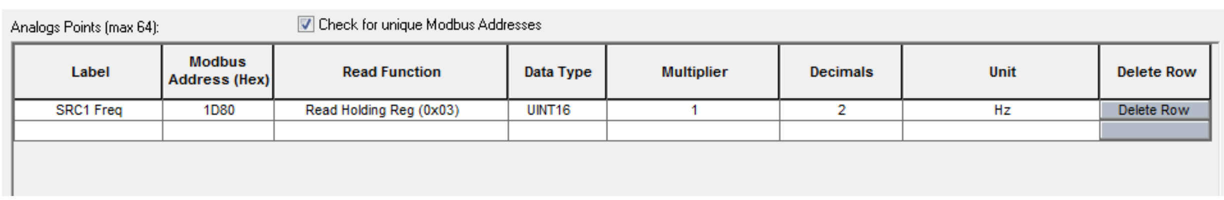


Name	False Value	True Value	Delete Row
GMD_FC1	0	1	Delete Row
GMD_FC2	On	Off	Delete Row
GMD_FC3	Low	High	Delete Row
GMD_FC4	Disabled	Enabled	Delete Row
GMD_FC5	No	Yes	Delete Row
GMD_FC6	Normal	Warning	Delete Row
GMD_FC7	Normal	Alarm	Delete Row
GMD_FC8	Normal	Trip	Delete Row
GMD_FC9	Not Ready	Ready	Delete Row
GMD_FC10	Errors	OK	Delete Row

Click each field to enter (or edit) the **Name** of the enumeration as shown in the list of Digital Points, along with the text to display for a **False Value** or a **True Value**. Use the **Delete Row** button to delete entries. All fields have a 13 character maximum.

When done, click **OK** to save changes.

7. To add an Analog Point enter a name in the **Label** column and an address in the **Modbus Address** column. The remaining columns fill with default values that can be edited as needed. Use the **Delete Row** button to delete entries.



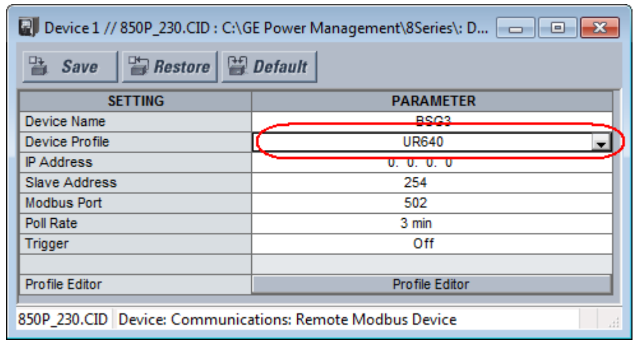
Label	Modbus Address (Hex)	Read Function	Data Type	Multiplier	Decimals	Unit	Delete Row
SRC1 Freq	1D80	Read Holding Reg (0x03)	UINT16	1	2	Hz	Delete Row

When checked, the **Check for unique Modbus Addresses** checkbox does not allow duplicate addresses.

The following fields are available for each Digital Point:

- **Label:** The name for the point, to a maximum of 13 characters
- **Modbus Address (Hex)**: The Modbus Address for the point, in hexadecimal
- **Read Function**: The Modbus function to be used for reading the point (function 3 or function 4).
- Data Type: SINT16 - Signed Integer (16-bit), UINT16 - Unsigned Integer (16-bit), SINT32 - Signed Long (32 -bit), UINT32 - Unsigned Long (32-bit), FLOAT - IEED Floating Point Number (32-bit).
- **Multiplier**: The multiplier to apply to the read data.
- **Decimals**: The number of decimal places to add to the read data. For example, a Decimal entry of 2 results in dividing the read data by 10*10=100.
- **Unit**: The units associated with this value, to a maximum of 6 characters.

8. To select a profile, navigate to **Device > Communications > Remote Modbus Device > Device 1.** Under **Device Profile,** select a profile from the drop-down list.



Click Save to save your changes. If you are working online, a new CID file will be created and sent to the relay.

NOTE

When a new CID file is uploaded, the DEVICE IN SERVICE state (Setpoints > Device > Installation) switches to "Not Ready" for the duration of the upload.

Transient Recorder

The Transient Recorder contains waveforms captured at the same sampling rate as the other relay data at the point of trigger. By default, data is captured for all AC current and voltage inputs available on the relay as ordered. Transient record is generated upon change of state of at least one of the assigned triggers: “Trigger Source”, “Trigger on Pickup”, “Trigger on Operate”, “Trigger on Alarm”, or “Trigger on Trip”.

The number of cycles captured in a single transient record varies based on the number of records, sample rate, and the number of selected channels. There is a fixed amount of data storage for the Transient Recorder: the more data captured, the less the number of cycles captured per record.

Path: Setpoints > Device > Transient Recorder

NUMBER OF RECORDS

Range: 1 to 16 in steps of 1

Default: 5

The selection from the range defines the desired number of records.

SAMPLES PER CYCLE

Range: 8/c, 16/c, 32/c, 64/c, 128/c

Default: 32/c

This setpoint provides a selection of samples-per-cycle for representing the waveform. The waveform records can be viewed using the EnerVista 8 Series Setup software.

TRIGGER MODE

Range: Overwrite, Protected

Default: Overwrite

When “Overwrite” setting is selected, the new records overwrite the old ones, meaning the relay will always keep the newest records as per the selected number of records. In “Protected” mode, the relay will keep the number of records corresponding to the selected number of records, without saving further records that are beyond the selected number of records.

TRIGGER POSITION

Range: 0 to 100% in steps of 1%

Default: 20%

This setting indicates the location of the trigger with respect to the selected length of record. For example at 20% selected trigger position, the length of each record will be split on 20% pre-trigger data, and 80% post-trigger data.

TRIGGER SOURCE:

Range: Off, Any FlexLogic operand

Default: Off

The trigger source can be any digital input: an operand from the list of FlexLogic operands, a contact input, a contact output, a virtual input or output, or a remote input or output.

TRIGGER ON ANY PICKUP

Range: On, Off

Default: Off

Selection of "On" setting enables triggering of the recorder upon pickup condition detected by any of the protection or control elements.

TRIGGER ON ANY OPERATE

Range: On, Off

Default: Off

Selection of "On" setting enables triggering of the recorder upon operate state of any of the enabled protection or control elements.

TRIGGER ON TRIP

Range: On, Off

Default: Off

Selecting the "On" setting enables triggering of the recorder when any of the protection elements configured as a "Trip" function operates, or the state of the operand assigned to operate the #1 Trip output relay changes to "high".

TRIGGER ON ALARM

Range: On, Off

Default: Off

Selecting "On" setting enables triggering of the recorder when any of the protection elements configured as "Alarm", or "Latched Alarm" function operates, or the state of the operand assigned to trigger the Alarm LED changes to "high".

DIGITAL INPUT 1 to 64

Range: Off, Any FlexLogic operand

Default: Off

ANALOG INPUT 1 to 16

Range: Off, Any FlexLogic analog parameter

Default: Off

Data Logger

The data logger samples and records up to 16 analog parameters at a configured rate. All data is stored in non-volatile memory, where the information is retained upon a relay control power loss.

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

The selection of the rate for logging data also affects the duration of recorded data. The data logger has longer duration for sampling rates at longer periods of time (i.e. "1 minute", "30 minutes", "1 hour"), as compared to sampling rates at short periods (i.e. "per cycle", or "per second").

The recorded data can be downloaded to 8 Series EnerVista program and displayed with parameters on the vertical axis and time on the horizontal axis.

NOTE

If data is not available for the entire duration of pre-trigger, the trigger position will be based on available pre-trigger.

Path: **Setpoints > Device > Data Logger**

FUNCTION

Range: Disabled, Continuous, Triggered

Default: Continuous

This setting configures the mode in which the data logger operates. When set to "Continuous", the data logger actively records any configured channels at the rate defined in the Data Logger Rate setting. The data logger is idle in this mode if no channels are configured. When set to "Triggered", the data logger begins to record any configured channels at the instance of the rising edge of the trigger (FlexLogic operand). The data logger ignores all subsequent triggers and continues to record data until the active record is full. Once the data logger is full, capturing of data stops until it is cleared.

Clear Data Logger

Once the data logger is full, a Clear Data Logger command is required to clear the data logger record, before a new record can be started. Performing the Clear Data Logger command also stops the current record and resets the data logger to be ready for the next trigger. The Clear Data Logger command is located at **Setpoints > Records > Clear Records**. The Data Logger Storage Capacity table below shows an example of the dependency of the data logger storage capacity with respect to the selected number of channels, and the selected rate (time interval) at which the logged values are taken. The Data Logger buffer space can be monitored to produce an alarm when the logged data occupies 80% of the data logger storage space. Target message, and operand "Data Logger ALRM" is generated at this time.

TRIGGER

Range: Off, Any FlexLogic operand

Default: Off

This setting selects the signal used to trigger the start of a new data logger record. Any FlexLogic operand can be used as a trigger source. The Triggered setting only applies when the Data Logger Function is set to "Triggered".

TRIGGER POSITION

Range: 0 to 50% steps of 1%

Default: 20%

This setpoint defines the percentage of buffer space that is used for recording pre-trigger samples.

RATE

Range: 1 cycle, 1 second, 30 seconds, 1 minute, 15 minutes, 30 minutes, 1 hour, 6 hours, 8 hours, 12 hours, 24 hours

Default: 1 minute

This setting selects the time interval at which the actual value is recorded.

CHANNEL 1(16) SOURCE

Range: Off, Any FlexAnalog parameter

Default: Off

This setpoint selects the metering analog value that is to be recorded in Channel 1(16) of the data log. The parameters available in a given relay are dependent on: the type of relay, the type and number of CT/VT hardware installed, and the type and number of Analog Inputs hardware installed. Upon startup, the relay automatically prepares the parameter list.

CHANNEL 1(16) MODE

Default: Sample

Range: Sample, Min, Max, Mean

This setpoint defines the type of sample to be logged in the data logger record with respect to the selected rate, i.e the time interval selected under the setpoint "Rate".

While enabled the Data Logger executes every protection pass and each of the four modes —Sample, Max, Min or Mean. The flexanalog values are updated at protection-pass rate:

In "Sample" mode the data logger records the flexanalog value updated in the first protection-pass from the time interval selected under setpoint "Rate".

In "Max" mode the data logger records the maximum protection pass value of the selected flexanalog parameter from all protection pass values from the time interval selected under setpoint "Rate".

In "Min" mode the data logger records the minimum protection pass value of the selected flexanalog parameter from all protection pass values from the time interval selected under setpoint "Rate".

In "Mean" mode, the data logger records the average value among all the values at protection-pass rate, from the time interval selected under setpoint "Rate".

The mean (average) is calculated simply using the well known ratio between the sum of all the values and their number over the time interval.

Figure 5-8: Data Logger Storage Capacity

Sampling Rate [sec]		Number of Channels	Time-Window covered			
			[sec]	[min]	[hour]	[day]
1 cycle	50Hz	1	1310.7	21.8	0.4	0.0
		8	546.1	9.1	0.2	0.0
		16	327.7	5.5	0.1	0.0
	60Hz	1	1092.3	18.2	0.3	0.0
		8	455.1	7.6	0.1	0.0
		16	273.1	4.6	0.1	0.0
1		1	65536.0	1092.3	18.2	0.8
		8	27306.0	455.1	7.6	0.3
		16	16384.0	273.1	4.6	0.2
30		1	1966080.0	32768.0	546.1	22.8
		8	819180.0	13653.0	227.6	9.5
		16	491520.0	8192.0	136.5	5.7
60		1	3932160.0	65536.0	1092.3	45.5
		8	1638360.0	27306.0	455.1	19.0
		16	983040.0	16384.0	273.1	11.4
900		1	58982400.0	983040.0	16384.0	682.7
		8	24575400.0	409590.0	6826.5	284.4
		16	14745600.0	245760.0	4096.0	170.7
1800		1	117964800.0	1966080.0	32768.0	1365.3
		8	49150800.0	819180.0	13653.0	568.9
		16	29491200.0	491520.0	8192.0	341.3
3600		1	235929600.0	3932160.0	65536.0	2730.7
		8	98301600.0	1638360.0	27306.0	1137.8
		16	58982400.0	983040.0	16384.0	682.7

Fault Reports

When enabled, this function monitors the pre-fault trigger. The pre-fault data are stored in the memory for prospective creation of the fault report on the rising edge of the pre-fault trigger. The element waits for the fault trigger as long as the pre-fault trigger is asserted, but not shorter than 1 second. When the fault trigger occurs, the fault data is stored and the complete report is created. If the fault trigger does not occur within 1 second after the pre-fault trigger drops out, the element resets and no record is created.

The user-programmable fault report contains a header with the following information:

- Relay model
- Device name
- Firmware revision
- Date and time of trigger
- Name of pre-fault trigger (FlexLogic operand)
- Name of Fault trigger (FlexLogic operand)
- Active setting group at the time of pre-fault trigger
- Active setting group at the time of fault trigger.

The fault report continues with the following information:

- All current and voltage phasors (one cycle after the fault trigger)
- Pre-fault values for all programmed analog channels (one cycle before pre-fault trigger)

- Fault values of all programmed analog channels (one cycle after the fault trigger)

Each Fault Report created can be saved as a text file using the EnerVista 8 Series Setup software. The file names are numbered sequentially to show which file is older than the other.

The trigger can be any FlexLogic operand, but in most applications it is expected to be the same operand, usually a virtual output, that is used to drive an output relay to trip a breaker. A FAULT RPT TRIG event is automatically created when the report is triggered.

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

The fault report stores data, in non-volatile memory, pertinent to an event when triggered. Each fault report is stored as a file to a maximum capacity of fifteen (15) files. A sixteenth (16th) trigger overwrites the oldest file.

The EnerVista 8 Series Setup software is required to view all captured data. The relay faceplate display can be used to view the date and time of trigger, the fault type and the distance location of the fault.

Path: **Setpoints > Device > Fault Report**

FUNCTION

Range: Disabled, Enabled
Default: Disabled

PRE-FAULT TRIGGER

Range: Off, Any FlexLogic operand
Default: Off

This setpoint specifies the FlexLogic operand to capture the pre-fault data. The rising edge of this operand stores one cycle-old data for subsequent reporting. The element waits for the fault trigger to actually create a record as long as the operand selected as PRE-FAULT TRIGGER is “On”. If the operand remains “Off” for 1 second, the element resets and no record is created.

FAULT TRIGGER

Range: Off, Any FlexLogic operand
Default: Off

This setpoint specifies the FlexLogic operand to capture the fault data. The rising edge of this operand stores the data as fault data and results in a new report. The trigger (not the pre-fault trigger) controls the date and time of the report. The distance to fault calculations are initiated by this signal.

ANALOG CHANNELS 1 to 32

These settings specify an actual value such as voltage or current magnitude, true RMS, phase angle, frequency, temperature, etc., to be stored should the report be created. Up to 32 analog channels can be configured.

Event Data

The Event Data feature stores 64 FlexAnalog quantities each time an event occurs. The relay is able to capture a maximum of 1024 records. The Event Data behaviour matches that of the Event Recorder. This is a Platform feature and a 'Basic' option so it has no dependencies.

There is no Enabling/Disabling of the feature. It is always 'ON'.

When changes are made to the Event Data settings, the Event data is cleared and the Snapshot.txt file is deleted. The Event Record remains as is and is not cleared.

Path: **Setpoints > Device > Event Data**

PARAMETER 1 to 64

Range: Off, any FlexAnalog Parameter
Default: Off

Flex States

Path: **Setpoints > Device > Flex States**

PARAMETER 1 (to 256)

Range: Off, Any FlexLogic operand
Default: Off

Front Panel

The 845 relay provides an easy to use faceplate for menu navigation using 5 navigation pushbuttons and a high quality graphical display. Conveniently located on the panel is a group of 7 pushbuttons for Up/Down value selection, Enter, Home, Escape, Help, and Reset functions. The faceplate also includes 3 programmable function pushbuttons with LEDs. Fourteen other status LEDs are available, 12 of which are programmable.

Please refer to Front Control Panel Interface.

NOTICE The USB port on the Front Panel is intended for connection to a portable PC.

Programmable LEDs

Path: **Setpoints > Device > Programmable LEDs**

LED "TRIP"

Range: Off, Any FlexLogic operand
Default: Any Trip

The setpoint requires assigning a FlexLogic operand to turn on the LED "TRIP", when triggered. This indicator always latches, and a reset command must be initiated to allow the latch to be reset.

The LED can be also triggered by the operation of a protection, control, or monitoring element with its function selected as "Trip".

LED "ALARM"

Range: Off, Any FlexLogic operand
Default: Any Alarm

The setpoint requires assigning a FlexLogic operand to turn on the LED "ALARM", when triggered. The indicator is a self-reset indicator, unless it is initiated from a protection, control, or monitoring element whose function is selected as "Latched Alarm". Resetting the Latched Alarm LED is performed by initiating a Reset command.

LED 5 (17) NAME

Range: Up to 13 alphanumeric characters

Default: LED 5

The setpoint is used to select the LED name by choosing up to 13 alphanumeric characters.

LED 5 (17) COLOR

Range: Off, Red, Green, Orange

Default: Orange

The setpoint selects the color of the LED. Three colors are available for selection: Red, Green, and Orange.

LED 5 (17) TRIGGER

Range: Off, Any FlexLogic operands

Default: Testing On

This setpoint requires the assigning of a FlexLogic operand to trigger the selected LED upon operation.

LED 5 (17) TYPE

Range: Self-reset, Latched

Default: Testing On

The setpoint defines the type of LED indication as either Self-Reset (the LED resets after the FlexLogic operand drops out), or Latched (the LED stays latched upon dropping out of the FlexLogic operand).

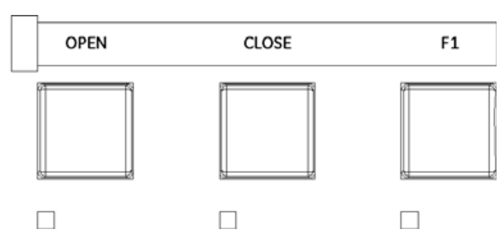
Note 1:

- **LED 1: IN-SERVICE** – non-programmable. The LED is hardcoded to show a green light when the relay is fully functional and an orange light when the relay is not programmed, or experiences a self-test error.
- **LED 2: TRIP** - see the default setpoint above and the description
- **LED 3: ALARM** - see the default setpoint above and the description
- **LED 4: PICKUP** – non-programmable. The LED is hardcoded to show a green light when at least one element has picked up.

Programmable Pushbuttons

The user-programmable pushbuttons provide an easy and error-free method of entering digital state (on, off) information. Depending on the faceplate three to ten pushbuttons are available for programming.

Figure 5-9: Programmable PBs on Front Panel



Each pushbutton asserts its own ON and OFF FlexLogic operands (for example, PUSHBUTTON 1 ON and PUSHBUTTON 1 OFF). These operands are available for each pushbutton and are used to program specific actions. Each pushbutton has an associated LED indicator. By default, this indicator displays the present status of the corresponding pushbutton (ON or OFF). This can be changed by programming the LED Trigger setting in the Programmable LED settings menu.

The activation and deactivation of user-programmable pushbuttons is dependent on whether latched or self-reset mode is programmed.

LATCHED MODE

In Latched Mode, a pushbutton can be set (activated) by directly pressing the associated front panel pushbutton. The pushbutton maintains the set state until deactivated by a Reset command or after a user-specified time delay. The state of each pushbutton is stored in non-volatile memory and maintained through loss of control power.

The pushbutton is Reset (deactivated) in Latched Mode by directly pressing the associated active front panel pushbutton. It can also be programmed to Reset automatically through the PB 1 AUTORESET and PB 1 AUTORESET DELAY settings. These settings enable the auto-reset timer and specify the associated time delay. The auto-reset timer can be used in select-before-operate (SBO) switching device control applications, where the command type (CLOSE/OPEN) must be selected prior to command execution. The selection must Reset automatically if control is not executed within a specified time period.

SELF-RESET MODE

In Self-reset mode, a pushbutton remains active for the time it is pressed (the pulse duration) plus the Dropout time specified in the PUSHBTN 1 DROPOUT TIME setting. The pushbutton is Reset (deactivated) in Self-reset mode when the dropout delay specified in the PUSHBTN 1 DROPOUT TIME setting expires.The pulse duration of the 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 may cause transient assertion of the operating signals.

The operation of each user-programmable pushbutton can be inhibited through the PUSHBTN 1 LOCK setting. If locking is applied, the pushbutton ignores the commands executed through the front panel pushbuttons. The locking functions are not applied to the auto-reset 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 accidental pressing of the front panel pushbuttons.

Pushbutton states can be logged by the Event Recorder and displayed as Target Messages. In latched mode, user-defined messages can also be associated with each pushbutton and displayed when the pushbutton is ON or changing to OFF.

Path: **Setpoints > Device > Programmable PBs > Pushbutton 1(X)**

FUNCTION

Range: Self-reset, Latched, Disabled

Default: Self-reset

This setting selects the characteristic of the pushbutton. If set to "Disabled" the pushbutton is not active and the corresponding FlexLogic operands (both ON and OFF) 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 being physically pressed.

When in **Self-reset** mode and activated locally, the pushbutton control logic asserts the ON corresponding FlexLogic operand as long as the pushbutton is being physically pressed, and after being released the deactivation of the operand is delayed by the PUSHBTN 1 DROPOUT TIME setting. The OFF operand is asserted when the pushbutton element is deactivated.

If set to **Latched** the control logic alternates the state of the corresponding FlexLogic operand between ON and OFF on each button press or by virtually activating the pushbutton (assigning Set and Reset operands). When in **Latched** mode, the states of the FlexLogic operands are stored in a non-volatile memory. Should the power supply be lost, the correct state of the pushbutton is retained upon subsequent power-up of the relay.

ID TEXT

Range: Up to 13 alphanumeric characters
Default: Open (PB1), Close (PB2), F1 (PB3), Gnd Trip Enabled (PB4), SCADA Enabled (PB5), Hot Line Tag (PB6), Demand Reset (PB7), Alt Settings (PB8), Target Reset (PB9), PB Block (PB10)

This setting specifies the 13-character line of the user-programmable message and is intended to provide the ID information of the pushbutton.

ON TEXT

Range: Up to 13 alphanumeric characters
Default: PB1 On (or PB[X] On)

This setting specifies the 13-character line of the user-programmable message and is displayed when the pushbutton is in the "ON" position. Refer to the *Working with Graphical Display Pages* section for instructions on entering alphanumeric characters from the keypad.

OFF TEXT

Range: Up to 13 alphanumeric characters
Default: PB1 Off (or PB[X] On)

This setting specifies the 13-character line of the user-programmable message and is displayed when the pushbutton is activated from the "ON" to the "OFF" position and the PUSHBUTTON 1 FUNCTION is "Latched". This message is not displayed when the PUSHBUTTON 1 FUNCTION is "Self-reset" as the pushbutton operand status is implied to be "OFF" upon its release. The length of the "OFF" message is configured with the PRODUCT SETUP/DISPLAY PROPERTIES/FLASH MESSAGE TIME setting.

The message programmed in the PUSHBTN 1 ID and PUSHBTN 1 ON TEXT settings will be displayed as long as PUSHBUTTON 1 ON operand is asserted, but not longer than the time period specified by the FLASH MESSAGE TIME setting. After the flash time has expired, the default message or other active target message is displayed. The instantaneous Reset of the flash message will be executed if any relay front panel button is pressed or if any new target or message becomes active.

The PUSHBTN 1 OFF TEXT setting is linked to PUSHBUTTON 1 OFF operand and will be displayed in conjunction with PUSHBTN 1 ID only if the pushbutton element is in "Latched" mode.

HOLD PRESSED

Range: 0.0 to 10.0 s in steps of 0.1 s
Default: 0.1 s

This setting specifies the time required for a pushbutton to be pressed before it is deemed active.

The timer is Reset upon release of the pushbutton. Note that any pushbutton operation will require the pushbutton to be pressed a minimum of 60 ms. This minimum time is required prior to activating the pushbutton hold timer.

AUTORESET

Range: Disabled, Enabled
Default: Disabled

This setting enables the user-programmable pushbutton Autoreset feature. The setting is applicable only if the pushbutton is in "Latched" mode.

AUTORESET DELAY

Range: 0.2 to 600.0 s in steps of 0.1 s
Default: 1.0 s

This setting specifies the time delay for automatic Reset of the pushbutton when in the "Latched" mode.

LOCK

Range: Off, Any FlexLogic operand

Default: Off

This setting assigns a FlexLogic operand serving to inhibit pushbutton operation from the front panel pushbuttons. This locking functionality is not applicable to pushbutton autoreset.

DROPOUT TIME

Range: 0.0 to 600.0 s in steps of 0.1 s

Default: 0.0 s

This setting applies only to "Self-reset" mode and specifies the duration of the pushbutton "active" status after the pushbutton has been released. The length of time the operand remains on has no effect on the pulse duration.

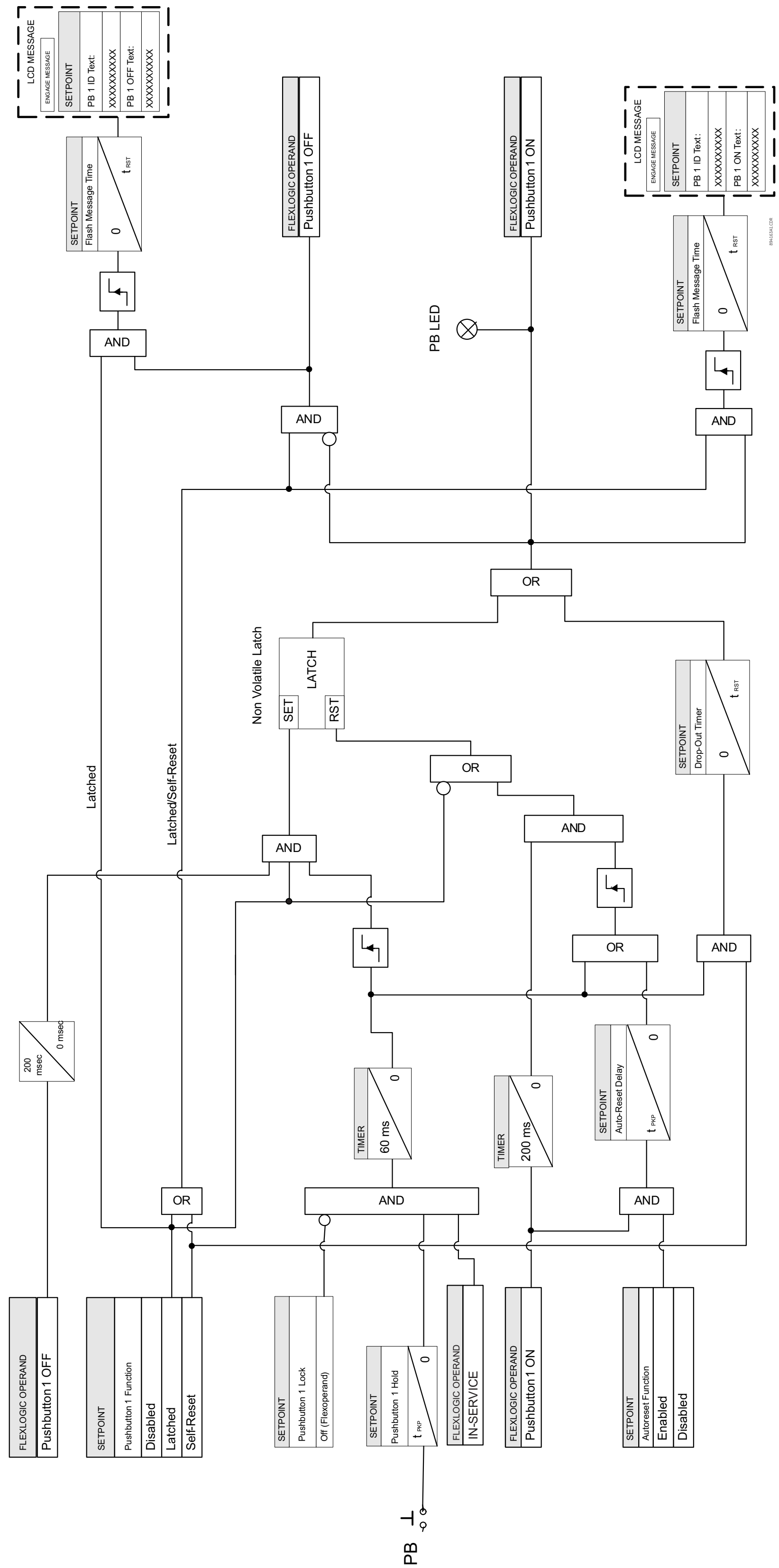
The setting is required to set the duration of the pushbutton operating pulse.

EVENTS

Range: Disabled, Enabled

Default: Enabled

Figure 5-10: Pushbuttons Logic Diagram



Tab Pushbuttons

The Tab Pushbuttons provide an easy and error-free method of entering digital state (on, off) information. Twenty (20) Tab Pushbuttons are available for programming.

The digital state of the Tab Pushbuttons can be entered locally (by directly pressing the front panel pushbutton) or through Modbus by specifying the correct COMMAND sequence. Typical applications include breaker control, autorecloser blocking, and settings groups changes. The Tab Pushbuttons are under the control level of password protection. Only one pushbutton can be pressed at a time. If multiple pushbuttons are pressed simultaneously, the button pressed first takes the priority.

The Tab Pushbutton settings can be accessed from **Setpoints > Device > Front Panel > Tab Pushbuttons > Tab PB1**. The Tab Pushbutton control can be executed by navigating to **Status > Summary > Tab Pushbuttons**. By default, the summary page is shown to quickly glance at the active tab pushbuttons. The individual pages can then be accessed from the summary page.Each Tab Pushbutton asserts its own OFF and ON FlexLogic operands (for example, TAB PB 1 ON and TAB PB 1 OFF). These operands are available for each pushbutton and can be used to program specific actions. Each pushbutton has an associated "LED" indicator. By default, this indicator displays the present status of the corresponding pushbutton ON state.

The activation and deactivation of Tab Pushbuttons is dependent on whether latched or self-reset mode is programmed.

SELF-RESET MODE: In Self-reset mode, a Tab Pushbutton remains active for the time it is pressed (the pulse duration) plus the Dropout time specified in the settings. The pushbutton is deactivated in Self-reset mode when the dropout delay specified in the Dropout Time setting expires. The pulse duration of the pushbutton must be at least 100ms to operate the pushbutton.

LATCHED MODE: In Latched Mode, a pushbutton can be set (activated) by directly pressing the associated tab pushbutton. The pushbutton maintains the set state until deactivated by another press of the same button. The state of each pushbutton is stored in non-volatile memory and maintained through the loss of control power.

Path: **Setpoints > Device > Front Panel > Tab PBs > Tab PB1(X)**

FUNCTION

Range: Self-reset, Latched, Disabled
Default: Self-reset

This setting selects the characteristic of the pushbutton. If set to "Disabled" the pushbutton is not active and the corresponding FlexLogic operands (both ON and OFF) are de-asserted. If set to Self-reset the control logic is activated by the pulse issued when the pushbutton is being physically pressed.

When in Self-Reset mode and activated locally, the pushbutton control logic asserts the Tab PB [X] ON FlexLogic operand as long as the pushbutton is being physically pressed, and after being released the deactivation of the operand is delayed by the Dropout Time setting. The OFF operand is asserted when the pushbutton element is deactivated.

If set to Latched, the control logic alternates the state of the corresponding FlexLogic operand between ON and OFF on each button press. When in Latched mode, the states of the FlexLogic operands are stored in a non-volatile memory. Should the power supply be lost, the correct state of the pushbutton is retained upon subsequent power-up of the relay. When the pushbutton operand is in the ON state, the operand appears on the target message until the pushbutton is pressed again to change it to the OFF state.

ID TEXT

Range: Up to 13 alphanumeric characters
Default: Tab PB 1 (or Tab PB[X])

This setting specifies the 13-character line of the user-programmable message and is intended to provide the ID information of the pushbutton. This text is used to describe the pushbutton in the FlexLogic operands.

LINE 1 TEXT

Range: 2 lines of alphanumeric characters
Default: [blank]

This setting specifies the text that is displayed on Line 1 of the button when in the normal view.

LINE 2 TEXT

Range: 2 lines of alphanumeric characters
Default: [blank]

This setting specifies the text that is displayed on Line 2 of the button when in the normal view.

LINE 1 SHORT TEXT

Range: 2 lines of alphanumeric characters
Default: [blank]

This setting specifies the text that is displayed on Line 1 of the button when in the summary view. This is also the text that appears on the tabs when operating the pushbuttons from the Single Line Diagram view.

LINE 2 SHORT TEXT

Range: 2 lines of alphanumeric characters
Default: [blank]

This setting specifies the text that is displayed on Line 2 of the button when in the summary view.

BUTTON COLOR

Range: Black, Red, Yellow, Blue, Green, Teal, Purple, White
Default: Black

This setting specifies the background color of the Tab Pushbutton. If the button is disabled, the button color by default is shown as grey.

TEXT COLOR

Range: Black, Red, Yellow, Blue, Green, Teal, Purple, White
Default: White

This setting specifies the text color of the Tab Pushbutton.

INDICATOR COLOR

Range: Black, Red, Yellow, Blue, Green, Teal, Purple, White
Default: Yellow

This setting specifies the color of the "LED" indicator for the Tab Pushbutton.

INDICATOR TRIGGER

Range: TAB PB 1 ON, Any FlexLogic operand
Default: TAB PB 1 ON

This setting assigns a FlexLogic operand to trigger the Indicator to change color from the default color (white) to the selected color.

HOLD PRESSED

Range: 0.1 to 10.0 s in steps of 0.1 s
Default: 0.1 s

This setting specifies the time required for a pushbutton to be pressed before it is deemed active.

The timer is Reset upon release of the pushbutton. Note that any pushbutton operation will require the pushbutton to be pressed a minimum of 100ms.

AUTORESET

Range: Disabled, Enabled

Default: Disabled

This setting enables the Tab Pushbutton Autoreset feature. The setting is applicable only if the pushbutton is in "Latched" mode.

AUTORESET DELAY

Range: 0.2 to 600.0 s in steps of 0.1 s

Default: 1.0 s

This setting specifies the time delay for automatic Reset of the pushbutton when in the "Latched" mode.

LOCK

Range: Any FlexLogic operand

Default: Off

This setting assigns a FlexLogic operand to inhibit pushbutton operation from the front panel pushbuttons. This locking functionality is not applicable to pushbutton autoreset.

DROPOUT TIME

Range: 0.0 s to 600.0 s in steps of 0.1 s

Default: 0.0 s

This setting applies only to "Self-reset" mode and specifies the duration of the pushbutton "active" status after the pushbutton has been released. The length of time the operand remains on has no effect on the pulse duration.

The setting is required to set the duration of the pushbutton operating pulse.

EVENTS

Range: Disabled, Enabled

Default: Enabled

Annunciator

Description

The graphical annunciator panel provides an emulation of a conventional physical annunciator panel with backlit indicators each inscribed with a description of the alarm condition that lights the indicator. The annunciator has 36 user-configurable (programmable) indicators. The indicators can be arranged in pages of 3x3 or 2x2 grids. Each indicator can have up to 3 lines of configurable text. When the indicators are not active (i.e. a configured FlexOperand for the annunciator is not triggered), the background is black and the foreground text color is grey. When the associated FlexOperand becomes active, the background and the foreground turns brighter in color per the color configuration. When disabled, the indicators are greyed out with no text.

Layout - If the grid layout is selected to be 3x3, the annunciator has 4 pages. If the grid layout is 2x2, the annunciator has 9 pages. The numbering of the indicators is shown as follows.

Grid Layout 3x3 – Indicator Numbering

Page 1	Page 2	Page 3	Page 4
1 4 7	10 13 16	19 22 25	28 31 34
2 5 8	11 14 17	20 23 26	29 32 35
3 6 9	12 15 18	21 24 27	30 33 36

Grid Layout 2x2 – Indicator Numbering

Page 1	Page 2	Page #	Page 9
1 3	5 7	... ...	33 35
2 4	6 8	... ...	34 36

Navigation - The annunciator panel can be displayed in two ways. By default, the annunciator panel is programmed as one of the homescreens. This means that when on the home page, pressing the home button multiple times rotates through all the homescreens. Alternatively, the annunciator can be accessed by navigating to **Status\Summary\Annunciator\Page1**. Individual annunciator pages can also be assigned as a homepage. If the auto navigation setting is enabled in the setup, the screen automatically jumps from home to the annunciator page with the first active alarm. Pages with active alarms will have a maroon flashing tab pushbutton label. If other pages have active alarms, the ">>" button will show a flashing label.

Path: **Setpoints > Device > Front Panel > Annunciator > Annunciator Setup**

Reset Annunciator

Default: Off

Range: Off, any FlexLogic operand

This setting designates a FlexLogic operand that, when activated, acknowledges/resets all annunciator windows in the graphical front panel. This setting is the same as that defined under **Setpoints > Device > Resetting > Reset Annunciator**. Refer to the Resetting section in this chapter for additional details.

The Reset Annunctr OP (OPRD) FlexLogic operand is activated by the two sources of RESET command, operand source and manual source. Each individual source of a RESET ANNUNCIATOR command also activates its individual operand Reset Annunctr OP (OPRD) or Reset Annunctr OP (MNUL) to identify the source of the command. Both of these operands generate an event in the event record when activated. The Reset Annunciator setting selects the operand that activates the Reset Annunctr OP (OPRD) operand. The RESET pushbutton in the front panel or the reset command from the Enervista 8 Series Setup software activates the Reset Annunctr OP (MNUL) operand.

PAGE LAYOUT

Range: 3x3, 2x2

Default: 3x3

This setting selects the grid layout of the annunciator pages. The default 3x3 grid layout provides 4 annunciator pages and 2x2 provides 9 pages.

AUTO NAVIGATION

Range: Disabled, Enabled

Default: Enabled

This setting when enabled, automatically navigates to the annunciator panel page from where the indication was triggered. While in the annunciator panel, if no action is taken, the screen returns back to the home page after the timeout setting.

Path: **Setpoints > Device > Front Panel > Annunciator > Indicator 1(36)**

ALARM INPUT

Range: Off, any FlexLogic Operand

Default: Off

This setting specifies the input operand used to activate the corresponding indicator.

ALARM TYPE

Range: Off, Self-Reset, Latched

Default: Off

This setting specifies the alarm type. Self-Reset alarms track the state of the corresponding input operand. Latched alarms can be reset using Reset pushbutton or through Acknowledgement via graphical front panel.

The alarm type of each annunciator indicator may be configured as Off, Self-Reset, or Latched. The default mode is Off. In this mode, the indicator is greyed out without any text. In self-reset mode (Figure: Self-Reset Mode), the indicator's inactive state is by default in black background with dark grey color text. When the associated operand becomes active (i.e. the assigned FlexOperand is triggered), the configured background color and foreground text color appears. In latched mode (Figure: Latched), the configured operand causes the background to flash when it becomes active. If the alarm is then acknowledged or reset, the background stops flashing. If the operand becomes inactive, the indicator returns to its default colors. The behavior of these modes conforms to ISA-18.1-1979 (R2004) standard - A-4-5-6 (self-reset), and M-6 (latched).

Figure 5-11: Self-Reset Mode

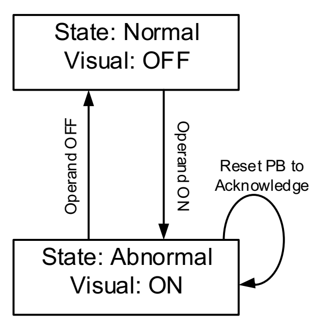
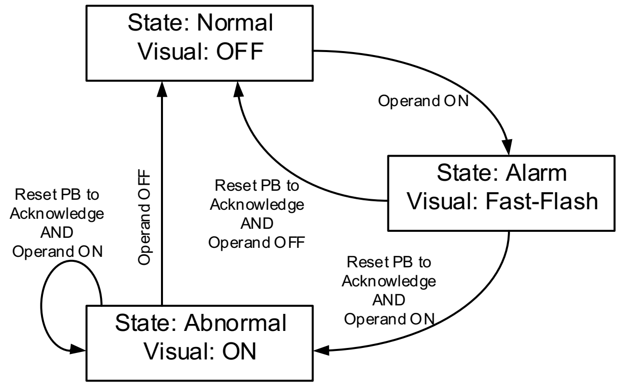


Figure 5-12: Latched Mode



When any annunciator page is displayed with an alarm condition, the navigation keys can be used to select an indicator. Once selected, the alarm condition can be acknowledged by pressing the reset pushbutton or by pressing the enter key. A confirmation message is displayed for acknowledging the alarm. Pressing the Reset or Enter key again acknowledges the alarm and pressing the Escape button discards the message. When the alarms are active under latched mode, a power loss retains the previous state of the alarm as the alarm states are stored in non-volatile memory.

TEXT LINE 1 (2,3)

Range: 15 Alphanumeric Characters
Default: [blank]

These settings specify the displayed text on the corresponding line in the alarm indicator. Three lines can be displayed with each line allowing up to 15 alphanumeric characters.

TEXT COLOR

Range: Black, Red, Yellow, Blue, Green, Teal, Purple, White
Default: White

This setting specifies the color of the alarm indicator text.

BACK COLOR

Range: Black, Red, Yellow, Blue, Green, Teal, Purple, White
Default: Red

This setting specifies the color of the alarm indicator background. When the indicator becomes active, the background changes color from the default Black to the programmed alarm back color.

Display Properties

Some relay messaging characteristics can be modified to suit different situations using the Front Panel Display Properties setting.

Path: **Setpoints > Device > Front Panel > Display Properties**

COLOR SCHEME

Range: Green (open), Red (open)

Default: Green (open)

This setting defines the color scheme for the breaker status. If it is programmed Green (open), the breaker open status is shown in the color green on the single line diagram and on the device status.

FLASH MESSAGE TIME

Range: 1 to 10 s in steps of 1 s

Default: 5 s

Flash messages are status, warning, error, or information messages displayed for several seconds in response to certain key presses during programming. These messages override any normal messages. The duration of a flash message on the display can be changed to accommodate different reading rates.

MESSAGE TIMEOUT

Range: 10 to 900 s in steps of 1 s

Default: 30 s

If no pushbutton has been pressed for a certain period of time, the relay automatically reverts to its default message (screen). The inactivity time is modified via this setting to ensure messages remain on the screen long enough during programming.

The target message interrupts the message timeout, overriding it. The message timeout starts timing after each target message, and if no more activity is recorded for the specified time, the display goes back to the default screen.

SCREEN SAVER

Range: Off, On

Default: Off

When the screen saver is set to ON, the LCD backlighting is turned off after the Message Timeout followed by a time of 5 min, providing that no PB has been pressed and no target messages are active. When a PB press occurs, or a target becomes active, the LCD backlighting is turned on.

TARGET AUTO NAVIGATION

Range: Disabled, Enabled

Default: Disabled

When the target auto navigation is set to Enabled, it will override the current menu page and go to the target message page when a target is active.

The Active target Icon shown above, will be the only indication of active target messages.

LANGUAGE

Range: English, German, Polish, Russian

Default: English

This setting selects the language used to display the settings, metering, status, and targets. The range is dependent on the order code of the relay.

Default Screens

The 8 Series relay provides the convenience of configuring and displaying up to three default screens from a predefined list. Each type of screen to display can be selected, and the display time programmed. The sequence of displaying the screens starts after the time of inactivity programmed in the Message Timeout setpoint, when no PB has been pressed, and no target message is present. Pressing a pushbutton, or the presence of a target message inhibits the sequential display of default screens. The screen displays resume only after the target messages are cleared, and no PB pressing is recorded for 30 seconds. When configured the home screen is changed to the first screen defined by this feature. Display timeouts also return to this first screen (i.e. default screen 1).

If the default screens feature is disabled and there are no home screens programmed, the home page will show the **Metering > Summary > Values** screen after the message timeout inactivity period.

Path: **Setpoints > Device > Front Panel > Default Screen**

FUNCTION

Range: Disabled, Enabled

Default: Enabled

This setpoint enables the feature. Displaying of the screen starts 30 s after setting the feature to "Enabled", providing no targets have been issued, nor a PB has been pressed.

DISPLAY TIME

Range: 5 to 900 s in steps of 1 s

Default: 10 s

The display time is the amount of time that each of the three screens are displayed within the display sequence.

DEFAULT SCREEN 1(3)

Range: varieties of screens for selection

Default: SLD (for Default Screen 1 only), Off (for Default Screen 2/3 only)

This setpoint enables the user to input up to 3 default screens from a list of screens.

Home Screens

The home screens allow the selection of a set of pages as home pages (max. 10. Multiple home pages are configured and navigated to by pressing the home button repeatedly. Navigate through all available home screens by repeatedly pressing the home button.

When returning to the home screen (either by pressing escape or directly pressing the Home button) through the different menus, the last accessed home screen is shown. Subsequent presses of the Home button navigates to the next programmed home screen on the list.

While accessing the home screens, the tab pushbutton navigation labels show the root menu – i.e. Targets, Status, Metering, Setpoints, and Records. The exceptions are the Tab Pushbuttons screens which instead show pushbuttons in the navigation labels.

If the default screens are enabled, the first default screen is shown after 30 seconds plus the inactivity period defined in **Setpoints > Device > Front Panel > Display Properties > Message Timeout**. If the default screens feature and screen saver are disabled, the screen defaults to the Values screen after the inactivity period.

When the home screens are programmed and the default screens feature is enabled but the screens are set to Off, the last accessed home screen is shown as the home page.

By Default, the first home screen is configured to show the first single line diagram.

NOTE

When on any single line diagram page, if an object is selected, the home button will not function. The selected object must first be de-selected by pressing the escape button to be able to use the home button functionality again.

Path: **Setpoints > Device > Front Panel > Home Screens**

HOME SCREEN 1

Range: All available pages
Default: SLD1

HOME SCREEN 2

Range: All available pages
Default: Tab PB Summary

HOME SCREEN 3

Range: All available pages
Default: Annunciator Pg 1

HOME SCREEN 4

Range: All available pages
Default: Values

HOME SCREEN 5 to 10

Range: All available pages
Default: Off

Clear Records

The Clear Records command is accessible from the front panel and from the EnerVista 8 Series Setup software.

Path: **Device > Clear Records**

Records can be cleared either by assigning “On” or a FlexLogic operand to the appropriate setting.

NOTICE

The Clear Records command is also available from **Records > Clear Records**, however there the allowable settings are only “ON” and “OFF”. (FlexLogic operands cannot be used.)

Resetting

Some events can be programmed to latch the faceplate LED event indicators and target message on the display. Depending on the application some auxiliary output relays can be programmed to latch after the triggering event is cleared. Once set, the latching mechanism holds all the latched indicators, messages, and auxiliary output relays in the set state, after the initiating condition has cleared, until a RESET command is received to return these latches (except the FlexLogic latches) to the reset state.

The RESET command can be sent from the faceplate Reset pushbutton, a remote device via a communication channel, or any programmed FlexLogic operand. Executing the RESET command from either source creates a general FlexLogic operand RESET OP. Each individual source of a RESET command also creates its individual operand RESET OP (PB), RESET (COMMS), and RESET OP (OPERAND) to identify the source of the command.

RESET INPUT 1(2,3):

Range: Off, Any FlexLogic operand
Default: Off

The setpoint selects an operand from the list of FlexLogic operands. The targets, LEDs, and latched output relays reset upon assertion from any of the operands selected as Reset Inputs.

Installation

Path: **Setpoints > Device > Installation**

DEVICE NAME

Range: Up to 13 alphanumeric characters

An alphanumeric name may be assigned to the device.

DEVICE IN SERVICE

Default: Not Ready

Range: Not Ready, Ready

The relay is defaulted to the "Not Ready" state when it leaves the factory. This safeguards against the installation of a relay whose settings have not been entered. When powered up successfully, the "IN SERVICE" LED becomes red. The relay in the "Not Ready" state blocks signaling of any output relay. These conditions remain until the relay is explicitly put in the "Ready" state.

SERVICE COMMAND

Range: 0 to 65535

Default: 0

See *Password Recovery Procedure* for details.

TEMPERATURE DISPLAY

Range: Celsius, Fahrenheit

Default: Celsius

Selects engineering unit of temperature display.

VALIDATE CANBUS IO

Range: NO, YES

When the relay is booted the 8 Series relay enumerates the installed IO cards automatically. When the relay is commissioned and the Validate CANBUS IO command is set to Yes the current auto detect value is saved to non-volatile memory. This value is then used to configure all display dependencies and used in self-test validation.

REMOTE IO DETECT VALUE

Range: Up to 6 alphanumeric characters

Shows the letter type of the Remote RTD card Board ID installed (e.g. GGGG).

CURRENT CUTOFF

Range: 0.000 to 1.000 p.u. in steps of 0.001 p.u.

Default: 0.020 p.u.

VOLTAGE CUTOFF

Range: 0.0 to 300.0 in steps of 0.1 V

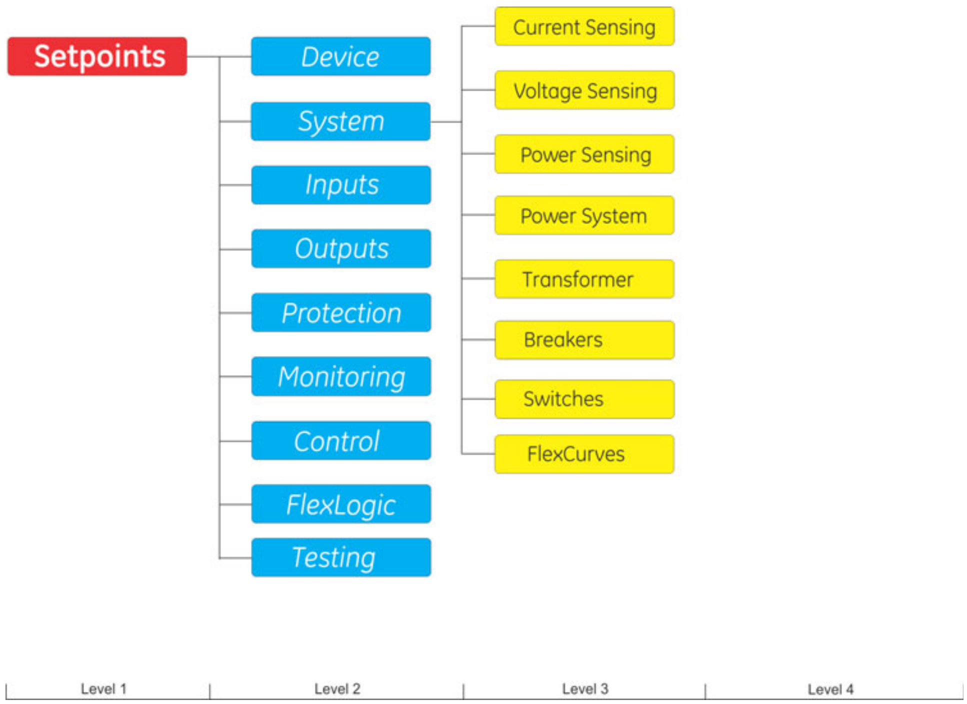
Default: 1.0 V

NOTICE

Lower the Voltage Cutoff and Current Cutoff levels with care as the relay accepts lower signals as valid measurements. Unless dictated otherwise by a specific application, the default settings of "0.020 pu" for current and "1.0 V" for voltage are recommended."

System

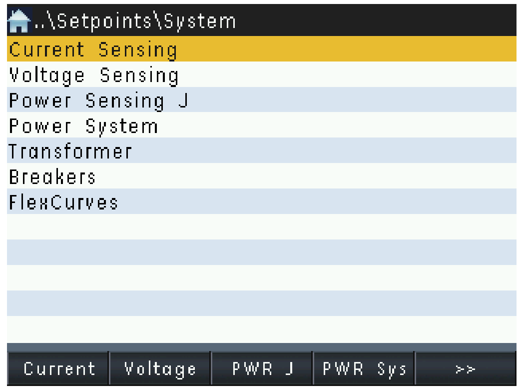
Figure 5-13: System Display Hierarchy



To measure and function properly, the following information must be entered on the 845 relay:

- Current Sensing: information related to phase and ground CT primary ratings
- Voltage Sensing: information related to Phase and Aux. VT connections, secondary voltage, and VT ratios
- Power Sensing: information related to voltage and current banks polarity residing on the same card
- Power System: information related to system frequency, tracking frequency, phase rotation Transformer: information related to transformer losses, temperature rise over ambient, winding resistance, type of transformer, capacity, winding voltage, phase shifting, grounding, etc.
- Breakers: information related to detecting the status of breakers by assigning contact inputs
- FlexCurves: information related to inverse time curves with user-programmable points

Path: Setpoints > System



Current Sensing

The names and the configuration of the current banks below apply only to 845 orders for the protection of either two-winding transformers with voltage, or three-winding transformers.

Path: Setpoints > System > Current Sensing > CT Bank 1-J1

CT BANK NAME

Range: Any combination of 13 alphanumeric characters

Default: CT Bank 1-J1

PHASE CT PRIMARY

Range: 1 A to 12000 A in steps of 1A

Default: 500 A

Enter the phase CT primary current for current sensing bank J1.

GROUND CT PRIMARY

Range: 1 A to 12000 A

Default: 500 A

Enter the rated Ground CT primary current for the ground current input for the selected Current 1 bank.

Path: Setpoints > System > Current Sensing > Current Bank 2-K1

Path: Setpoints > System > Current Sensing > Current Bank 3-K2

The names and the configuration of the current banks below, applies only to 845 orders for two-winding transformers without voltage.

Path: Setpoints > System > Current Sensing > CT Bank 1-K1

Path: Setpoints > System > Current Sensing > Current Bank 2-K2

Voltage Sensing

Traditional VT

The Voltage Sensing menu provides the setup for all VTs (PTs) connected to the relay voltage terminals.

Path: Setpoints > System > Voltage Sensing > Ph VT Bnk1-J2

PHASE VT BANK NAME

Range: Any combination of 13 alphanumeric characters

Default: Ph VT Bnk 1-J2

Enter the name of the phase voltage from bank J2.

PHASE VT CONNECTION

Range: Wye, Delta

Default: Wye

Select the type of phase VT connection to match the VTs (PTs) connected to the relay.

PHASE VT SECONDARY

Range: 10.0 to 240.0 V in steps of 0.1 V

Default: 120.0 V

Select the output secondary voltage for phase VTs connected to the J2 bank.

PHASE VT RATIO

Range: 1.00 to 5000.00 in steps of 0.01

Default: 1.00

Select the phase VT ratio to match the ratio of the VTs connected to the J2 bank.

AUX. VT NAME

Range: Any combination of 13 alphanumeric characters

Default: Ax VT Bnk1-J2

Enter the name of the auxiliary voltage from bank J2.

AUX. VT CONNECTION

Range: Van, Vbn, Vcn, Vab, Vbc, Vca, Vn

Default: Van

Select the voltage type corresponding to the one applied to the Aux VT relay terminals from bank J2. Select Vn (neutral voltage), if the neutral voltage is applied to the relay auxiliary VT.

AUX. VT SECONDARY

Range: 10.0 to 240.0 V in steps of 0.1 V

Default: 120.0 V

Select the output secondary voltage of the aux. VT connected to the aux. VT input from bank J2.

AUX. VT RATIO

Range: 1.00 to 5000.00 in steps of 0.01

Default: 1.00

Select the aux. VT ratio to match the ratio of the VT connected to the aux. VT input from bank J2.

NOTICE

The nominal **PHASE VT SECONDARY** and the **AUX VT SECONDARY** voltage settings are the voltages across the phase VT terminals and the auxiliary VT terminals correspondingly when nominal voltage is applied.

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

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

Power Sensing

The power computation in the 845 relay is performed using the voltage and current inputs from the card inserted in slot J. In cases when the connected VTs and CTs have opposite polarity, the power sensing menu provides for inverting the power measurement.

Path: **Setpoints > System > Power Sensing > Power 1**

3PH VT BANK INPUT

Range: Dependant upon the order code

Default: J2-3VT

This setpoint selects the 3-phase VT inputs used for Power (X) computation.

3PH CT BANK INPUT

Range: Dependant upon the order code

Default: J1-3CT

This setpoint selects the 3-phase CT inputs for Power (X) computation.

PHASE CT&VT POLARITY

Range: Same, Inverse

Default: Same

When “Inverse” is selected, this setpoint inverts (multiplies phase currents by “-1”) the CT polarity for the phase currents from CT bank J1, with respect to the phase voltages from the VT bank J2.

NOTE

The setpoint for inversion of the power metering will be useful to avoid the physical inversion of the CT connections on the relay. As the power metering will affect the power directional elements, the user must determine the correct forward and reverse direction of the power, before setup.

RESET EVENT ENERGY

Range: Off, Any FlexLogic operand

Default:

At the rising edge of the FlexLogic operand selected under this setpoint, all energy metering values (under **Metering > Energy 1(X) > Energy**) are logged and reset to zero, and Reset Energy D/T is recorded and displayed.

The logged values are displayed as the Last Event Pos(Neg) WattHours and Last Event Pos(Neg) VarHours under **Metering > Energy 1(X) > Energy Log**.

An application example could be monitoring of the total energy accumulated at the end of an event or a shift interval. An event/shift interval can be defined per the breaker status operand (open or closed).

Power System

Path: Setpoints > System > Power System

NOMINAL FREQUENCY

Range: 60 Hz, 50 Hz

Default: 60 Hz

The power system NOMINAL FREQUENCY is used as a default to set the digital sampling rate if the system frequency cannot be measured from available AC signals. This may happen if the signals selected for frequency tracking are not present, or a valid frequency is not detected. 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 selection of the PHASE ROTATION setting must match the power system phase rotation. The phase sequence setting is required to properly calculate sequence components and power parameters. Note that this setting informs the relay of the actual system phase sequence, either ABC or ACB. CT and VT inputs on the relay labeled as a, b, and c, must be connected to system phases A, B, and C for correct operation.

FREQUENCY TRACKING

Range: Disabled, Enabled

Default: Enabled

Frequency measurement is accomplished by measuring the time between zero crossings of the composite signal of three-phase bus voltages, line voltage or three-phase currents. The signals are passed through a low pass filter to prevent false zero crossings. Frequency tracking utilizes the measured frequency to set the sampling rate for current and voltage which results in better accuracy for the Discrete Fourier Transform (DFT) algorithm for off-nominal frequencies.

The main frequency tracking source uses three-phase voltages. The frequency tracking is switched automatically to the alternative reference source, i.e., three-phase currents signal, if the frequency detected from the three-phase voltage inputs is declared invalid. The switching will not be performed if the frequency from the alternative reference signal is detected invalid. Upon detecting valid frequency on the main source, the tracking will be switched back to the main source. If a stable frequency signal is not available from any source, then the tracking frequency defaults to the nominal system frequency.

NOTICE

In cases when the 845 relay is ordered with phase voltage inputs, but voltages are not available on the relay (no PTs, or voltage reads zero), the source for frequency tracking is the CT bank from the same card, as the voltage bank. For 845 relay orders without VT inputs, the source for frequency tracking is K1 - the first CT bank from the card residing in K-slot. In this case automatic changing of the frequency source is not permitted

VOLTAGE FREQ TRACKING SOURCE

Range: Ph VT Bnk1-J2, Ax VT Bnk1-J2

Default: Ph VT Bnk1-J2

Transformer

INTRODUCTION

The percent (biased) differential protection is the main protection for power transformers with regards to detecting all types of transformer internal fault. This protection is based on Kirchoff's law, where the sum of all currents flowing in and out of the protected equipment equals zero. However, when applying this law to the overall differential protection, one must keep in mind that the direct summation of the measured currents per-phase, does not automatically result into zero differential current. This is because:

1. The transformer voltage ratio defines different winding nominal currents
2. The winding CTs are not rated to the exact match of the winding nominal currents
3. Physically, the transformer windings are connected in Delta, Wye or Zig-Zag configuration, and they introduce a phase shift.

For the correct performance of the overall percent differential protection, it is necessary to correct the magnitude and phase relationships of the CT secondary currents for each winding, in order to obtain near zero differential currents under normal transformer operating conditions. Traditionally, the phase shift between the currents from the transformer windings has been corrected by connecting the CTs from the Wye winding in Delta connection, and the CTs from the Delta winding in Wye connection. In the past, the magnitude correction has been accomplished using interposing CTs, or tapped relay windings. This however is not required any more when installing the 845 relay.

The 845 relay simplifies the process by performing the magnitude and phase shift compensations automatically (internally). Upon entering settings for the protected transformer and winding CT ratings, the relay automatically calculates and applies the correct magnitude scaling to the winding currents as well as applying the correct phase shift in order to prepare the currents for summation. To perform the correct currents compensation, all winding CTs need to be connected in Wye (polarity markings pointing away from the transformer). When the Tap Changer detection feature is enabled on the relay, the algorithm automatically compensates the currents for the differential computation based on the new voltage ratio corresponding to the detected tap.

Transformer Setup

General Setup

Most of the setpoints from the transformer general setup are used for computation of the hottest-spot winding temperature, aging factor, and accumulated loss of life.

Path: Setpoints > System > Transformer > Transformer Setup > see "General Setup"

..\Transformer\General Setup

Item Name	Value	Unit
Phase Compensation	Internal (software)	
Load Loss at Rated Load	100.000	kW
Rated Wndg Temp Rise	65°C (oil)	
No Load loss	10.000	kW
Type of Cooling	OA	
Top Oil Rise over Ambient	35	°C
Xfmr Thermal Capacity	1.00	kWh/°C
Wndg Thermal Time Constant	2.00	min
Energization Winding Source	CT Bank 1 -J1	
Year of Manufacture	1950	

Setup

Refer to the following explanations for setpoints, to select the correct values.

PHASE COMPENSATION

Range: Internal (software), External (with CTs)
Default: Internal (software)

Select the type of phase compensation to be performed by the relay. If set to Internal (software), the transformer magnitude and phase shift compensations are performed internally by the relay algorithm. If set to External (with CTs), the transformer phase shift is externally compensated by the CT connections. The relay still performs magnitude compensation when “External (with CTs)” option is selected.

NOTICE

When the phase compensation type External (with CTs) is selected, the relay does not apply phase compensation internally as per the entered winding angles from the transformer type selection. In this mode, the relay expects to measure already phase compensated currents on its terminals. In this mode, the relay only performs magnitude compensation.

LOAD LOSS AT RATED LOAD

Range: 0.001 to 20000.000 kW in steps of 0.001 kW
Default: 100.000 kW

This setting is taken from the transformer nameplate. If it is not available from the nameplate, the setting value can be computed as $P_R=I_{n(W)}^2*R$, where $I_{n(W)}$ is the winding rated current and R is the three-phase series resistance. The setting is used as input for the calculation of the hottest-spot winding temperature.

RATED WNDG TEMP RISE

Range: 55 °C (oil), 65 °C (oil), 80 °C (dry), 115 °C (dry), 150 °C (dry)
Default: 65 °C (oil)

This setting defines the winding temperature rise over 30°C ambient temperature. The setting is automatically selected for the transformer type as shown in the following figure. The data reflects the data outlined in ANSI/IEEE 57.91, ANSI/IEEE 57.92, and ANSI/IEEE 57.94 standards.

Figure 5-14: Data for Winding Temperature rise over 30°C

Rated Winding Temperature Rise		Power Capacity	Normal Life Expectancy	At Θ_{H_R}
OIL	55 °C	≤ 500 kVA	180000 hrs	95 °C
		≤ 100 MVA	$6.5x10^4$ hrs	
	65 °C	≤ 500 kVA	20 yrs	110 °C
		≤ 100 MVA	$6.5x10^4$ hrs	
		> 100 MVA		
DRY	80 °C	Any	20 yrs	140 °C
	115 °C	Any	20 yrs	175 °C
	150 °C	Any	20 yrs	210 °C

NO LOAD LOSS

Range: 0.001 to 20000.000 kW in steps of 0.001
Default: 125.000 kW

This setting is obtained from the transformer data and is used to calculate the aging acceleration factor.

TYPE OF COOLING

Range: OA, FA, Non-Directed FOA/FOW, Directed FOA/FOW, Sealed Self Cooled, Vented Self Cooled, Forced Cooled
Default: OA

The setting defines the type of transformer cooling and is used to calculate the aging acceleration factor. The values and their description for this setting are as follows:

"OA": oil-air

"FA": forced air

"Non-directed FOA/FOW": non-directed forced-oil-air/forced-oil-water

"Directed FOA/FOW": directed forced-oil-air/forced-oil-water

"Sealed Self Cooled", "Vented Self Cooled", "Forced Cooled": as named

TOP OIL RISE OVER AMBIENT

Range: 1 to 200°C in steps of 1
Default: 35°C

This setting is available from the transformer nameplate data.

XFMR THERMAL CAPACITY

Range: 0.00 to 200.00 kWh/°C in steps of 0.01
Default: 1.00 kWh/°C

The setting is available from the transformer nameplate data. If not, refer to the following calculations.

For the "OA" and "FA" cooling types:

C = 0.06 (core and coil assembly in lbs) + 0.04 (tank and fittings in lbs) +1.33 (gallons of oil), Wh/°C; or

C = 0.0272 (core and coil assembly in kg) + 0.01814 (tank and fittings in kg) + 5.034 (L of oil), Wh/°C

For the "Non-directed FOA/FOW" (non-directed forced-oil-air/forced-oil-water) or "Directed FOA/FOW" (directed forced-oil-air/forced-oil-water) cooling types, the thermal capacity is given by:

C = 0.06 (core and coil assembly in lbs.) + 0.06 (tank and fittings in lbs.) + 1.93 (gallons of oil), Wh/°C; or

C =0.0272 (weight of core and coil assembly in kg) + 0.0272 (weight of tank and fittings in kg) + 7.305 (L of oil), Wh/°C

For dry-type power transformers:

C = 0.048 x (weight of copper winding); or

C = 0.015 x (weight of core and copper windings from the nameplate); or

C = 0.12 x (weight of aluminum windings); or

C = 0.02 x (weight of core and aluminum coils from the nameplate)

WNDG THERMAL TIME CONSTANT

Range: 0.25 to 15.00 min in steps of 0.01
Default: 2.00 min

This setting is required for the insulation aging calculation. If this value is not available from the transformer data, select "2 min."

ENERGIZATION WINDING SOURCE

Range: None, CT Bank 1-J1, CT Bank 2-K1, CT Bank 2-K2
Default: None

Required for generating transient record or oscillography during an energization event of the transformer. This setting enables you to capture current waveform through corresponding CT on the winding side where energization happens on the transformer and compute/pick various parameters during an energization event. Voltage bank J2 will be taken into consideration for generating voltage waveform based on the 845 order code.

YEAR OF MANUFACTURE

Range: 1950 to 2100
Default: 1950

This setting captures the manufacturing year of the transformer as present in the transformer nameplate data or manufacturing records.

Windings

Path: **Setpoints > System > Transformer > Winding 1**

Path: **Setpoints > System > Transformer > Winding 2(3)**

All transformer windings from 845 are associated with CT bank inputs. Depending on the selected 845 order code, the following CT banks represent the winding currents:

1. 845 orders for two-winding transformers without voltage inputs:
   - Winding 1-K1 CT bank
   - Winding 2-K2 CT bank
2. 845 orders for two-winding transformers with voltage inputs:
   - Winding 1-J1 CT bank
   - Winding 2-K1 CT bank

   Voltage inputs: J2 VT bank
3. 845 orders for three-winding transformers (voltage inputs are always included):
   - Winding 1-J1 CT bank
   - Winding 2-K1 CT bank
   - Winding 3-K2 CT bank

   Voltage inputs: J2 VT bank

Transformer differential protection uses calculated quantities (per phase): fundamental, 2nd harmonic and 5th harmonic differential current phasors, and restraint current phasors. This information is extracted from the current transformers (CTs) connected to the relay by correcting the magnitude and phase relationships of the currents for each winding, so as to obtain zero (or near zero) differential currents under normal operating conditions. Traditionally, these corrections were accomplished by interposing CTs and tapped relay windings with some combination of CT connections.

The 845 simplifies these configuration issues. All CTs at the transformer can be connected wye (polarity markings pointing away from the transformer). User-entered settings in the relay characterizes the transformer being protected and allows the relay to automatically perform all necessary magnitude, phase angle, and zero-sequence compensation.

The settings specific to each winding are shown as follows.

WINDING SETTINGS

RATED MVA

Range: 0.001 to 2000.000 MVA in steps of 0.001
Default: 5.000 MVA

Enter the self-cooled (100%) load rating for the power transformer.

NOMINAL PH-PH VOLTAGE

Range: 0.001 to 1000.000 KV in steps of 0.001
Default: 13.800 kV

Enter the nominal phase to phase voltage rating winding 1 of the transformer.

CONNECTION

Range: Wye, Delta, Zig-Zag
Default: Wye

Enter the winding connection.

ANGLE WITH RESPECT TO W1 (only in Winding 2 and Winding 3 menu)

Range: 0°, 30°Lag, 60°Lag, 90°Lag, 120°Lag, 150°Lag, 180°Lag, 210°Lag, 240°Lag, 270° Lag, 300°Lag, 330°Lag
Default: 0°

Enter the angle by which the currents from Winding 2 (Winding 3) are lagging the currents from Winding 1.

GROUNDING

Range: Not within zone, Within zone
Default: Not within zone

Select "Within Zone", if there is a grounding path at the winding 1(2, 3) side of the transformer such as grounded neutral, grounding transformer, or grounded corner of a delta winding. Select "Not Within Zone", if there is no grounding path for the winding in the zone.

The Delta CT connection has the effect of removing the zero sequence components of the phase currents. If there were a grounding bank on the Delta winding of the power transformer within the zone of protection, a ground fault would result in differential (zero sequence) current and false trips. In such case, it would be necessary to insert a zero sequence current trap with the wye connected CTs on the Delta winding of the transformer.

In general, zero sequence removal is necessary if zero sequence can flow into and out of one transformer winding but not the other winding. Transformer windings that are grounded inside zone protection allow zero sequence current flow in that winding, and therefore it is from these windings that zero sequence removal is necessary.

WNDG RESISTANCE (3-Ph)

Range: 0.0001 to 100.0000 ohms in steps of 0.0001
Default: 10.0000 ohms

Enter the three-phase winding resistance from the transformer nameplate.

PHASE RELATIONSHIPS OF THREE-PHASE TRANSFORMERS

Power transformers that are built in accordance with ANSI and IEC standards are required to identify winding terminals and phase relationships among the windings of the transformer.

ANSI standard C.37.12.70 requires that the terminal labels include the characters 1, 2, 3 to represent the names of the individual phases. The phase relationship among the windings must be shown as a phasor diagram on the nameplate, with the winding terminals clearly labeled. This standard specifically states that the phase relationships are established for a condition where the source phase sequence of 1-2-3 is connected to transformer windings labeled 1, 2, and 3 respectively.

IEC standard 60076-1 (1993) states that the terminal markings of the three phases follow national practice. The phase relationship among the windings is shown as a specified notation on the nameplate, and there may be a phasor diagram. In this standard the arbitrary labeling of the windings is shown as I, II and III. This standard specifically states that the phase relationships are established for a condition where a source phase sequence of I-II-III is connected to transformer windings labeled I, II and III respectively.

Magnitude Compensation

The overall percent differential protection from the 845 relay uses the phase-phase voltage and the CT primary setting for Winding 1 as a reference, to perform magnitude compensation for (bring to common base) the currents measured from the other windings: Winding 2 and Winding 3.

To compute differential and restraint currents, the 845 relay uses Winding 1 phase-phase voltage and the primary CT rating from the Signal input used for Winding 1. The 845 relay computes magnitude compensation factors for Winding 2 and Winding 3 currents as shown below:

V_{W1}, V_{W2}, V_{W3} - Phase-to-phase voltages (Setpoint) programmed for Winding 1, Winding 2, and Winding 3

CT_{W1}, CT_{W2}, CT_{W3} – Current transformer rated primary current (Setpoint) programmed in Current Sensing menu and used as Signal Inputs to represent the currents from Winding 1, Winding 2, and Winding 3.

V_{min} – Minimum winding voltage

ΔV_{TLC} – Voltage difference between winding voltage at actual tap, and minimum voltage (Setpoint)

1. The setpoint Tap Position Detection from Tap Changer setup set to “Disabled”, or the setpoint TC Winding Currents set to “None”

$M_{W1}= 1$ – magnitude compensation factor for winding 1 - REFERENCE

$M_{W2}= (CT_{W2}.V_{W2})/(CT_{W1}.V_{W1})$ – magnitude compensation factor for winding 2 currents

$M_{W3}= (CT_{W3}.V_{W3})/(CT_{W1}.V_{W1})$ – magnitude compensation factor for winding 3 currents

2. Tap Position Detection set to “Enabled”, and CT bank selected for TC Winding Currents

The purpose of the tap changer installed on one of the transformer windings is to maintain transformer output voltage within a certain bandwidth. To do this, the tap changer either increases or decreases the turns of that winding i.e., changes its phase-phase voltage, which in return leads to a different transformation ratio. When the transformation ratio is changed, the nominal currents of the windings change as well, meaning that the computation for CT mismatch based on the initially entered CT and ph-ph voltage per winding, will be different, than the actual CT mismatch. This mismatch will appear as differential current.

To compensate for the differential current, in cases of installed tap changer causing the winding voltage to either go higher or lower than the nominal winding voltage entered in the setpoints, the 845 provides dynamic CT mismatch compensation based on detection of tap position.

The algorithm checks if the Tap Changer function is “Enabled”, and on which winding it is installed. To determine the winding, the algorithm checks which winding has the same selection of Signal input as the one selected for the tap changer.

If the Signal input selected for the OLTC (Onload Tap Changer) is the same as the one for the reference winding, the magnitude compensation factors for each non-reference winding will be computed using the following equation.

a. OLTC installed on Winding 1

$M_{W1} = 1$ – magnitude compensation factor for winding 1 - REFERENCE

$M_{W2} = (CT_{W2}.V_{W2})/ (CT_{W1}.(V_{min} + \Delta V_{TLC}))$ – magnitude compensation factor for winding 2 currents

$M_{W3} = (CT_{W3}.V_{W3})/(CT_{W1}.(V_{min} + \Delta V_{TLC}))$ – magnitude compensation factor for winding 3 currents

b. OLTC installed on Winding 2

$M_{W1} = 1$ – magnitude compensation factor for winding 1 - REFERENCE

$M_{W2} = (CT_{W2}.(V_{min} + \Delta V_{TLC}))/ (CT_{W1}.V_{W1})$ – magnitude compensation factor for winding 2 currents

$M_{W3} = (CT_{W3}.V_{W3})/(CT_{W1}.V_{W1})$ – magnitude compensation factor for winding 3 currents

c. OLTC installed on Winding 3

$M_{W1} = 1$ – magnitude compensation factor for winding 1 - REFERENCE

$M_{W2} = (CT_{W2}.V_{W2})/ (CT_{W1}.V_{W1})$ – magnitude compensation factor for winding 2 currents

$M_{W3} = (CT_{W3}.(V_{min} + \Delta V_{TLC}))/(CT_{W1}.V_{W1})$ – magnitude compensation factor for winding 3 currents

NOTE

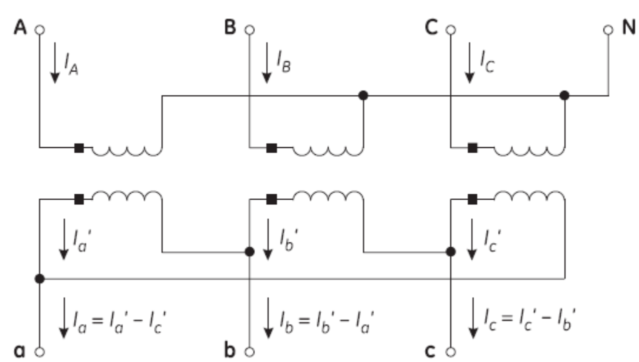
The maximum allowed magnitude compensation factor (and hence the maximum allowed CT ratio mismatch) is 20.

Phase Shift Compensation

Phase Compensation Reference: The overall percent differential protection from the 845 relay uses either the Delta, or the Zig-Zag winding (depending on the transformer setup) as a reference to perform phase shift compensation. If the transformer has only “Wye” connected windings, the phase currents from the first Wye winding in the setup are used as a reference.

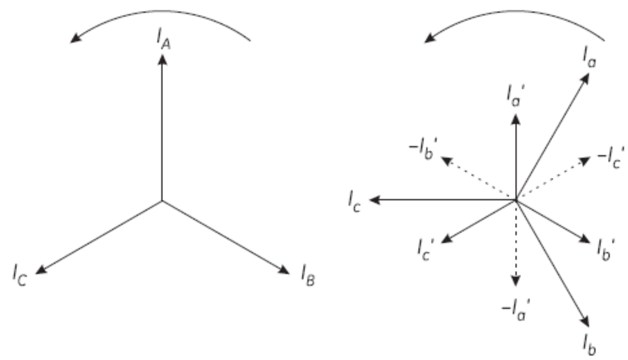
The power system phase sequence must be set when describing the winding phase relationships, since these relationships change, when the phase sequence changes. The example below shows why this happens, using a transformer described in IEC nomenclature as “Yd1”.

Figure 5-15: Example Transformer



The Example Transformer figure shows the physical connections within the transformer that produce a phase angle in the delta winding lagging the respective wye winding by 30°. The winding currents are also identified. Note that the total current out of the delta winding is described by an equation. Now assume that a source, with a sequence of ABC, is connected to transformer terminals ABC, respectively. The currents that would be present for a balanced load are shown below.

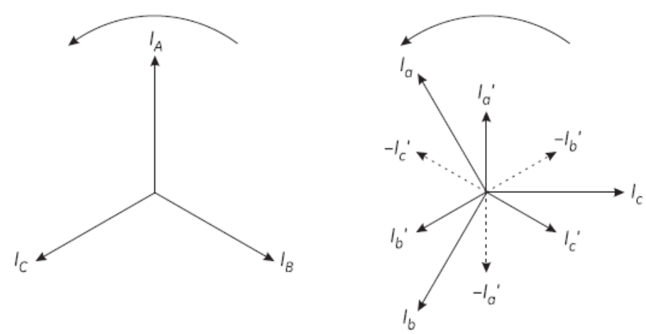
Figure 5-16: Phasors for ABC Sequence



Note that the delta winding currents lag the wye winding currents by 30°, which is in agreement with the transformer nameplate.

Now assume that a source, with a sequence of ACB is connected to transformer terminals A, C, B respectively. The currents that would be present for a balanced load are shown in the next figure: Phasors for ACB Sequence.

Figure 5-17: Phasors for ACB Sequence



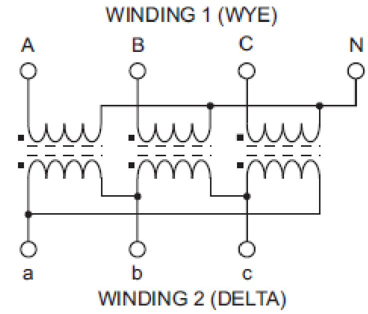
Note that the delta winding currents lead the wye winding currents by 30°, (which is a type Yd11 in IEC nomenclature), which is in disagreement with the transformer nameplate. This is because the physical connections and hence the equations used to calculate current for the delta winding have not changed. The transformer nameplate phase relationship information is only correct for a stated phase sequence.

It is suggested that for the ACB sequence the phase relationship can be returned to that shown on the transformer nameplate by connecting source phases A, B and C to transformer terminals A, C, and B respectively. This will restore the nameplate phase shifts but will cause incorrect identification of phases B and C within the relay, and is therefore not recommended.

All information presented in this manual is based on connecting the relay phase A, B and C terminals to the power system phases A, B and C respectively. The transformer types and phase relationships presented are for a system phase sequence of ABC, in accordance with the standards for power transformers. Users with a system phase sequence of ACB must determine the transformer type for this sequence.

The following diagram shows the internal connections of the Y/d30 transformer from our example.

Figure 5-18: Wye/Delta (30° lag) Transformer



Under balanced conditions, the winding 2 phase currents lag the corresponding phase currents of winding 1 by 30°. With CTs connected in a wye arrangement (polarity markings pointing away from the transformer), even after magnitude compensation, the summation of the currents from both transformer windings will not result in zero differential current, because they will NOT be 180° out-of-phase.

Traditionally, this problem was solved by connecting the CTs from the wye side of the transformer (winding 1) in a delta. This compensates for the phase angle lag introduced in the delta side (winding 2).

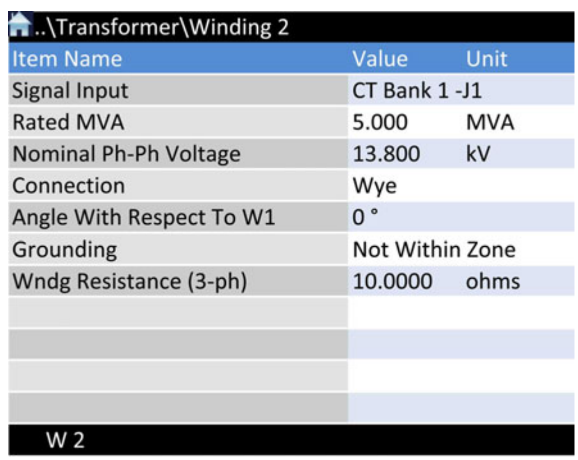
The 845 performs the phase angle correction internally based on the setpoint **"Angle With Respect to W1"** from the menu **System > Transformer > Transformer Setup > see "Winding 2"**, and the same setpoint from the menu **System > Transformer > Transformer Setup > see "Winding 3"** for three-winding transformer protection.

NOTE

The angle of Winding 1 is always 0°, and this setpoint is omitted from the Winding 1 setup menu.

The 845 supports all standard two-, and three-winding transformer types, and a variety of non-standard applications, where the selection of winding connection type and selected lagging angle with respect to Winding 1 are not described in the table of standard transformer types.

Figure 5-19: Menu for transformer windings setup



..\Transformer\Winding 2

Item Name	Value	Unit
Signal Input	CT Bank 1 -J1	
Rated MVA	5.000	MVA
Nominal Ph-Ph Voltage	13.800	kV
Connection	Wye	
Angle With Respect To W1	0 °	
Grounding	Not Within Zone	
Wndg Resistance (3-ph)	10.0000	ohms

W 2

As shown in the menu for transformer windings setup, the 30° lag of the Delta winding currents, will result in a 0° phase shift applied to Delta currents (Delta –phase reference), and a 30° phase angle correction (phase shift) applied to the winding 1 currents (Wye winding). These angle corrections are described in the table as Phase shift.

In general, zero sequence removal is necessary if zero sequence can flow into and out of one transformer winding but not the other windings. Transformer windings that are grounded **inside the zone** of protection allow zero sequence current flow in that winding, and therefore it is from these windings that zero sequence removal is necessary.

The 845 performs this phase angle compensation and zero sequence removal automatically, based on the settings entered for the transformer. All CTs are connected Wye (polarity markings pointing away from the transformer). All currents are phase and zero sequence compensated internally before the calculation of differential and restraint quantities.

The phase reference winding (w_f) is the winding which will have a phase shift of 0° applied to it. The phase reference winding is chosen to be the delta or zigzag (non-wye) winding with the lowest winding index, if one exists. For a transformer that has no delta or zigzag windings, the first "wye" winding is chosen.

The phase compensation angle ϕ_{comp} is the angle by which a winding current is shifted with reference to the angle of the reference winding, and is calculated by the 845 for each winding as follows

$\phi_{comp}[w] = | \phi[w_f] - \phi[w] |$ where Rotation = "ABC"

$\phi_{comp}[w] = | \phi[w] - \phi[w_f] |$ where Rotation = "ACB"

The following figure: Phase and Zero Sequence Compensation for Typical Values of ϕ_{comp}, shows the phase shift compensation equations of transformer winding currents, based on typical phase compensation angles ϕ_{comp}, and whether or not the zero sequence current is removed:

where:

$I_A[w]$ = uncompensated winding 'w' phase A current

$I_A^p[w]$ = phase and zero sequence compensated winding 'w' phase A current

Figure 5-20: Phase and Zero Sequence Compensation for Typical Values of φ comp

$\Phi_{COMP}[W]$	GROUNDING[W] = "NOT WITHIN ZONE"	GROUNDING[W] = "WITHIN ZONE"
0°	$I_A^p[w] = I_A[w]$ $I_B^p[w] = I_B[w]$ $I_C^p[w] = I_C[w]$	$I_A^p[w] = \frac{2}{3}I_A[w] - \frac{1}{3}I_B[w] - \frac{1}{3}I_C[w]$ $I_B^p[w] = \frac{2}{3}I_B[w] - \frac{1}{3}I_A[w] - \frac{1}{3}I_C[w]$ $I_C^p[w] = \frac{2}{3}I_C[w] - \frac{1}{3}I_A[w] - \frac{1}{3}I_B[w]$
30° lag	$I_A^p[w] = \frac{1}{\sqrt{3}}I_A[w] - \frac{1}{\sqrt{3}}I_C[w]$ $I_B^p[w] = \frac{1}{\sqrt{3}}I_B[w] - \frac{1}{\sqrt{3}}I_A[w]$ $I_C^p[w] = \frac{1}{\sqrt{3}}I_C[w] - \frac{1}{\sqrt{3}}I_B[w]$	$I_A^p[w] = \frac{1}{\sqrt{3}}I_A[w] - \frac{1}{\sqrt{3}}I_C[w]$ $I_B^p[w] = \frac{1}{\sqrt{3}}I_B[w] - \frac{1}{\sqrt{3}}I_A[w]$ $I_C^p[w] = \frac{1}{\sqrt{3}}I_C[w] - \frac{1}{\sqrt{3}}I_B[w]$
60° lag	$I_A^p[w] = -I_C[w]$ $I_B^p[w] = -I_A[w]$ $I_C^p[w] = -I_B[w]$	$I_A^p[w] = -\frac{2}{3}I_C[w] + \frac{1}{3}I_A[w] + \frac{1}{3}I_B[w]$ $I_B^p[w] = -\frac{2}{3}I_A[w] + \frac{1}{3}I_B[w] + \frac{1}{3}I_C[w]$ $I_C^p[w] = -\frac{2}{3}I_B[w] + \frac{1}{3}I_A[w] + \frac{1}{3}I_C[w]$
90° lag	$I_A^p[w] = \frac{1}{\sqrt{3}}I_B[w] - \frac{1}{\sqrt{3}}I_C[w]$ $I_B^p[w] = \frac{1}{\sqrt{3}}I_C[w] - \frac{1}{\sqrt{3}}I_A[w]$ $I_C^p[w] = \frac{1}{\sqrt{3}}I_A[w] - \frac{1}{\sqrt{3}}I_B[w]$	$I_A^p[w] = \frac{1}{\sqrt{3}}I_B[w] - \frac{1}{\sqrt{3}}I_C[w]$ $I_B^p[w] = \frac{1}{\sqrt{3}}I_C[w] - \frac{1}{\sqrt{3}}I_A[w]$ $I_C^p[w] = \frac{1}{\sqrt{3}}I_A[w] - \frac{1}{\sqrt{3}}I_B[w]$
120° lag	$I_A^p[w] = I_B[w]$ $I_B^p[w] = I_C[w]$ $I_C^p[w] = I_A[w]$	$I_A^p[w] = \frac{2}{3}I_B[w] - \frac{1}{3}I_A[w] - \frac{1}{3}I_C[w]$ $I_B^p[w] = \frac{2}{3}I_C[w] - \frac{1}{3}I_A[w] - \frac{1}{3}I_B[w]$ $I_C^p[w] = \frac{2}{3}I_A[w] - \frac{1}{3}I_B[w] - \frac{1}{3}I_C[w]$
150° lag	$I_A^p[w] = \frac{1}{\sqrt{3}}I_B[w] - \frac{1}{\sqrt{3}}I_A[w]$ $I_B^p[w] = \frac{1}{\sqrt{3}}I_C[w] - \frac{1}{\sqrt{3}}I_B[w]$ $I_C^p[w] = \frac{1}{\sqrt{3}}I_A[w] - \frac{1}{\sqrt{3}}I_C[w]$	$I_A^p[w] = \frac{1}{\sqrt{3}}I_B[w] - \frac{1}{\sqrt{3}}I_A[w]$ $I_B^p[w] = \frac{1}{\sqrt{3}}I_C[w] - \frac{1}{\sqrt{3}}I_B[w]$ $I_C^p[w] = \frac{1}{\sqrt{3}}I_A[w] - \frac{1}{\sqrt{3}}I_C[w]$
180° lag	$I_A^p[w] = -I_A[w]$ $I_B^p[w] = -I_B[w]$ $I_C^p[w] = -I_C[w]$	$I_A^p[w] = -\frac{2}{3}I_A[w] + \frac{1}{3}I_B[w] + \frac{1}{3}I_C[w]$ $I_B^p[w] = -\frac{2}{3}I_B[w] + \frac{1}{3}I_A[w] + \frac{1}{3}I_C[w]$ $I_C^p[w] = -\frac{2}{3}I_C[w] + \frac{1}{3}I_A[w] + \frac{1}{3}I_B[w]$

210° lag	$I_A^P[w] = \frac{1}{\sqrt{3}}I_C[w] - \frac{1}{\sqrt{3}}I_A[w]$ $I_B^P[w] = \frac{1}{\sqrt{3}}I_A[w] - \frac{1}{\sqrt{3}}I_B[w]$ $I_C^P[w] = \frac{1}{\sqrt{3}}I_B[w] - \frac{1}{\sqrt{3}}I_C[w]$	$I_A^P[w] = \frac{1}{\sqrt{3}}I_C[w] - \frac{1}{\sqrt{3}}I_A[w]$ $I_B^P[w] = \frac{1}{\sqrt{3}}I_A[w] - \frac{1}{\sqrt{3}}I_B[w]$ $I_C^P[w] = \frac{1}{\sqrt{3}}I_B[w] - \frac{1}{\sqrt{3}}I_C[w]$
240° lag	$I_A^P[w] = I_C[w]$ $I_B^P[w] = I_A[w]$ $I_C^P[w] = I_B[w]$	$I_A^P[w] = \frac{2}{3}I_C[w] - \frac{1}{3}I_A[w] - \frac{1}{3}I_B[w]$ $I_B^P[w] = \frac{2}{3}I_A[w] - \frac{1}{3}I_B[w] - \frac{1}{3}I_C[w]$ $I_C^P[w] = \frac{2}{3}I_B[w] - \frac{1}{3}I_A[w] - \frac{1}{3}I_C[w]$
270° lag	$I_A^P[w] = \frac{1}{\sqrt{3}}I_C[w] - \frac{1}{\sqrt{3}}I_B[w]$ $I_B^P[w] = \frac{1}{\sqrt{3}}I_A[w] - \frac{1}{\sqrt{3}}I_C[w]$ $I_C^P[w] = \frac{1}{\sqrt{3}}I_B[w] - \frac{1}{\sqrt{3}}I_A[w]$	$I_A^P[w] = \frac{1}{\sqrt{3}}I_C[w] - \frac{1}{\sqrt{3}}I_B[w]$ $I_B^P[w] = \frac{1}{\sqrt{3}}I_A[w] - \frac{1}{\sqrt{3}}I_C[w]$ $I_C^P[w] = \frac{1}{\sqrt{3}}I_B[w] - \frac{1}{\sqrt{3}}I_A[w]$
300° lag	$I_A^P[w] = -I_B[w]$ $I_B^P[w] = -I_C[w]$ $I_C^P[w] = -I_A[w]$	$I_A^P[w] = -\frac{2}{3}I_B[w] + \frac{1}{3}I_A[w] + \frac{1}{3}I_C[w]$ $I_B^P[w] = -\frac{2}{3}I_C[w] + \frac{1}{3}I_A[w] + \frac{1}{3}I_B[w]$ $I_C^P[w] = -\frac{2}{3}I_A[w] + \frac{1}{3}I_B[w] + \frac{1}{3}I_C[w]$
330° lag	$I_A^P[w] = \frac{1}{\sqrt{3}}I_A[w] - \frac{1}{\sqrt{3}}I_B[w]$ $I_B^P[w] = \frac{1}{\sqrt{3}}I_B[w] - \frac{1}{\sqrt{3}}I_C[w]$ $I_C^P[w] = \frac{1}{\sqrt{3}}I_C[w] - \frac{1}{\sqrt{3}}I_A[w]$	$I_A^P[w] = \frac{1}{\sqrt{3}}I_A[w] - \frac{1}{\sqrt{3}}I_B[w]$ $I_B^P[w] = \frac{1}{\sqrt{3}}I_B[w] - \frac{1}{\sqrt{3}}I_C[w]$ $I_C^P[w] = \frac{1}{\sqrt{3}}I_C[w] - \frac{1}{\sqrt{3}}I_A[w]$

Magnitude, Phase Angle, and Zero Sequence Compensation

The complete magnitude, phase angle, and zero sequence compensation is as follows:

Winding 1 compensated currents:

$I_A^C[w1] = M[w1] * I_A^P[w1]$

$I_B^C[w1] = M[w1] * I_B^P[w1]$

$I_C^C[w1] = M[w1] * I_C^P[w1]$

Winding 2 compensated currents:

$I_A^C[w2] = M[w2] * I_A^P[w2]$

$I_B^C[w2] = M[w2] * I_B^P[w2]$

$I_C^C[w2] = M[w2] * I_C^P[w2]$

Winding 3 compensated currents:

$I_A^C[w3] = M[w3] * I_A^P[w3]$

$I_B^C[w3] = M[w3] * I_B^P[w3]$

$I_C^C[w3] = M[w3] * I_C^P[w3]$

where: $I_A^C[w]$, $I_B^C[w]$, and $I_C^C[w]$ - magnitude, phase and zero sequence compensated winding phase currents

M[w1]- magnitude compensation factor for winding 1 (see previous sections)

M[w2]- magnitude compensation factor for winding 2 (see previous sections)

M[w3] - magnitude compensation factor for winding 3 (see previous sections)

$I_A^P[w]$, $I_B^P[w]$, and $I_C^P[w]$- phase and zero sequence compensated winding phase currents (see earlier)

The magnitude compensation factor for the reference winding is 1.

Differential and Restraint Current Calculations

Two Winding Transformer

Differential currents are calculated as follows:

$Id_A = I_A^C[w1] + I_A^C[w2]$

$Id_B = I_B^C[w1] + I_B^C[w2]$

$Id_C = I_C^C[w1] + I_C^C[w2]$

Restraint currents are calculated as follows:

$Ir_A = \max\{|I_A^C[w1]|, |I_A^C[w2]|\}$

$Ir_B = \max\{|I_B^C[w1]|, |I_B^C[w2]|\}$

$Ir_C = \max\{|I_C^C[w1]|, |I_C^C[w2]|\}$

where Id_A, Id_B and Id_C are the phase differential currents, and Ir_A, Ir_B, and Ir_C are the phase restraint currents.

Three-Winding Transformer

Differential currents are calculated as follows:

$Id_A = I_A^C[w1] + I_A^C[w2] + I_A^C[w3]$

$Id_B = I_B^C[w1] + I_B^C[w2] + I_B^C[w3]$

$Id_C = I_C^C[w1] + I_C^C[w2] + I_C^C[w3]$

Restraint currents are calculated as follows:

$Ir_A = \max\{|I_A^C[w1]|, |I_A^C[w2]|, |I_A^C[w3]|\}$

$Ir_B = \max\{|I_B^C[w1]|, |I_B^C[w2]|, |I_B^C[w3]|\}$

$Ir_C = \max\{|I_C^C[w1]|, |I_C^C[w2]|, |I_C^C[w3]|\}$

EXAMPLE

Consider a typical Wye/Delta power transformer with the following data:

..\Transformer\Winding 1

Item Name	Value	Unit
Signal Input	CT Bank 1 -J1	
Rated MVA	5.000	MVA
Nominal Ph-Ph Voltage	13.800	kV
Connection	Wye	
Grounding	Not Within Zone	
Wndg Resistance (3-ph)	10.0001	ohms

W 1

..\Transformer\Winding 2

Item Name	Value	Unit
Signal Input	CT Bank 2 -K1	
Rated MVA	5.000	MVA
Nominal Ph-Ph Voltage	4.16	kV
Connection	Delta	
Angle With Respect To W1	30° Lag	
Grounding	Not Within Zone	
Wndg Resistance (3-ph)	10.0000	ohms

W 2

- Winding 1: CT Bank 1 – J1 = 500/5 CT ratio
- Winding 2: CT Bank 2 – K1 = 1500/5 CT ratio
- Transformer is 50% loaded

Magnitude Compensation

Based on 50% loading the winding currents are calculated as follows:

Winding 1 load current: $I_{load}(W1) = 2.5MVA/(\sqrt{3} * 13.8kV) = 104.5$ Amps

Winding 2 load current: $I_{load}(W2) = 2.5MVA/(\sqrt{3} * 4.16kV) = 347$ Amps

Since Winding 1 is always magnitude compensation reference, the currents from winding 1 , are scaled only to be presented in times Winding 1 CT.

$M_{W1} = 1$, - magnitude compensation factor for winding 1 - REFERENCE

Winding 1 currents = $(M_{W1} * I_{load}(W_1))/CT_{W1} = 104.5/500 = 0.209 \times CT_{W1}$

Magnitude compensation for winding 2 currents:

$M_{W2} = (CT_{W2}.V_{W2})/ (CT_{W1}.V_{W1}) = (1500*4.16)/(500*13.8) = 0.9043$, -magnitude comp. factor for Winding 2 currents

Winding 2 currents = $(M_{W2} * I_{load}(W_2))/CT_{W2} = (0.9043*347)/1500 = 0.209 \times CT_{W2}$

To check that the measured currents from both windings will sum-up to zero after applying magnitude compensation, one can perform the following simple calculations:

Phase Shift Compensation

From the transformer example, the phase reference winding is winding 2 (i.e.,$w_f = 2$). The phase compensation angle for each winding is then calculated as follows (Rotation = "ABC"):

$\phi_{comp}[1] = -30° - 0° = -30° = 30°$ lag

$\phi_{comp}[2] = -30° - (-30°) = 0°$

The non-reference Wye winding will be rotated by -30° degrees to be in-phase and match the currents from the Delta winding.

Per *figure: Two-winding transformer connections* for phase compensation angle of 30 lag, the relay will use the following phase and zero-sequence compensation equations:

Winding 1 (Wye – grounded neutral):

$I_A^p [w]= (1/\sqrt{3})I_A [w] - (1/\sqrt{3})I_C [w]$

$I_B^p [w]= (1/\sqrt{3})I_B [w] - (1/\sqrt{3})I_A[w]$

$I_C^p [w]= (1/\sqrt{3})I_C [w] - (1/\sqrt{3})I_B [w]$

Winding 2 (Delta):

$I_A^p[w] = I_A [w]$

$I_B^p[w] = I_B [w]$

$I_C^p[w]= I_C [w]$

The complete compensated winding 1 and winding 2 currents would be as follows:

Winding 1	Winding 2
$I_A^c[w1] = 0.209xCT\angle 0^0$	$I_A^c[w2] = 0.209xCT\angle 180^0 lag$
$I_B^c[w1] = 0.209xCT\angle 120^0 lag$	$I_B^c[w2] = 0.209xCT\angle 300^0 lag$
$I_C^c[w1] = 0.209xCT\angle 240^0 lag$	$I_C^c[w2] = 0.209xCT\angle 60^0 lag$

The differential and restraint currents would be as follows:

Differential currents:

$Id_A = 0 \times CT$

$Id_B = 0 \times CT$

$Id_C = 0 \times CT$

Restraint currents:

$Ir_A = 0.209 \times CT$

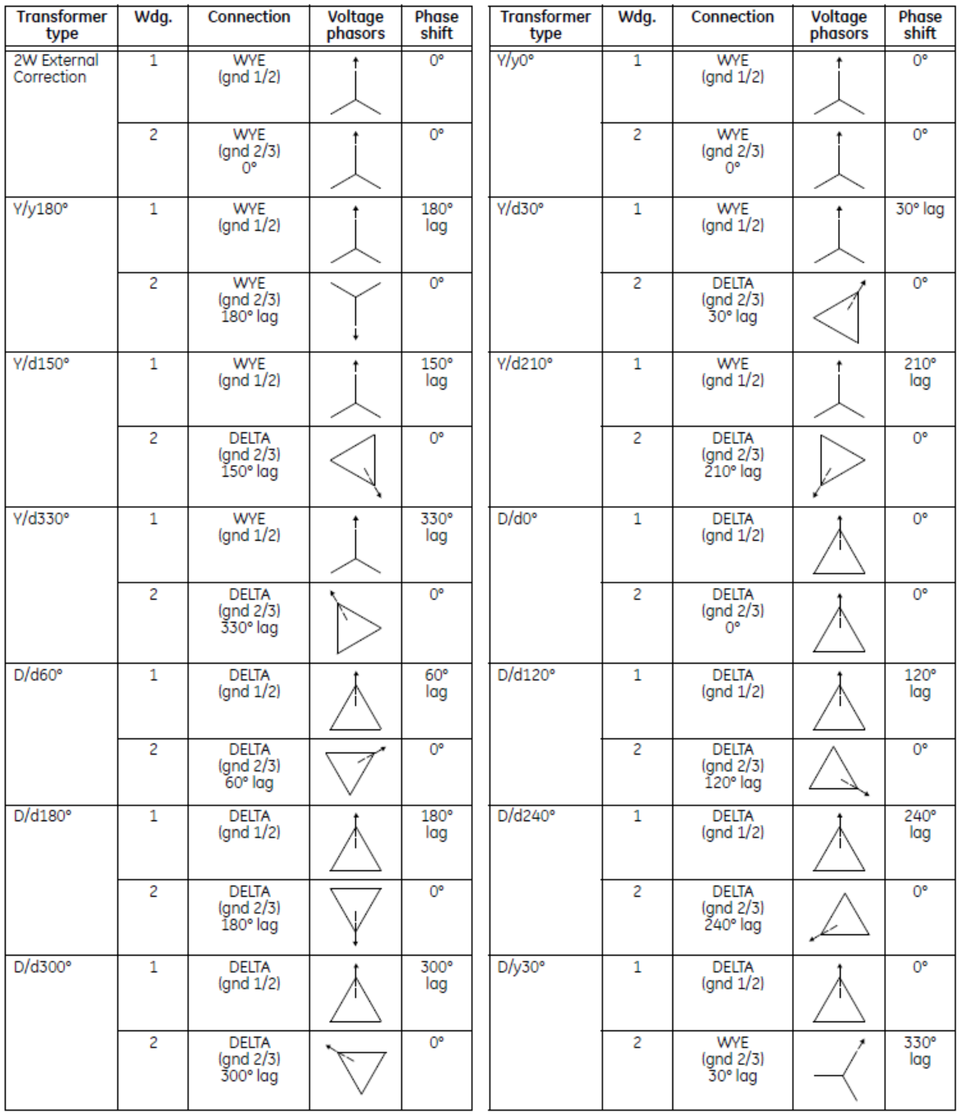
$Ir_B = 0.209 \times CT$

$Ir_C = 0.209 \times CT$

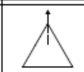
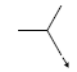
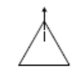
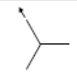
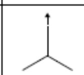
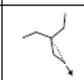
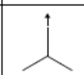
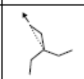
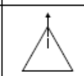
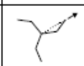
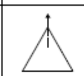
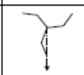
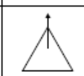
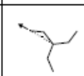
Transformer Types and Phase Shift compensation angles

The figures below show standard two-winding and three-winding transformer types, and the phase compensation angles which reference the phase reference winding used by the relay.

Figure 5-21: Two-winding transformer connections



Transformer type	Wdg.	Connection	Voltage phasors	Phase shift	Transformer type	Wdg.	Connection	Voltage phasors	Phase shift
2W External Correction	1	WYE (gnd 1/2)		0°	Y/y0°	1	WYE (gnd 1/2)		0°
	2	WYE (gnd 2/3) 0°		0°		2	WYE (gnd 2/3) 0°		0°
Y/y180°	1	WYE (gnd 1/2)		180° lag	Y/d30°	1	WYE (gnd 1/2)		30° lag
	2	WYE (gnd 2/3) 180° lag		0°		2	DELTA (gnd 2/3) 30° lag		0°
Y/d150°	1	WYE (gnd 1/2)		150° lag	Y/d210°	1	WYE (gnd 1/2)		210° lag
	2	DELTA (gnd 2/3) 150° lag		0°		2	DELTA (gnd 2/3) 210° lag		0°
Y/d330°	1	WYE (gnd 1/2)		330° lag	D/d0°	1	DELTA (gnd 1/2)		0°
	2	DELTA (gnd 2/3) 330° lag		0°		2	DELTA (gnd 2/3) 0°		0°
D/d60°	1	DELTA (gnd 1/2)		60° lag	D/d120°	1	DELTA (gnd 1/2)		120° lag
	2	DELTA (gnd 2/3) 60° lag		0°		2	DELTA (gnd 2/3) 120° lag		0°
D/d180°	1	DELTA (gnd 1/2)		180° lag	D/d240°	1	DELTA (gnd 1/2)		240° lag
	2	DELTA (gnd 2/3) 180° lag		0°		2	DELTA (gnd 2/3) 240° lag		0°
D/d300°	1	DELTA (gnd 1/2)		300° lag	D/y30°	1	DELTA (gnd 1/2)		0°
	2	DELTA (gnd 2/3) 300° lag		0°		2	WYE (gnd 2/3) 30° lag		330° lag

Transformer type	Wdg.	Connection	Voltage phasors	Phase shift
D/y150°	1	DELTA (gnd 1/2)		0°
	2	WYE (gnd 2/3) 150° lag		210° lag
D/y330°	1	DELTA (gnd 1/2)		0°
	2	WYE (gnd 2/3) 330° lag		30° lag
Y/z150°	1	WYE (gnd 1/2)		150° lag
	2	ZIG-ZAG (gnd 2/3) 150° lag		0°
Y/z330°	1	WYE (gnd 1/2)		330° lag
	2	ZIG-ZAG (gnd 2/3) 330° lag		0°
D/z60°	1	DELTA (gnd 1/2)		60° lag
	2	ZIG-ZAG (gnd 2/3) 60° lag		0°
D/z180°	1	DELTA (gnd 1/2)		180° lag
	2	ZIG-ZAG (gnd 2/3) 180° lag		0°
D/z300°	1	DELTA (gnd 1/2)		300° lag
	2	ZIG-ZAG (gnd 2/3) 300° lag		0°

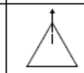
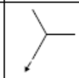
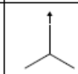
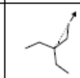
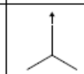
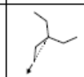
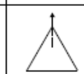
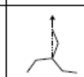
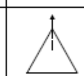
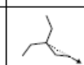
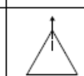
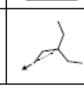
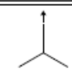
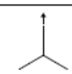
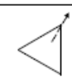
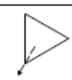
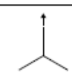
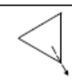
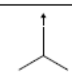
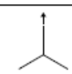
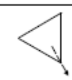
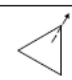
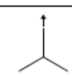
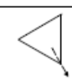
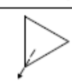
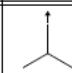
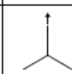
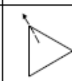
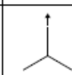
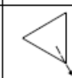
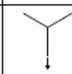
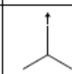
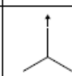
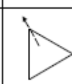
Transformer type	Wdg.	Connection	Voltage phasors	Phase shift
D/y210°	1	DELTA (gnd 1/2)		0°
	2	WYE (gnd 2/3) 210° lag		150° lag
Y/z30°	1	WYE (gnd 1/2)		30° lag
	2	ZIG-ZAG (gnd 2/3) 30° lag		0°
Y/z210°	1	WYE (gnd 1/2)		210° lag
	2	ZIG-ZAG (gnd 2/3) 210° lag		0°
D/z0°	1	DELTA (gnd 1/2)		0°
	2	ZIG-ZAG (gnd 2/3) 0° lag		0°
D/z120°	1	DELTA (gnd 1/2)		120° lag
	2	ZIG-ZAG (gnd 2/3) 120° lag		0°
D/z240°	1	DELTA (gnd 1/2)		240° lag
	2	ZIG-ZAG (gnd 2/3) 240° lag		0°

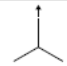
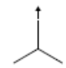
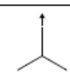
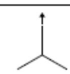
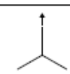
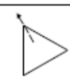
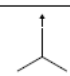
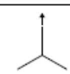
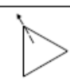
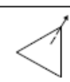
Figure 5-22: Three-winding transformer connections

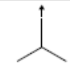
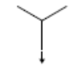
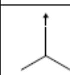
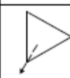
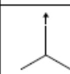
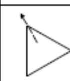
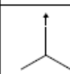
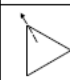
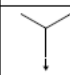
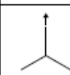
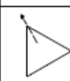
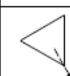
Transformer type	Wdg.	Connection	Voltage phasors	Phase shift
3W External Correction	1	WYE		0°
	2	WYE 0°		0°
	3	WYE 0°		0°
Y/y0°/d30°	1	WYE		30° lag
	2	WYE 0°		30° lag
	3	DELTA 30° lag		0°
Y/y0°/d210°	1	WYE		210° lag
	2	WYE 0°		210° lag
	3	DELTA 210° lag		0°
Y/y180°/d30°	1	WYE		30° lag
	2	WYE 180° lag		210° lag
	3	DELTA 30° lag		0°
Y/y180°/ d210°	1	WYE		210° lag
	2	WYE 180° lag		30° lag
	3	DELTA 210° lag		0°
Y/d30°/y0°	1	WYE		30° lag
	2	DELTA 30° lag		0°
	3	WYE 0°		30° lag

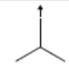
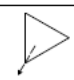
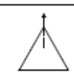
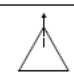
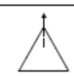
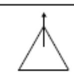
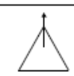
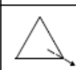
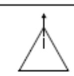
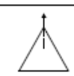
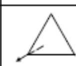
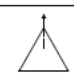
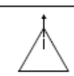
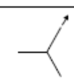
Transformer type	Wdg.	Connection	Voltage phasors	Phase shift
Y/y0°/d150°	1	WYE		150° lag
	2	WYE 0°		150° lag
	3	DELTA 150° lag		0°
Y/y0°/d330°	1	WYE		330° lag
	2	WYE 0°		330° lag
	3	DELTA 330° lag		0°
Y/y180°/ d150°	1	WYE		150° lag
	2	WYE 180° lag		330° lag
	3	DELTA 150° lag		0°
Y/y180°/ d330°	1	WYE		330° lag
	2	WYE 180° lag		150° lag
	3	DELTA 330° lag		0°
Y/d30°/y180°	1	WYE		30° lag
	2	DELTA 30° lag		0°
	3	WYE 180° lag		210° lag

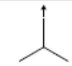
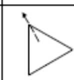
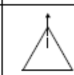
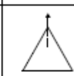
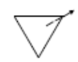
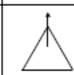
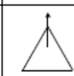
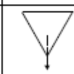
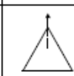
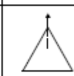
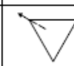
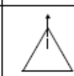
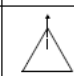
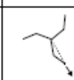
Transformer type	Wdg.	Connection	Voltage phasors	Phase shift
Y/d30°/d30°	1	WYE		30° lag
	2	DELTA 30° lag		0°
	3	DELTA 30° lag		0°
Y/d30°/d210°	1	WYE		30° lag
	2	DELTA 30° lag		0°
	3	DELTA 210° lag		180° lag
Y/d150°/y0°	1	WYE		150° lag
	2	DELTA 150° lag		0°
	3	WYE 0°		150° lag
Y/d150°/d30°	1	WYE		150° lag
	2	DELTA 150° lag		0°
	3	DELTA 30° lag		120° lag
Y/d150°/ d210°	1	WYE		150° lag
	2	DELTA 150° lag		0°
	3	DELTA 210° lag		300° lag

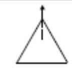
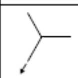
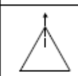
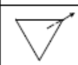
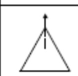
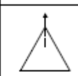
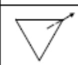
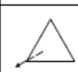
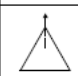
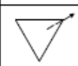
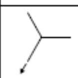
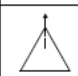
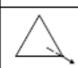
Transformer type	Wdg.	Connection	Voltage phasors	Phase shift
Y/d30°/d150°	1	WYE		30° lag
	2	DELTA 30° lag		0°
	3	DELTA 150° lag		240° lag
Y/d30°/d330°	1	WYE		30° lag
	2	DELTA 30° lag		0°
	3	DELTA 330° lag		60° lag
Y/d150°/ y180°	1	WYE		150° lag
	2	DELTA 150° lag		0°
	3	WYE 180° lag		330° lag
Y/d150°/ d150°	1	WYE		150° lag
	2	DELTA 150° lag		0°
	3	DELTA 150° lag		0°
Y/d150°/ d330°	1	WYE		150° lag
	2	DELTA 150° lag		0°
	3	DELTA 330° lag		180° lag

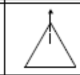
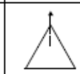
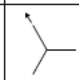
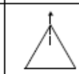
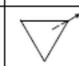
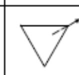
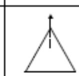
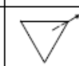
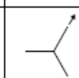
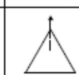
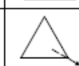
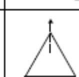
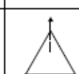
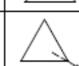
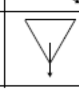
Transformer type	Wdg.	Connection	Voltage phasors	Phase shift
Y/d210°/y0°	1	WYE		210° lag
	2	DELTA 210° lag		0°
	3	WYE 0°		210° lag
Y/d210°/d30°	1	WYE		210° lag
	2	DELTA 210° lag		0°
	3	DELTA 30° lag		180° lag
Y/d210°/ d210°	1	WYE		210° lag
	2	DELTA 210° lag		0°
	3	DELTA 210° lag		0°
Y/d330°/y0°	1	WYE		330° lag
	2	DELTA 330° lag		0°
	3	WYE 0°		330° lag
Y/d330°/d30°	1	WYE		330° lag
	2	DELTA 330° lag		0°
	3	DELTA 30° lag		300° lag

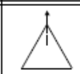
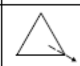
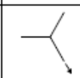
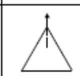
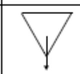
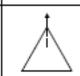
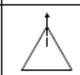
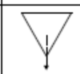
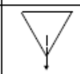
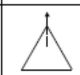
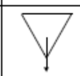
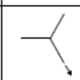
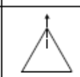
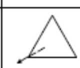
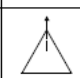
Transformer type	Wdg.	Connection	Voltage phasors	Phase shift
Y/d210°/ y180°	1	WYE		210° lag
	2	DELTA 210° lag		0°
	3	WYE 180° lag		30° lag
Y/d210°/ d150°	1	WYE		210° lag
	2	DELTA 210° lag		0°
	3	DELTA 150° lag		60° lag
Y/d210°/ d330°	1	WYE		210° lag
	2	DELTA 210° lag		0°
	3	DELTA 330° lag		240° lag
Y/d330°/ y180°	1	WYE		330° lag
	2	DELTA 330° lag		0°
	3	WYE 180° lag		150° lag
Y/d330°/ d150°	1	WYE		330° lag
	2	DELTA 330° lag		0°
	3	DELTA 150° lag		180° lag

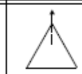
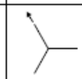
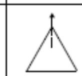
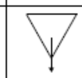
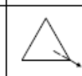
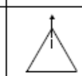
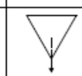
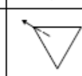
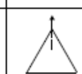
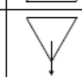
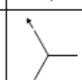
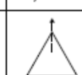
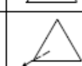
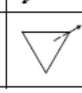
Transformer type	Wdg.	Connection	Voltage phasors	Phase shift
Y/d330°/ d210°	1	WYE		330° lag
	2	DELTA 330° lag		0°
	3	DELTA 210° lag		120° lag
D/d0°/d0°	1	DELTA		0°
	2	DELTA 0°		0°
	3	DELTA 0°		0°
D/d0°/d120°	1	DELTA		120° lag
	2	DELTA 0°		120° lag
	3	DELTA 120° lag		0°
D/d0°/d240°	1	DELTA		240° lag
	2	DELTA 0°		240° lag
	3	DELTA 240° lag		0°
D/d0°/y30°	1	DELTA		0°
	2	DELTA 0°		0°
	3	WYE 30° lag		330° lag

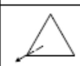
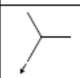
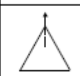
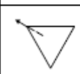
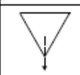
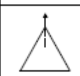
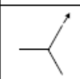
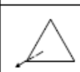
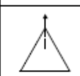
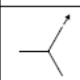
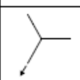
Transformer type	Wdg.	Connection	Voltage phasors	Phase shift
Y/d330°/ d330°	1	WYE		330° lag
	2	DELTA 330° lag		0°
	3	DELTA 330° lag		0°
D/d0°/d60°	1	DELTA		60° lag
	2	DELTA 0°		60° lag
	3	DELTA 60° lag		0°
D/d0°/d180°	1	DELTA		180° lag
	2	DELTA 0°		180° lag
	3	DELTA 180° lag		0°
D/d0°/d300°	1	DELTA		300° lag
	2	DELTA 0°		300° lag
	3	DELTA 300° lag		0°
D/d0°/y150°	1	DELTA		0°
	2	DELTA 0°		0°
	3	WYE 150° lag		210° lag

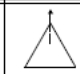
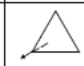
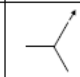
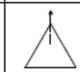
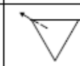
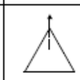
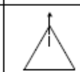
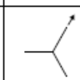
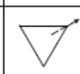
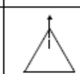
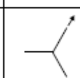
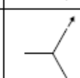
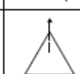
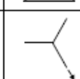
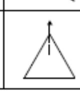
Transformer type	Wdg.	Connection	Voltage phasors	Phase shift
D/d0°/y210°	1	DELTA		0°
	2	DELTA 0°		0°
	3	WYE 210° lag		150° lag
D/d60°/d0°	1	DELTA		60° lag
	2	DELTA 60° lag		0°
	3	DELTA 0°		60° lag
D/d60°/d240°	1	DELTA		240° lag
	2	DELTA 60° lag		180° lag
	3	DELTA 240° lag		0°
D/d60°/y210°	1	DELTA		0°
	2	DELTA 60° lag		300° lag
	3	WYE 210° lag		150° lag
D/d120°/ d120°	1	DELTA		120° lag
	2	DELTA 120° lag		0°
	3	DELTA 120° lag		0°

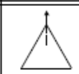
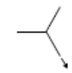
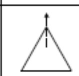
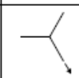
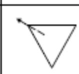
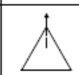
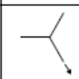
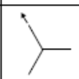
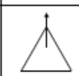
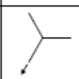
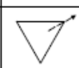
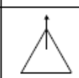
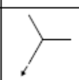
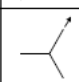
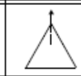
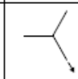
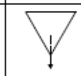
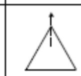
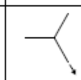
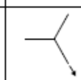
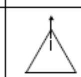
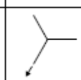
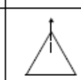
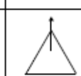
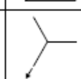
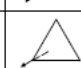
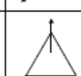
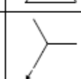
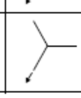
Transformer type	Wdg.	Connection	Voltage phasors	Phase shift
D/d0°/y330°	1	DELTA		0°
	2	DELTA 0°		0°
	3	WYE 330° lag		30° lag
D/d60°/d60°	1	DELTA		60° lag
	2	DELTA 60° lag		0°
	3	DELTA 60° lag		0°
D/d60°/y30°	1	DELTA		0°
	2	DELTA 60° lag		300° lag
	3	WYE 30° lag		330° lag
D/d120°/d0°	1	DELTA		120° lag
	2	DELTA 120° lag		0°
	3	DELTA 0°		120° lag
D/d120°/ d180°	1	DELTA		120° lag
	2	DELTA 120° lag		0°
	3	DELTA 180° lag		300° lag

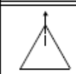
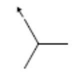
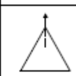
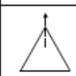
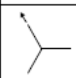
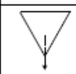
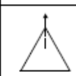
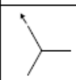
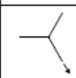
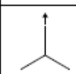
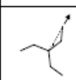
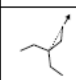
Transformer type	Wdg.	Connection	Voltage phasors	Phase shift
D/d120°/ y150°	1	DELTA		0°
	2	DELTA 120° lag		240° lag
	3	WYE 150° lag		210° lag
D/d180°/d0°	1	DELTA		180° lag
	2	DELTA 180° lag		0°
	3	DELTA 0°		180° lag
D/d180°/ d180°	1	DELTA		0°
	2	DELTA 180° lag		180° lag
	3	DELTA 180° lag		180° lag
D/d180°/ y150°	1	DELTA		0°
	2	DELTA 180° lag		180° lag
	3	WYE 150° lag		210° lag
D/d240°/d0°	1	DELTA		240° lag
	2	DELTA 240° lag		0°
	3	DELTA 0°		240° lag

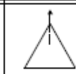
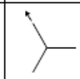
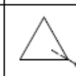
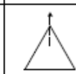
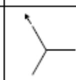
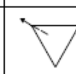
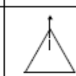
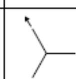
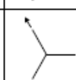
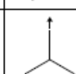
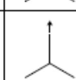
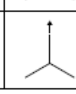
Transformer type	Wdg.	Connection	Voltage phasors	Phase shift
D/d120°/ y330°	1	DELTA		0°
	2	DELTA 120° lag		240° lag
	3	WYE 330° lag		30° lag
D/d180°/ d120°	1	DELTA		120° lag
	2	DELTA 180° lag		300° lag
	3	DELTA 120° lag		0°
D/d180°/ d300°	1	DELTA		300° lag
	2	DELTA 180° lag		120° lag
	3	DELTA 300° lag		0°
D/d180°/ y330°	1	DELTA		0°
	2	DELTA 180° lag		180° lag
	3	WYE 330° lag		30° lag
D/d240°/d60°	1	DELTA		240° lag
	2	DELTA 240° lag		0°
	3	DELTA 60° lag		180° lag

Transformer type	Wdg.	Connection	Voltage phasors	Phase shift
D/d240°/ d240°	1	DELTA		240° lag
	2	DELTA 240° lag		0°
	3	DELTA 240° lag		0°
D/d240°/ y210°	1	DELTA		0°
	2	DELTA 240° lag		120° lag
	3	WYE 210° lag		150° lag
D/d300°/ d180°	1	DELTA		300° lag
	2	DELTA 300° lag		0°
	3	DELTA 180° lag		120° lag
D/y30°/d240°	1	DELTA		0°
	2	WYE 30° lag		330° lag
	3	DELTA 240° lag		120° lag
D/y30°/y210°	1	DELTA		0°
	2	WYE 30° lag		330° lag
	3	WYE 210° lag		150° lag

Transformer type	Wdg.	Connection	Voltage phasors	Phase shift
D/d240°/y30°	1	DELTA		0°
	2	DELTA 240° lag		120° lag
	3	WYE 30° lag		330° lag
D/d300°/d0°	1	DELTA		300° lag
	2	DELTA 300° lag		0°
	3	DELTA 0°		300° lag
D/y30°/d60°	1	DELTA		0°
	2	WYE 30° lag		330° lag
	3	DELTA 60° lag		300° lag
D/y30°/y30°	1	DELTA		0°
	2	WYE 30° lag		330° lag
	3	WYE 30° lag		330° lag
D/y150°/d0°	1	DELTA		0°
	2	WYE 150° lag		210° lag
	3	DELTA 0°		0°

Transformer type	Wdg.	Connection	Voltage phasors	Phase shift
D/y150°/d120°	1	DELTA		0°
	2	WYE 150° lag		210° lag
	3	DELTA 120° lag		240° lag
D/y150°/d300°	1	DELTA		0°
	2	WYE 150° lag		210° lag
	3	DELTA 300° lag		60° lag
D/y150°/y330°	1	DELTA		0°
	2	WYE 150° lag		210° lag
	3	WYE 330° lag		30° lag
D/y210°/d60°	1	DELTA		0°
	2	WYE 210° lag		150° lag
	3	DELTA 60° lag		300° lag
D/y210°/y30°	1	DELTA		0°
	2	WYE 210° lag		150° lag
	3	WYE 30° lag		330° lag
D/y150°/d180°	1	DELTA		0°
	2	WYE 150° lag		210° lag
	3	DELTA 180° lag		180° lag
D/y150°/y150°	1	DELTA		0°
	2	WYE 150° lag		210° lag
	3	WYE 150° lag		210° lag
D/y210°/d0°	1	DELTA		0°
	2	WYE 210° lag		150° lag
	3	DELTA 0°		0°
D/y210°/d240°	1	DELTA		0°
	2	WYE 210° lag		150° lag
	3	DELTA 240° lag		120° lag
D/y210°/y210°	1	DELTA		0°
	2	WYE 210° lag		150° lag
	3	WYE 210° lag		150° lag

Transformer type	Wdg.	Connection	Voltage phasors	Phase shift
D/y330°/d0°	1	DELTA		0°
	2	WYE 330° lag		30° lag
	3	DELTA 0°		0°
D/y330°/ d180°	1	DELTA		0°
	2	WYE 330° lag		30° lag
	3	DELTA 180° lag		180° lag
D/y330°/ y150°	1	DELTA		0°
	2	WYE 330° lag		30° lag
	3	WYE 150° lag		210° lag
Y/z30°/z30°	1	WYE		30° lag
	2	ZIG-ZAG 30° lag		0°
	3	ZIG-ZAG 30° lag		0°

Transformer type	Wdg.	Connection	Voltage phasors	Phase shift
D/y330°/ d120°	1	DELTA		0°
	2	WYE 330° lag		30° lag
	3	DELTA 120° lag		240° lag
D/y330°/ d300°	1	DELTA		0°
	2	WYE 330° lag		30° lag
	3	DELTA 300° lag		60° lag
D/y330°/ y330°	1	DELTA		0°
	2	WYE 330° lag		30° lag
	3	WYE 330° lag		30° lag
Y/y0°/y0°	1	WYE		0°
	2	WYE 0°		0°
	3	WYE 0°		0°

Xfmer Status Detection

The 845 relay can be set to detect the status of the protected transformer when energized or de-energized. The detection of the transformer energized/de-energized status is set to produce operands, which can be used for transformer monitoring applications, and to trigger an LED (operand set by the factory to trigger LED "Transformer De-Energized"). The transformer status is detected based on measured voltage, or breaker status, which can be supervised by a current above the programmed minimum level.

Detection by breaker status

When the 'b' auxiliary contacts from all switching devices (which can be used to energize the transformer) are assigned to the **ALL BREAKERS OPEN** setpoints, closed contacts indicate de-energization. When Current Supervision is enabled, any current exceeding the minimum energization current indicates energization.

Detection by voltage

When energization sensing by voltage is enabled, any voltage drops below the minimum energization voltage indicates de-energization. However, if Current Supervision is enabled, any of the winding currents that exceed the minimum energization current shows that the transformer is being energized.

Current Supervision

The Current Supervision is set to support the decision for the Transformer Energized or De-Energized status. If all winding currents drop below the minimum transformer magnetizing current after transformer de-energization, this will be added to the decision from the selected sensing method (Opened Breakers, or Voltage), and will indicate de-energization. Any current exceeding the minimum energization current will indicate energization.

Path: **Setpoints > System > Transformer > Xfmr Status Detection**

SENSING BY BREAKERS OPEN

Range: Disabled, Enabled

Default: Disabled

This method of sensing indicates that when all transformer breakers are detected open, the transformer must be de-energized. For a more secure detection, the breakers open detection can be supervised by the detection of the minimum current, when the Current Supervision setpoint is enabled.

ALL BREAKERS OPEN

Range: Off, Any FlexLogic operand

Default: Off

Select the FlexLogic operand from the list representing to assert a flag when all transformer breakers are open. This can be "52b" contacts from the transformer breakers wired in series before connected to the relay, or another FlexLogic operand (Virtual Output) becoming high upon the open status of all breakers.

SENSING BY VOLTAGE

Range: Disabled, Ph VT Bank 1-J2, Ax VT Bank1-J2

Default: Disabled

Select Ph VT Bnk1-J2 to detect the transformer status if all three-phase VTs are connected to the phase VT terminals on the relay. Select Ax VT Bnk1-J2 if only one voltage input is available from the system, and it is connected to Vaux terminals of the voltage bank J2. In order for the relay to detect the transformer status accurately, the VTs must be placed within the differential zone of protection between the Breaker and the winding. If the VTs are placed outside the zone of protection, the transformer status will not be correct. Even when the breaker is open, the relay can show the Transformer Energized status.

NOTE

The transformer status detection will work even if only one voltage input is available from the power system. In such cases, the voltage input must be connected to the appropriate phase voltage terminals on the relay. Since the other two voltages per the logic diagram will be zero, the transformer de-energized status will be detected when the magnitude of the connected single voltage input is below the minimum voltage setting.

MINIMUM VOLTAGE

Range: 0.50 to 0.99 x VT in steps of 0.01 x VT

Default: 0.85 x VT

Select the minimum voltage level required for the energized/de-energized transformer status. Note that during faults the voltage tends to decrease. If the voltage stays below the minimum voltage for more than 50 ms, the transformer will show the transformer de-energized status. This situation can be avoided if Current Supervision is set to "Enabled". In this case, even if all the voltages collapse below the minimum voltage level, the transformer will still show energized, because during fault conditions at least one phase will measure substantial current.

NOTICE

When Sensing by Voltage is set to Ph VT Bnk1-J1, the 845 relay calculates delta voltages, and compares them against the specified minimum voltage threshold given in times VT. If Wye is programmed for phase VT connection, the VT unit is obtained by multiplying the programmed secondary voltage through the VT ratio and SQRT(3). If Delta is programmed for phase VT connection, multiplication of SQRT(3) is not necessary.

When Sensing by Voltage is set to Ax VT Bnk1-J2, the minimum voltage threshold applies to the voltage measured at the auxiliary voltage input from the J2 terminals..

CURRENT SUPERVISION

Range: Disabled, Enabled

Default: Disabled

Current supervision can be used to add another element into one or another sensing mechanism for detecting the Transformer Energized, or Transformer De-Energized status. When "Enabled" the relay scans all the winding currents and compares the measurements against the programmed setpoint "Minimum Current" level.

MINIMUM CURRENT

Range: 0.020 to 0.500 x CT in steps of 0.001

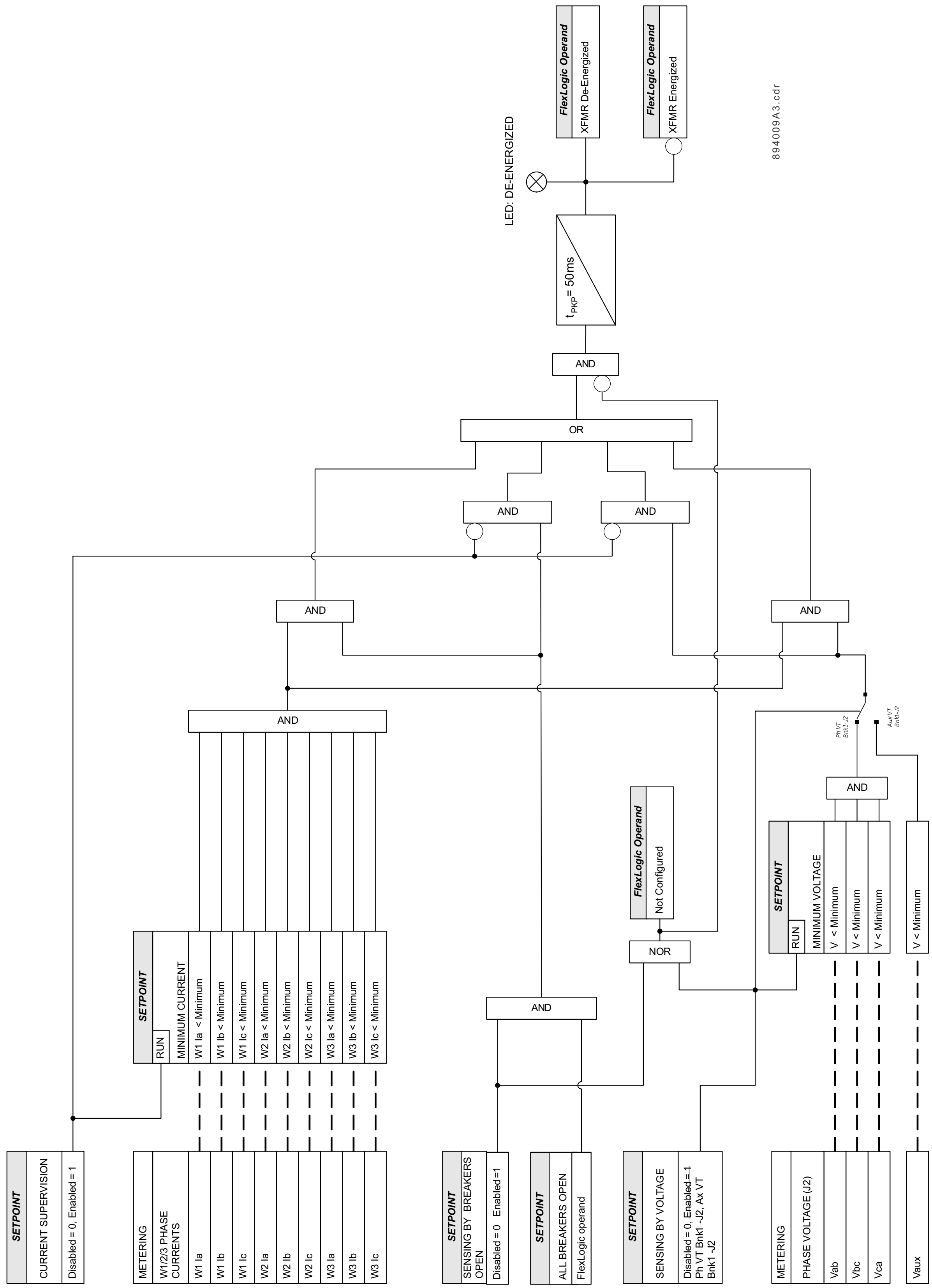
Default: 0.050 x CT

Select the minimum current, below which the transformer is considered de-energized. Current supervision alone cannot change the Transformer De-Energized status unless all transfer breakers are open or the voltage drops below the Minimum Voltage level. Note that if no load is connected to a transformer which has been energized, the current transformers from the closed breaker will detect only the transformer magnetizing current. In order to have Transformer energized status supervised by current, the level of the minimum current must be below the transformer magnetizing current.

When Enabled, a current level (< Minimum Current) alone does not change the Transformer De-Energized status unless all transformer breakers are open or voltage drops below Minimum Voltage level. Moreover, when Current Supervision is enabled, neither All Breakers Open nor a voltage less than the Minimum Voltage can change the Transformer De-Energized status unless current falls below the Minimum Current level.

When Current Supervision is Disabled, transformer De-Energized status monitoring is based on the All Breakers Open condition or voltage less than Minimum Voltage condition.

Figure 5-23: Transformer Status Detection Logic Diagram



Thermal Inputs

The 845 relay can be set to monitor the hottest-spot winding temperature, the aging acceleration factor and the transformer insulation life. In order for the relay to perform the correct calculations, the user needs to enter transformer data and program RTD inputs for measuring ambient and top-oil temperatures. The following menu shows the selections for ambient and top-oil temperatures.

Path: **Setpoints > System > Transformer > Thermal Inputs**

WINDING CURRENTS

Range: CT Bank1-J1, CT Bank 2 – K1, CT Bank 3 –K2

Default: CT Bank 1-J1

Select the bank representing the currents (loading) of the winding to which the thermal elements are applied.

AMBIENT TEMPERATURE

Range: Monthly Average, RTD 1, RTD 2....RTD x

Default: Monthly Average

Select RTD input if the ambient temperature is to be measured directly. Select the “Monthly Average” setting and enter an average temperature for every month of the year, if direct ambient temperature measurement is not available.

NOTE

The setpoints for average monthly temperatures will show on the screen only when the “Monthly Average” setting is selected. In all other cases, these setpoints will be hidden.

AMBIENT TEMPERATURE AVG - Jan to Dec

Range: -60°C to 60°C (-76°F to 140°F) in steps of 1°C

Default: Jan= -20, Feb= -20, Mar= -10, Apr= 10, May= 20, Jun= 30, Jul= 30, Aug= 30, Sep= 20, Oct= 10, Nov= 10, Dec= -10

TOP-OIL TEMPERATURE

Range: Computed, RTD 1, RTD 2....RTD x

Default: Computed

Select RTD input for direct measurement of top-oil temperature. If such input is not available, select the setting “Computed”.

NOTE

Refer to SETPOINTS/RTD Temperature, on how to select RTD, to be used for measuring ambient and top-oil temperatures.

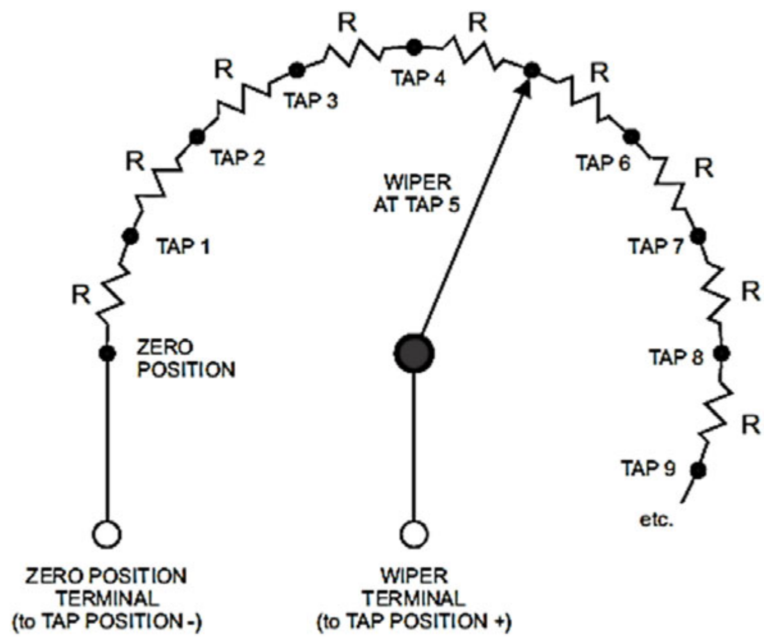
On-load Tap Changer

This section contains the settings to configure the tap position input. The 845 relay offers tap position detection by monitoring either a resistive input from the tap changer control circuitry, a dcmA analog input, or by Binary Coded Decimal (BCD) inputs. Based on the detected tap, the 845 relay dynamically corrects for CT ratio mismatch resulting from the changes of the voltage ratio of the transformer. Thus, the percent differential function of the device can be set for greater sensitivity. See Section: Windings> *Magnitude Compensation > item 2. LTC compensation set to "Enabled"*, for more details on the tap position input.

Tap detection using Resistive Input

A typical tap position input layout is shown in the figure: Tap position input. Minimum tap position and minimum tap voltage correspond to the "TAP 1" label in the figure.

Figure 5-24: Tap position input



In this method of detection, the resistive output from the tap changer is connected to the Ohms input on the relay. The maximum resistance supported by the Ohms input is 5.1kΩ. The user defines the minimum and maximum tap, voltage increment per tap, and the Ohms per tap.

Tap detection using dcmA analog input

In this method, the user selects Analog Input 1 dedicated for detection of DC milliamp value corresponding to a tap position. To detect the tap, the relay measures the dcmA current at the terminal of the Analog Input 1 and compares it to the corresponding dcmA current computed for each tap.

Tap detection using BCD input

The Binary Coded Decimal (BCD) is another way of detecting tap position by using the combination of six bits each driven by contact input. The user wires and selects the contact input per bit number. Each combination of six bits corresponds to a certain tap position. Refer to the following table: *All BCD combinations supported by the relay*:

Path: Setpoints > Monitoring > Transformer > Tap Changer

TAP POSITION DETECTION

Range: Disabled, Enabled
Default: Disabled

TC WINDING CURRENTS

Range: None, J1, K1, K2

Default: None

Enter the CT bank associated with the winding with tap changer. Enter 'None' if the transformer is not equipped with a tap changer. Enter 'None' if automatic magnitude compensation based on tap position used for the differential protection is not needed. The setting "None" can be selected in cases where either the transformer is not equipped with Tap Changer, or it is equipped with Tap Changer, but it is not desired to automatically compensate winding currents forming the differential current in the transformer differential protection, or in cases where the differential protection is not used at all.

All transformer windings from 845 are associated with CT bank inputs. Depending on 845 ordering, the following CT banks represent the winding currents:

1. 845 orders for two-winding transformers without voltage inputs:
   - K1 CT bank is used for Winding 1
   - K2 CT bank is used for Winding 2
2. 845 orders for two-winding transformers with voltage inputs:
   - J1 CT bank is used for Winding 1
   - K1 CT bank is used for Winding 2
3. 845 orders for three-winding transformers (voltage inputs always included):
   - J1 CT bank is used for Winding 1
   - K1 CT bank is used for Winding 2
   - K2 CT bank is used for Winding 3

NOTE

If the Tap Changer setpoint TC Winding Currents is set to J1, K1, or K2, the computed tap position voltage will be used for automatic magnitude mismatch compensation for the winding represented by the same CT bank currents. Otherwise, if the setpoint TC Winding Currents is set to "None", the mismatch magnitude computation is not automatically updated to include the new transformation ratio. In such cases, the relay may display differential current, where this current will be higher for taps far away from the tap representing the nominal winding voltage, and it will be lower for taps closer to the nominal voltage tap. It is recommended to increase the minimum PKP setting of the Percent Differential characteristic to be above the maximum differential current that can be seen at either Maximum tap, or Minimum tap.

TAP DETECTION INPUT

Range: BCD, Ohms In 1, Analog Ip 1

Default: BCD

Select either BCD(Binary Coded Decimals), or Ohms In 1 or Analog Ip 1 input for detection of the tap positions. The Ohms input provides maximum total resistance of up to 5.1 kΩ. For example, the maximum resistance increment per tap for a 33-position tap changer should not exceed 151 Ω.If Analog In 1 is selected, the relay measures DC mA current, and detects the tap position according to the selection for "DCmA at Min Tap", and "DCmA at Max Tap" setpoints.

⚠WARNING

If Analog Input 1 is selected as the tap detection input, then Analog Input 1 will not be available for use in any other application. The Analog Input 1 is excluded from the list of analog inputs, and its range is forced to 0.000 – 20.000 mA. The Tap changer monitors the measured μA. When the total number of taps per the tap changer setup is computed, the tap position is detected based on minimum tap corresponding to the measured DCmA at MIN TAP, maximum tap corresponding to the measured DCmA at MAX TAP, and the μA step obtained by dividing the total μA of DCmA at MIN TAP and DCmA at MAX TAP by the total number of taps.

MIN TAP

Range: -19 to +35 in steps of 1
Default: -16

This setting defines the minimum tap from the tap changer. The 845 uses the setting to signal when the minimum tap is reached.

NEUTRAL TAP

Range: -17 to +37 in steps of 1
Default: 0

This setting defines the neutral tap position. The 845 uses the setting to signal when the neutral tap is reached.

MAX TAP

Range: 0 to +39 in steps of 1
Default: +16

This setting defines the maximum tap from the tap changer. The 845 uses this setting to signal when the maximum tap is reached.

MIN TAP VOLTAGE

Range: 0.01 to 20000.00 kV in steps of 0.01 kV
Default: 61.00 kV
Enter the voltage at the minimum position

VOLTAGE INCREMENT PER TAP

Range: 0.01 to 20.00 kV in steps of 0.01 kV
Default: 0.50 kV

Enter the voltage increment per tap change.

Ohms at MIN TAP

Range: 0 to 5100 Ohms in steps of 1 Ohm
Default: 33 Ohms

Enter the resistance in Ohms corresponding to the minimum tap. This setting is used only when Ohms input is selected as “Tap Detection Input”.

Ohms at MAX TAP

Range: 0 to 5100 Ohms in steps of 1 Ohm
Default: 1089 Ohms

Enter the resistance in Ohms corresponding to the maximum tap. This setting is used only when Ohms input is selected as “Tap Detection Input”.

DCmA at MIN TAP

Range: 0.000 to 20.000 mA in steps of 0.001 mA
Default: 4.000 mA

Enter the DCmA current corresponding to the minimum tap. This setting is used only when Analog In 1 is selected as “Tap Detection Input”.

DCmA at MAX TAP

Range: 0.000 to 20.000 mA in steps of 0.001 mA
Default: 18.000 mA

Enter the DCmA current corresponding to the maximum tap. This setting is used only when Analog In 1 is selected as “Tap Detection Input”.

BCD BIT 1- 5 INPUT

Range: Off, Contact Input 1(X), Virtual Input 1(X), Remote Input 1(X)
Default: Off

The six BCD inputs require selection of contact inputs, virtual inputs, or remote inputs. The tap position is detected by the state combination of high/low bits received from the tap changer mechanism.

BCD BIT 6 INPUT:

Range: Off, Contact Input 1(X), Virtual Input 1(X), Remote Input 1(X)
Default: Off

This input provides the configuration of the BCD Bit 6 input. The tap position provided by the transformer can be either positive from 1 to 39, or positive and negative from -19 to 19.

BCD BIT 6 input provides the configuration of the positive BCD BIT 6 or the sign (-) of the BCD code.

The selection of BCD BIT 6 working mode is made according to the TAP MIN setting.

When the TAP MIN setpoint is configured with a negative value, the BCD BIT 6 will provide the sign(-) of the BCD.

Hence, the maximum range for BCD tap detection of negative and positive taps goes from -19 to +19.

When, TAP MIN setting is positive the BCD BIT 6 INPUT provides the BCD 20 code. As a result, the full BCD range goes from 1 to 39.

INVERSE TAP POSITIONS

Range: Disabled, Enabled
Default: Disabled

When “Disabled”, increasing the tap position increases turns and hence the winding voltage, used also for automatic compensation of the currents mismatch, which otherwise could be seen as differential current upon changing tap. This usually is the case when the OLTC(On-Load Tap Changer) is installed on the winding connected to the load.

When “Enabled”, increasing the tap position will decrease the ampere-turns of the winding. When the OLTC is installed on the winding connected to the source, increasing the tap will have to decrease the turns, to maintain constant voltage at the secondary winding connected to load. This usually is the case when the OLTC is installed on the winding connected to the source.

Binary Coded Decimal (BCD) inputs

To configure the BCD decoder inputs into an I/O card the BCD BIT x INPUT setpoints must be programmed.

- With 4 BCD bits programmed, only 9 tap positions can be detected.
- Five BCD bits programmed can be used for detection of up to 19 tap positions.
- With all 6 BCD bits programmed, the relay can detect up to 39 tap positions.

The physical connection between the output BCD decoder and the I/O card (for five BCD bits programmed) is shown in the next figure: An example *of BCD decoder connections to an IO_A card for up to 19 taps*.

The selection of the suitable setting depends on the customer’s criteria. In both cases, when the BCD format is chosen, the neutral tap position must be entered.

Figure 5-25: An example of BCD decoder connections to an IO_A card for up to 19 taps

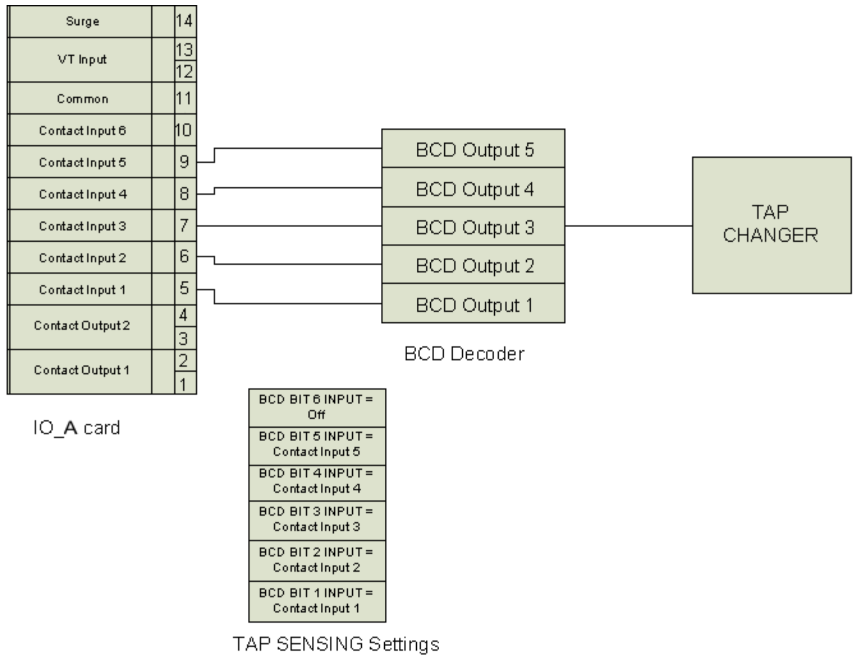


Table 5-5: All BCD combinations supported by the relay

MIN TAP	BCD bit 6 Input	BCD bit 5 Input	BCD bit 4 Input	BCD bit 3 Input	BCD bit 2 Input	BCD bit 1 Input	TAP Position
+Tap	0	0	0	0	0	0	0
+Tap	0	0	0	0	0	1	1
+Tap	0	0	0	0	1	0	2
+Tap	0	0	0	0	1	1	3
+Tap	0	0	0	1	0	0	4
+Tap	0	0	0	1	0	1	5
+Tap	0	0	0	1	1	0	6
+Tap	0	0	0	1	1	1	7
+Tap	0	0	1	0	0	0	8
+Tap	0	0	1	0	0	1	9
+Tap	0	0	1	0	1	0	invalid
+Tap	0	0	1	0	1	1	invalid
+Tap	0	0	1	1	0	0	invalid
+Tap	0	0	1	1	0	1	invalid
+Tap	0	0	1	1	1	0	invalid
+Tap	0	0	1	1	1	1	invalid
+Tap	0	1	0	0	0	0	10
+Tap	0	1	0	0	0	1	11
+Tap	0	1	0	0	1	0	12
+Tap	0	1	0	0	1	1	13
+Tap	0	1	0	1	0	0	14
+Tap	0	1	0	1	0	1	15
+Tap	0	1	0	1	1	0	16
+Tap	0	1	0	1	1	1	17
+Tap	0	1	1	0	0	0	18

MIN TAP	BCD bit 6 Input	BCD bit 5 Input	BCD bit 4 Input	BCD bit 3 Input	BCD bit 2 Input	BCD bit 1 Input	TAP Position
+Tap	0	1	1	0	0	1	19
+Tap	0	1	1	0	1	0	invalid
+Tap	0	1	1	0	1	1	invalid
+Tap	0	1	1	1	0	0	invalid
+Tap	0	1	1	1	0	1	invalid
+Tap	0	1	1	1	1	0	invalid
+Tap	0	1	1	1	1	1	invalid
+Tap	1	0	0	0	0	0	20
+Tap	1	0	0	0	0	1	21
+Tap	1	0	0	0	1	0	22
+Tap	1	0	0	0	1	1	23
+Tap	1	0	0	1	0	0	24
+Tap	1	0	0	1	0	1	25
+Tap	1	0	0	1	1	0	26
+Tap	1	0	0	1	1	1	27
+Tap	1	0	1	0	0	0	28
+Tap	1	0	1	0	0	1	29
+Tap	1	0	1	0	1	0	invalid
+Tap	1	0	1	0	1	1	invalid
+Tap	1	0	1	1	0	0	invalid
+Tap	1	0	1	1	0	1	invalid
+Tap	1	0	1	1	1	0	invalid
+Tap	1	0	1	1	1	1	invalid
+Tap	1	1	0	0	0	0	30
+Tap	1	1	0	0	0	1	31
+Tap	1	1	0	0	1	0	32
+Tap	1	1	0	0	1	1	33
+Tap	1	1	0	1	0	0	34
+Tap	1	1	0	1	0	1	35
+Tap	1	1	0	1	1	0	36
+Tap	1	1	0	1	1	1	37
+Tap	1	1	1	0	0	0	38
+Tap	1	1	1	0	0	1	39
+Tap	1	1	1	0	1	0	invalid
+Tap	1	1	1	0	1	1	invalid
+Tap	1	1	1	1	0	0	invalid
+Tap	1	1	1	1	0	1	invalid
+Tap	1	1	1	1	1	0	invalid
+Tap	1	1	1	1	1	1	Invalid
....	....	...	...	...	...	...	...
-Tap	0	0	0	0	0	1	+1
-Tap	0	0	0	0	0	0	0
-Tap	1	0	0	0	0	0	0
-Tap	1	0	0	0	0	1	-1
-Tap	1	0	0	0	1	0	-2
...	...	...	...	...	...	...	...
-Tap	1	1	1	0	0	1	-19

Breakers

The status of each winding breaker is detected on the 845 relay by monitoring the state/states of either one, or preferably two contact inputs. It is highly recommended to monitor the status of the breaker using both breaker auxiliary contacts 52a, and 52b. However using only one of them is also acceptable.

The breaker connection/disconnection to/from the power system (racked-out by the breaker racking mechanism, or isolated by the associated disconnect switches on a fixed circuit breaker) is provided by monitoring the contact input "BKR CONNECTED". If the contact input selected under the "BKR CONNECTED" setpoint is asserted, the breaker is considered connected to the primary system. When the breaker is determined disconnected, the breaker state is shown to be neither open, nor closed. The trolley is integrated with a circuit breaker (CB), which works as a Disconnect switch. CB Trolley status is decided based on the contact input selected under the "CONNECTED" and "BKR TROLLEY" setpoints.

NAME

Range: Up to 13 alphanumeric characters
Default: BKRX

CONTACT INPUT 52a

Range: Off, Any FlexLogic operand
Default: Off

Selects the Contact Input connected to the Breaker auxiliary contact 52a.

CONTACT INPUT 52b

Range: Off, Any FlexLogic operand
Default: Off

Selects the Contact Input connected to the Breaker auxiliary contact 52b.

CONNECTED

Range: Off, Any FlexLogic operand
Default: Off

Select a contact input to show whether the breaker is connected (Racked-in, or disconnect switches switched-on), or disconnected (racked-out, or disconnect switches switched-off) from the system.

BKR TROLLEY

Range: Off, Any FlexLogic operand
Default: Off

Select a contact input to show whether the Breaker Trolley is connected or disconnected from the system.

TRIP RELAY SELECT

Range: Off, Any Output Relay
Default: Relay 1

Any output relay from the list of available output relays can be programmed for breaker tripping action. Please refer to the table from the section Output Relaysfor more detail on output relay availability with respect to their assignment.

CLOSE RELAY SELECT

Range: Off, Relay X
Default: Relay 2

Any output relay from the list of available output relays can be programmed for breaker closing action. Please refer to the table from the section Output Relaysfor more detail on output relay availability with respect to their assignment.

Table 5-6: Breaker status depending on availability of contacts 52a and 52b

52a Contact Configured	52b Contact Configured	Breaker Status	
		Open	Closed
Yes	Yes	52a contact open 52b contact closed	52a contact closed 52b contact open
Yes	No	52a contact open	52a contact closed
No	Yes	52b contact closed	52b contact open
No	No	Breaker Not Configured	

Table 5-7: Breaker status with both contacts 52a and 52b configured

52a Contact Status	52b Contact Status	Breaker Status
Off	On	BKR Opened
On	Off	BKR Closed
On	On	BKR Unknown State
Off	Off	BKR Unknown State

Figure 5-26: Breaker Connected/Disconnected (Racked-In/Racked-Out) Detection

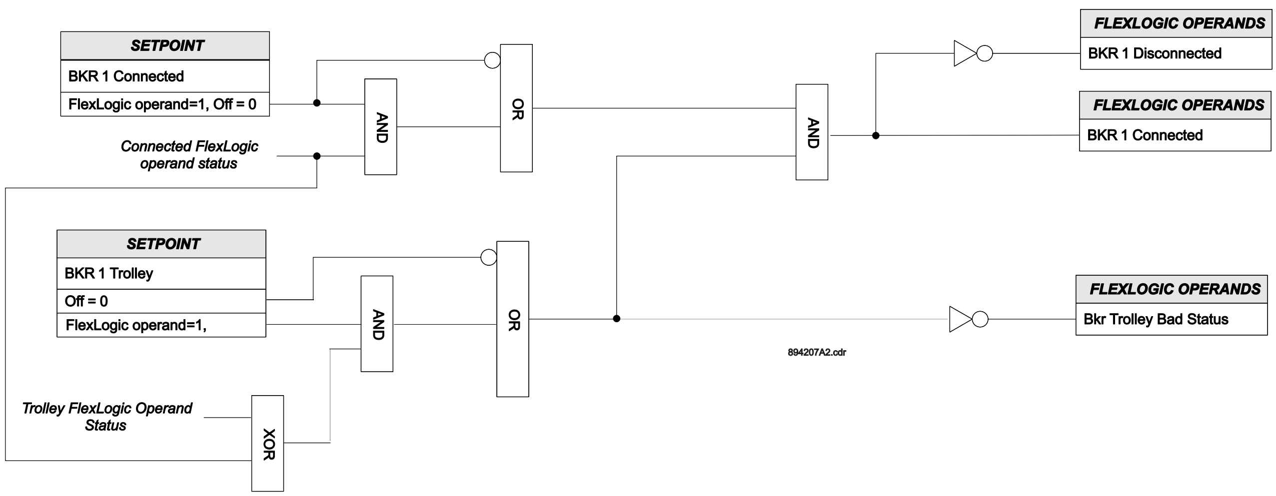
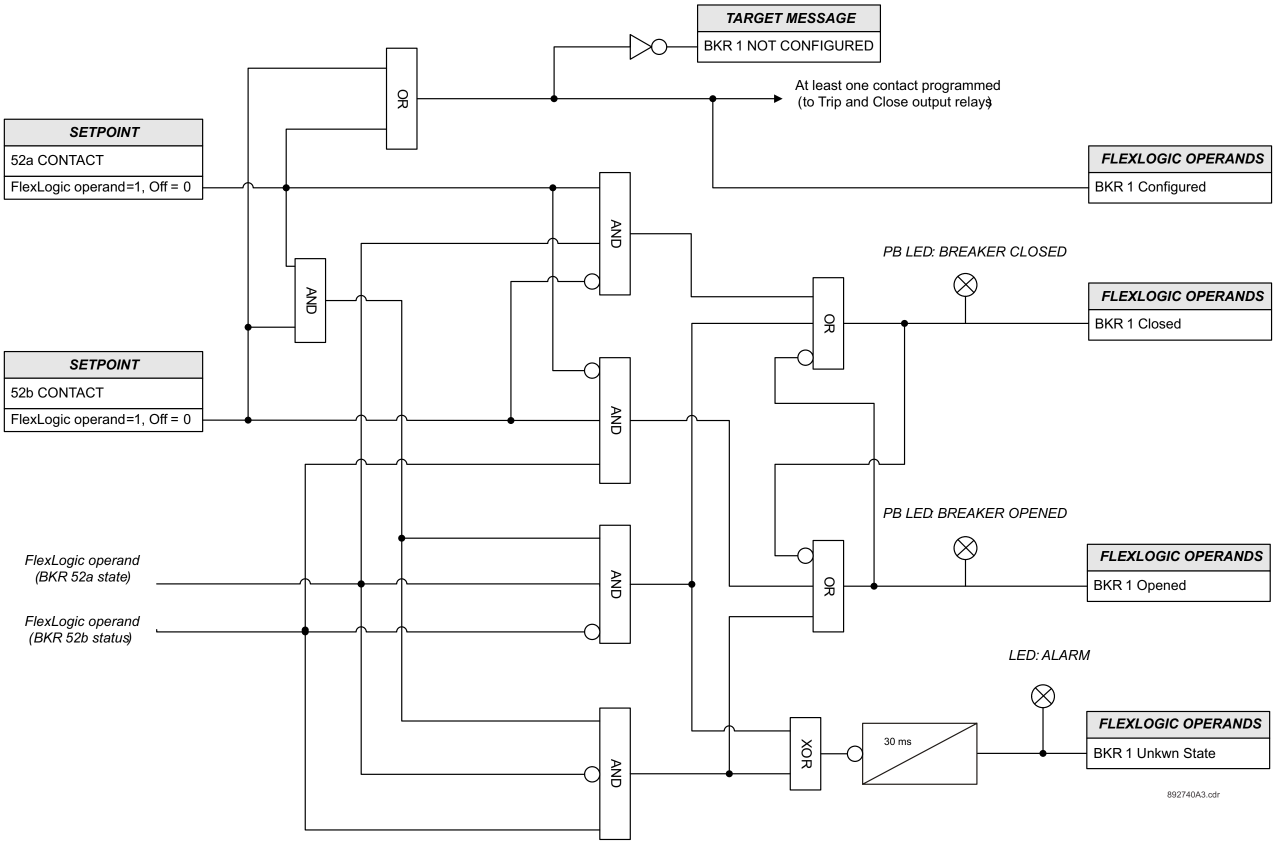


Figure 5-27: Breaker State Detection logic diagram


TARGET MESSAGE
BKR 1 NOT CONFIGURED
At least one contact programmed
(to Trip and Close output relays)
SETPOINT
52a CONTACT
FlexLogic operand=1, Off = 0
SETPOINT
52b CONTACT
FlexLogic operand=1, Off = 0
FlexLogic operand
(BKR 52a state)
FlexLogic operand
(BKR 52b status)
OR
AND
AND
AND
AND
AND
OR
OR
XOR
30 ms
FLEXLOGIC OPERANDS
BKR 1 Configured
PB LED: BREAKER CLOSED
FLEXLOGIC OPERANDS
BKR 1 Closed
PB LED: BREAKER OPENED
FLEXLOGIC OPERANDS
BKR 1 Opened
LED: ALARM
FLEXLOGIC OPERANDS
BKR 1 Unkwn State
892740A3.cdr

Switches

The Single Line Diagram (SLD) from the 8 Series relays can be configured with up to 9 disconnect switches. The disconnect switch detection is performed by monitoring the state/states of either one or preferably two contact inputs 89a and 89b. Monitoring the status of the switch using both auxiliary contacts 89a, and 89b is recommended, however using only one of them is also possible.When both contacts are programmed, the switch can be monitored for state discrepancy, i.e. both auxiliary contacts OFF, or both auxiliary contacts ON during operation. Discrepancy Alarm Delay can be programmed to reflect the transition of the switch during operation from Closed to Opened, and Opened to Closed. If no auxiliary contact discrepancy is detected after the time delay expires, the switch will be in one of its normal states, i.e. Opened or Closed. However, if contact inputs discrepancy is detected after the time delay expires, the relay will issue a “SW1(9) Discrepancy” target message and illuminate the ALARM LED. The switch discrepancy condition can be reset by the operand assigned under Reset Alarm setpoint, providing both contact inputs 89a and 89b show normal states on the relay.

Path: **Setpoints > System > Switches > Switch 1(9)**

NAME

Range: 13 alphanumeric characters

Default: SW 1

Assign a user-defined name to the disconnect switch. This name is used in the SLD, flash messages related to disconnect switch 1, and the event recorder.

CONTACT INPUT 89a

Range: Off, Any FlexLogic operand

Default: Off

Select an operand (usually NO aux. contact wired to contact input in the relay) to reflect the status of the Disconnect Switch auxiliary contact 89a.

CONTACT INPUT 89b

Range: Off, Any FlexLogic operand

Default: Off

Select an operand (usually NC auxiliary contact wired to contact input in the relay) to reflect the status of the Disconnect Switch auxiliary contact 89b.

ALARM DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s

Default: 2.000 s

This setting specifies the required time interval to overcome transient disagreement between the 89a and 89b auxiliary contacts during disconnect switch operation. If transient disagreement still exists after this time has expired, SW1(9) Discrepancy FlexLogic operand is asserted for alarm and/or blocking purposes.

RESET ALARM

Range: Off, Any FlexLogic operand

Default: Off

Select an operand from the list of FlexLogic operands, which when asserted resets the Switch Discrepancy state. Please note that resetting the discrepancy alarm will work only after no discrepancy condition exists between the switch aux contacts 89a and 89b.

OPEN RELAY SELECT

Range: Off, Relay 1, ..., Relay X

Default: Off

This setpoints selects an output relay from the list of available output relays that is used to open the Disconnect Switch once an open command is issued either from the front panel or remotely. This output relay is controlled from the Switch Control menu.

CLOSE RELAY SELECT

Range: Off, Relay 1, ..., Relay X

Default: Off

This setpoint selects an output relay from the list of available output relays that is used to close the Disconnect Switch upon issued close command from either front panel or remotely. This output relay is controlled from Switch Control menu.

NOTICE

Refer to the section Output Relays for details on output relay selection availability.

EVENTS

Range: Disabled, Enabled

Default: Enabled

This setting disables or enables the disconnect switch operation events.

TARGETS

Range: Disabled, Self-Reset, Latched

Default: Enabled

This setting disables or enables the disconnect switch operation Targets.

The logic for Switch configuration and the Open, and Close status is shown in the following tables.

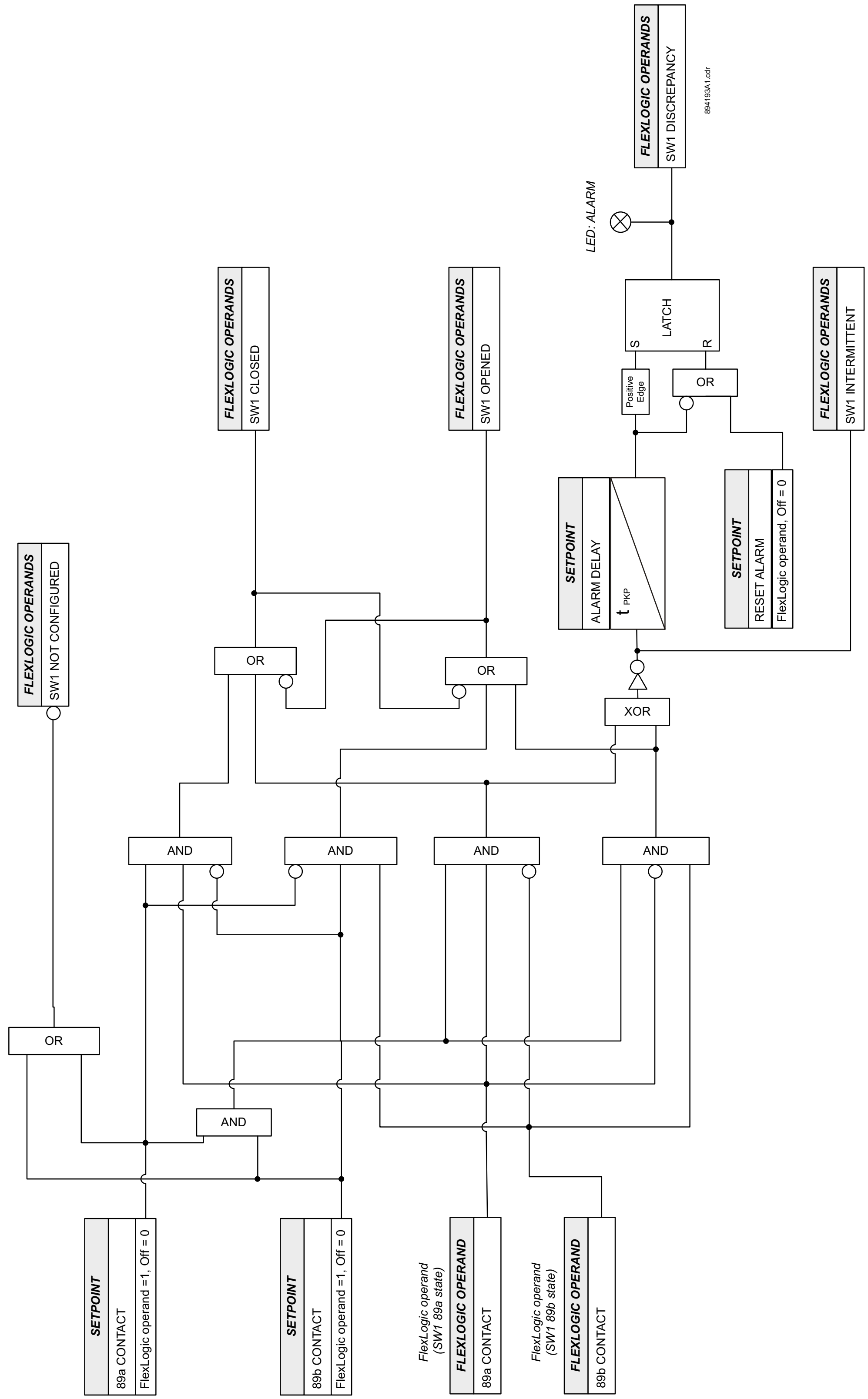
Table 5-8: Switch configuration with Open and Close status

Contact Input 89a setpoint programming	Contact Input 89b setpoint programming	Switch Status	
		Open	Closed
Yes	Yes	89a contact open 89b contact closed	89a contact closed 89b contact open
Yes	No	89a contact open	89a contact closed
No	Yes	89b contact closed	89b contact open
No	No	Not Configured	

Table 5-9: Switch status with both contacts 89a and 89b programmed

89a Contact Status	89b Contact Status	Disconnect Switch Status
Off	On	SW[X] Opened
On	Off	SW[X] Closed
On	On	SW[X] Intermittent, SW[X] Discrepancy
Off	Off	

Figure 5-28: Disconnect Switch State Detection logic diagram



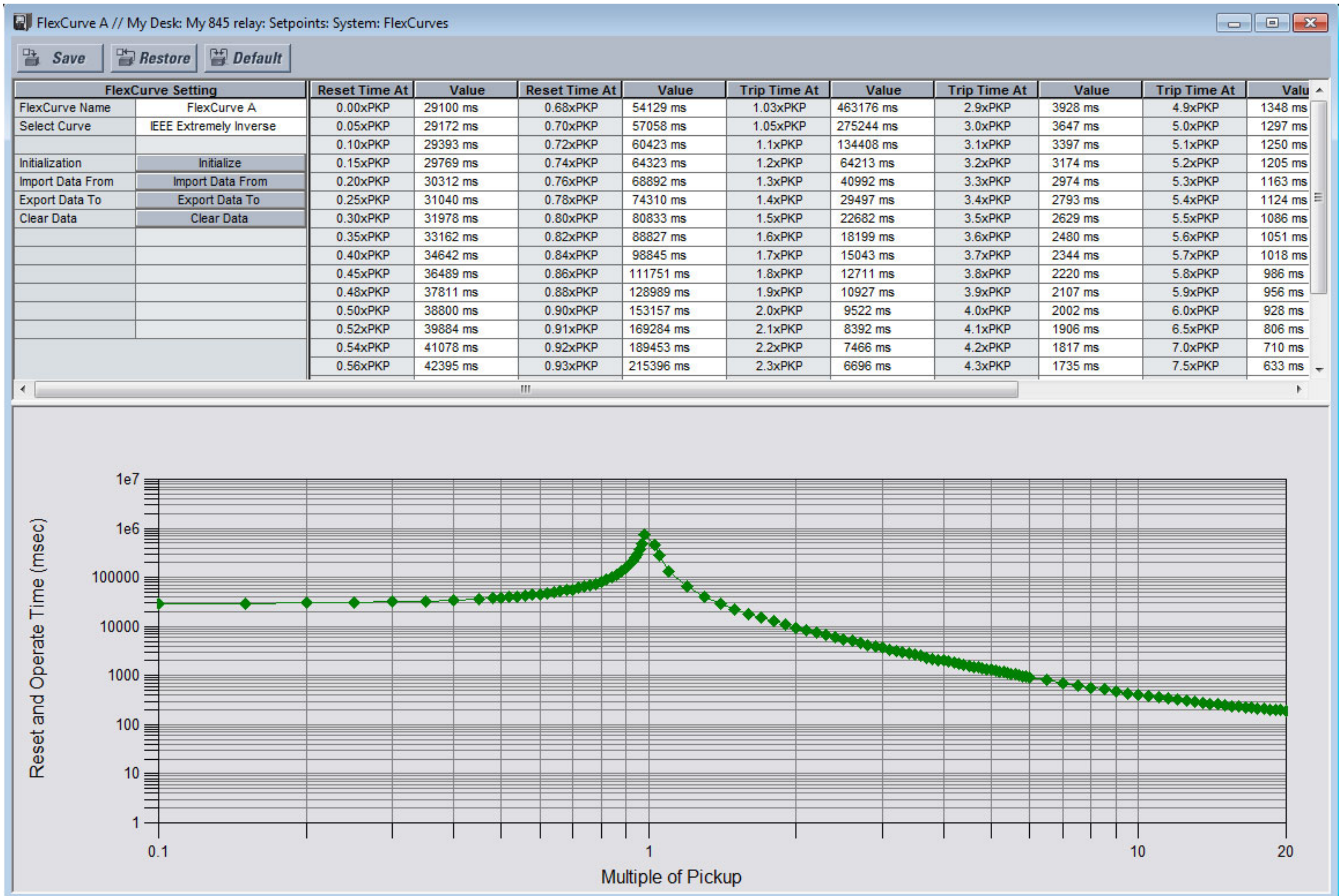
FlexCurves

The relay incorporates four programmable FlexCurves - FlexCurve A, B, C and D. The points for these curves are defined in the EnerVista 8 Series Setup software. User-defined curves can be used for Time Overcurrent protection in the same way as IEEE, IAC, ANSI, and IEC curves. Each of the four FlexCurves has 120-point settings for entering times to reset and operate, 40 points for reset (from 0 to 0.98 times the Pickup value) and 80 for operate (from 1.03 to 20 times the Pickup). This data is converted into two continuous curves by linear interpolation between data points.

Path: **Setpoints > System > FlexCurves**

NOTE

Use the EnerVista 8 Series Setup software program to select, design or modify any of the FlexCurves.



FlexCurve Setting	
FlexCurve Name	FlexCurve A
Select Curve	IEEE Extremely Inverse
Initialization	Initialize
Import Data From	Import Data From
Export Data To	Export Data To
Clear Data	Clear Data

Reset Time At	Value	Reset Time At	Value	Trip Time At	Value	Trip Time At	Value	Trip Time At	Valu
0.00xPKP	29100 ms	0.68xPKP	54129 ms	1.03xPKP	463176 ms	2.9xPKP	3928 ms	4.9xPKP	1348 ms
0.05xPKP	29172 ms	0.70xPKP	57058 ms	1.05xPKP	275244 ms	3.0xPKP	3647 ms	5.0xPKP	1297 ms
0.10xPKP	29393 ms	0.72xPKP	60423 ms	1.1xPKP	134408 ms	3.1xPKP	3397 ms	5.1xPKP	1250 ms
0.15xPKP	29769 ms	0.74xPKP	64323 ms	1.2xPKP	64213 ms	3.2xPKP	3174 ms	5.2xPKP	1205 ms
0.20xPKP	30312 ms	0.76xPKP	68892 ms	1.3xPKP	40992 ms	3.3xPKP	2974 ms	5.3xPKP	1163 ms
0.25xPKP	31040 ms	0.78xPKP	74310 ms	1.4xPKP	29497 ms	3.4xPKP	2793 ms	5.4xPKP	1124 ms
0.30xPKP	31978 ms	0.80xPKP	80833 ms	1.5xPKP	22682 ms	3.5xPKP	2629 ms	5.5xPKP	1086 ms
0.35xPKP	33162 ms	0.82xPKP	88827 ms	1.6xPKP	18199 ms	3.6xPKP	2480 ms	5.6xPKP	1051 ms
0.40xPKP	34642 ms	0.84xPKP	98845 ms	1.7xPKP	15043 ms	3.7xPKP	2344 ms	5.7xPKP	1018 ms
0.45xPKP	36489 ms	0.86xPKP	111751 ms	1.8xPKP	12711 ms	3.8xPKP	2220 ms	5.8xPKP	986 ms
0.48xPKP	37811 ms	0.88xPKP	128989 ms	1.9xPKP	10927 ms	3.9xPKP	2107 ms	5.9xPKP	956 ms
0.50xPKP	38800 ms	0.90xPKP	153157 ms	2.0xPKP	9522 ms	4.0xPKP	2002 ms	6.0xPKP	928 ms
0.52xPKP	39884 ms	0.91xPKP	169284 ms	2.1xPKP	8392 ms	4.1xPKP	1906 ms	6.5xPKP	806 ms
0.54xPKP	41078 ms	0.92xPKP	189453 ms	2.2xPKP	7466 ms	4.2xPKP	1817 ms	7.0xPKP	710 ms
0.56xPKP	42395 ms	0.93xPKP	215396 ms	2.3xPKP	6696 ms	4.3xPKP	1735 ms	7.5xPKP	633 ms

The following table for FlexCurves A, B, C, and D details the 120 points as well as the characteristic for each of them, and a blank cell to write the time value when the operation (for $I > I_{pickup}$) or the reset (for $I < I_{pickup}$) is required.

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

The first two columns (40 points) correspond to the RESET curve. The other 4 columns, with 80 points in total, correspond to the OPERATE curve. The reset characteristic values are between 0 and 0.98xPKP, and the operation values are between 1.03 and 20xPKP.

The final curve is created by means of a linear interpolation from the defined points. This is a separate process for the RESET and the OPERATE curve.

The definition of these points is performed in a separate module from the relay, using a configuration program included in EnerVista 8 Series Setup software, which incorporates a graphical environment for viewing the curve, thus making it easy to create.

NOTICE

The relay using a given FlexCurve applies linear approximation for times lying between the user-entered points. Therefore, special care must be taken when setting the points close to a Pickup multiple of 1; that is, 0.97*Ipickup and 0.98*Ipickup should be set to a similar value as 1.03*Ipickup. Otherwise, the thermal model may incorrectly estimate the TCU% level resulting in undesired behavior.

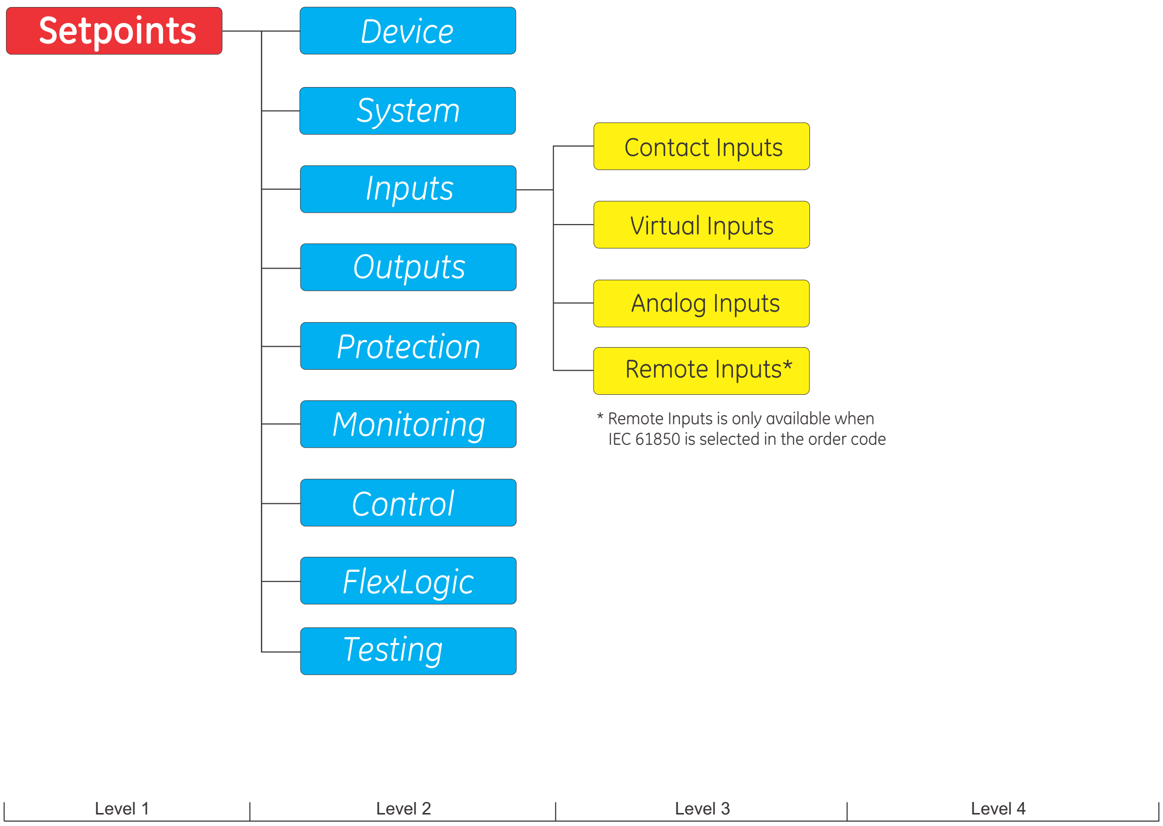
FLEXCURVE A, B, C, D CONFIGURATION WITH ENERVISTA 8 SERIES SETUP SOFTWARE

The EnerVista 8 Series Setup software allows for easy configuration and management of FlexCurves and their associated data points. Prospective FlexCurves can be configured from a selection of standard curves to provide the best approximate fit, then specific data points can be edited afterwards. Alternately, curve data can be imported from a specified file (.csv format) by selecting the Import Data From setting.

Curves and data can be exported, viewed, and cleared by clicking the appropriate buttons. FlexCurves A, B, C, and D are customized by editing the operating time (ms) values at pre-defined per-unit current multiples. Note that the pickup multiples start at zero (implying the "reset time"), operating time below Pickup, and operating time above Pickup.

Inputs

Figure 5-29: Inputs Display Hierarchy



Contact Inputs

The 845 relay is equipped with a number of Contact Inputs, depending on the Order Code, which can be used to provide a variety of functions such as for circuit breaker control, external trips, blocking of protection elements, etc. Contact inputs accept wet and dry input signals. A wet type contact input signal requires an external DC voltage source. A dry type contact input signal uses an internal DC voltage source. Depending on the DC source level, the voltage threshold (17V, 33V, 84V, 166V) can be selected. The Contact Inputs can be located on the HV I/O and Arc Flash cards located on slots 'B' or 'C' or 'F' or 'G' or 'H' or all.

NOTE

The maximum load current that can be delivered by the relay +24 V wetting voltage supply is 100 mA. When the internal +24 V supply is used, the current limitations of the 24V supply must be considered.

The Contact Inputs are either open or closed with a programmable debounce time to prevent false operation from induced voltage. The debounce time is adjustable per manufacturer specifications.

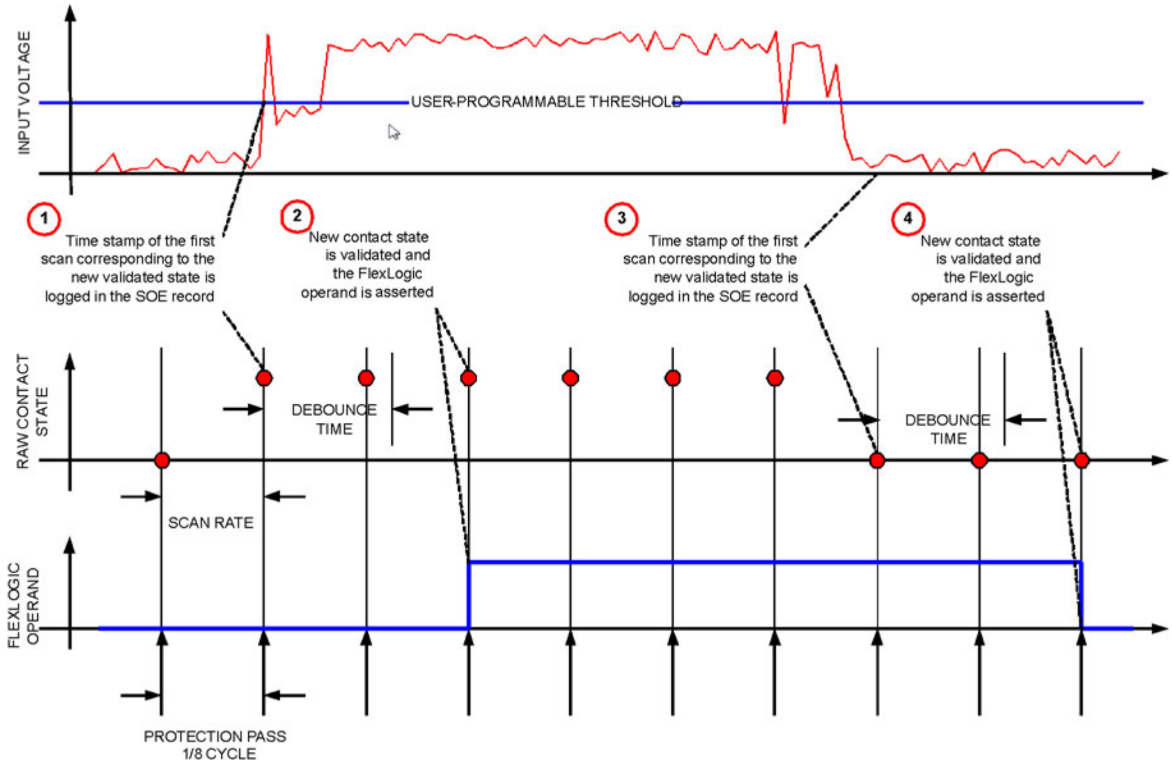
A raw status is scanned for all Contact Inputs synchronously at the constant rate of one protection pass (1/8 cycle) as shown in the figure below. The DC input voltage is compared to a user-settable threshold. A new Contact Input state must be maintained for a user-configurable debounce time in order for the relay to validate the new contact state. In the figure below, the debounce time is set at 2.5 ms; thus the 3rd sample in a row validates the change of state (mark no. 2 in the diagram). Once validated (debounced), the new state will be declared and a FlexLogic operand will be asserted at the time of a new protection pass. A time stamp of the first sample in the sequence that validates the new state is used when logging the change of the Contact Input into the Event Recorder (mark no. 1 in the diagram).

Protection and control elements, as well as FlexLogic equations and timers, are executed eight times in a power system cycle. The protection pass duration is controlled by the frequency tracking mechanism. The FlexLogic operand reflecting the debounced state of the contact is updated at the protection pass following the debounce (marked no. 2 on the figure below). The update is performed at the beginning of the protection pass so all protection and control functions, as well as FlexLogic equations, are fed with the updated states of the Contact Inputs.

The FlexLogic operand response time to the Contact Input change is related to the debounce time setting plus up to one protection pass (variable and depending on system frequency if frequency tracking enabled). For example, 8 protection passes per cycle on a 60 Hz system correspond to a protection pass every 2.1 ms. With a contact debounce time setting of 3.0 ms, the FlexLogic™ operand-assert time limits are: 4.2 + 0.0 = 4.2 ms and 4.2 + 2.1 = 6.3 ms. The 4.2 ms is the minimum protection pass period that contains a debounce time, 3.0 ms.

Regardless of the contact debounce time setting, the Contact Input event is time-stamped with 1 protection pass accuracy using the time of the first scan corresponding to the new state (mark no. 1 below). Therefore, the time stamp reflects a change in the DC voltage across the Contact Input terminals that was not accidental as it was subsequently validated using the debounce timer. The debounce algorithm is symmetrical: the same procedure and debounce time are used to filter the LOW-HIGH (marks no.1 and 2 in the figure below) and HIGH-LOW (marks no. 3 and 4 below) transitions.

Figure 5-30: Contact Input Debouncing Mechanism and Time-stamping Sample Timing



Path: Setpoints > Inputs > Contact Inputs

The Contact Inputs menu contains configuration settings for each Contact Input as well as voltage threshold for all Contact Inputs.

..\Inputs\Contact Inputs
Item Name
CI Voltage Threshold
Contact Input 1
Contact Input 2
Contact Input 3
Contact Input 4
Contact Input 5
Contact Input 6
Contact Input 7
Contact Input 8
Contact Input 9
Contact Input 10
CI DC Volt CI 1 CI 2 CI 3 >>

Path: Setpoints > Inputs > Contact Inputs > CI Voltage Threshold

Depending on the order code, Voltage Threshold value can be configured for all the Contact Inputs (Slot F/G/H with order code 'A' or 'M' or 'F') or for each group of Contact Inputs (Slot F/G/H with order code 'B' or 'K' and Slot B/C with order code 'C').

As an example, the following section shows description of the settings for Slot F with order code ‘A’, Slot G with order code ‘B’ and Slot B with order code ‘C’.

..\Contact Inputs\CI Voltage Threshold

Item Name	Value	Unit
Voltage Threshold/Slot F	33	Vdc
Voltage Threshold /G13-G17	33	Vdc
Voltage Threshold /G19-G23	33	Vdc
Voltage Threshold/B1-B5	33	Vdc
Voltage Threshold /B7-B11	33	Vdc
Voltage Threshold /B13-B17	33	Vdc

CI DCVolt

Contact input card type ‘A’ allocated at Slot F requires one Voltage Threshold configuration for all the contact inputs. Contact input card type ‘B’ allocated at Slot G has two groups of five contact inputs and therefore requires two Voltage Threshold settings. While Contact input card type ‘C’ allocated at Slot B has three groups of five contact inputs, and therefore requires three Voltage Threshold settings.

Each Voltage Threshold setting is distinct by the slot or terminal numbers. For example: ‘Voltage Threshold/Slot F’ specifies the threshold setting of all the contact inputs in Slot F with order code ‘A’; while ‘Voltage Threshold/G13-G17’ specifies the threshold setting for group of five contact inputs with terminals G13 to G17.

Upon start-up, the relay processor determines (from an assessment of the installed modules) which Contact Inputs are available, then displays settings for only these inputs.

VOLTAGE THRESHOLD /[X]

Range: 17, 33, 84, 166 VDC

Default: 17 VDC

The setting determines the minimum voltage required to detect a closed Contact Input. The value is selected according to the following criteria: 17 for 24 V sources, 33 for 48 V sources, 84 for 110 to 125 V sources and 166 for 250 V sources.

NOTICE

For internal wetting set the Voltage Threshold to 17V.

NOTICE

When thresholds above 17V are selected, the internal +24V is disabled.

Path: Setpoints > Inputs > Contact Inputs > Contact Input X

NAME

Range: Up to 13 alphanumeric characters

Default: CI 1

An alphanumeric name may be assigned to a Contact Input for diagnostic, setting, and event recording purposes. The CI X ON (Logic 1) FlexLogic operand corresponds to Contact Input “X” being closed, while CI X OFF corresponds to Contact Input “X” being open.

DEBOUNCE TIME

Range: 0.0 to 16.0 ms in steps of 0.5 ms

Default: 10.0 ms

The Debounce Time defines the time required for the contact to overcome ‘contact bouncing’ conditions. As this time differs for different contact types and manufacturers, set it as a maximum contact debounce time (per manufacturer specifications) plus some margin to ensure proper operation.

EVENTS

Range: Enabled, Disabled

Default: Enabled

For example, to use Contact Input F1 as a status input from the breaker 52b contact, to seal-in the trip relay and record it in the Event Records menu, make the following settings changes:

CONTACT INPUT 1 NAME: "52b"

CONTACT INPUT 1 EVENTS: "Enabled"

NOTICE The 52b contact is closed when the breaker is open and open when the breaker is closed.

Virtual Inputs

The 845 relay is equipped with 64 Virtual Inputs that can be individually programmed to respond to input signals from the keypad or from communications protocols. This has the following advantages over Contact Inputs only:

- The number of logic inputs can be increased without introducing additional hardware.
- Logic functions can be invoked from a remote location over a single communication channel.
- The same logic function can be invoked both locally via contact input or front panel keypad, and/or remotely via communications.
- Panel switches can be replaced entirely by virtual switches to save cost and wiring.

All Virtual Input operands are defaulted to “Off” (logic 0) unless the appropriate input signal is received.

Path: **Setpoints > Inputs > Virtual Inputs > Virtual Input**

FUNCTION

Range: Disabled, Enabled

Default: Disabled

If this setting is set to “Disabled,” the input will be forced to OFF (logic 0) regardless of any attempt to alter the input. If set to “Enabled,” the input operates as shown on the logic diagram below, and generates output FlexLogic operands in response to received input signals and the applied settings.

NAME

Range: Up to 13 Alphanumeric Characters

Default: VI 1

An alphanumeric name may be assigned to a Virtual Input for diagnostic, setting, and event recording purposes.

TYPE

Range: Latched, Self-reset

Default: Latched

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

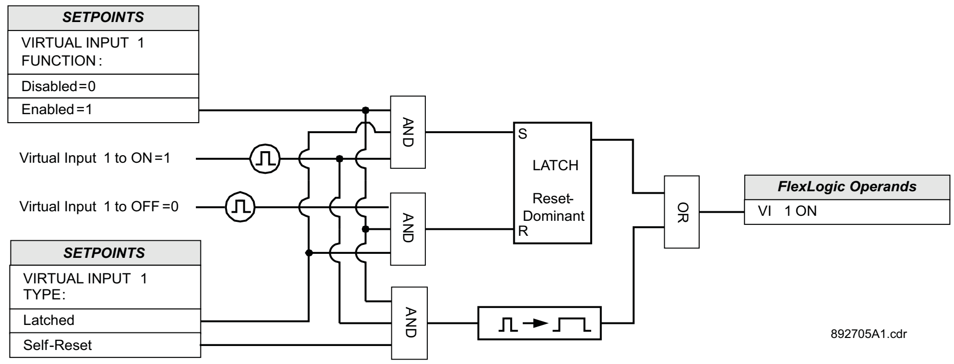
NOTICE The self-reset operating mode generates the output operand for a single evaluation of the FlexLogic equations (i.e., a pulse of one protection pass). If the operand is to be used anywhere other than internally in a FlexLogic equation, it will likely have to be lengthened in time. A FlexLogic timer with a delayed reset time can perform this function.

EVENTS

Range: Enabled, Disabled

Default: Enabled

Figure 5-31: Virtual Inputs Scheme Logic



Remote Inputs

Remote inputs provide a means of exchanging digital state information between Ethernet-networked devices supporting IEC 61850. Remote inputs that create FlexLogic operands at the receiving relay are extracted from GOOSE messages originating in remote devices.

Remote input 1 must be programmed to replicate the logic state of a specific signal from a specific remote device for local use. The programming is performed by the three settings shown in the Virtual Inputs section.

Path: Setpoints > Inputs > Remote Inputs

NAME

Range: Up to 13 Alphanumeric Characters

Default: VI 1

An alphanumeric name may be assigned to a Remote Input for diagnostic, setting, and event recording purposes.

EVENTS

Range: Enabled, Disabled

Default: Enabled

This setting enables event generation whenever **Remote Input Status** is updated.

Analog Inputs

The 8 Series relay can monitor any external quantity from the DcmA transducers such as vibration, field current, pressure, tap position etc., using 'Analog Inputs'. Any one of the standard transducer output ranges: 0 to 1 mA, 0 to 5 mA, 0 to 10mA, 0 to 20 mA, or 4 to 20 mA can be connected to the Analog Input terminals. Polarity of these inputs must be observed for proper operation. The analog input circuitry is isolated as a group with the analog output circuitry and the RTD circuitry, only one ground reference is used for the three circuits. Transducers limit this isolation to ±36 V with respect to the 8 Series safety ground.

Depending upon the order code, the 8 Series relay supports one optional DC analog card. The analog card has 4 analog inputs and 7 analog outputs. For each element, when the measured analog input quantity exceeds the Pickup level for longer than the associated time delay, the relay can be configured to cause an alarm, or trip. The element will drop out only when the user programmed Dropout ratio has been met.

NOTE

The connected analog input is still read and displayed in METERING /ANALOG INPUTS if the trip function or alarm function is set to "Disabled", and the Analog Input is not Disabled.

Path: **Setpoints > Inputs > Analog Inputs > Analog Input 1(X)**

Settings

FUNCTION

Range: Disabled, Enabled

Default: Disabled

This setting disables the Analog Input function or enables it for any generic application or any specific application i.e., Tap Position. Upon selecting a specific application its value is also displayed in the Transformer metering menu.

NOTE

In the Tap Changer Setup, DcmA input is selected as 'Tap Detection Input' and Analog Input 1 Function is set as 'Tap Position'. All other settings for Analog Input 1 are hidden.

NAME

Range: Any combination of 13 Characters

Default: Anlp 1

This setting allows the assignment of symbolic names to each analog input. The length is limited to 13 characters.

UNITS

Range: Any combination of 6 Characters

Default: units

This setting allows the assignment of symbolic names to the engineering units. The length is limited to 6 characters.

RANGE

Range: 0 to 1 mA, 0 to 5 mA, 0 to 10 mA, 0 to 20 mA, 4 to 20 mA

Default: 0 to 1 mA

This setting provides the selection for the analog input range.

MIN VALUE

Range: -500000 to 500000 units in steps of 1 unit

Default: 0

For the MINIMUM VALUE setpoint, enter the value which corresponds to the minimum output value of the transducer. For example, if a temperature transducer which outputs 4 to 20 mA for temperatures 0 to 250°C is connected to the analog input, then enter "0" for the MINIMUM VALUE. The relay then interprets 4 mA as representing 0°C. Intermediate values between the minimum and maximum are scaled linearly.

MAX VALUE

Range: -500000 to 500000 units in steps of 1 unit

Default: 0

For the MAXIMUM VALUE setpoint, enter the value which corresponds to the maximum output value of the transducer. For example, if a temperature transducer which outputs 4 to 20 mA for temperatures 0 to 250°C is connected to the analog input, then enter "250" for the MAXIMUM VALUE. The relay then interprets 20 mA as representing 250°C. Intermediate values between the minimum and maximum are scaled linearly.

TRIP FUNCTION

Range: Disabled, Trip, Configurable

Default: Disabled

Selecting the Trip or Configurable setting enables the Trip function of the analog input. If Disabled is selected, the main function still remains enabled and reads the meter value.

TRIP TYPE

Range: Over, Under

Default: Over

This setting determines if pickup occurs when the analog input is over or under the programmed threshold.

TRIP PICKUP

Range: -500000 to 500000 units in steps of 1 unit

Default: 20

This setpoint provides the trip pickup level in the engineering units defined in the setting.

TRIP DROPOUT RATIO

Range: 2 to 20 in steps of 1%

Default: 5%

This setting represents the variation of pickup value, in percentage of pickup, at which the element will effectively drop out. The drop out ratio is defined as follows:

- Drop Out = pickup – pickup * dropout ratio /100, when TRIP TYPE is Over
- Drop Out = pickup + pickup * dropout ratio /100, when TRIP TYPE is Under

For example, if the pickup level is 5000 μA, TRIP TYPE is set to “Over” and DROPOUT RATIO set to “10%”, the actual dropout will be 4500 μA. Conversely, if the TRIP TYPE is “Under” with the same dropout ratio, the actual dropout will be 5500 μA.

TRIP PICKUP DELAY

Range: 0 to 600 s in steps of 1 s

Default: 2

This setpoint will operate if the trip pickup condition is maintained for a longer time than the delay time set here.

TRIP DROPOUT DELAY

Range: 0 to 600 s in steps of 1 s

Default: 0

This setpoint selects a fixed time interval to delay dropping out the output signal after being generated.

TRIP OUTPUT RELAY X

For details see Common Setpoints.

ALARM FUNCTION

Range: Disabled, Alarm, Latched Alarm

Default: Disabled

The selection of Alarm or Latched Alarm setting enables the alarm function.

ALARM TYPE

Range: Over, Under

Default: Over

This setting determines if alarm pickup will occur when the analog input is over or under the programmed threshold.

ALARM PICKUP

Range: -500000 to 500000 units in steps of 1 unit

Default: 10

This setpoint provides the alarm pickup level in engineering units as defined in the setting.

ALARM DROPOUT RATIO

Range: 2 to 20 in steps of 1%
Default: 5%

This setting represents the variation of pickup value, in percentage of pickup, at which the alarm element will effectively drop out. The drop out ratio is defined as follows:

- Drop Out = pickup – pickup * dropout ratio /100, when ALARM TYPE is Over
- Drop Out = pickup + pickup * dropout ratio /100, when ALARM TYPE is Under

For example, if the pickup level is 5000 μA, ALARM TYPE is set to “Over” and DROPOUT RATIO set to “10%”, the actual dropout will be 4500 μA. Conversely, if the ALARM TYPE is “Under” with the same dropout ratio, the actual dropout will be 5500 μA.

ALARM PICKUP DELAY

Range: 0 to 600 s in steps of 1 s
Default: 2

This setpoint will operate the element if the alarm pickup condition is maintained for a longer time than the delay time set here.

ALARM DROPOUT DELAY

Range: 0 to 600 s in steps of 1 s
Default: 0

This setpoint selects a fixed time interval to delay dropping out the output signal after being generated.

ALARM OUTPUT RELAY X

For details see Common Setpoints.

BLOCK

Range: Any FlexLogic operand
Default: Off

EVENTS

Range: Disabled, Enabled
Default: Enabled

This setting enables or disables the events of the Analog Input function.

TARGETS

Range: Disabled, Self-Reset, Latched
Default: Latched

The selection of the Self-Reset or Latched setting enables the targets of the Analog Input function.

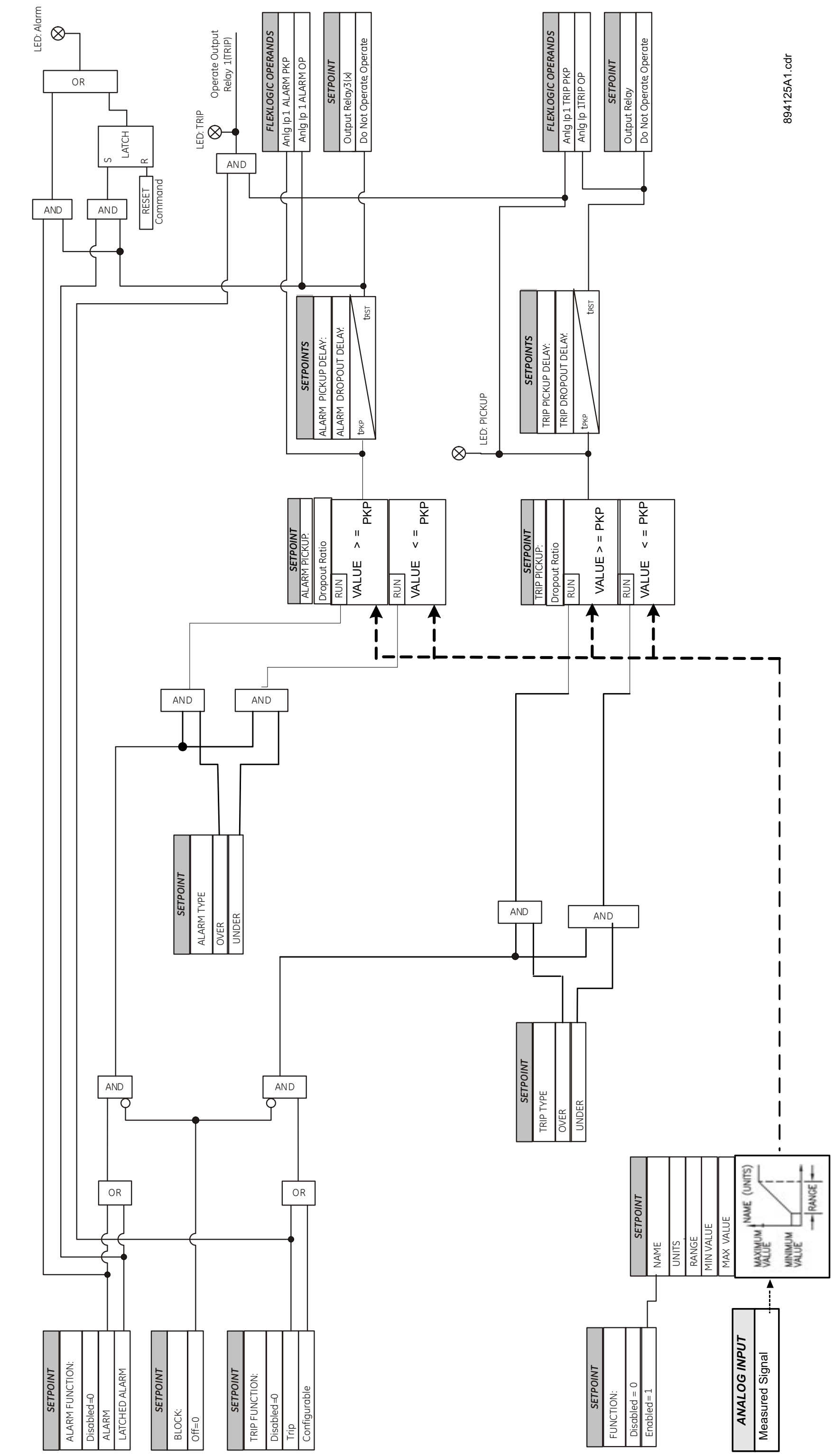
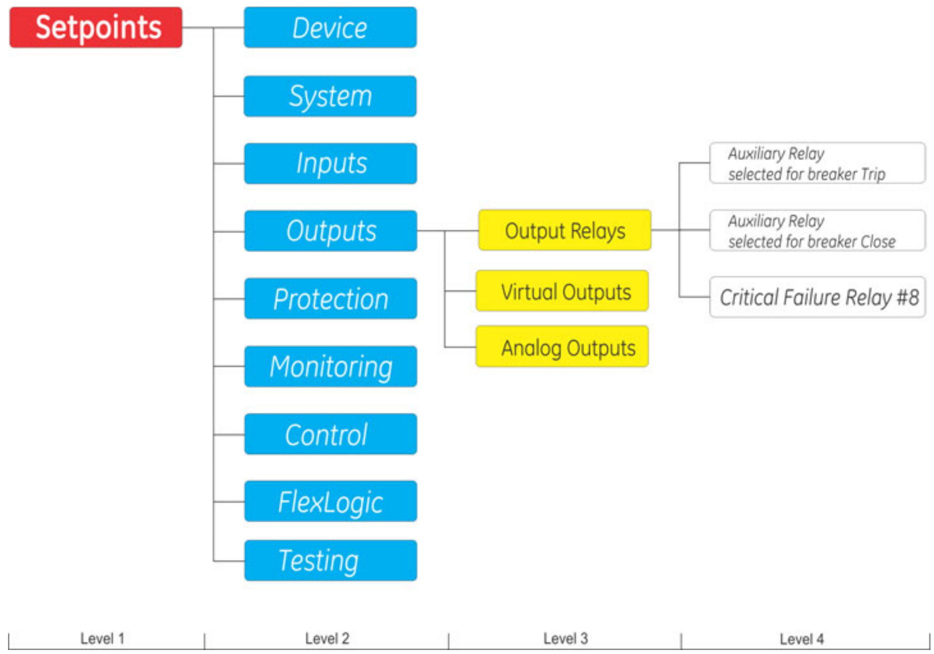


Figure 5-32: Analog Input Threshold Logic Diagram

Outputs

Figure 5-33: Outputs Display Hierarchy



Output Relays

The 845 Transformer Protection System relay is equipped with a number of electromechanical output relays specified at the time of ordering. The card A I/O module from slot F, for example, provides five output relays.

The 845 auxiliary relays, starting with Aux. Relay 1, can be energized from the menu of each protection or control feature, or from their respective menus when assigning a FlexLogic operand (trigger) under the setpoint "Aux Rly # Operate".

The auxiliary relays can be used for different applications. Any output relays can be programmed for either tripping or closing a breaker. For each of the breakers, a pair of auxiliary relays can be selected for tripping and closing. Depending on how an Aux. Relay is assigned, one of the following output relay logic diagrams applies:

1. If the auxiliary output relay is programmed under the Breaker menu for breaker tripping, the operation of the output follows the Trip logic diagram below.
2. If the auxiliary output relay is programmed under the Breaker menu for breaker closing, the operation of the output follows the Close logic diagram.
3. If the auxiliary output is not programmed for tripping or closing a breaker, the operation of the output follows the Auxiliary Relay Generic logic from logic diagram.

The Trip and Close auxiliary relays follow the respective Trip and Close logic, meaning they will have fixed operating characteristics as they depend on breaker feedback for resetting. The auxiliary relays selected for breaker tripping are also available for selection from the menus of all protection elements. The auxiliary relays selected for breaker closing are excluded from the list for selection from the menu of all elements. Refer to the Breaker setup section on how to select an auxiliary relay for breaker trip and close.

The operation of output relays selected for breaker Trip and breaker Close are breaker-controlled relays designed to be controlled by the state of the breaker as monitored by a 52a contact, 52b contact, or both.

If the selection for the Type setpoint is "Pulsed", the Trip and Close relay operation follows the logic outlined below:

- The Trip and Close relays reset after breaker is detected in a state corresponding to the command. When a command is sent to one of these special relays, it remains in operation until the requested change of the breaker state is confirmed and the initiating condition has Reset.
- If the command Resets without a change of breaker state, the output relay is Reset after a default interval of 2 seconds.
- If neither of the breaker auxiliary contacts. 52a or 52b, is programmed to a logic input, the Trip Relay Resets after a default interval of 100 ms after the initiating input Resets. The Close Relay is Reset after 200 ms.
- The Seal-In Time setpoint is available only when the output relay is selected as "Pulsed". In all other cases the Seal-In Time setpoint is hidden and deactivated. The default setting for the seal-in time is 100 ms.

If the Type selected is "Latched", the output relay is energized by any Trip or Open command and remains energized upon element dropout. Latched auxiliary outputs can be reset with a reset command.If the type selected is "Self-Reset", the output relay is energized when the corresponding element operates and it stays energized until the element drops out.

52a Contact Configured	52b Contact Configured	Relay Operation
Yes	Yes	The Trip Relay and Close Relay continue operating until the breaker is detected opened or closed using both 52a and 52b contacts as per the breaker detection logic.
Yes	No	The Trip Relay continues operating until 52a indicates an open breaker. The Close Relay continues operating until 52a indicates a closed breaker.
No	Yes	The Trip Relay continues operating until 52b indicates an open breaker. The Close Relay continues operating until 52b indicates a closed breaker.
No	No	Trip Relay operates upon a Trip command and stays "high" until the 100 ms default time expires. The Close Relay operates upon a Close command and Resets after the 200 ms time expires.

OUTPUT RELAY AVAILABILITY

The output relays can be used for many different purposes such as opening and closing breakers, contactors, switches, control of primary equipment such as motor, transformer, generator, for blocking or supervision purposes, for interlocking, ect. To avoid using the same output relay for two totally different actions, the 8series relays checks the assignments of these output relays, and prevents their usage for some other actions. For this purpose, the output relays that have been already assigned for some action, are hidden from the menus of other elements. For example, if output relay 1 has been assigned under Trip Relay Select setpoint to trip breaker 1, this output relay will be hidden from the list of outputs available to select in the menu for opening or closing a Switch, and vice versa. The table below defines the dependency of output relay availability based on the first come-first serve principal.

Place selected	Assigned/Non-assigned Output Relays	Available/Hidden
Output Relays in: **Setpoints > Protection > Control > Monitoring Elements**	BKR [1-3] Trip Relay Select BKR [1-3] Close Relay Select SW [1-9] Open Relay Select SW [1-9] Close Relay Select Other Auxiliary Relays	Available Hidden Hidden Hidden Available
Output Relays in Control Elements with Restoration Ability	BKR [1-3] Trip Relay Select BKR [1-3] Close Relay Select SW [1-9] Close Relay Select SW [1-9] Open Relay Select Other Auxiliary Relays **NOTE**: The elements producing close commands are directly linked to their respective breakers for closing/restoring.	Hidden Hidden Hidden Hidden Available
Setpoints > System > Switch [X] > Open Relay Select	BKR [1-3] Trip Relay Select BKR [1-3] Close Relay Select SW [1-9] Close Relay Select Other Auxiliary Relays	Hidden Hidden Hidden Available
Setpoints > System > Switch [X] > Close Relay Select	BKR [1-3] Trip Relay Select BKR [1-3] Close Relay Select SW [1-9] Open Relay Select Other Auxiliary Relays	Hidden Hidden Hidden Available
Setpoints > System > Breaker [X] > Trip Relay Select	BKR [1-3] Close Relay Select SW [1-9] Open Relay Select SW [1-9] Close Relay Select Other Auxiliary Relays	Hidden Hidden Hidden Available
Setpoints > System > Breaker [X] > Close Relay Select	BKR [1-3] Trip Relay Select SW [1-9] Open Relay Select SW [1-9] Close Relay Select Other Auxiliary Relays	Hidden Hidden Hidden Available

CRITICAL FAILURE RELAY

The 8 Series relay is equipped with one output relay (# 8 - "Critical Failure Relay") for failsafe indication. The Critical Failure Relay is a Form-C contact with one NO and one NC contact (no control power). There are no user-programmable setpoints associated with this output relay.

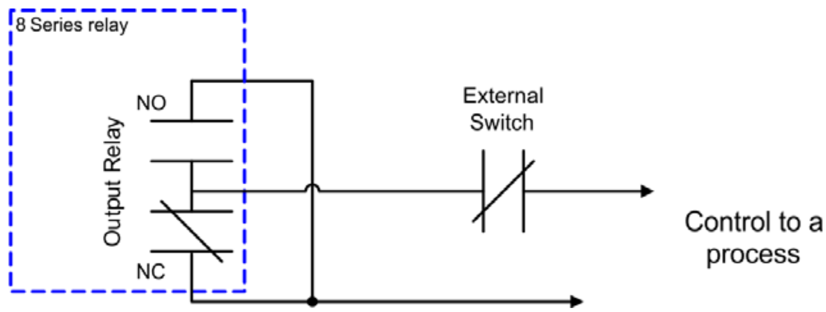
NOTE

Please refer to "Self-Test Errors" section from the manual for details on the status of the output relays during Relay Not Ready state, or detection of Major Self-Test error.

MAINTAINING AN UNINTERRUPTED PROCESS

The Output Relays are operational (can be closed/opened) while the 845 Transformer Protection System is In-Service. If the relay goes into "Out-of-Service" mode, the status of all previously energized output relays changes to de-energized. If an output relay was used to maintain a running process, or to hold a motor contactor while energized, the process or the motor contactor will be interrupted. To keep the process uninterrupted, the following connection scheme can be applied:

Figure 5-34: Maintaining an uninterrupted process upon a relay Major Error



If the output relay is energized during the In-Service relay condition, the NO contact will be closed, and the NC contact will be open. The process is running. If the relay goes into "Out-of-Service" mode, the output relay will be de-energized, and the process will still be running, as the NC contact will be closed. An external switch, or stop pushbutton must be installed in series to the relay output contacts, so that one can stop the process if needed.

Auxiliary Relay selected for breaker Trip

Path: Setpoints > Outputs > Output Relays > Aux Relay 1

NAME

Range: Up to 13 alphanumeric characters
Default: Aux Relay 1

The setpoint is used to name the Trip relay by selecting up to 13 alphanumeric characters.

SEAL-IN TIME (displayed only if Type=Pulsed)

Range: 0.00 to 9.99 s in steps of 0.01 s
Default: 0.10 s

This setting defines the time to be added to the Reset time of Relay 1 "Trip" output, thus extending its pulse width. This is useful for those applications where the 52 contacts reporting the breaker state are faster than the 52 contacts that are responsible for interrupting the coil current.

BLOCK

Range: Disabled, Any FlexLogic operand
Default: Disabled

This setting defines a Block to the Trip output relay. When the selected input is asserted, the Trip output relay is blocked.

OPERATE

Range: Off, On, Any FlexLogic operand
Default: Off

This setpoint provides a selection of any operand from the list of FlexLogic or communications, which can be used to energize the Trip output relay.

When set to On, the output relay is constantly asserted (On=1).

When set to Off and no FlexLogic operand is selected, the output relay operates as set in individual protection elements.

NOTE

Setting OPERATE to On supersedes individual protection function settings.

TYPE

Range: Self-Reset, Latched, Pulsed
Default: Latched

This setting defines the sequence type of the Trip output relay. The functionality is described in the Outputs > Output Relays > Trip and Close Relays section.

OPERATION

Range: Non-Failsafe, Failsafe
Default: Non-Failsafe

Failsafe operation causes the output relay to be energized when the Trip condition signal is low and de-energized when the same signal is high. A failsafe relay also changes state (if not already activated by an operand driving this output relay) when control power is removed from the 845. Conversely a non-failsafe relay is de-energized in its normal non-activated state and will not change state when control power is removed from the 845 (if not already activated by a protection element).

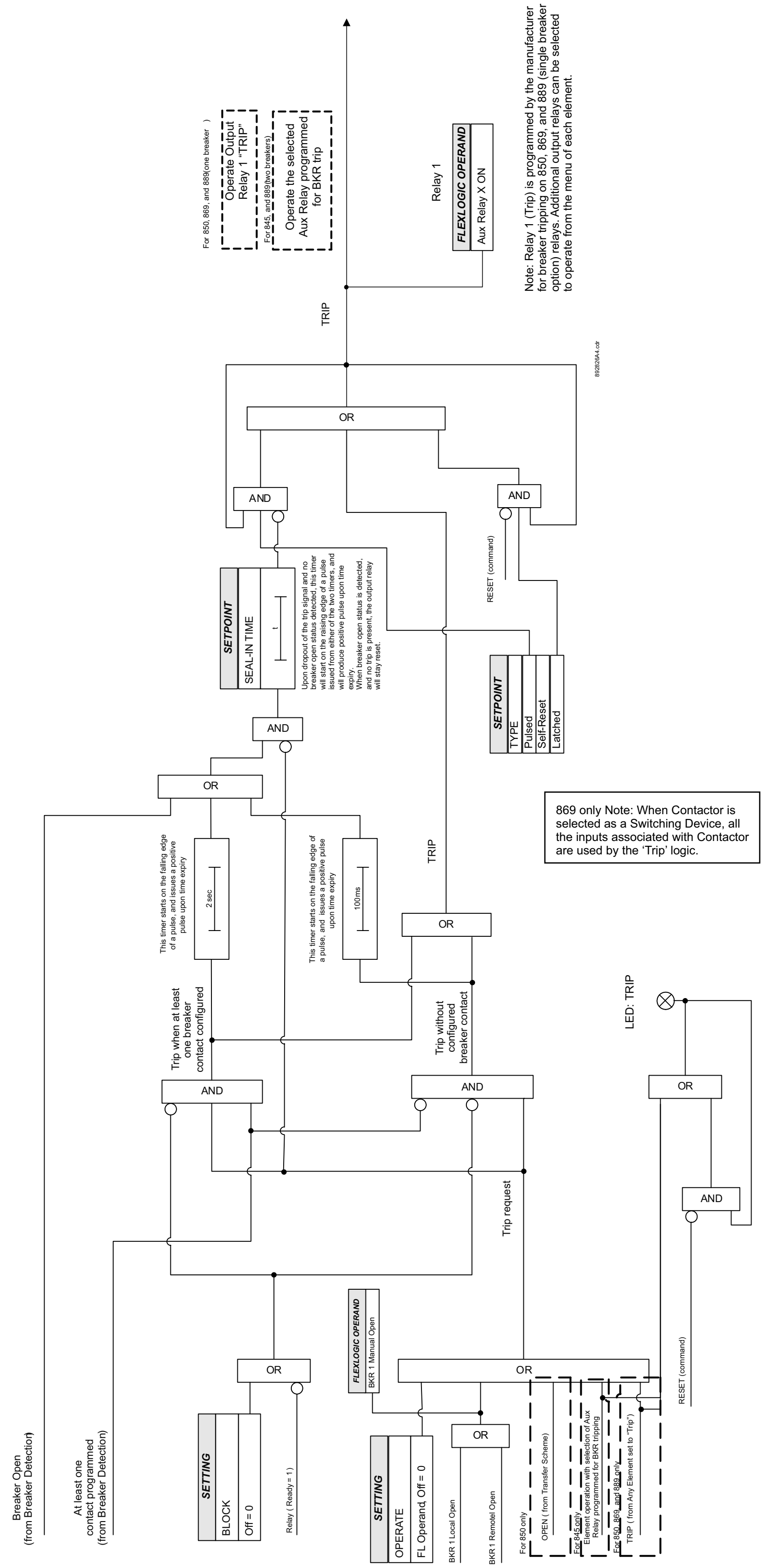
EVENTS

Range: Disabled, Enabled
Default: Enabled

NOTE

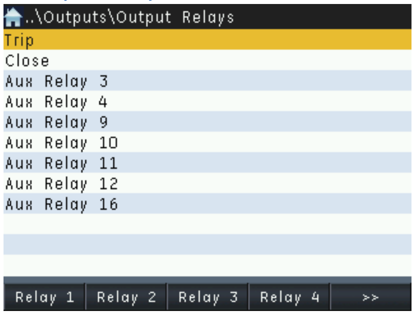
When the setpoint Function in the protection element menu is set to "Trip", the output relays selected under the Breaker menu for breaker tripping need to be re-selected from the protection element menu. These output relays will not be operational even if selected to operate from the protection element menu, if the function is set to "Alarm", "Latched Alarm", or “Configurable”.

Figure 5-35: Relay 1 “TRIP” Selected for Breaker 1 logic diagram



Aux Relay selected for breaker Close

Path: Setpoints > Outputs > Output Relays

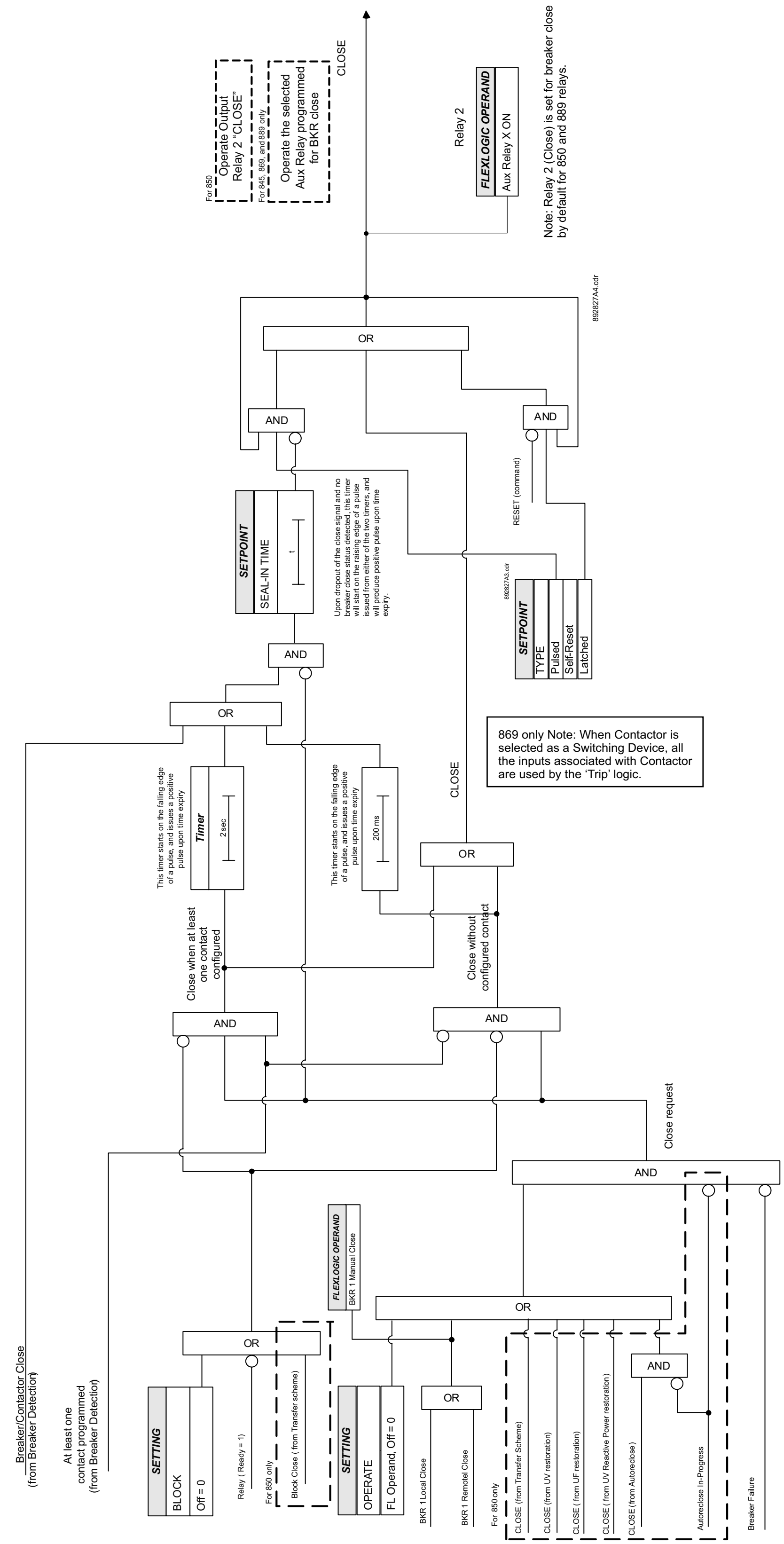


Path: Setpoints > Outputs > Output Relays > Aux Relay 2 (Close)

NOTE

The output relays selected under the Breaker menu for breaker closing are excluded from the list of outputs for selection under the menus of all elements providing such output relay selection.

Figure 5-36: “Close” Selected for Breaker 1 logic diagram



Auxiliary Output Relays

The 845 relay is equipped with Auxiliary Output relays. The I/O cards, and the number of auxiliary output relays are defined at the time of relay ordering. Auxiliary Relays can be energized directly from the menu of the protection or control feature or from their respective menus by assigning a FlexLogic operand (trigger) under the setpoint "Aux Rly # Operate".
Changing the state of any of the Auxiliary Relays will be inhibited if the 845 relay is in "Not Ready" mode.

NAME

Range: Up to 13 alphanumeric characters
Default: Aux Rly #

The setpoint is used to name the auxiliary output relay by selecting up to 13 alphanumeric characters.

SEAL-IN TIME (displayed only if Type=Pulsed)

Range: 0.00 to 9.99 s in steps of 0.01 s
Default: 0.10 s

When type = Pulsed is selected, the setpoint "AUX RLY # SEAL-IN TIME" is displayed in the menu for selection of the time interval for which the output relay will remain Energized. The actual time, for which the output relay stays energized, starts from the time of output first trigger, and ends when Output Seal-In Time expires. The Seal-In time applies at the dropdown edge of the output relay. If during timing out of the Seal-In Time, another pulse/pulses occur, the Seal-In Time will be reapplied to the last pulse, resulting in prolonged time for which the output will stay energized before going to de-energized mode.

BLOCK

Range: Disabled, Any FlexLogic operand
Default: Disabled

This setting defines a block to the Auxiliary output relay. When the selected input is asserted, the Aux relay is blocked.

OPERATE

Range: Off, On, Any FlexLogic operand
Default: Off

This setpoint provides a selection of any operand from the list of FlexLogic or communications, which can be used to energize the auxiliary output relay.

When set to On, the output relay is constantly asserted (On=1).

When set to Off and no FlexLogic operand is selected, the output relay operates as set in individual protection elements.

NOTE

Setting OPERATE to On supersedes individual protection function settings.

TYPE

Range: Self-Reset, Latched, Pulsed
Default: Pulsed

If Self-Reset is selected, the output relay is energized as long as the element is in operating mode, and resets when the element drops out. If Latched is selected, the output relay stays energized upon element dropout. The latched auxiliary outputs can be reset by issuing a reset command. For Pulse selection, see SEAL-IN TIME (displayed only if Type = Pulsed).

OPERATION

Range: Non-Failsafe, Failsafe

Default: Non-Failsafe

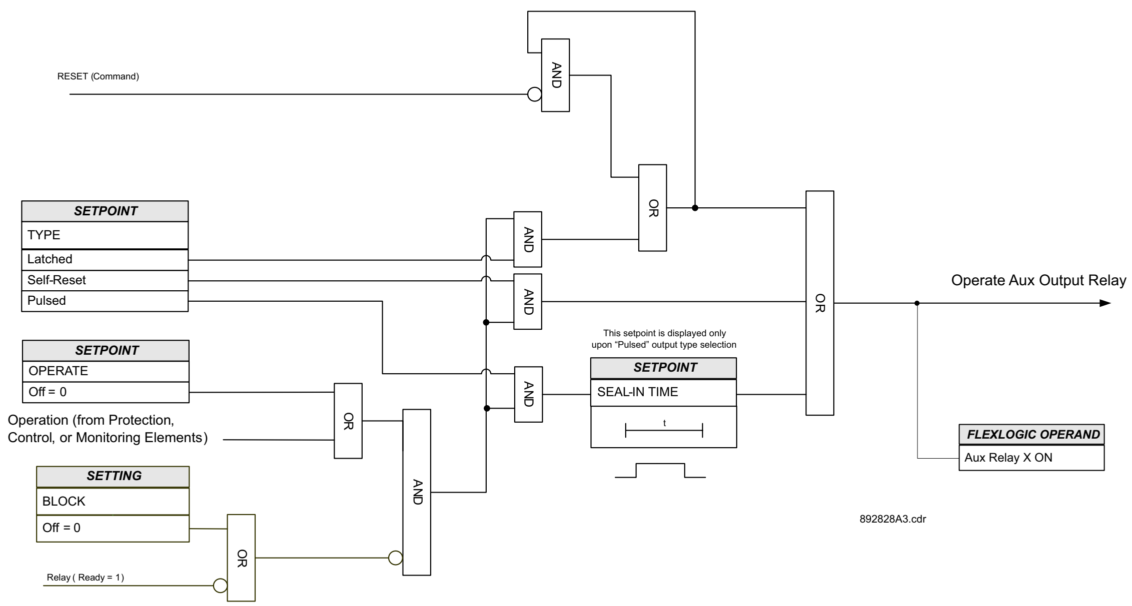
Failsafe operation causes the output relay to be energized when the operand assigned to the OPERATE AUX RLY # setting is low and de-energized when the same operand is high. A failsafe relay also changes state (if not already activated by an operand driving this output relay) when control power is removed from the 845. Conversely, a non-failsafe relay is de-energized in its normal non-activated state and will not change state when control power is removed from the 845 (if not already activated by a protection element).

EVENTS

Range: Disabled, Enabled

Default: Enabled

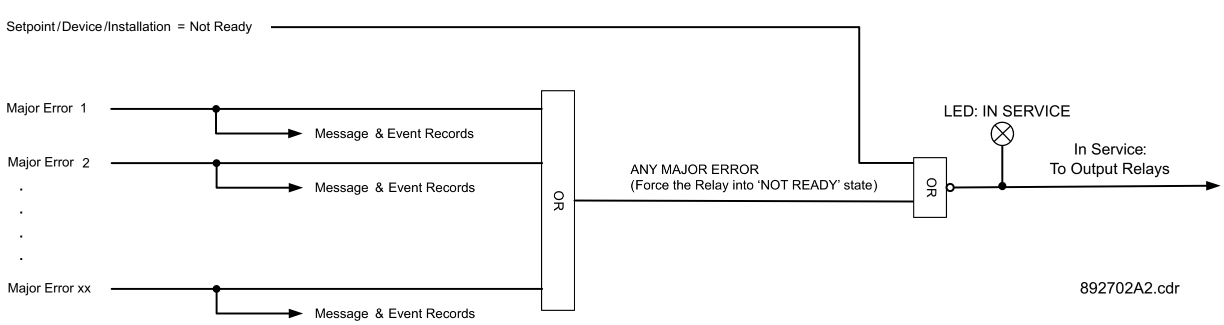
Figure 5-37: Auxiliary Relays generic logic



Critical Failure Relay #8

The 845 relay is equipped with one output relay (# 8 - "Critical Failure Relay") for failsafe indication. The Critical Failure Relay is a Form-C contact with one NO and one NC contact (no control power). There are no user-programmable setpoints associated with this output relay. The logic for this relay is shown below.

Figure 5-38: Critical Failure Relay 8 Scheme



Virtual Outputs

The 845 relay is equipped with 96 virtual outputs that may be assigned for use via FlexLogic. Virtual outputs not assigned for use are set to OFF (Logic 0).

A name can be assigned to each virtual output. Any change of state to a virtual output can be logged as an event if programmed to do so. Virtual outputs are resolved in each protection pass via the evaluation of FlexLogic equations.

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

Virtual Output 1 NAME: *Trip*

Virtual Output 1 Events: *Enabled*

Path: **Setpoints > Outputs > Virtual Outputs > Virtual Outputs 1 (32)**

NAME

Range: up to 13 alphanumeric characters
Default: VO 1

An alphanumeric name may be assigned to a virtual output for diagnostic, setting, and event recording purposes.

EVENTS

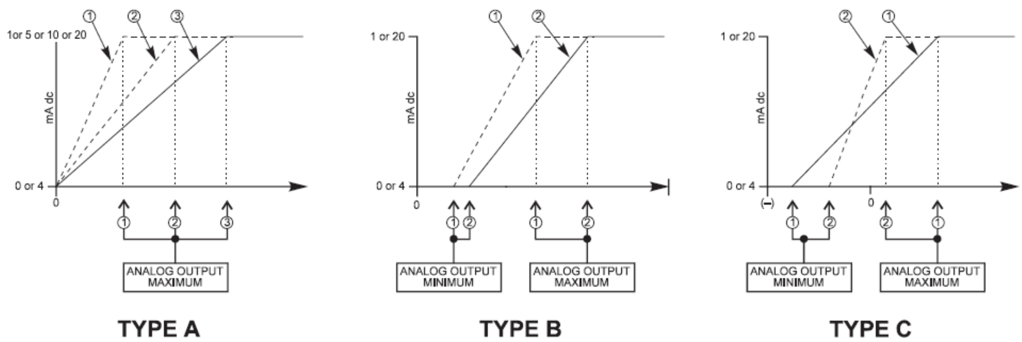
Range: Disabled, Enabled
Default: Disabled

Analog Outputs

Description

Depending on the order code, the 8 Series relay supports one optional DC analog card. The Analog card has 4 analog inputs and 7 analog outputs. There are three Analog Output channel scenarios for analog minimum and maximum output range: A, B, and C shown in the figure below. Type A characteristics apply when the minimum range is 0 and the maximum range is a positive (+ve) value. Type B characteristics apply when the minimum and maximum ranges are definitely positive (+ve) values. Type C characteristics apply when the minimum range is a negative (-ve) and the maximum range is a positive (+ve) value. The following diagram illustrates these characteristics.

Figure 5-39: Analog Outputs Channel Characteristics



Path: **Setpoints > Outputs > Analog Outputs > Analog Output 1(X)**

FUNCTION

Range: Disabled, Enabled
Default: Disabled

RANGE

Range: 0 to 1 mA, 0 to 5 mA, 0 to 10 mA, 0 to 20 mA, or 4 to 20 mA
Default: 0 to 1 mA

This setting provides the selection for the analog output range.

PARAMETER

Range: Off, any Flex Analog Parameter
Default: Off

This setting selects the measured parameter to control the Analog Output level.

MIN VALUE

Range: Populates per selection of the analog parameter
Default: 0

This setting defines the minimum value of the analog output quantity. It populates based on the selection of the analog parameter.

MAX VALUE

Range: Populates per selection of the analog parameter
Default: 0

This setting defines the maximum value of the analog output quantity. It populates based on the selection of the analog parameter.

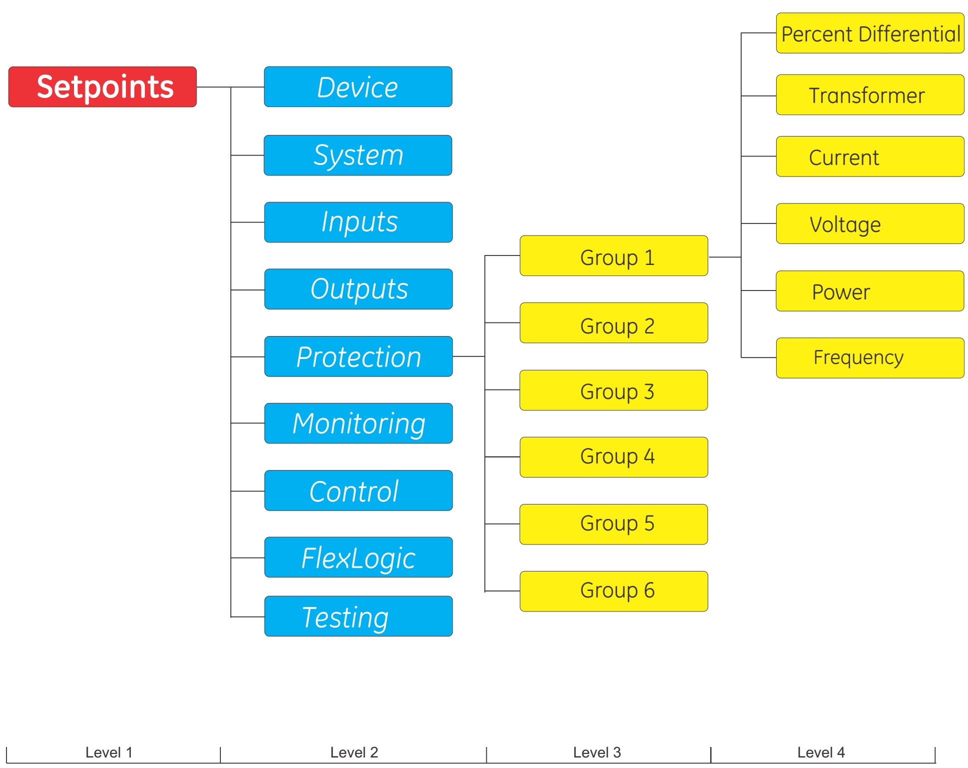
Each channel can be programmed to represent a FlexAnalog parameter available in the respective 8 Series relay. The range and steps is the same as the range of the FlexAnalog.

845 Transformer Protection System

Chapter 6: Protection

The 845 protection elements are organized in six (6) identical setpoint groups: Setpoint Group 1 to Setpoint Group 6.

Figure 6-1: Protection Display Hierarchy



Each Setpoint Group has the same protection functions, depending on the relay order code.

Transformer Elements

- Percent Differential
- Transformer Overload

Current Elements

- Phase Time Overcurrent Protection (51P)
- Phase Instantaneous Overcurrent Protection (50P)
- Phase Directional Overcurrent Protection (67P)
- Neutral Time Overcurrent Protection (51N)
- Neutral Instantaneous Overcurrent Protection (50N)
- Neutral Directional Overcurrent Protection (67N)
- Ground Time Overcurrent Protection (51G)
- Ground Instantaneous Overcurrent Protection (50G)
- Ground Directional Overcurrent Protection (67G)
- Restricted Ground Fault (87G)
- Negative Sequence Time Overcurrent Protection (51_2)
- Negative Sequence Instantaneous Overcurrent Protection (50_2)

Voltage Elements

- Phase Undervoltage Protection (27P)
- Auxiliary Undervoltage (27X)
- Phase Overvoltage Protection (59P)
- Auxiliary Overvoltage Protection (59X)
- Neutral Overvoltage Protection (59N)
- Negative Sequence Overvoltage Protection (59_2)
- Volts per Hertz (24)

Power Elements

- Directional Power (32)

Frequency Elements

- Underfrequency (81U)
- Overfrequency (81O)
- Frequency Rate of Change (81R)

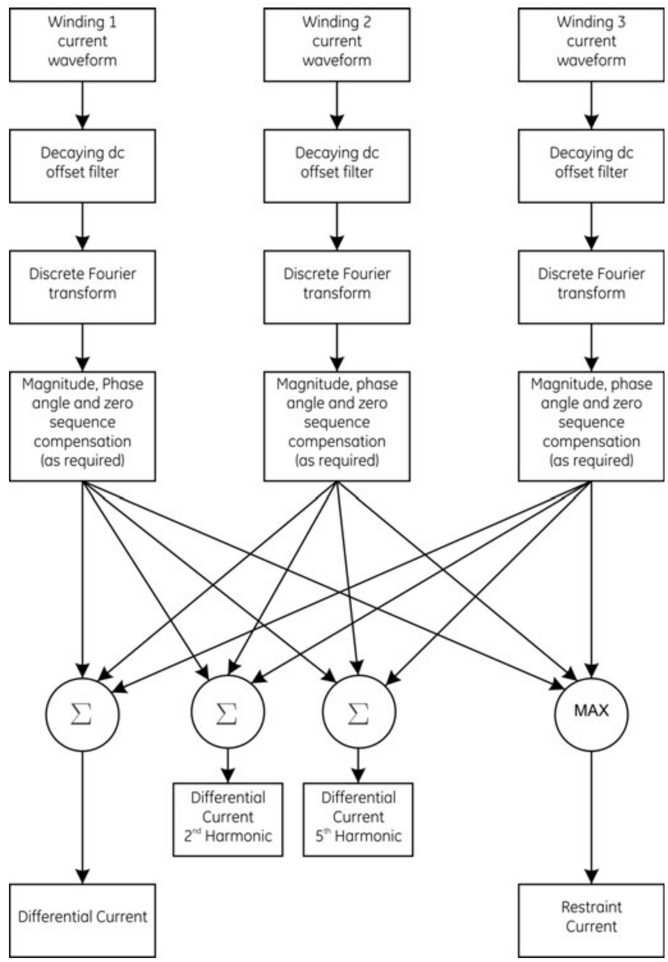
Percent Differential

The 845 relay provides one Overall Percent Differential element per setpoint group. The setpoints from the protection menu define a dual slope, dual breakpoint differential/restraint characteristic. The filtering and calculation of transformer differential and restraint currents, and differential current 2nd and 5th harmonics are as shown in the figure: Filtering and calculation of differential and restraint currents.

NOTE

The K2 CT bank is connected to Winding 1, which is the High-Voltage winding of the GSU connected to the system. In contrast, the K1 CT bank is connected at the neutral side of the generator, and must be configured as Winding 2 (K1).

Figure 6-2: Filtering and Calculation of differential and restraint currents



The 845 continuously calculates per-phase differential and restraint currents, and compares the ratio between the two values with a user pre-defined differential/restraint characteristic. The purpose of the characteristic is to define the zone of differential protection operation and the zone of no operation. The differential characteristic provides setpoints for sensitivity, dependability, and security for all types of faults, and is programmed by the user to reflect a variety of transformer differential protection applications.

The differential current is calculated per-phase as a vector sum of the currents from all windings after magnitude and angle compensation.

Eq. 1

$$Id = \vec{I}_{1_{comp}} + \vec{I}_{2_{comp}} + \vec{I}_{3_{comp}}$$

The restraint current is calculated as a maximum of the same internally compensated currents:

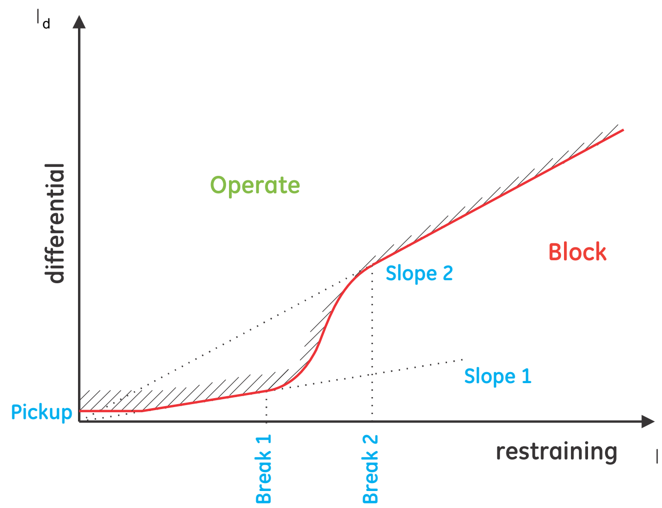
Eq. 2

$$Ir = \max\left(\left|\vec{I}_{1_{comp}}\right|, \left|\vec{I}_{2_{comp}}\right|, \left|\vec{I}_{3_{comp}}\right|\right)$$

$$Ir = \max\left(\left|\vec{I}_{1_{comp}}\right|, \left|\vec{I}_{2_{comp}}\right|\right)$$

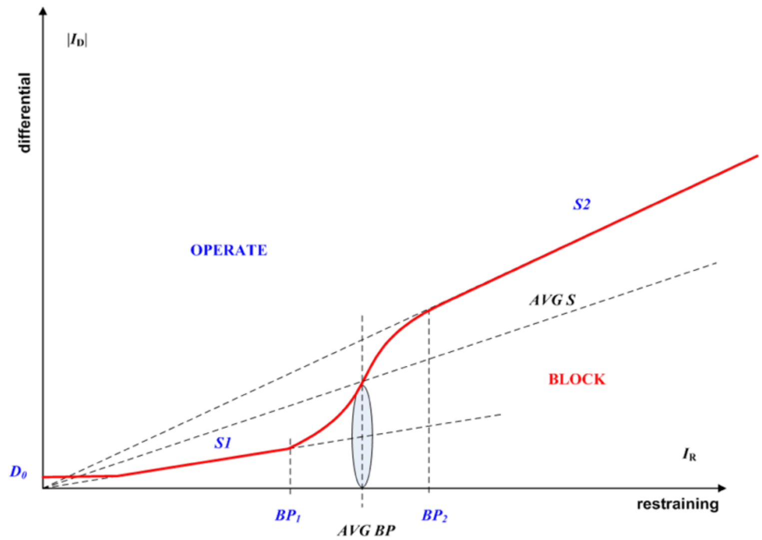
NOTE: Refer to the Transformer Setup chapter for the winding currents magnitude and phase shift compensations performed by the 845 relay.

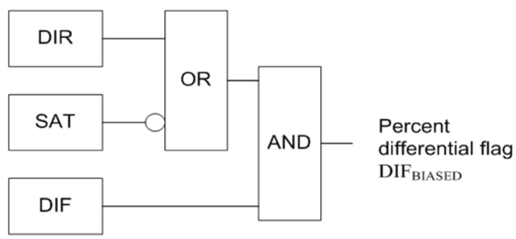
Figure 6-3: Differential/Restraint Characteristic for main transformer



The above figure shows the differential/restraint characteristic of the main transformer percent differential protection.

The decision for operation or no operation is complemented by detection of CT saturation, followed by currents directional check. The saturation flag (SAT) can only be initiated during an external fault, providing the magnitude of any of the restraints is bigger than a threshold average using the Break1 and Break 2 setting programmed in the menu. While at the same time, the differential/restraint ratio is below a slope average calculated based on Slope 1 and Slope 2 settings. The directional flag is not checked unless the SAT flag is initiated. Normally during internal faults, the trajectory of the differential/restraint ratio does not cross the average calculated breakpoint threshold, in which case the directional flag is not checked. The directional flag is checked during external faults (SAT flag triggered), where due to saturation, the differential/restraint trajectory is able to enter the operating region. Usually the angle between the currents during external fault and CT saturation remains bigger than 90 degrees, in which case the percent differential protection does not operate. However, while in the operating region, the protection would operate, on evolving faults (external to internal fault), as the directional flag would be high (angle less than 90 degrees).





Recommendations for configuring the Differential/Restraint characteristic

The following setpoints define the differential/restraint characteristic:

Minimum Pickup: This setpoint is expressed in xCT of Winding 1 (J1 CT bank for relays ordered with voltage, or K1 CT bank for relays ordered without voltage inputs). The minimum pickup defines the minimum differential current required for operation. The pickup setting must be higher than the amount of differential current that is seen under normal transformer loading conditions, and must be higher than the maximum differential current that is seen during transformer tap changer operation, providing the tap changer automatic differential current compensation is disabled, i.e. the setpoint TC Winding Currents from Tap Changer setup set to “None”. If this setpoint is set to a current bank (J1, K1, K2) representing any of the transformer winding currents, the Minimum Pickup can be set to be more sensitive but not below the differential current caused by CT errors during normal transformer loading.

For example, for a 20MVA, 25MVA, or 28MVA power transformer with a 138kV/4.16kV ratio, and class C current transformers CT(w1) 200:5, and CT(w2) 3000:5, the CT errors and the minimum pickup setting is calculated as follows:

Winding 1 (138kV) CT – reference. Magnitude factor: M(w1) = 1

Winding 2(4.16kV) CT – non reference. Magnitude factor: M(w2) = 4.16 *3000/138*200 = 0.4521

Based on emergency MVA rating:

Winding 1 rated current = 28MVA/(138kV*sqrt(3)) = 117 Amps

Winding 2 rated current =28MVA/(4.16*sqrt(3)) = 3890 Amps

The accuracy of the Class C current transformer is defined in the IEEE standard C37.110 as not exceeding 10% for symmetrical current magnitudes of up to 20 times the rating for a standard burden resistance:

117Amps *10% = 11.7 Amps = > 11.7/200 = 0.0585 xCT(w1)

3890 Amps *10% = 389 Amps = > 389/3000*M(w2) = 389/3000*0.4521 =0.0585 xCT (w1)

In the worst case, the errors from the two CTs as expressed in xCT(w1) as a reference can be summed:

Minimum Pickup = 0.0585 + 0.0585 = 0.117 (0.2xCT setting for Pickup is sufficient)

Slope 1: This setting defines the desired differential/restraint ratio for detecting internal faults. The percent Slope 1 setting must be above the differential/restraint ratio during external faults with non-significant fault current magnitude, but with long lasting DC component, which is able to cause CT saturation.

The Slope 1 setting can be calculated based on the restraint current during emergency loading of the transformer:

Restraint current Winding 1 = 117 Amps/200 = 0.585 xCT

Restraint current Winding 2(scaled) = 3890/3000*0.4521 = 0.585 xCT

Differential current = CT error = 0.117 xCT

Slope 1 = (0.117/0.585)*100 = 20%

Adding 5% margin, produces a Slope 1 setting of 25%

Slope 2: The Slope 2 setting ensures stability during heavy through fault conditions, where CT saturation results in high differential current. Slope 2 must be set high enough to cope with the worst case when the CTs from one winding saturate but the CTs from the other winding do not saturate during external fault. In such case the ratio of the differential to restraint current can be as high as 95 to 98%.

Break 1: Break 1 must be set to reflect the through current (restraint current) expressed in times winding 1 CT (w1) below which CT saturation due to DC components and/or residual magnetism is not expected. The latter may be as high as 80% of the nominal flux, effectively reducing the CT capabilities by factor of 5.

Therefore, this setting must correspond to the end of the linear operation of the CT with the worst characteristic, counting up to 80% remnant flux in the CT core. To calculate this setting, CTs knee-point voltage and CT secondary burden are needed.

$$B_1 = \left[\frac{V_{sat} \bullet M^{c}_{(w)}}{R_b \bullet I^{CT}_{sec}}\right] \bullet 0.2 \text{ (xCT)}$$

where $R_b = 2 \bullet R_{lead} + R_{CTsec} + R_{relay}$ is the CT burden resistance which includes CT secondary resistance R_{CTsec} , 2 times conductor resistance R_{lead} and the relay input resistance R_{relay}.

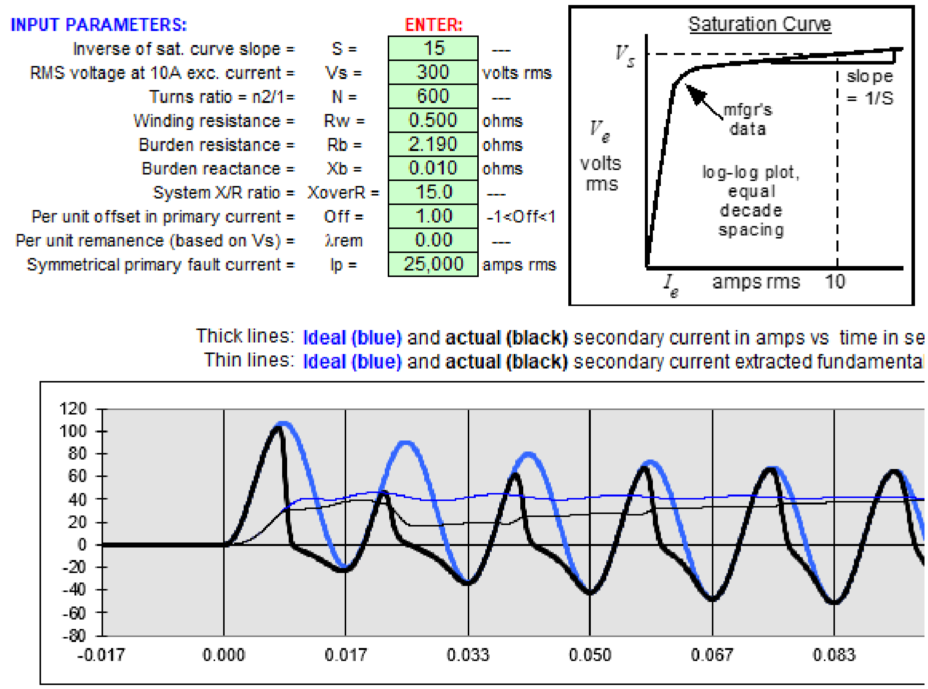
I^{CT}_{sec} is the CT secondary nominal current. V_{sat} is the CT knee-point voltage. The Break 1 is calculated per the formula above for each winding CT, and then the smallest per value is entered as a setting.

Break 2: Break 2 setting defines the beginning of Slope 2 used to provide stability during heavy through fault conditions, where CT saturation results in high differential current. Break 2 must be set to the through-fault current which causes the worst CT to saturate, with saturation free time of at least half power cycle.

To define the degree of CT saturation, the IEEE CT saturation tool can be used:

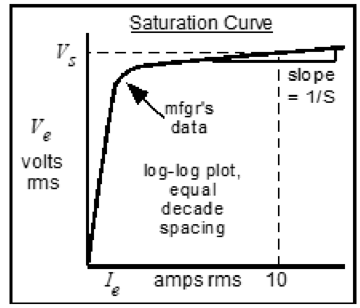
For example, let the CT 3000:5 on winding 2 be the worst one which would saturate first during external faults, and let the maximum external fault current be 25kA, with an X/R ratio of 15. The CT voltage kneepoint from the saturation characteristic is 300 V, with winding resistance of 0.5 Ohms, Burden resistance of 2.19 Ohms, and Burden reactance of 0.01 Ohms.

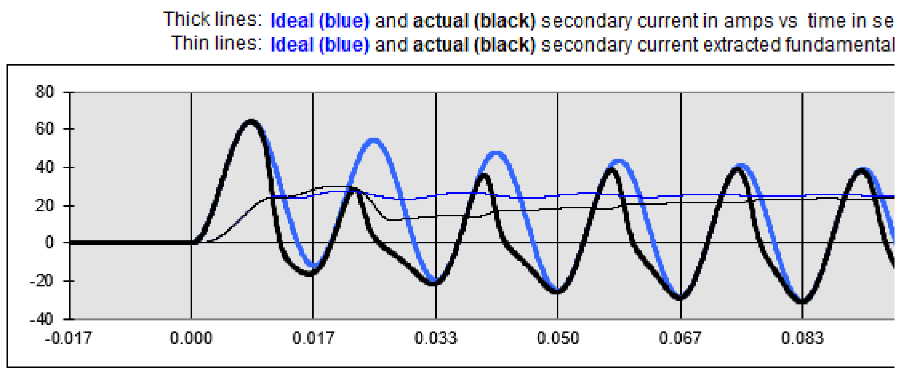
Logging this data into the CT sat tool, produces the following CT saturation waveform:



The waveform shows that during this external bolted fault with maximum fault current of 25 kA, the CT (3000:5) will saturate severely, and produce only a ¼ of a cycle saturation free time. Break 2 must be set to a through fault current so that the CT (3000:5) produces at least ½ cycle saturation free time. The solution is to change the fault current to 15000 kA. The waveform now shows a bigger part of the first cycle before saturation.

INPUT PARAMETERS:		ENTER:	
Inverse of sat. curve slope =	S =	15	---
RMS voltage at 10A exc. current =	Vs =	300	volts rms
Turns ratio = n2/1=	N =	600	---
Winding resistance =	Rw =	0.500	ohms
Burden resistance =	Rb =	2.190	ohms
Burden reactance =	Xb =	0.010	ohms
System X/R ratio =	XoverR =	15.0	---
Per unit offset in primary current =	Off =	1.00	-1<Off<1
Per unit remanence (based on Vs) =	λrem	0.00	---
Symmetrical primary fault current =	Ip =	15,000	amps rms





The fault current of 15000 Amps would then be translated as 15000/3000 = 5 times winding 2 CT. Bringing this to the same scale with respect to winding 1 CT reference , i.e. multiplying by a magnitude of 0.4521, the Break 2 setting would be:

Break 2 = 5 *0.4521 = 2.21 xCT (w1)

Figure 6-4: Examples of differential/restraint trajectory during internal fault

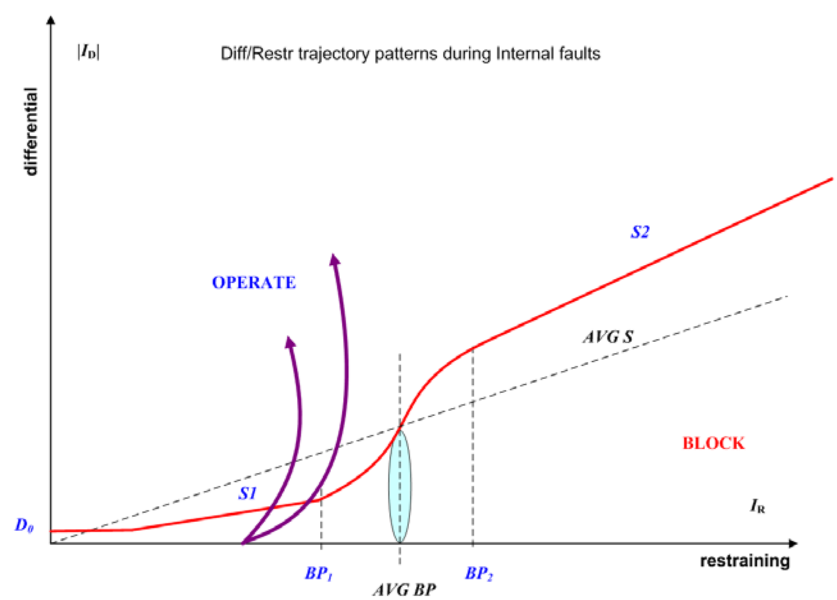
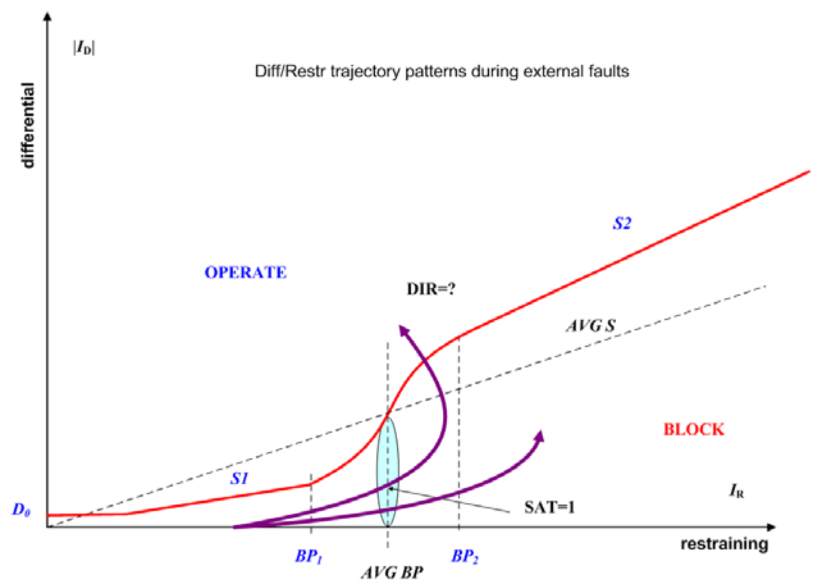


Figure 6-5: Examples of differential/restraint trajectory during external fault



Path: Setpoints > Protection > Group 1 (6) > Transformer > Percent Differential

FUNCTION

Range: Disabled, Trip, Configurable

Default: Disabled

The selection of the **Trip,** or **Configurable** setting enables the Percent Phase Differential function. The trip output relays selected to trip each breaker will operate, if the Percent Differential protection operates and these trip outputs are selected in the Percent Differential menu as "Operate".

PICKUP

Range: 0.05 to 1.00 x CT in steps of 0.01

Default: 0.20 x CT

This setting defines the minimum differential current required for operation. The setting is selected based on the amount of differential current that might be seen under normal conditions. This differential current is a result of the transformer magnetizing current, CT inaccuracies, and transformer ratio that would change by the transformer on-load tap changer. When the tap changer feature is set properly, the 845 compensates the transformation ratio which impacts the differential protection automatically.

SLOPE 1

Range: 1 to 100% in steps of 1

Default: 25%

This setting is applicable for restraint currents (through currents) of zero to kneepoint 1, and defines the ratio of differential/restraint currents, above which the element will operate. This slope is set to ensure sensitivity on internal faults at normal transformer loading. The value of slope 1 must be above the maximum differential currents which may be seen for through currents with magnitudes less than break 1 setting. The differential currents can be caused by winding CT inaccuracies, the constant transformer magnetizing current, and the leakage current from in-zone grounding transformers. Usually a margin of 2% to 5% is added to this setting.

BREAK 1

Range: 0.50 to 2.00 x CT in steps of 0.01 x CT
Default: 1.50 x CT

The setting for Break 1 defines the limit of linear operation of the magnitude reference CT, accounting for up to 80% residual flux, that effectively reduces the capability of the CT by a factor of 5. Break 1 must be set below the current that can cause CT saturation due to DC components and/or residual magnetism. Very often the Break 1 setting is based on the transformer winding 1 nominal current (100% transformer loading). In such cases, one must check whether or not this setting complies with the above recommendation regarding the CT linear performance. This breakpoint marks the end of slope 1, where no CT saturation is expected for restraining (through) currents smaller than that breakpoint.

BREAK 2

Range: 2.00 to 30.00 x CT in steps of 0.01 x CT
Default: 4.00 x CT

Break 2 must be set below the fault current that is most likely to saturate any of the transformer CTs due to an AC component alone. The setting is expressed in times CT, where the CT rating is the magnitude reference CT either user selected, or selected automatically.

SLOPE 2

Range: 1% to 100% in steps of 1%
Default: 95%

The Slope 2 setting ensures stability during through fault conditions, resulting in CT saturation and spurious high differential current. Slope 2 must be set high to cater for the worst case scenario, where only CTs from one winding saturate, but the CTs from the other winding(s) do not saturate. In such cases the differential/restraint ratio can go as high as 95% to 98%.

NOTE

Setting Slope 1 higher than Slope 2 must be avoided, as it is not practical, even though the ranges for both slopes can allow for one to do so. Correct programming of the differential-restraint characteristic is achieved when Slope 1 is used for sensitivity of operation during internal fault in the range of 15% to 35%, and Slope 2 set usually from 80% to 98%, is used to provide secure area for the diff./restr. trajectory during external faults and CT saturation.

PICKUP DELAY

Range: 0.000 to 10.000 in steps of 0.001 s
Default: 0.000 s

This setting defines the pickup time delay of the percent differential element.

INRUSH INHIBIT

Range: Disabled, 2nd Harm Block
Default: 2nd Harm Block

This setting enables or disables the inrush inhibit function. None of the settings for inrush inhibit are active, when the function is set to “Disabled”.

INRUSH INHIBIT LEVEL

Range: 1.0% to 40.0% in steps of 0.1%
Default: 20.0%

This setting specifies the ratio of the 2^{nd} harmonic differential current to the fundamental frequency differential current for the selected mode of the 2^{nd} harmonic inhibit. The percent differential protection will be blocked from operation if the actual ratio of the differential 2nd harmonic current to the fundamental frequency differential current is above this threshold.

INRUSH INHIBIT MODE

Range: "Per Phase", "Average", "2-out-of-3", "1-out-of-3"

Default: Per Phase

This setting specifies the mode of blocking during transformer magnetizing (inrush) conditions.

If set to "Per phase", the function performs inrush inhibit per each phase individually.

If set to "Average", the relay calculates the average 2nd harmonic level and compares this level against the setting for inrush inhibit level. Averaging of the 2nd harmonics follows an adaptive algorithm depending on per-phase magnitude of the fundamental frequency differential current. If the differential current on any of the three phases goes below the differential current cut-off level of 0.04 x CT, the 2nd harmonic current from that phase is dropped (zeroed) from the equation for averaging, and the divider is decreased from 3 to 2. The same happens if the magnitude of the differential current on one of two remaining phases during this same energization drops below the cut-off level. In this case the 2nd harmonic on this phase will be dropped from summation, and the divider will be decreased to 1.

If set to "2-out-of-3", the relay estimates the 2nd harmonic differential current per-phase, and blocks the differential protection for all three phases, if the 2nd harmonic content from **any two phases** is higher than the 2nd harmonic value entered in the setpoint "inrush inhibit level".

If set to "1-out-of-3", the relay estimates the 2nd harmonic differential current per-phase, and blocks the differential protection for all three phases, if the 2nd harmonic content from **any phase** is higher than the 2nd harmonic value entered in the setpoint "inrush inhibit level". This method is also known as the "cross-blocking" method.

OVEREXCITATION INHIBIT

Range: Disabled, 5th Harmonic

Default: 5th Harmonic

This setting provides 5^{th} harmonic differential protection blocking during an over excitation condition resulting from an increased V/Hz ratio.

An overexcitation condition resulting from an increased V/Hz ratio poses a danger to the protected transformer. A given transformer can tolerate an overfluxing condition for a limited time, as the danger is associated with thermal processes in the core. Instantaneous tripping of the transformer from the differential protection is not desirable.

The relay uses a traditional 5^{th} harmonic ratio for inhibiting the differential function during overexcitation conditions.

OVEREXCITATION LEVEL

Range: 1.0% to 40.0% in steps of 0.1%

Default: 10.0%

This setting specifies the level of 5th harmonic during overexcitation (overfluxing) transformer conditions. When the 5th harmonic level exceeds the specified OVEREXCITATION LEVEL setting (5th harmonic ratio) the differential element is blocked. The overexcitation inhibit works on a per-phase basis.

BLOCK

Range: Any FlexLogic operand

Default: Off

RELAYS

Range: Do Not Operate, Operate

Default: Do Not Operate

Any, or all of the output relays can be selected to operate, upon percent differential operation.

The 845 relay provides one instantaneous differential element per setpoint group.

The Instantaneous differential protection is not biased protection and operates similar to the instantaneous overcurrent protection. Inputs to this protection are computed by the relay per-phase differential currents. Operation occurs if any of the computed phase differential current is above the instantaneous differential pickup setting. The instantaneous differential protection is usually set to operate during high fault currents, and if used, its pickup must be set according to the following criteria:

- The pickup setting (xCT) must be selected higher than the maximum inrush current during transformer energization.
- The pickup setting must be set higher than the differential current caused CT saturation during faults outside the zone of protection.
- The pickup setting must be selected lower than the maximum fault current during internal faults.

INSTANTANEOUS DIFF FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

INST DIFF PICKUP

Range: 3.00 to 30.00 x CT in steps of 0.01 x CT
Default: 10.00 x CT

This setting defines the pickup level of the differential current required for operation.

INST DIFF BLOCK

Range: Any FlexLogic operand
Default: Off

INST DIFF OUTPUT RELAYS

Range: Do Not Operate, Operate
Default: Do Not Operate

The menu includes a list of available output relays to be set for operation or no operation upon protection operation.

NOTICE

The output relays selected under the Breaker menu for breaker trip need to be reselected if the Percent Differential function is set to “Trip”. These output relays will not be operational even if selected to operate if the Percent Differential function is set to “Configurable”.

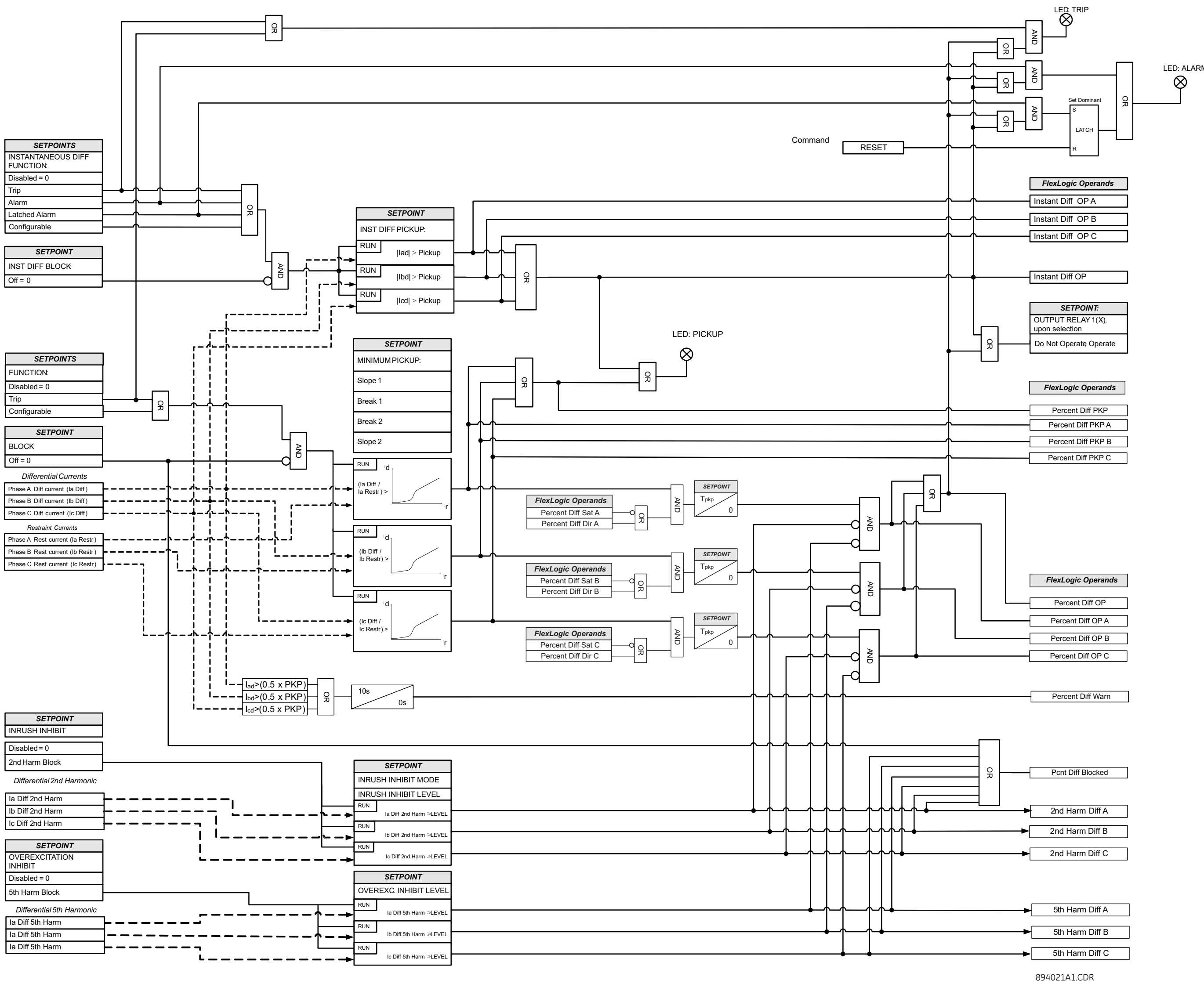
EVENTS

Range: Disabled, Enabled
Default: Disabled

TARGETS

Range: Disabled, Self-Reset, Latched
Default: Latched

Figure 6-6: Percent and Instantaneous Differential Protection Logic Diagram


LED: TRIP
LED: ALARM
Set Dominant
LATCH
Command
RESET
SETPOINTS
INSTANTANEOUS DIFF FUNCTION
Disabled = 0
Trip
Alarm
Latched Alarm
Configurable
SETPOINT
INST DIFF BLOCK
Off = 0
INST DIFF PICKUP:
|Iad| > Pickup
|Ibd| > Pickup
|Icd| > Pickup
FlexLogic Operands
Instant Diff OP A
Instant Diff OP B
Instant Diff OP C
Instant Diff OP
OUTPUT RELAY 1(X), upon selection
Do Not Operate Operate
LED: PICKUP
FUNCTION:
Disabled = 0
Trip
Configurable
BLOCK
Off = 0
MINIMUM PICKUP:
Slope 1
Break 1
Break 2
Slope 2
Percent Diff PKP
Percent Diff PKP A
Percent Diff PKP B
Percent Diff PKP C
Differential Currents
Phase A Diff current (Ia Diff)
Phase B Diff current (Ib Diff)
Phase C Diff current (Ic Diff)
Restraint Currents
Phase A Rest current (Ia Restr)
Phase B Rest current (Ib Restr)
Phase C Rest current (Ic Restr)
(Ia Diff / Ia Restr) >
(Ib Diff / Ib Restr) >
(Ic Diff / Ic Restr) >
Percent Diff Sat A
Percent Diff Dir A
Percent Diff Sat B
Percent Diff Dir B
Percent Diff Sat C
Percent Diff Dir C
Tpkp
Percent Diff OP
Percent Diff OP A
Percent Diff OP B
Percent Diff OP C
Iad>(0.5 x PKP)
Ibd>(0.5 x PKP)
Icd>(0.5 x PKP)
10s
0s
Percent Diff Warn
INRUSH INHIBIT
2nd Harm Block
Differential 2nd Harmonic
Ia Diff 2nd Harm
Ib Diff 2nd Harm
Ic Diff 2nd Harm
INRUSH INHIBIT MODE
INRUSH INHIBIT LEVEL
Ia Diff 2nd Harm >LEVEL
Ib Diff 2nd Harm >LEVEL
Ic Diff 2nd Harm >LEVEL
Pcnt Diff Blocked
2nd Harm Diff A
2nd Harm Diff B
2nd Harm Diff C
OVEREXCITATION INHIBIT
5th Harm Block
Differential 5th Harmonic
Ia Diff 5th Harm
OVEREXC. INHIBIT LEVEL
Ia Diff 5th Harm >LEVEL
Ib Diff 5th Harm >LEVEL
Ic Diff 5th Harm >LEVEL
5th Harm Diff A
5th Harm Diff B
5th Harm Diff C
894021A1.CDR

Transformer Overload

The Transformer overload element may be used as an instantaneous element with no intentional delay or as a definite time element. Each winding load current is compared with the pickup setpoint to produce an alarm or trip condition. Alternatively, the overload detection is available through the Over-temperature alarm input. An external transformer over temperature detector can be connected to this input.

Setpoints

Path: Setpoints > Protection > Group 1(6) > Transformer > Overload

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable

Default: Disabled

PICKUP

Range: 50 to 300 % in steps of 1 %

Default: 208 %

This setting identifies the level of transformer overload, where the pickup delay starts timing. For a two winding transformer, the setting is expressed as a percentage of the transformer base MVA rating, and is normally set at or above the maximum rated MVA from the transformer nameplate. For a three winding transformer, the setting is expressed as a percentage of the winding base MVA rating.

PICKUP DELAY

Range: 0 to 60000 seconds in steps of 1 s

Default: 10 seconds

OVERTEMP INPUT

Range: Off, Any FlexLogic operand

Default: Off

Select Any FlexLogic operand that, when asserted, indicates the transformer cooling system has failed or an over-temperature condition exists on the transformer.

BLOCK

Range: Off, Any FlexLogic operand

Default: Off

OUTPUT RELAYS

Range: Do Not Operate, Operate

Default: Do Not Operate

EVENTS

Range: Enabled, Disabled

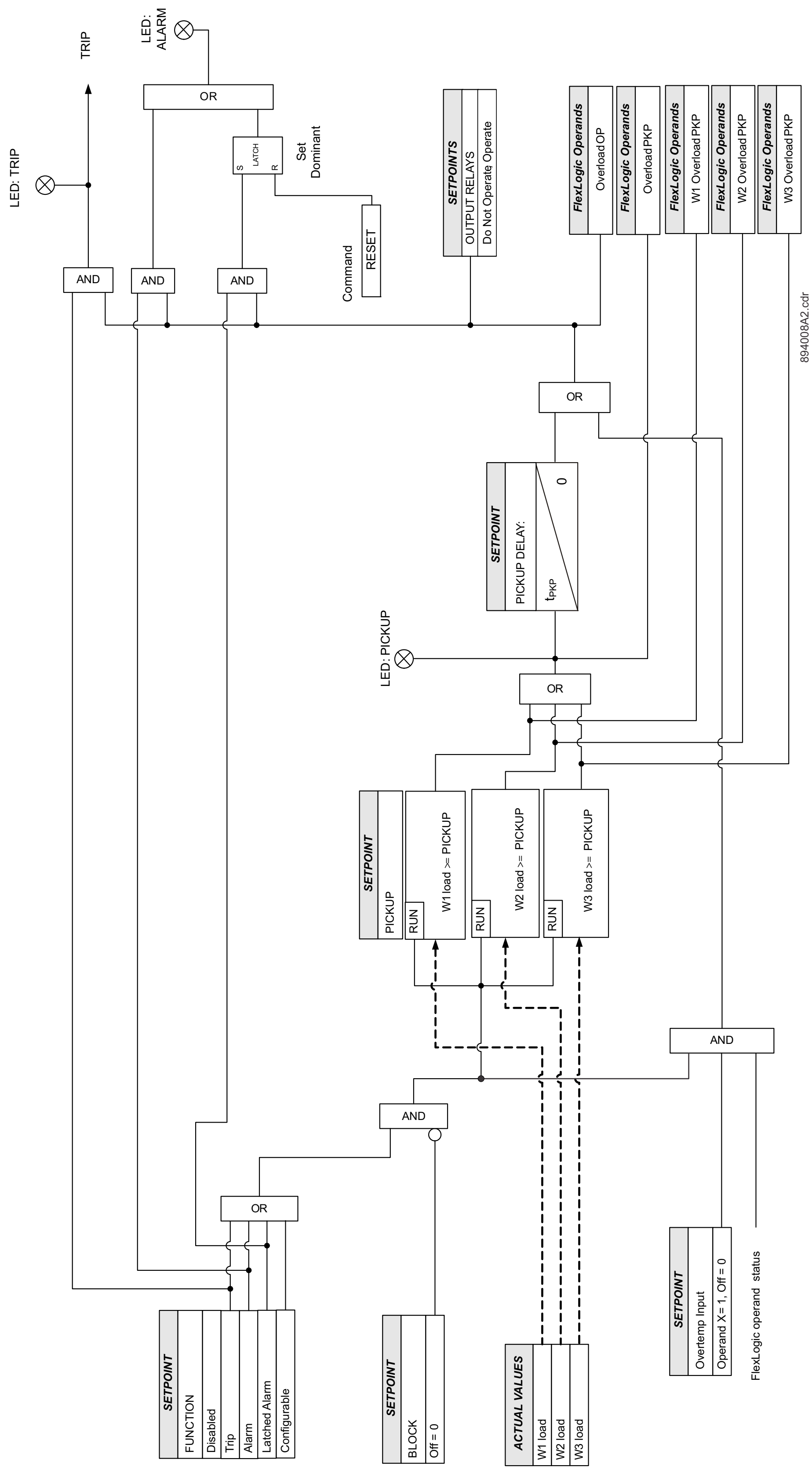
Default: Enabled

TARGETS

Range: Self-reset, Latched, Disabled

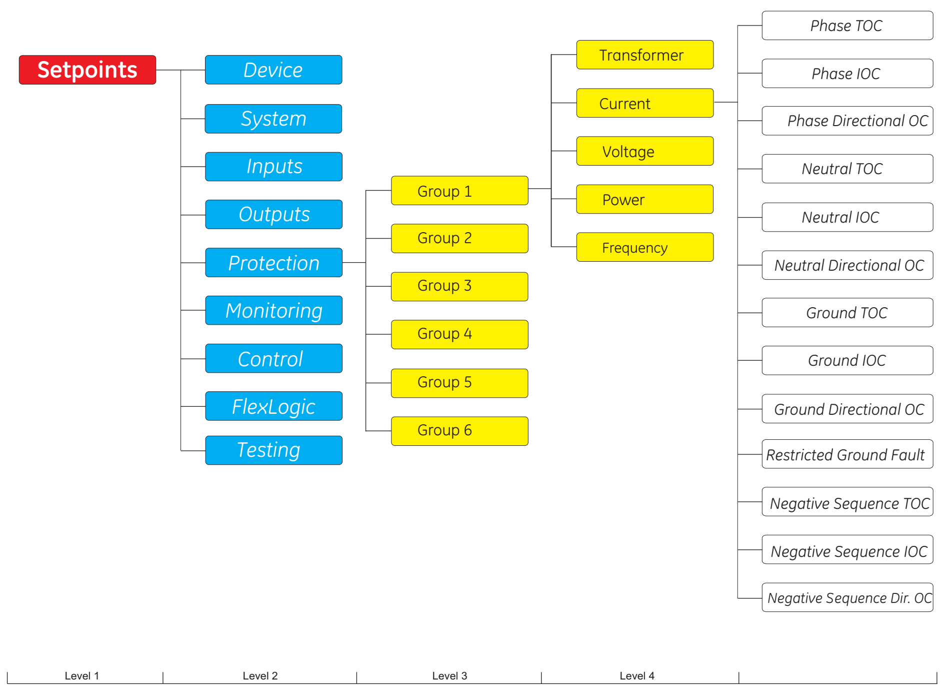
Default: Latched

Figure 6-7: Transformer Overload Logic Diagram



Current Elements

Figure 6-8: Current Elements Display Hierarchy



Description

The relay has six setpoint groups. The programming of the time-current characteristics of these elements is identical in all cases and is only covered in this section. The required curve is established by programming a Pickup Current, Curve Shape, Curve Multiplier, and Reset Time. The Curve Shape can be either a standard shape or a user-defined shape programmed with the FlexCurve feature. Accurate coordination may require changing the time overcurrent characteristics of particular elements under different conditions.

Inverse Time Overcurrent Curves

The Inverse Time Overcurrent Curves used by the Time Overcurrent elements are the IEEE, IEC, GE Type IAC, ANSI, I^2t and I^4t standard curve shapes. This allows for simplified coordination with downstream devices.

If none of these curve shapes is adequate, FlexCurves™ may be used to customize the inverse time curve characteristics. The definite time curve is also an option that may be appropriate if only simple protection is required.

Table 6-1: OVERCURRENT CURVE TYPES

IEEE	ANSI	IEC	GE TYPE IAC	OTHER
IEEE Extremely Inverse	ANSI Extremely Inverse	IEC Curve A (BS 142)	IAC Extremely Inverse	I^2t
IEEE Very Inverse	ANSI Very Inverse	IEC Curve B (BS 142)	IAC Very Inverse	I^4t
IEEE Moderately Inverse	ANSI Normally Inverse	IEC Curve C (BS 142)	IAC Inverse	FlexCurves™ A, B, C and D
	ANSI Moderately Inverse	IEC Short Inverse	IAC Short Inverse	Recloser Curve
				Definite Time

A time dial multiplier setting allows the 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 (TD MULTIPLIER) setting value. For example, all times for a multiplier of 10 are 10 times the multiplier 1 or base curve values. Setting the multiplier to zero results in an instantaneous response to all current levels above Pickup.

Time Overcurrent time calculations are made with an internal *energy capacity* memory variable. When this variable indicates that the energy capacity has reached 100%, a Time Overcurrent element will operate. If less than 100% energy capacity is accumulated in this variable and the current falls below the dropout threshold of 97 to 98% of the Pickup value, the variable must be reduced. Two types of this resetting operation are available: “Instantaneous” and “Timed”. The “Instantaneous” selection is intended for applications with other relays, such as most static relays, which set the energy capacity directly to zero when the current falls below the reset threshold. The “Timed” selection can be used where the relay must coordinate with electromechanical relays.

IEEE CURVES

The IEEE Time Overcurrent curve shapes conform to industry standards and the IEEE C37.112-1996 curve classifications for extremely, very, and moderately inverse. The IEEE curves are derived from the formula:

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

Where:

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

Table 6-2: IEEE INVERSE TIME CURVE CONSTANTS

IEEE CURVE SHAPE	A	B	P	t_r
IEEE Extremely Inverse	28.2	0.1217	2.000	29.1
IEEE Very Inverse	19.61	0.491	2.000	21.6
IEEE Moderately Inverse	0.0515	0.1140	0.02000	4.85

Table 6-3: 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

ANSI CURVES

The ANSI time overcurrent curve shapes conform to industry standards and the ANSI C37.90 curve classifications for extremely, very, and moderately inverse. The ANSI curves are derived from the following formulae:

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

Where:

- T = operate time (in seconds)
- TDM = Multiplier setting
- I = input current
- I_{pickup} = Pickup Current setting
- A to E = constants
- T_{RESET} = reset time in seconds (assuming energy capacity is 100% and RESET is "Timed")

t_r = characteristic constant

Table 6-4: ANSI INVERSE TIME CURVE CONSTANTS

ANSI CURVE SHAPE	A	B	C	D	E	t_r
ANSI Extremely Inverse	0.0399	0.2294	0.5000	3.0094	0.7222	5.67
ANSI Very Inverse	0.0615	0.7989	0.3400	-0.2840	4.0505	3.88
ANSI Normally Inverse	0.0274	2.2614	0.3000	-4.1899	9.1272	5.95
ANSI Moderately Inverse	0.1735	0.6791	0.8000	-0.0800	0.1271	1.08

Table 6-5: ANSI CURVE TRIP TIMES (IN SECONDS)

MULTIPLIER (TDM)	CURRENT (I/Ipickup)									
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
ANSI EXTREMELY INVERSE										
0.5	2.000	0.872	0.330	0.184	0.124	0.093	0.075	0.063	0.055	0.049
1.0	4.001	1.744	0.659	0.368	0.247	0.185	0.149	0.126	0.110	0.098
2.0	8.002	3.489	1.319	0.736	0.495	0.371	0.298	0.251	0.219	0.196
4.0	16.004	6.977	2.638	1.472	0.990	0.742	0.596	0.503	0.439	0.393
6.0	24.005	10.466	3.956	2.208	1.484	1.113	0.894	0.754	0.658	0.589
8.0	32.007	13.955	5.275	2.944	1.979	1.483	1.192	1.006	0.878	0.786
10.0	40.009	17.443	6.594	3.680	2.474	1.854	1.491	1.257	1.097	0.982
ANSI VERY INVERSE										
0.5	1.567	0.663	0.268	0.171	0.130	0.108	0.094	0.085	0.078	0.073
1.0	3.134	1.325	0.537	0.341	0.260	0.216	0.189	0.170	0.156	0.146
2.0	6.268	2.650	1.074	0.682	0.520	0.432	0.378	0.340	0.312	0.291
4.0	12.537	5.301	2.148	1.365	1.040	0.864	0.755	0.680	0.625	0.583
6.0	18.805	7.951	3.221	2.047	1.559	1.297	1.133	1.020	0.937	0.874
8.0	25.073	10.602	4.295	2.730	2.079	1.729	1.510	1.360	1.250	1.165
10.0	31.341	13.252	5.369	3.412	2.599	2.161	1.888	1.700	1.562	1.457
ANSI NORMALLY INVERSE										
0.5	2.142	0.883	0.377	0.256	0.203	0.172	0.151	0.135	0.123	0.113
1.0	4.284	1.766	0.754	0.513	0.407	0.344	0.302	0.270	0.246	0.226
2.0	8.568	3.531	1.508	1.025	0.814	0.689	0.604	0.541	0.492	0.452
4.0	17.137	7.062	3.016	2.051	1.627	1.378	1.208	1.082	0.983	0.904
6.0	25.705	10.594	4.524	3.076	2.441	2.067	1.812	1.622	1.475	1.356
8.0	34.274	14.125	6.031	4.102	3.254	2.756	2.415	2.163	1.967	1.808
10.0	42.842	17.656	7.539	5.127	4.068	3.445	3.019	2.704	2.458	2.260
ANSI MODERATELY INVERSE										
0.5	0.675	0.379	0.239	0.191	0.166	0.151	0.141	0.133	0.128	0.123
1.0	1.351	0.757	0.478	0.382	0.332	0.302	0.281	0.267	0.255	0.247
2.0	2.702	1.515	0.955	0.764	0.665	0.604	0.563	0.533	0.511	0.493
4.0	5.404	3.030	1.910	1.527	1.329	1.208	1.126	1.066	1.021	0.986
6.0	8.106	4.544	2.866	2.291	1.994	1.812	1.689	1.600	1.532	1.479
8.0	10.807	6.059	3.821	3.054	2.659	2.416	2.252	2.133	2.043	1.972
10.0	13.509	7.574	4.776	3.818	3.324	3.020	2.815	2.666	2.554	2.465

IEC CURVES

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

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

Where:

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

Table 6-6: IEC (BS) INVERSE TIME CURVE CONSTANTS

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

Table 6-7: IEC CURVE TRIP TIMES (IN SECONDS)

MULTIPLIER (TDM)	CURRENT (I/I_{pickup})									
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
IEC CURVE A										
0.05	0.860	0.501	0.315	0.249	0.214	0.192	0.176	0.165	0.156	0.149
0.10	1.719	1.003	0.630	0.498	0.428	0.384	0.353	0.330	0.312	0.297
0.20	3.439	2.006	1.260	0.996	0.856	0.767	0.706	0.659	0.623	0.594
0.40	6.878	4.012	2.521	1.992	1.712	1.535	1.411	1.319	1.247	1.188
0.60	10.317	6.017	3.781	2.988	2.568	2.302	2.117	1.978	1.870	1.782
0.80	13.755	8.023	5.042	3.984	3.424	3.070	2.822	2.637	2.493	2.376
1.00	17.194	10.029	6.302	4.980	4.280	3.837	3.528	3.297	3.116	2.971
IEC CURVE B										
0.05	1.350	0.675	0.338	0.225	0.169	0.135	0.113	0.096	0.084	0.075
0.10	2.700	1.350	0.675	0.450	0.338	0.270	0.225	0.193	0.169	0.150
0.20	5.400	2.700	1.350	0.900	0.675	0.540	0.450	0.386	0.338	0.300
0.40	10.800	5.400	2.700	1.800	1.350	1.080	0.900	0.771	0.675	0.600
0.60	16.200	8.100	4.050	2.700	2.025	1.620	1.350	1.157	1.013	0.900
0.80	21.600	10.800	5.400	3.600	2.700	2.160	1.800	1.543	1.350	1.200
1.00	27.000	13.500	6.750	4.500	3.375	2.700	2.250	1.929	1.688	1.500
IEC CURVE C										
0.05	3.200	1.333	0.500	0.267	0.167	0.114	0.083	0.063	0.050	0.040
0.10	6.400	2.667	1.000	0.533	0.333	0.229	0.167	0.127	0.100	0.081
0.20	12.800	5.333	2.000	1.067	0.667	0.457	0.333	0.254	0.200	0.162
0.40	25.600	10.667	4.000	2.133	1.333	0.914	0.667	0.508	0.400	0.323

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
0.60	38.400	16.000	6.000	3.200	2.000	1.371	1.000	0.762	0.600	0.485
0.80	51.200	21.333	8.000	4.267	2.667	1.829	1.333	1.016	0.800	0.646
1.00	64.000	26.667	10.000	5.333	3.333	2.286	1.667	1.270	1.000	0.808
IEC SHORT INVERSE										
0.05	0.153	0.089	0.056	0.044	0.038	0.034	0.031	0.029	0.027	0.026
0.10	0.306	0.178	0.111	0.088	0.075	0.067	0.062	0.058	0.054	0.052
0.20	0.612	0.356	0.223	0.175	0.150	0.135	0.124	0.115	0.109	0.104
0.40	1.223	0.711	0.445	0.351	0.301	0.269	0.247	0.231	0.218	0.207
0.60	1.835	1.067	0.668	0.526	0.451	0.404	0.371	0.346	0.327	0.311
0.80	2.446	1.423	0.890	0.702	0.602	0.538	0.494	0.461	0.435	0.415
1.00	3.058	1.778	1.113	0.877	0.752	0.673	0.618	0.576	0.544	0.518

IAC CURVES

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

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

Where:

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

Table 6-8: GE TYPE IAC INVERSE TIME CURVE CONSTANTS

IAC CURVE SHAPE	A	B	C	D	E	t_r
IAC Extremely Inverse	0.0040	0.6379	0.6200	1.7872	0.2461	6.008
IAC Very Inverse	0.0900	0.7965	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 6-9: 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

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 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	0.618	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 curves for the I^2t are derived from the formula:

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

Where:

T = operate time (in seconds)
TDM = Multiplier setting
I = input current
I_{pickup} = Pickup Current setting
T_{RESET} = reset time in seconds (assuming energy capacity is 100% and RESET is “Timed”)

Table 6-10: 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

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
10.00	444.44	250.00	111.11	62.50	40.00	27.78	20.41	15.63	123.5	10.00
100.00	4444.44	2500.00	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

I^4T CURVES

The curves for the I^4t are derived from the formula:

$$T = TDM \times \left[\frac{100}{\left(I / I_{pickup}\right)^4} \right], \quad T_{RESET} = TDM \times \left[\frac{100}{\left(I / I_{pickup}\right)^{-4}} \right]$$

Where:

T = operate time (in seconds)
TDM = Multiplier setting
I = input current
I_{pickup} = Pickup Current setting
T_{RESET} = reset time in seconds (assuming energy capacity is 100% and RESET is "Timed")

Table 6-11: I^4T 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	0.1975	0.0625	0.0123	0.0039	0.0016	0.0008	0.0004	0.0002	0.00015	0.0001
0.10	1.9753	0.6250	0.1235	0.0391	0.0160	0.0077	0.0042	0.0024	0.0015	0.0010
1.00	19.753	6.250	1.235	0.391	0.160	0.077	0.042	0.024	0.015	0.010
10.00	197.531	62.500	12.346	3.906	1.600	0.772	0.416	0.244	0.152	0.100
100.00	1975.31	625.00	123.46	39.06	16.00	7.72	4.16	2.44	1.52	1.00
600.00	11851.9	3750.0	740.7	234.4	96.00	46.3	25.0	14.65	9.14	6.00

FLEXCURVES

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

$$T = TDM \times \left[FlexCurve\,Time\ at\ \left(I / I_{pickup}\right) \right]\ when\ \left(I / I_{pickup}\right) \geq 1.00$$
$$T_{RESET} = TDM \times \left[FlexCurve\,Time\ at\ \left(I / I_{pickup}\right) \right]\ when\ \left(I / I_{pickup}\right) \leq 0.98$$

Where:

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

DEFINITE TIME CURVES

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 0.05 to 600 makes this delay adjustable from 50 to 600000 milliseconds.

$$T = TDM \text{ in seconds, when } I > I_{pickup}$$

$$T_{RESET} = TDM \text{ in seconds}$$

Where:

T = operate time (in seconds)

TDM = Multiplier setting

I = input current

I_{pickup} = Pickup Current setting

T_{RESET} = reset time in seconds (assuming energy capacity is 100% and RESET is "Timed")

Percent of Load-To-Trip

The Percent of Load-to-Trip is calculated from the phase with the highest current reading. It is the ratio of this current to the lowest pickup setting among the phase time and the instantaneous overcurrent elements. If all of these elements are disabled, the value displayed is "0".

Phase Time Overcurrent Protection (51P)

The 845 relay TOC element can be configured with any of the IEEE, ANSI, IEC, and IAC standard inverse curves, any of the four FlexCurves, or set to definite time. The selection of Time Dial Multiplier (TDM) and minimum PKP, helps to fine tune the protection for accurate upstream/downstream coordination and during certain conditions, such as manual closing and Maintenance.

The settings of this function are applied to each of the three phases to produce Pickup and Trip flags per phase. There is no intentional "dead band" when the current is above the Pickup level. However the Pickup accuracy is guaranteed within the current input accuracy of 1.5% above the set PKP value. The TOC Pickup flag is asserted, when the current on any phase is above the PKP value. The TOC Trip flag is asserted if the element stays picked up for the time defined by the selected inverse curve and the magnitude of the current. The element drops from Pickup without operating if the measured current drops below 97 to 98% of the Pickup value before the time for operation is reached. When Definite Time is selected, the time for TOC operation is defined only by the TDM setting. The selection of TDM when in Definite Time mode sets the time to operate in seconds.

Path: **Setpoints > Protection > Group 1(6) > Current > Phase TOC > Phase TOC 1(X)**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

SIGNAL INPUT

Range: Dependant upon the order code
Default: CT Bank 1-J1

This setting provides the selection for the current input bank. The default bank names can be changed in: Setpoints > System > Current Sensing > [Name] > CT Bank Name.

INPUT

Range: Phasor, RMS
Default: Phasor

PICKUP

Range: 0.050 to 30.000 x CT in steps of 0.001 x CT
Default: 1.000 x CT

CURVE

Range: IEEE Extremely / Very / Moderately Inverse; ANSI Extremely / Very / Normally / Moderately Inverse; Definite time IEC A / B / C and Short Inverse; IAC Extremely / Very / Inverse / Short Inverse; FlexCurve A / B / C / D, I2t, I4t
Default: IEEE Moderately Inverse

TDM

Range: 0.05 to 600.00 in steps of 0.01
Default: 1.00

The setting provides a selection for Time Dial Multiplier which modifies the operating times per the selected inverse curve. For example, if an IEEE Extremely Inverse curve is selected with TDM = 2, and the fault current is 5 times bigger than the PKP level, the operation of the element will not occur before 2.59 s have elapsed after Pickup.

RESET

Range: Instantaneous, Timed

Default: Instantaneous

Selection of an Instantaneous or a Timed reset time is provided using this setting. If Instantaneous reset is selected, the Phase TOC element will reset instantaneously providing the current drops below 97-98% of the Phase TOC PKP level. If Timed reset is selected, the time to reset is calculated based on the reset equation for the selected inverse curve.

DIRECTION

Range: Disabled, Forward (Ph Dir OC 1 FWD), Reverse (Ph Dir OC 1 REV)

Default: Disabled

VOLTAGE RESTRAINT

Range: Disabled, Enabled

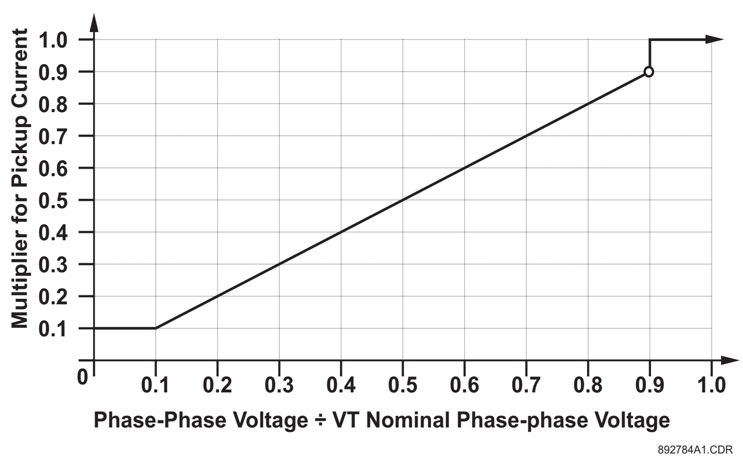
Default: Disabled

This setting enables or disables the Voltage Restraint function for the TOC element. When set to “Enabled” this feature lowers the Pickup value of each individual Phase Time Overcurrent element in a fixed relationship with its corresponding phase input voltage.

If cold load pickup, autoreclosing, or manual close blocking features are controlling the protection, the Phase TOC Voltage Restraint does not work, even if “Enabled” is selected.

Voltage restraint is used to lower the current pickup level for TOC function in linear proportion as shown in figure below. For example, if phase TOC PICKUP setting is set to 1.000 XCT, in case of system faults cause generator terminal voltage drops to 0.4 pu (ratio of Phase-Phase Voltage/ VT Nominal Phase-phase voltage), the new pickup with voltage restraint would be 1.000*0.4=0.400 xCT. During the fault condition when the voltage drops, the overcurrent relay pickup also drops linearly and it should be verified that for the limiting case the new voltage restraint relay pickup should be lower than (around 50% of) the fault current. Refer IEEE C37.102-2006, Annex-A for more details.

Figure 6-9: Voltage Restraint characteristics for Phase TOC



BLOCK

Range: Off, Any FlexLogic operand

Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

EVENTS

Range: Enabled, Disabled

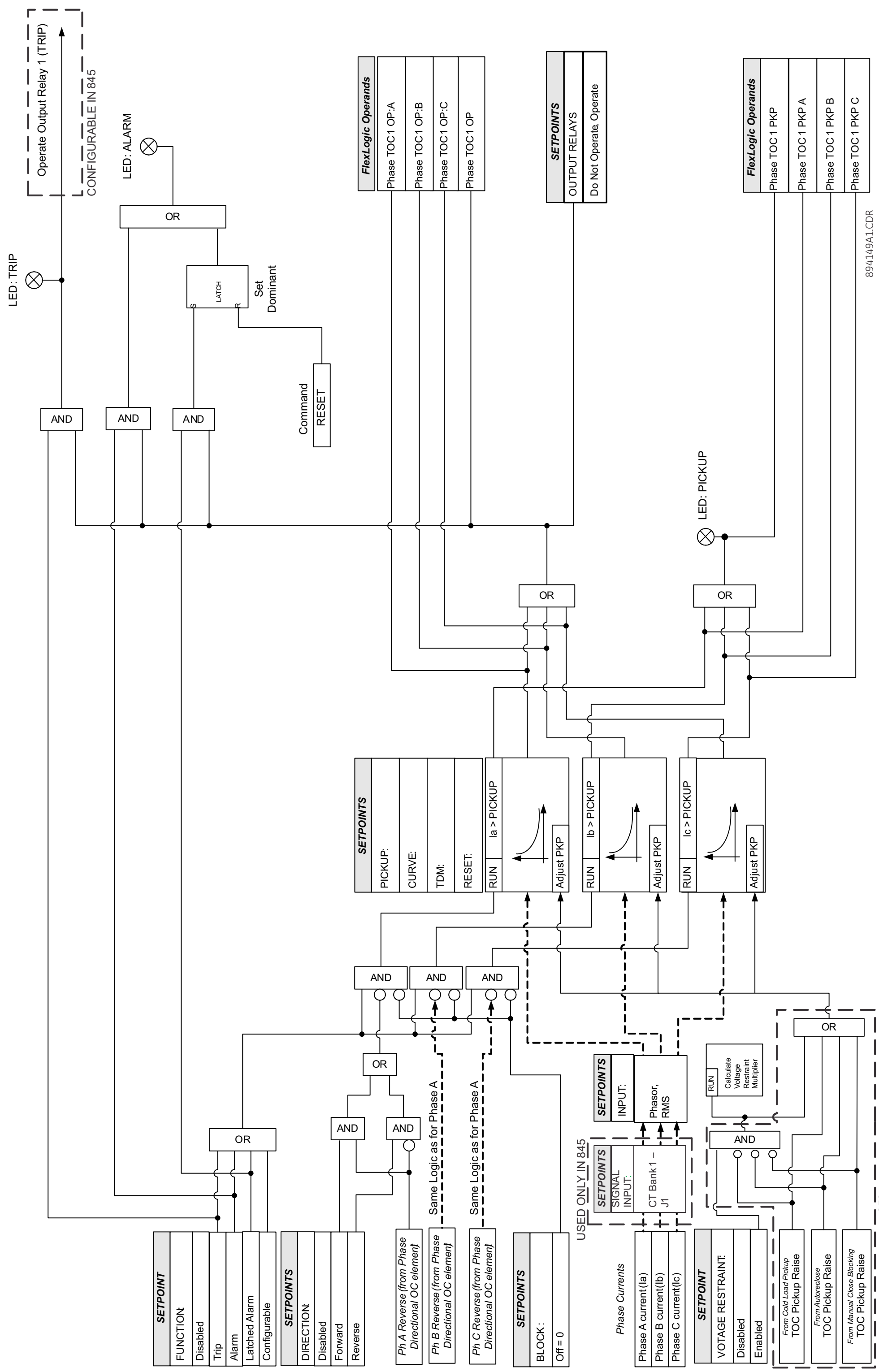
Default: Enabled

TARGETS

Range: Self-reset, Latched, Disabled

Default: Self-reset

Figure 6-10: Phase Time Overcurrent Protection logic diagram



Phase Instantaneous Overcurrent Protection (50P)

The 845 IOC element consists of the equivalent of three separate instantaneous overcurrent relays (one per phase) - ANSI device 50P - all with identical characteristics. The settings of this function are applied to each of the three phases to produce Pickup and Trip flags per phase. There is no intentional "dead band" when the current is above the Pickup level. However the Pickup accuracy is guaranteed within the current input accuracy of 3% above the set PKP value. The IOC Pickup flag is asserted, when the current of any phase is above the PKP value. The IOC Operate flag is asserted if the element stays picked up for the time defined in PH IOC PKP DELAY. The element drops from Pickup without operating if the measured current drops below 97-98% of the Pickup value before the time for operation is reached.

Path: **Setpoints > Protection > Group1(6) > Current > Phase IOC 1(X)**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

SIGNAL INPUT

Range: Dependant upon the order code
Default: CT Bank 1-J1 (dependant on order code)

This setting provides the selection for the current input bank. The default bank names can be changed in: Setpoints > System > Current Sensing > [Name] > CT Bank Name.

INPUT

Range: Phasor, RMS
Default: Phasor

PICKUP

Range: 0.050 to 30.000 x CT in steps of 0.001 x CT
Default: 1.000 x CT

DIRECTION

Range: Disabled, Forward (Ph Dir OC 1 FWD), Reverse (Ph Dir OC 1 REV)
Default: Disabled

PICKUP DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 0.000 s

DROPOUT DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 0.000 s

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

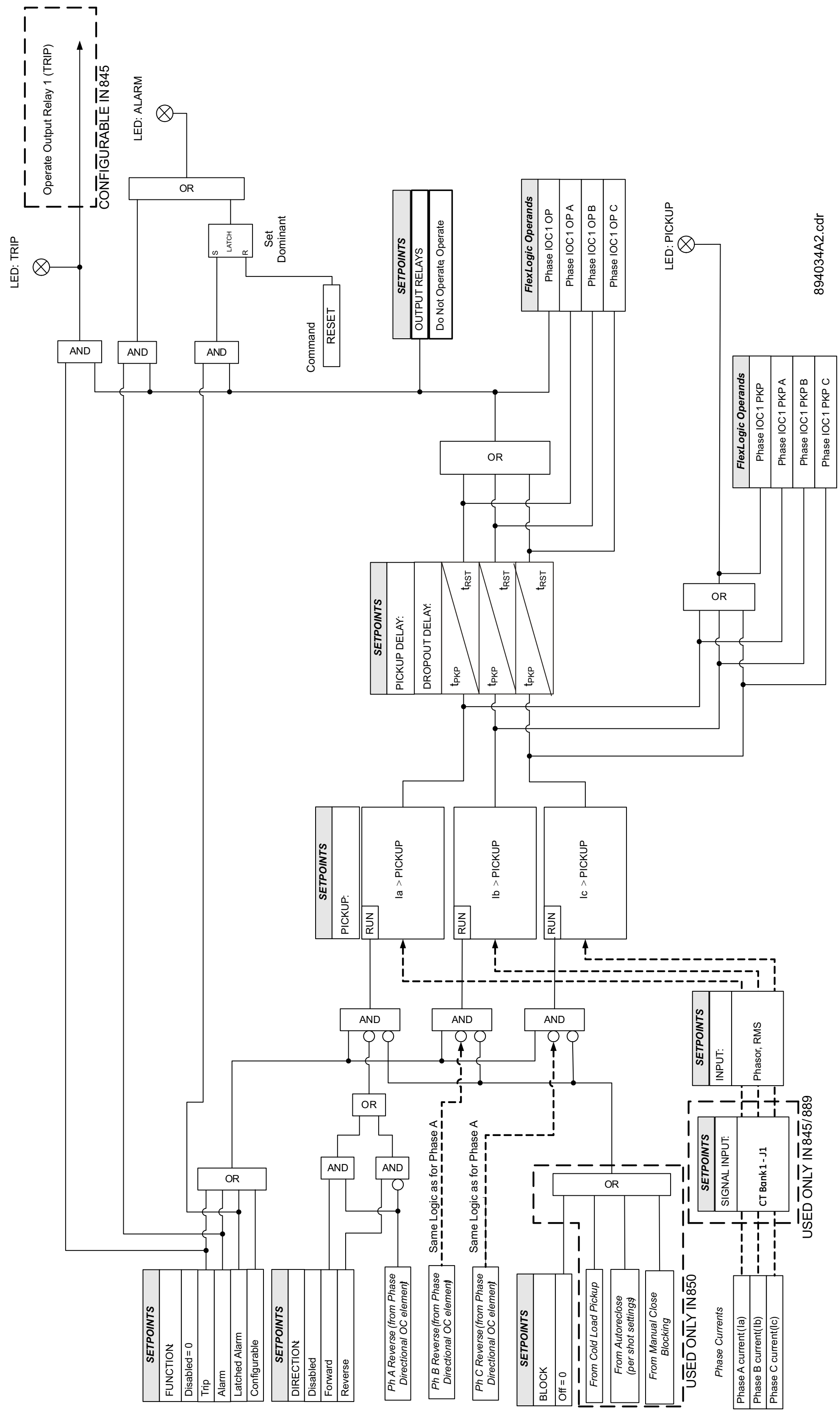
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

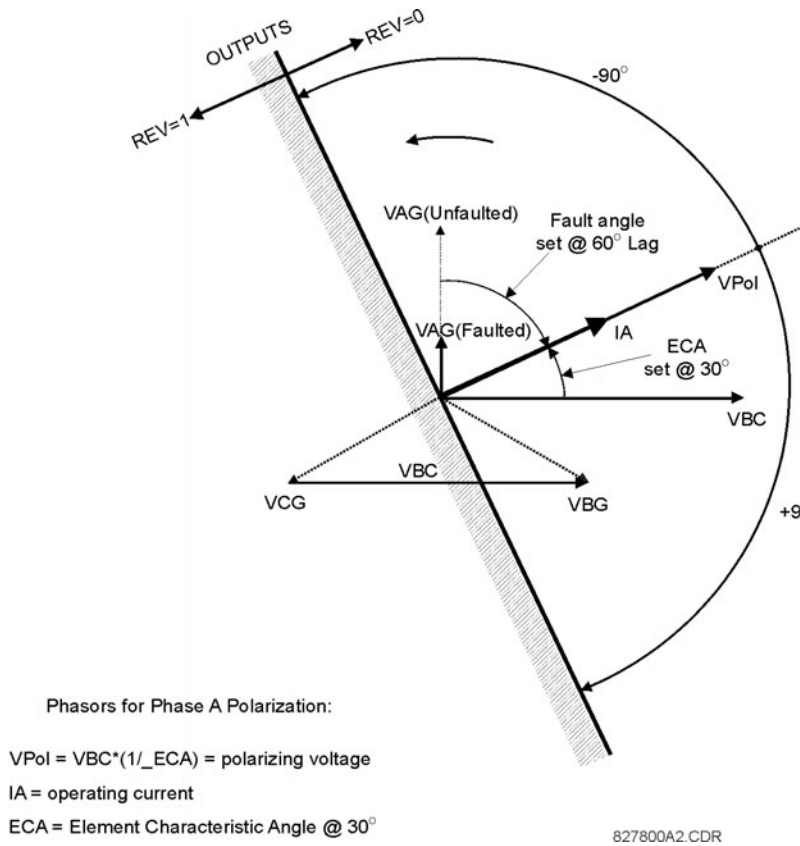
Range: Self-reset, Latched, Disabled
Default: Self-reset

Figure 6-11: Phase Instantaneous Overcurrent logic diagram



Phase Directional Overcurrent Protection (67P)

The 845 Phase Directional Overcurrent protection 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 by sending directional bits to inputs of these elements.



The element is intended to send a directional 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. 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 remembers the measurement of the polarizing voltage 3 cycles back - from the moment the voltage collapsed below the "polarizing voltage threshold" - and uses it to determine direction. The voltage memory remains valid for one second after the voltage has collapsed.

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

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

PHASE	OPERATING SIGNAL	POLARIZING SIGNAL (Vpol)	
		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)

Path: **Setpoints > Protection > Group1(6) > Current > Phase Dir OC 1(X)**

FUNCTION

Range: Disabled, Enabled

Default: Disabled

SIGNAL INPUT

Range: dependant upon the order code

Default: CT Bank 1-J1

This setting provides the selection for the current input bank. The default bank names can be changed in: Setpoints > System > Current Sensing > [Name] > CT Bank Name.

ECA

Range: 0° to 359° in steps of 1°

Default: 30°

The setting is used to select the element characteristic angle, i.e. the angle by which the polarizing voltage is shifted in the leading direction to achieve dependable operation.

POLARIZING V THRESHOLD

Range: 0.050 to 3.000 x VT in steps of 0.001 x VT

Default: 0.700 x VT

The 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.

REV WHEN V MEM EXP

Range: No, Yes

Default: No

The setting is used to select the required operation upon expiration of voltage memory. When set to "Yes" the directional element output value is forced to 'Reverse' when voltage memory expires; when set to "No" the directional element is 'Forward' when voltage memory expires.

BLOCK

Range: Off, Any FlexLogic operand

Default: Off

EVENTS

Range: Enabled, Disabled

Default: Enabled

TARGETS

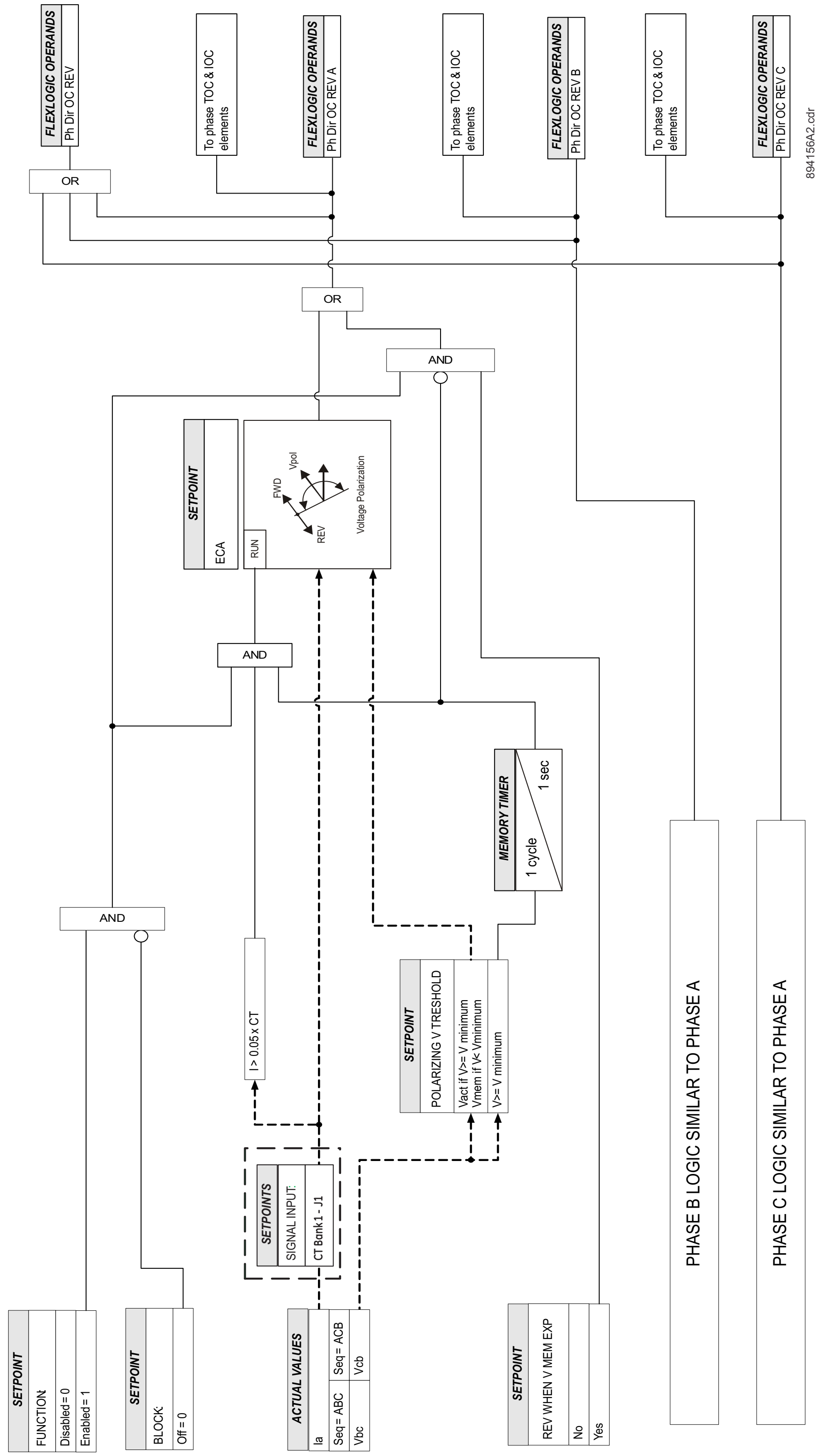
Range: Self-reset, Latched, Disabled

Default: Self-reset

NOTICE

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 change the directional signal. Some protection elements such as Instantaneous Overcurrent may respond to reverse faults before the directional signal has changed. A coordination time of at least 10 ms must therefore be added to all the instantaneous protection elements under the supervision of the Phase Directional element. If current reversal is a concern, a longer delay – in the order of 20 ms – is needed.

Figure 6-12: Phase Directional Overcurrent Protection logic diagram



Neutral Time Overcurrent Protection (51N)

The 845 computes the neutral current (In) using the following formula:

|In|=|Ia+Ib+Ic|

The settings of this function are applied to the neutral current to produce Trip or Pickup flags. The Neutral TOC Pickup flag is asserted when the neutral current is above the PKP value. The Neutral TOC Trip flag is asserted if the element stays picked up for the time defined by the selected inverse curve and the magnitude of the current. The element drops from Pickup without operation if the measured current drops below 97 to 98% of the Pickup value before the time for operation is reached. When Definite Time is selected, the time for Neutral TOC operation is defined only by the TDM setting.

Path: **Setpoints > Protection > Group 1(6) > Current > Neutral TOC 1(X)**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

SIGNAL INPUT

Range: dependant upon the order code
Default: CT Bank 1-J1

This setting provides the selection for the current input bank. The default bank names can be changed in: Setpoints > System > Current Sensing > [Name] > CT Bank Name.

INPUT

Range: Phasor, RMS
Default: Phasor

This selection defines the method of processing of the current signal. It could be Root Mean Square (RMS) or Fundamental Phasor Magnitude.

PICKUP

Range: 0.050 to 30.000 x CT in steps of 0.001 x CT
Default: 1.000 x CT

CURVE

Range: IEEE Extremely/Very/Moderately Inverse
ANSI Extremely/Very/Normally/Moderately Inverse
Definite time
IEC A/B/C and Short Inverse
IAC Extremely/Very/Inverse/Short Inverse
FlexCurve A/B/C/D, I2t, I4t
Default: IEEE Moderately Inverse

This setting sets the shape of the selected over-current inverse curve. If none of the standard curve shapes is appropriate, a FlexCurve can be created. Refer to the User curve and the FlexCurve setup for more details on their configurations and usage.

TDM

Range: 0.05 to 600.00 in steps of 0.01
Default: 1.00

This setting provides selection of the Time Dial Multiplier by which the times from the inverse curve are modified. For example if an ANSI Extremely Inverse curve is selected with TDM = 2, and the fault current is 5 times bigger than the PKP level, the operation of the element will not occur until 2.59s of time has elapsed from pickup.

RESET

Range: Instantaneous, Timed

Default: Instantaneous

The selection of an Instantaneous or a Timed reset time is provided for this setting. If the Instantaneous reset is selected, the neutral TOC element will reset instantaneously providing the current drops below 97-98% of the Neutral TOC PKP level, before the time for operation is reached.

DIRECTION

Range: Disabled, Forward (Ntrl Dir OC 1 FWD), Reverse (Ntrl Dir OC 1 REV)

Default: Disabled

BLOCK

Range: Off, Any FlexLogic operand

Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

EVENTS

Range: Enabled, Disabled

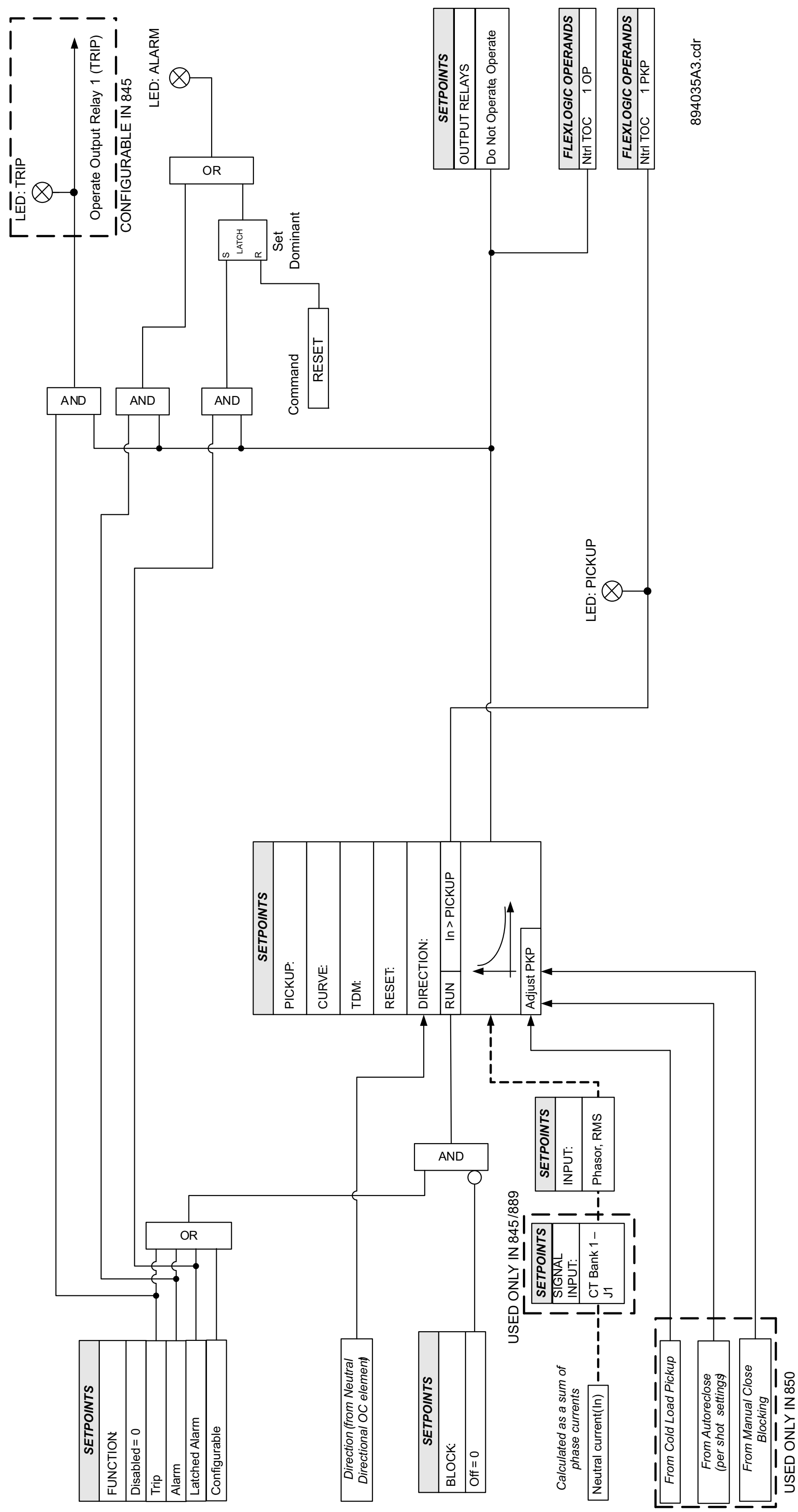
Default: Enabled

TARGETS

Range: Self-reset, Latched, Disabled

Default: Self-reset

Figure 6-13: Neutral Time Overcurrent Protection logic diagram



Neutral Instantaneous Overcurrent Protection (50N)

The 845 Neutral Instantaneous Overcurrent protection element computes the neutral current (In) using the following formula:

$|In| = |Ia + Ib + Ic|$

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:

$Iop = 3 * (|I\_0| - K * |I\_1|)$

where $K = 1/16$ and $|I\_0| = 1/3 * |In|$

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

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

The positive-sequence restraint must be considered when testing for Pickup accuracy and response time (multiple of Pickup). The operating quantity depends on how test currents are injected into the relay (single-phase injection: Iop = 0.9375 * I_injected three-phase pure zero sequence injection: Iop = 3 * I_injected).

The settings of this function are applied to the neutral current to produce Pickup and Trip flags. The Neutral IOC Pickup flag is asserted, when the neutral current is above the PKP value. The Neutral IOC Operate flag is asserted if the element stays picked up for the time defined by the Neutral IOC PKP Delay setting. If the Pickup time delay is set to 0.000 seconds, the Pickup and Operate flags are asserted at the same time. The element drops from Pickup without operation if the neutral current drops below 97 to 98% of the Pickup value.

Path: **Setpoints > Protection > Group 1(6) > Current > Neutral IOC 1(X)**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

SIGNAL INPUT

Range: dependant upon the order code
Default: CT Bank 1-J1

This setting provides the selection for the current input bank. The default bank names can be changed in: Setpoints > System > Current Sensing > [Name] > CT Bank Name.

PICKUP

Range: 0.050 to 30.000 x CT in steps of 0.001 x CT
Default: 1.000 x CT

DIRECTION

Range: Disabled, Forward (Ntrl Dir OC 1 FWD), Reverse (Ntrl Dir OC 1 REV)
Default: Disabled

PICKUP DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 0.000 s

DROPOUT DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 0.000 s

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

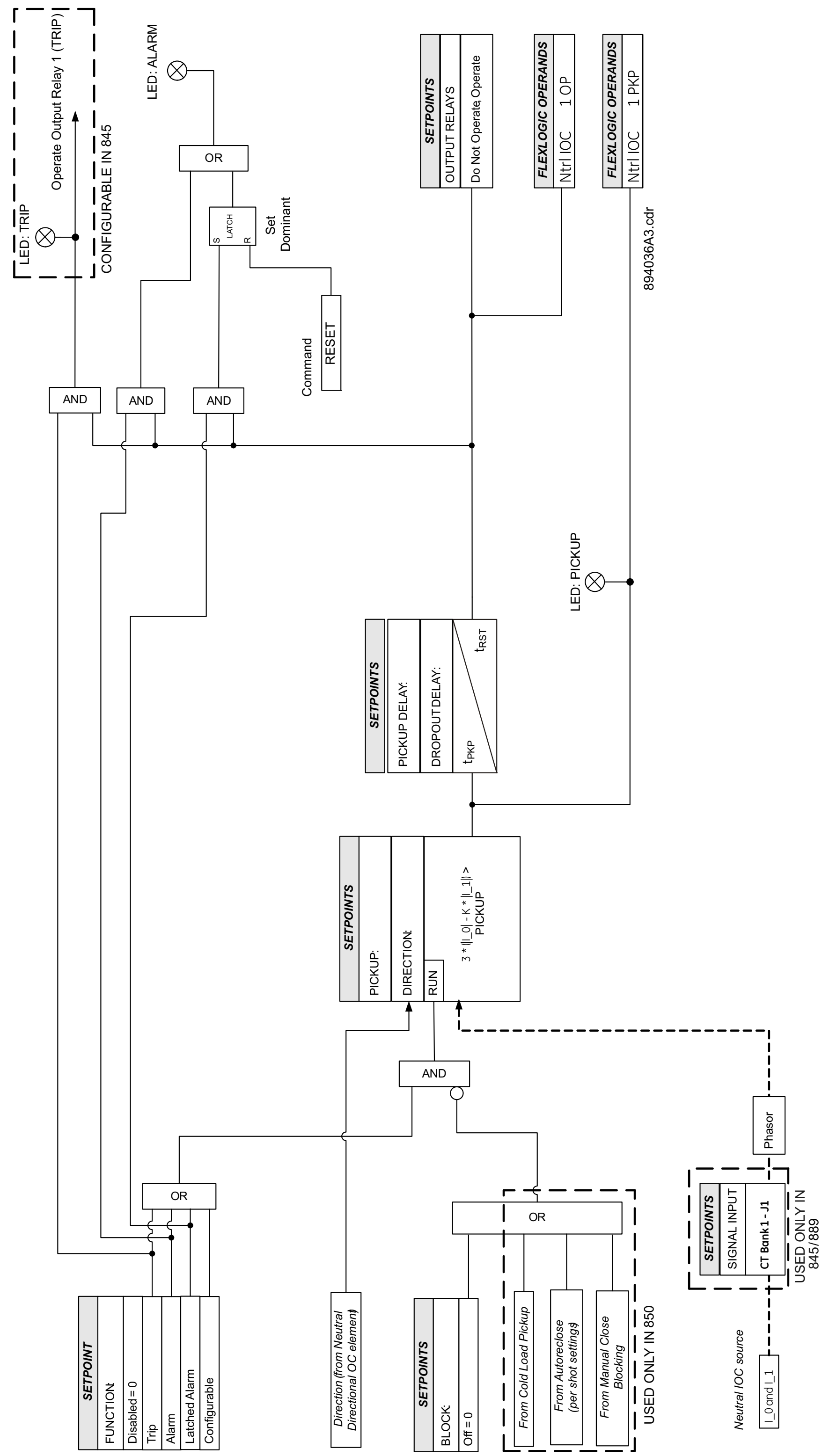
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Self-reset, Latched, Disabled
Default: Self-reset

Figure 6-14: Neutral Instantaneous Overcurrent Protection logic diagram



Neutral Directional Overcurrent Protection (67N)

The 845 Neutral Directional Overcurrent protection element provides both forward and reverse fault direction indications: the Ntrl Dir OC FWD and Ntrl Dir OC REV, respectively. The output operands are 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 neutral current calculated from the phase currents. There are separate Pickup settings for the forward-looking and reverse-looking functions. 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.

$Iop = 3 * (|I\_0| - K * |I\_1|)$

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

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

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

The positive-sequence restraint is removed for low currents. If the positive-sequence current is below 0.8 x CT, 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) for fault direction discrimination and may be programmed to use either zero-sequence voltage ("Calculated V0" or "Measured VX"), ground current (Ig), or both for polarizing. The following tables define the neutral directional overcurrent element.

<table>
<tr><th colspan="4">DIRECTIONAL UNIT</th><th rowspan="2">OVERCURRENT UNIT</th></tr>
<tr><th>POLARIZING MODE</th><th>DIRECTION</th><th colspan="2">COMPARED PHASORS</th></tr>
<tr><td rowspan="2">Voltage</td><td>Forward</td><td>–V_0</td><td>I_0 × 1∠ECA</td><td rowspan="4">$Iop = 3 \times (\lvert I\_0\rvert - K \times \lvert I\_1\rvert)$
if $\lvert I\_1\rvert > 0.8 \times CT$</td></tr>
<tr><td>Reverse</td><td>–V_0</td><td>–I_0 × 1∠ECA</td></tr>
<tr><td rowspan="2">Current</td><td>Forward</td><td>Ig</td><td>I_0</td></tr>
<tr><td>Reverse</td><td>Ig</td><td>–I_0</td></tr>
<tr><td rowspan="6">Dual</td><td rowspan="3">Forward</td><td>–V_0</td><td>I_0 × 1∠ECA</td><td rowspan="6">$Iop = 3 \times (\lvert I\_0\rvert)$
if $\lvert I\_1\rvert \leq 0.8 \times CT$</td></tr>
<tr><td colspan="2">or</td></tr>
<tr><td>Ig</td><td>I_0</td></tr>
<tr><td rowspan="3">Reverse</td><td>–V_0</td><td>–I_0 × 1∠ECA</td></tr>
<tr><td colspan="2">or</td></tr>
<tr><td>Ig</td><td>–I_0</td></tr>
</table>

Where:

$V\_0 = 1/3 * (Vag + Vbg + Vcg)$ = zero sequence voltage

$I\_0 = 1/3 * In = 1/3 * (Ia + Ib + Ic)$ = zero sequence current

ECA = element characteristic angle

In = neutral current

When POLARIZING VOLTAGE is set to "Measured VX," one-third of this voltage is used in place of V_0. The following figure explains the usage of the voltage polarized directional unit of the element by showing the voltage-polarized phase angle comparator characteristics for a phase A to ground fault, with:

ECA = 90° (element characteristic angle = centerline of operating characteristic)

FWD LA = 80° (forward limit angle = the ± angular limit with the ECA for operation

REV LA = 80° (reverse limit angle = the ± angular limit with the ECA for operation).

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

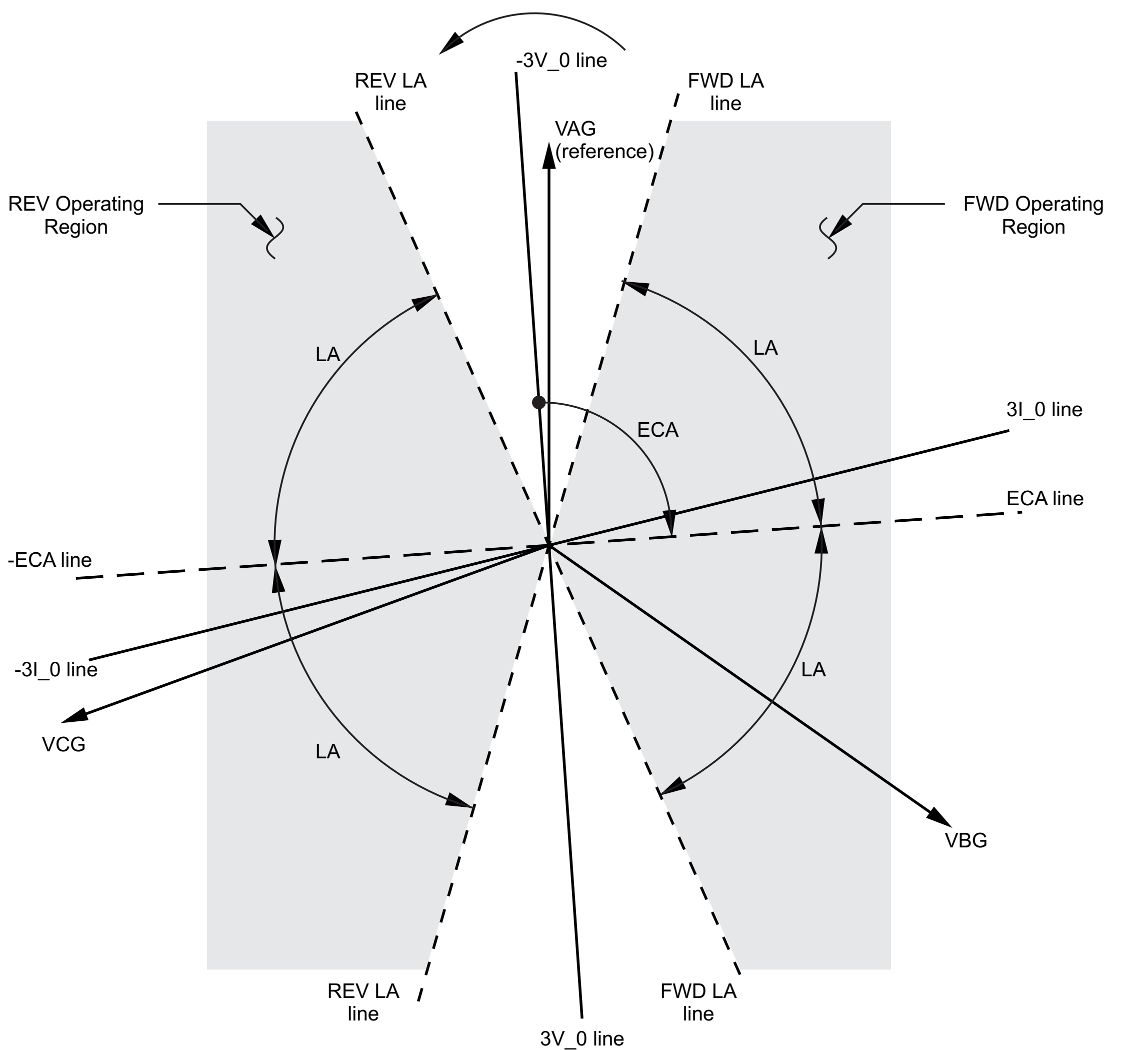
The forward-looking function is designed to be more secure as compared to the reverse-looking function, and should therefore be used for the tripping direction. The reverse-looking function is designed to be faster as compared to the forward-looking function and should be used for the blocking direction.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

The above bias should be taken into account when using the Neutral Directional Overcurrent element to directionalize other protection elements.

NOTE

For 845 relays ordered without voltage inputs, the polarizing signal for the Neutral Directional OC element is the ground current (Ig) from the bank selected as Signal Input in the element's menu. In this case the setponts "Polarizing Mode", and "Polarizing Voltage" are not displayed.

Figure 6-15: Neutral Directional Voltage-polarized Characteristics



Path: **Setpoints > Protection > Group 1(6) > Current > Neutral Directional OC 1(X)**

FUNCTION

Range: Disabled, Enabled

Default: Disabled

SIGNAL INPUT

Range: dependant upon the order code

Default: CT Bank 1-J1

This setting provides selection of the current input bank. The default bank names can be changed in Setpoints > System > Current Sensing > [Name] > CT Bank Name.

POLARIZING MODE

Range: Voltage, Current, Dual

Default: Voltage

This setting selects the polarizing mode for the directional unit.

- If **Voltage** polarizing mode is selected, the element uses the zero-sequence voltage angle for polarization. Select either the zero-sequence voltage V_0, calculated from the phase voltages, or the zero-sequence voltage supplied externally as the auxiliary voltage V_X.
  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 if the auxiliary voltage is connected to a zero-sequence voltage source (such as the open delta connected secondary of VTs).
  The zero-sequence (V_0) or auxiliary voltage (V_X), accordingly, must be greater than 0.02 x VT to be validated for use as a polarizing signal. If the polarizing signal is invalid, neither forward nor reverse indication is given.
- If **Current** polarizing mode is selected, the element uses the angle of the ground current measured on the ground current input. The ground CT must be connected between the ground and neutral point of an adequate source of ground current. The ground current must be greater than 0.05 x CT 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 mode 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

Selects the polarizing voltage used by the directional unit when "Voltage" or "Dual" polarizing mode is set. The polarizing voltage can be programmed to be either the zero-sequence voltage calculated from the phase voltages ("Calculated V_0") or supplied externally as an auxiliary voltage ("Measured VX")

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 higher if large system unbalances or poor CT performance are expected.

FORWARD ECA

Range: –90° to 90° in steps of 1°
Default: 75°

This setting defines the element characteristic angle (ECA) for the forward direction in "Voltage" polarizing mode. "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: 0.050 to 30.000 x CT in steps of 0.001 x CT
Default: 0.050 x CT

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: 0.050 to 30.000 x CT in steps of 0.001 x CT
Default: 0.050 x CT

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: Off, Any FlexLogic operand
Default: Off

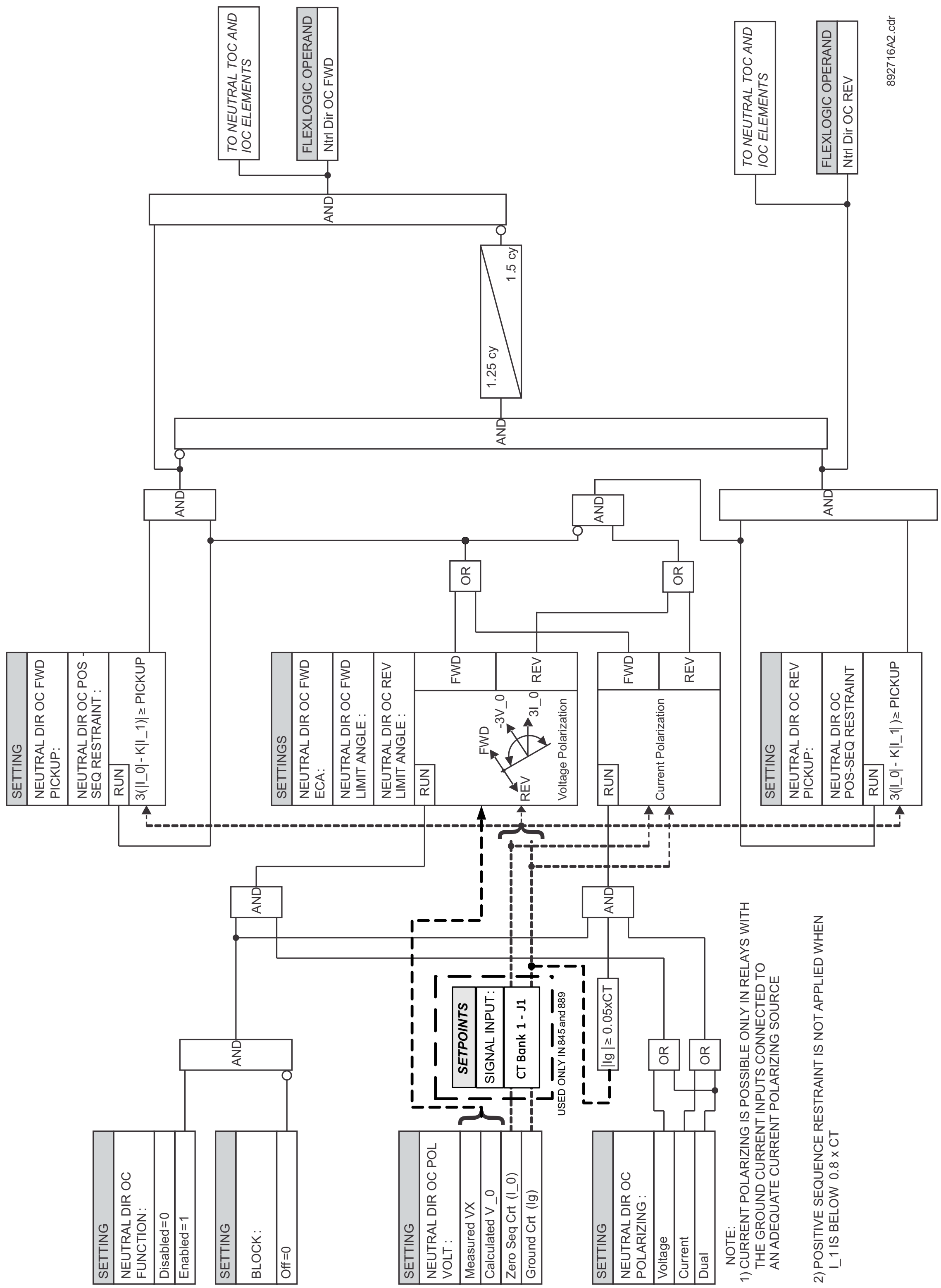
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Self-reset, Latched, Disabled
Default: Self-reset

Figure 6-16: Neutral Directional Overcurrent Protection logic diagram



Ground Time Overcurrent Protection (51G)

The 845 is equipped with the Ground Time Overcurrent protection element. The settings of this function are applied to the ground input current to produce Trip or Pickup flags. The Ground TOC Pickup flag is asserted when the ground current is above the PKP value. The Ground TOC Trip flag is asserted if the element stays picked up for the time defined by the selected inverse curve and the magnitude of the current. The element drops from Pickup without operation if the measured current drops below 97 to 98% of the Pickup value before the time for operation is reached. When Definite Time is selected, the time for Ground TOC operation is defined only by the TDM setting.

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

SIGNAL INPUT

Range: dependant upon the order code
Default: CT Bank 1-J1

This setting provides the selection for the current input bank. The default bank names can be changed in Setpoints > System > Current Sensing > [Name] > CT Bank Name.

INPUT

Range: Phasor, RMS
Default: Phasor

PICKUP

Range: 0.050 to 30.000 x CT in steps of 0.001 x CT
Default: 1.000 x CT

CURVE

Range: IEEE Extremely/Very/Moderately Inverse,
ANSI Extremely/Very/Normally/Moderately Inverse,
Definite time IEC A/B/C and Short Inverse,
IAC Extremely/Very/Inverse/Short Inverse
FlexCurve A/B/C/D, I2t, I4t
Default: IEEE, Moderately Inverse

TDM

Range: 0.05 to 600.00 in steps of 0.01
Default: 1.00

RESET

Range: Instantaneous, Timed
Default: Instantaneous

DIRECTION

Range: Disabled, Forward, Reverse
Default: Disabled

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

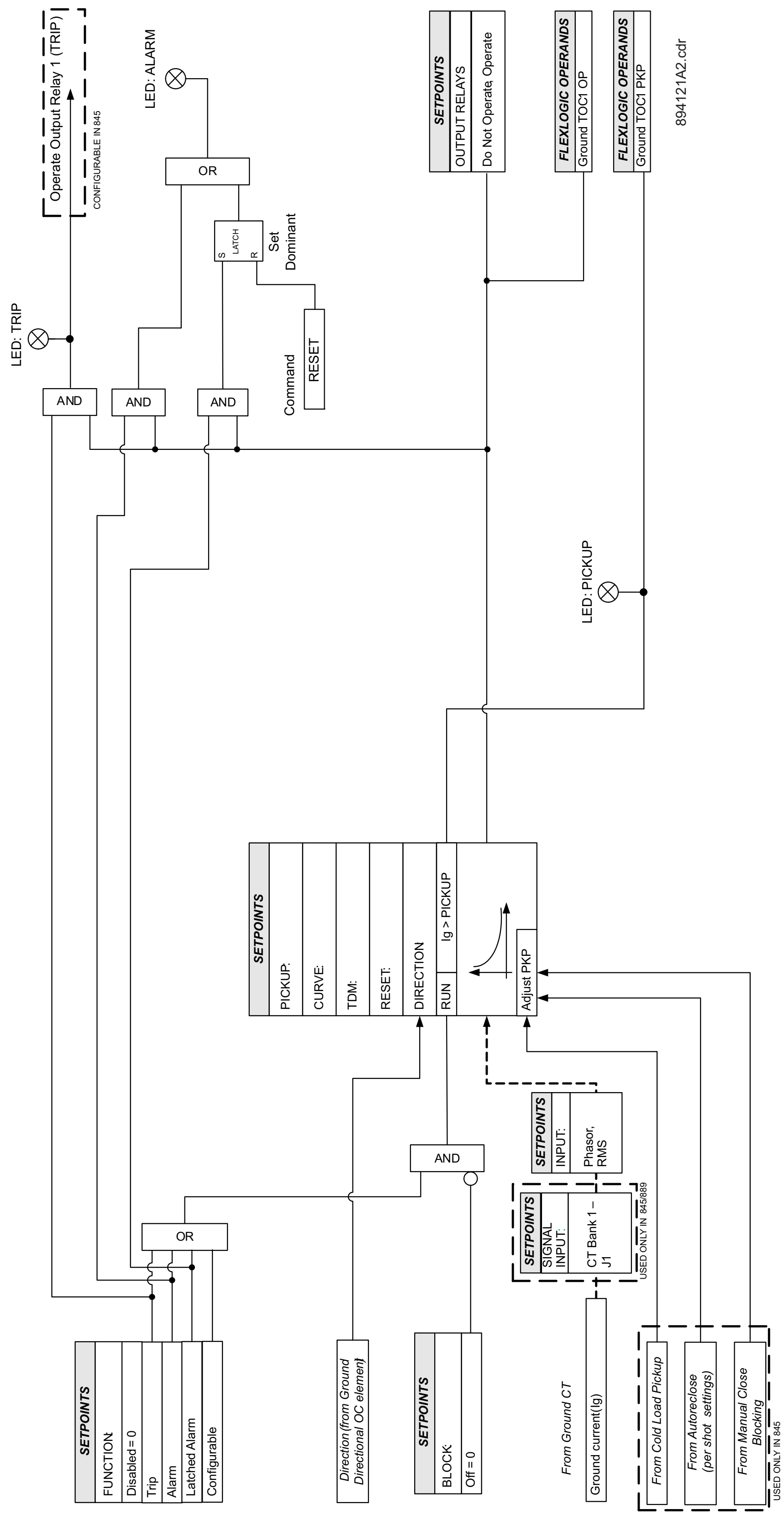
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Self-reset, Latched, Disabled
Default: Self-reset

Figure 6-17: Ground Time Overcurrent Protection logic diagram



Ground Instantaneous Overcurrent Protection (50G)

The 845 relay is equipped with the Ground Instantaneous Overcurrent protection element. The settings of this function are applied to the measured Ground current for producing Pickup and Trip flags. The Ground IOC Pickup flag is asserted when the Ground current is above the PKP value. The Ground IOC Operate flag is asserted if the element stays picked-up for the time defined by the Ground IOC PKP Delay setting. If the Pickup time delay is set to 0.000 seconds, the Pickup and Operate flags will be asserted at the same time. The element drops from Pickup without operation if the Ground current drops below 97 to 98% of the Pickup value.

Path: **Setpoints > Protection > Group 1(6) > Current > Ground IOC 1(X)**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

SIGNAL INPUT

Range: dependant upon the order code
Default: CT Bank 1-J1

This setting provides the selection for the current input bank. The default bank names can be changed in Setpoints > System > Current Sensing > [Name] > CT Bank Name.

PICKUP

Range: 0.050 to 30.000 x CT in steps of 0.001 x CT
Default: 1.00 x CT

DIRECTION

Range: Disabled, Forward, Reverse
Default: Disabled

PICKUP DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 0.000 s

DROPOUT DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 0.000 s

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

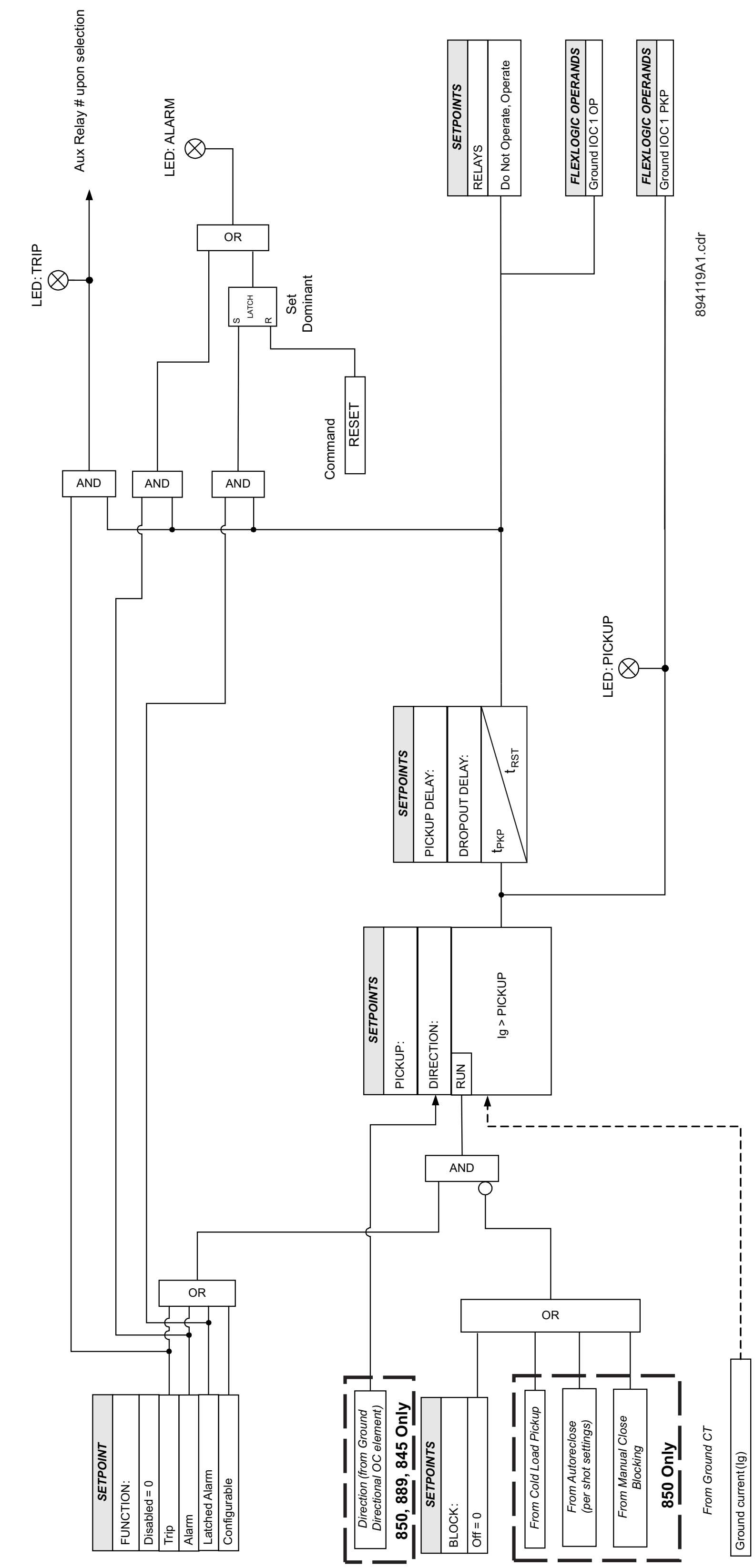
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Self-reset, Latched, Disabled
Default: Self-reset

Figure 6-18: Ground Instantaneous Overcurrent Protection logic diagram



Ground Directional Overcurrent Protection (67G)

The 845 Ground Directional Overcurrent protection element. It provides both forward and reverse fault direction indications: the Gnd Dir OC FWD and Gnd Dir OC REV operands, respectively. The output operands are 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 ground current. There are separate Pickup settings for the forward-looking and reverse-looking functions.

The following tables define the Ground Directional Overcurrent element.

The **directional unit** uses the ground current (Ig) for fault direction discrimination, and can be polarizing, by either “Calculated V0” zero-sequence voltage or “Measured VX” zero sequence voltage. The following tables define the ground directional overcurrent element.

Table 6-12: Quantities for Ground Current Configuration

Directional Unit				Overcurrent Unit
Polarizing Mode	**Direction**	**Compared Phasors**		
Voltage	Forward	-V_0	Ig	GROUND CURRENT (Ig)
		-V_0 = 1/3 (Vx)	Ig	
	Reverse	-V_0	-Ig	
		-V_0 = 1/3 (Vx)	-Ig	

Where:

V_0 = 1/3 * (Vag + Vbg + Vcg) = zero sequence voltage

When POLARIZING VOLTAGE is set to “Measured VX,” one-third of this voltage is used in place of V_0. The following figure explains the usage of the voltage polarized directional unit of the element by showing the voltage-polarized phase angle comparator characteristics for a phase A to ground fault, with:

ECA = 90° (element characteristic angle = centerline of operating characteristic)

FWD LA = 80° (forward limit angle = the ± angular limit with the ECA for operation)

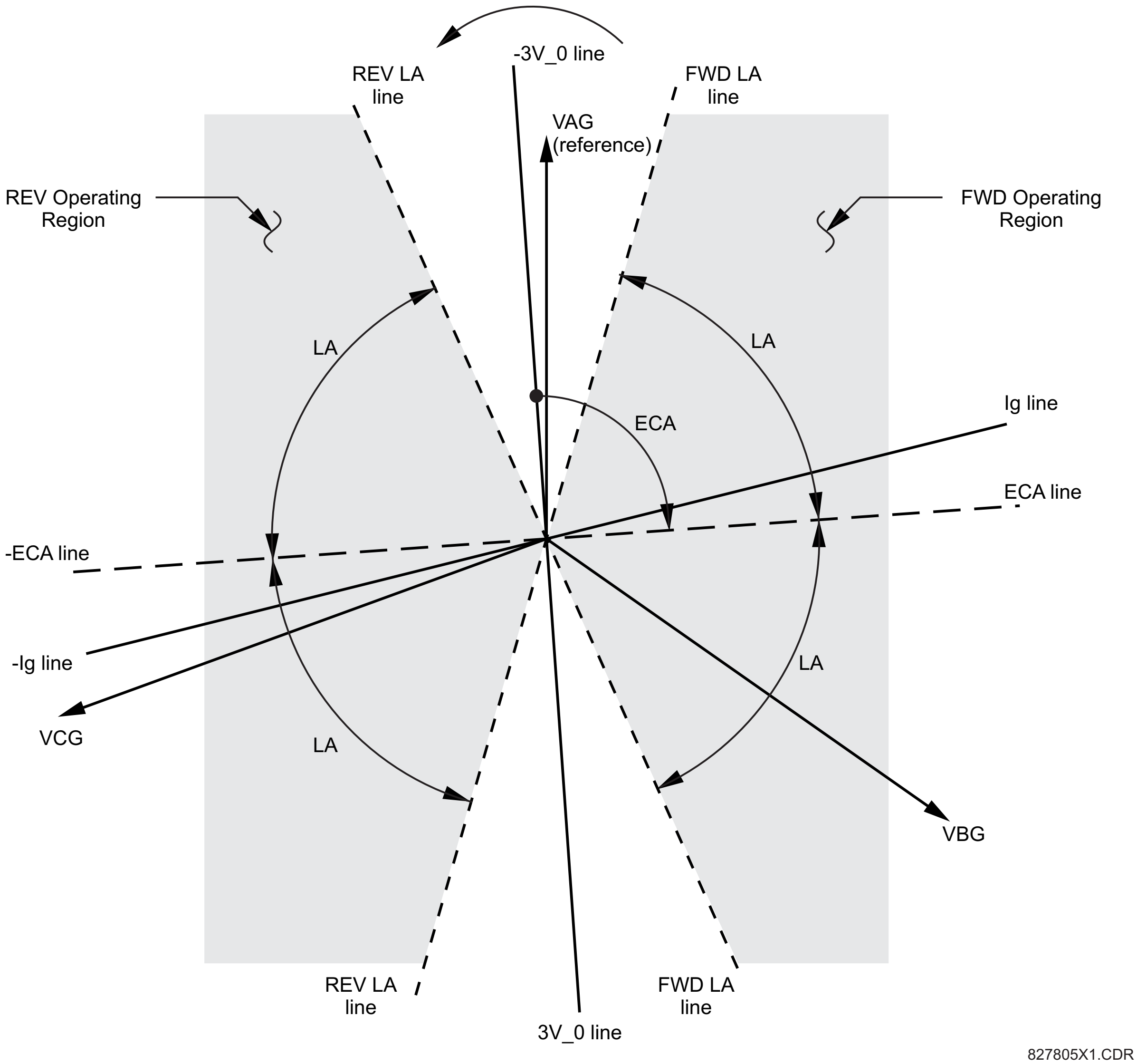
REV LA = 80° (reverse limit angle = the ± angular limit with the ECA for operation).

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

The forward-looking function is designed to be more secure as compared to the reverse-looking function, and should therefore 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 better protection coordination.

The above bias should be taken into account when using the Ground Directional Overcurrent element to directionalize other protection elements.

Figure 6-19: Ground Directional Voltage-polarized Characteristics



Path: Setpoints > Protection > Group 1(6) > Current > Ground Directional OC 1(X)

FUNCTION

Range: Disabled, Enabled

Default: Disabled

SIGNAL INPUT

Range: dependant upon the order code

Default: CT Bank 1-J1

This setting provides the selection for the current input bank. The default bank names can be changed in: Setpoints > System > Current Sensing > [Name] > CT Bank Name.

POLARIZING VOLTAGE

Range: Calculated V0, Measured VX

Default: Calculated V0

Selects the polarizing voltage used by the directional unit when "Voltage" or "Dual" polarizing mode is set. The polarizing voltage can be programmed to be either the zero-sequence voltage calculated from the phase voltages ("Calculated V_0") or supplied externally as an auxiliary voltage ("Measured VX")

FORWARD ECA

Range: –90° to 90° in steps of 1°

Default: 75°

This setting defines the element characteristic angle (ECA) for the forward direction in "Voltage" polarizing mode. "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: 0.050 to 30.000 x CT in steps of 0.001 x CT

Default: 0.050 x CT

This setting defines the Pickup level for the overcurrent unit of the element in the forward direction.

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: 0.050 to 30.000 x CT in steps of 0.001 x CT

Default: 0.050 x CT

This setting defines the Pickup level for the overcurrent unit of the element in the reverse direction.

BLOCK

Range: Off, Any FlexLogic operand

Default: Off

EVENTS

Range: Enabled, Disabled

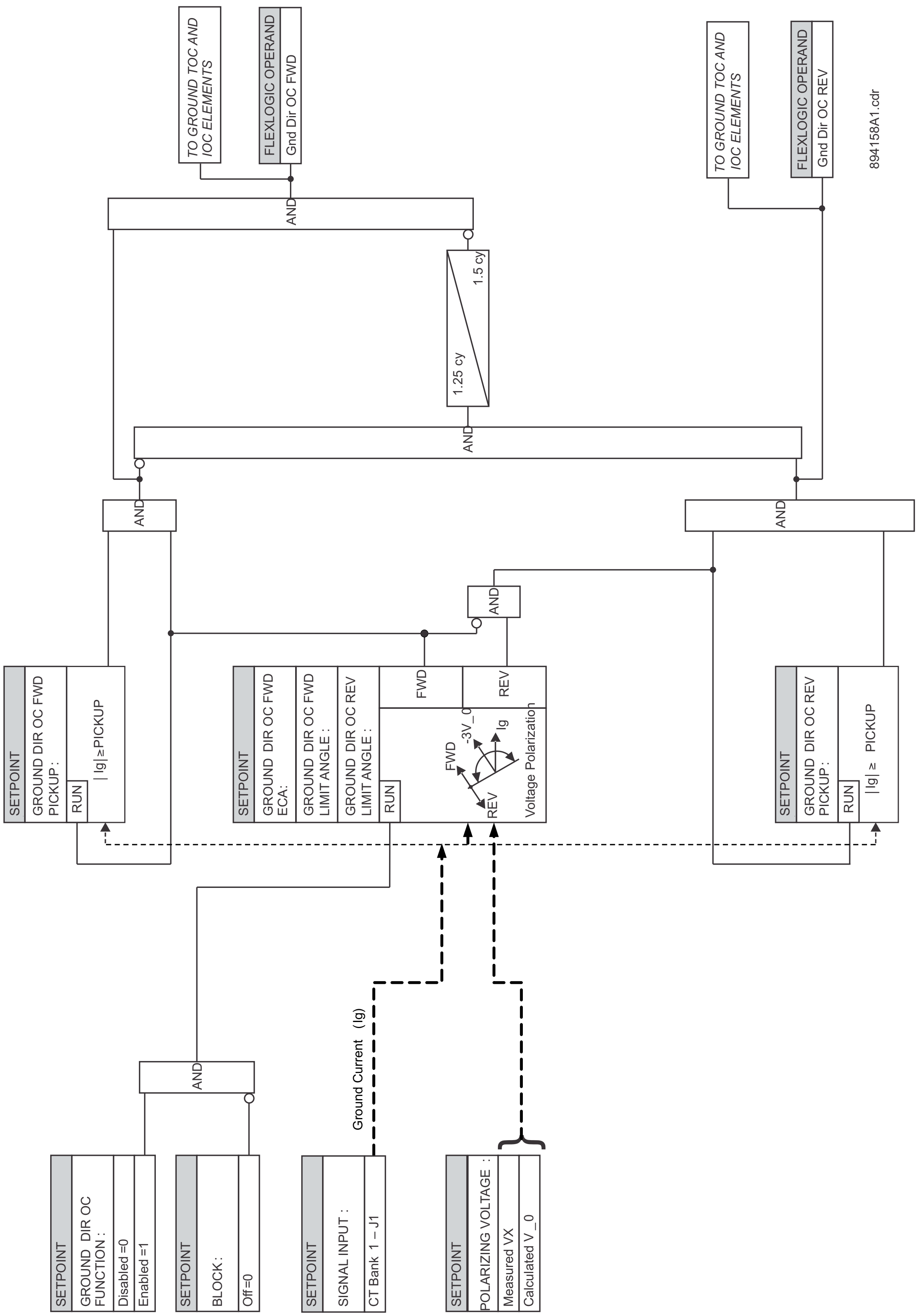
Default: Enabled

TARGETS

Range: Self-reset, Latched, Disabled

Default: Self-reset

Figure 6-20: Ground Directional Overcurrent Protection logic diagram



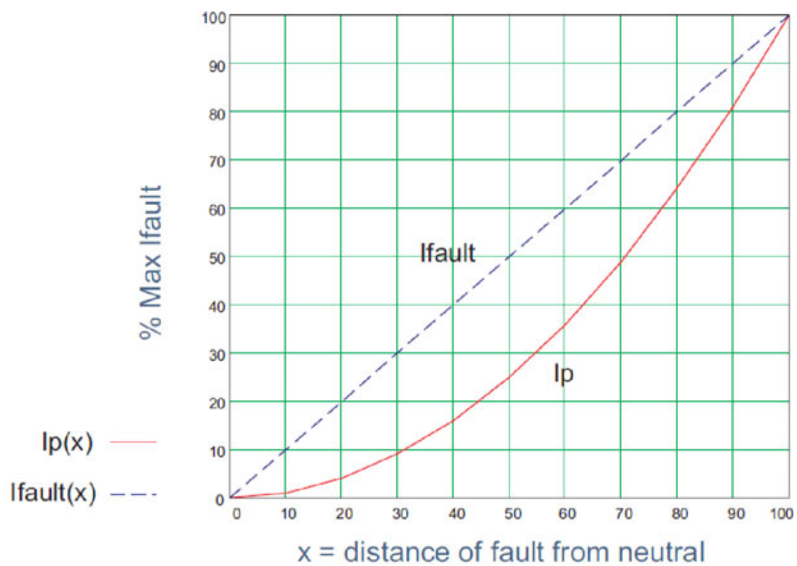
Restricted Ground Fault (87G)

The 845 relay is equipped with the Restricted Ground Fault (RGF) element, sometimes referred to as the Restricted Earth Fault (REF) element.

The Restricted Ground Fault (RGF) protection provides ground fault detection for low-magnitude ground fault currents primarily for ground faults close to the neutral point of the wye connected transformer winding. An internal ground fault on an impedance grounded wye winding produces a low magnitude ground fault current depending on the position of the fault with respect to the winding neutral point.

The diagram below shows the dependence of the fault current on the fault distance from the neutral point.

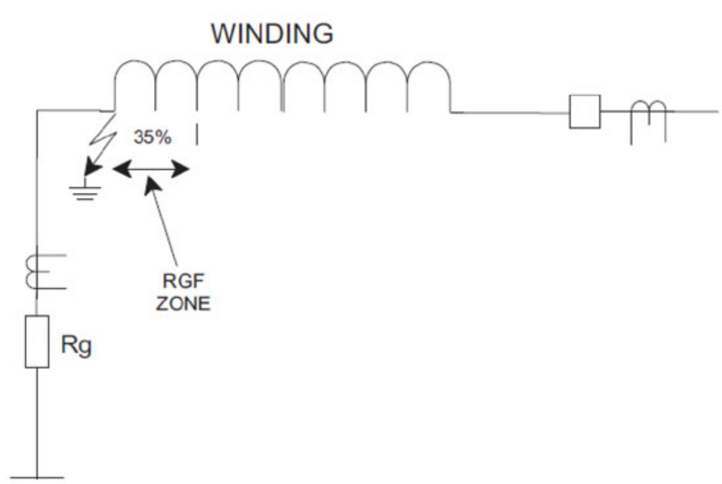
Figure 6-21: Fault current with respect to distance from neutral



The resultant primary current can be negligible for ground winding faults within 35% of the distance from the neutral point since the fault voltage is not the system voltage, but rather the result of the transformation ratio between the primary windings and the percentage of shorted turns.

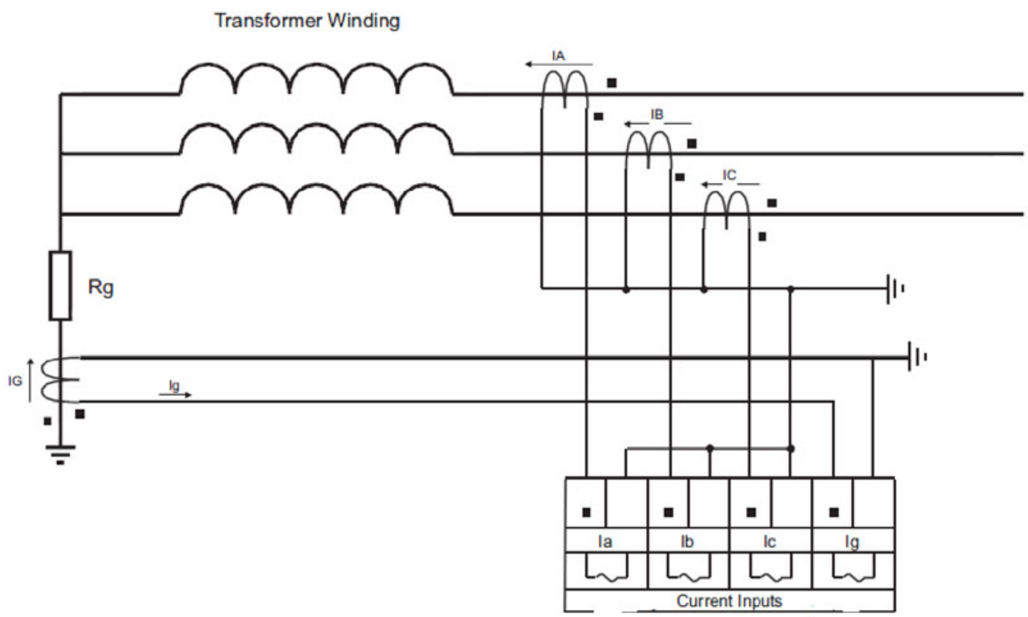
Application of Restricted Ground Fault protection extends the fault coverage towards the neutral point for low-impedance grounded winding.

Figure 6-22: Restricted Ground Fault zone of protection



845 implementation of the Restricted Ground Fault protection is a low impedance current differential scheme. The 845 calculates the magnitude of the ground differential current as an absolute value from the vector summation of the computed residual current, and the measured ground current, and applies a restraining current defined as the maximum measured line current (Imax) to produce a percent slope value. The slope setting allows determination of the sensitivity of the element based on the class and quality of the CTs used.The figure below shows typical wiring between the winding and ground CTs and the 845 CT terminals, to assure correct performance of the protection.

Figure 6-23: Three CT wiring for the Restricted Ground Fault protection



The 845 RGF protection includes ground current supervision mechanism to provide more security during external non-ground faults associated with CT saturation, that may result into spurious neutral current, and may jeopardize the security of the RGF 1 protection. When the GROUND CURRENT SUPERVISION setting is selected as “Enabled”, the algorithm checks if the ground current measured by the relay satisfies the selected GROUND CURRENT SUPERV LEVEL, before making operation decision. The ground current supervision is not active if the GROUND CURRENT SUPERVISION is selected as “Disabled”. The RGF 1 protection works without the supervision as well.

The settings of this function are applied to the ground and all three phase currents to produce pickup and trip flags. The RGF 1 pickup flag is asserted, when the restrained ground differential current is above the PKP value. The RGF 1 operate flag is asserted if the element stays picked up for the time defined in RGF 1 PKP DELAY. The element drops from Pickup without operation, if the calculated restrained ground differential current drops below 97-98% of the Pickup value, before the time for operation is reached.The Restricted Ground Fault function can be inhibited by a blocking input.

Path: **Setpoints > Protection > Group 1(6) > Current > RGF 1 (X)**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

SIGNAL INPUT

Range: dependant upon the order code
Default: CT Bank 1 -J1

PICKUP

Range: 0.050 to 30.000 x CT in steps of 0.001 x CT
Default: 0.300 x CT

This setting defines the minimum Pickup level of the ground differential current required for operation. The Pickup value is expressed in times Phase CT (primary) rating.

SLOPE

Range: 0 to 100% in steps of 1%
Default: 50%

This setting defines the slope as the ratio between the ground differential current and the maximum line current (ground restraining current) as a percentage. The RGF 1 element operates if the actual ground differential/restraint ratio is greater than the slope and the ground differential current is greater than the RGF 1 Pickup setting.

PICKUP DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 0.100 s

The RGF 1 Pickup Time Delay setting defines the time required for the RGF 1 element to operate after it has picked up. This time delay overrides the spurious ground differential current condition caused by CT saturation due to external non-ground faults, or during transformer energization. Since RGF 1 protection is intended to detect small ground fault currents, delayed clearance of such a fault is not a high concern. On the other hand delayed RGF 1 operation due to a spurious ground differential current caused by an out-of-zone fault can be used as a backup for downstream protections should they fail to clear the fault.

GND CURR SUPERV

Range: Disabled, Enabled
Default: Disabled

This setting enables or disables the ground current supervision of the RGF 1 function. If set to "Disabled", the RGF 1 function works without ground current supervision. The ground current level is monitored if the setting is set to "Enabled".

GND CURR SUPERV LEVEL

Range: 0.050 to 30.000 x CT in steps of 0.001 x CT
Default: 0.300 x CT

This setting defines the level of measured ground current above which operation of the RGF 1 protection is allowed. The setting is presented as a times ground CT (primary) rating. The measured ground current is compared to the setting only if the GROUND CURRENT SUPERVISION is set to "Enabled".

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Self-reset, Latched, Disabled
Default: Self-reset

Example: Transformer: 5MVA, 13.8kV/4.16kV, D/Yg1 type

Rg = 10 ohms

Phase CTs: 800:5

Ground CT: 300:5

Ifgnd (max) = 4.16kV/(10 ohms *v3) = 240A - maximum ground fault current

To detect a ground fault on the Wye winding at 15% distance from the neutral point, the relay shall detect ground differential current of:

Igd = (15x240)/100 = 36 A/800 = 0.045 x CT – PKP setting for the RGF protection

The transformer loading is almost unaffected for ground faults close to the winding neutral, so that the winding rated load can be used as a reference in defining the RGF 1 slope setting. The rated load for 4.16kV Wye winding is:

Irated = 5MVA/(4.16kV*v3) = 693 A

Slope setting, % = (36 A/693A)*100 = 5.1 %. Select 5% if the transformer is expected to run most of the time at full load. If most of the time the transformer runs at lower than the nominal loads, the slope setting can be set to higher value:

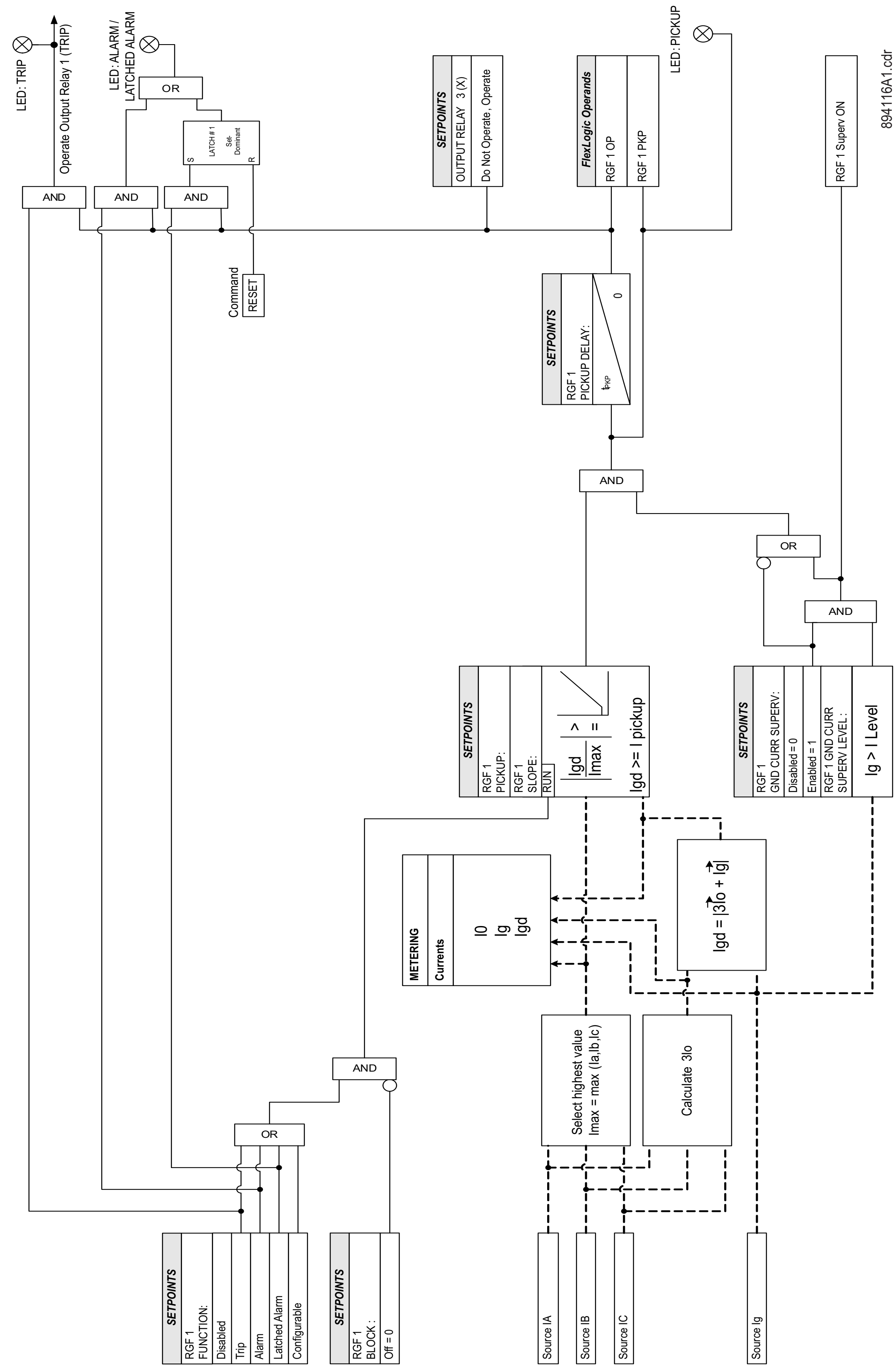
@ 70% load the slope setting would be: (36 / 485 A)*100 = 7%

@ 50% load the slope setting would be: (36 / 346 A)*100 = 10%

@ 30% load the slope setting would be: (36 / 208 A)*100 = 17%

The ground current supervision feature and/or the RGF 1 Pickup time delay can be used if CT saturation due to heavy external fault, is a concern.

Figure 6-24: Restricted Ground Fault Protection Logic Diagram



Negative Sequence Time Overcurrent Protection (51_2)

The 845 relay is equipped with the Negative Sequence Time Overcurrent protection element. The Negative Sequence Time Overcurrent element may be used to determine and clear unbalance in the system. The input for computing negative-sequence current is the fundamental phasor value. The 845 computes the negative sequence current magnitude |I_2| using the following formula:

$|I\_2|=1/3*|Ia+Ib*(1\angle 240^{\circ})+Ic*(1\angle 120^{\circ})|$

The settings of this function are applied to the calculated negative sequence current to produce Trip or Pickup flags. The Negative Sequence TOC Pickup flag is asserted when the negative sequence current is above the PKP value. The Negative Sequence TOC Trip flag is asserted if the element stays picked up for the time defined by the selected inverse curve and the magnitude of the current. The element drops from Pickup without operation if the measured current drops below 97 to 98% of the pickup value, before the time for operation is reached. When Definite Time is selected, the time for Negative Sequence TOC operation is defined only by the TDM setting.

Path: **Setpoints > Protection > Group 1(6) > Current > Negative Sequence TOC 1(X)**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

SIGNAL INPUT

Range: dependant upon the order code
Default: CT Bank 1-J1

This setting provides the selection for the current input bank. The default bank name can be changed in Setpoints > System > Current Sensing > [Name] > CT Bank Name.

PICKUP

Range: 0.050 to 30.000 x CT in steps of 0.001 x CT
Default: 1.000 x CT

CURVE

Range: IEEE Extremely/Very/Moderately Inverse
ANSI Extremely/Very/Normally/Moderately Inverse
IEC Curve A/B/C and Short Inverse
IAC Extremely/Very/Inverse/Short Inverse
FlexCurve A, FlexCurve B, FlexCurve C, FlexCurve D
I2t, I4t, Definite time
Default: IEEE Moderately Inverse

TDM

Range: 0.05 to 600.00 in steps of 0.01
Default: 1.00

RESET

Range: Instantaneous, Timed
Default: Instantaneous

DIRECTION

Range: Disabled, Forward, Reverse
Default: Disabled

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

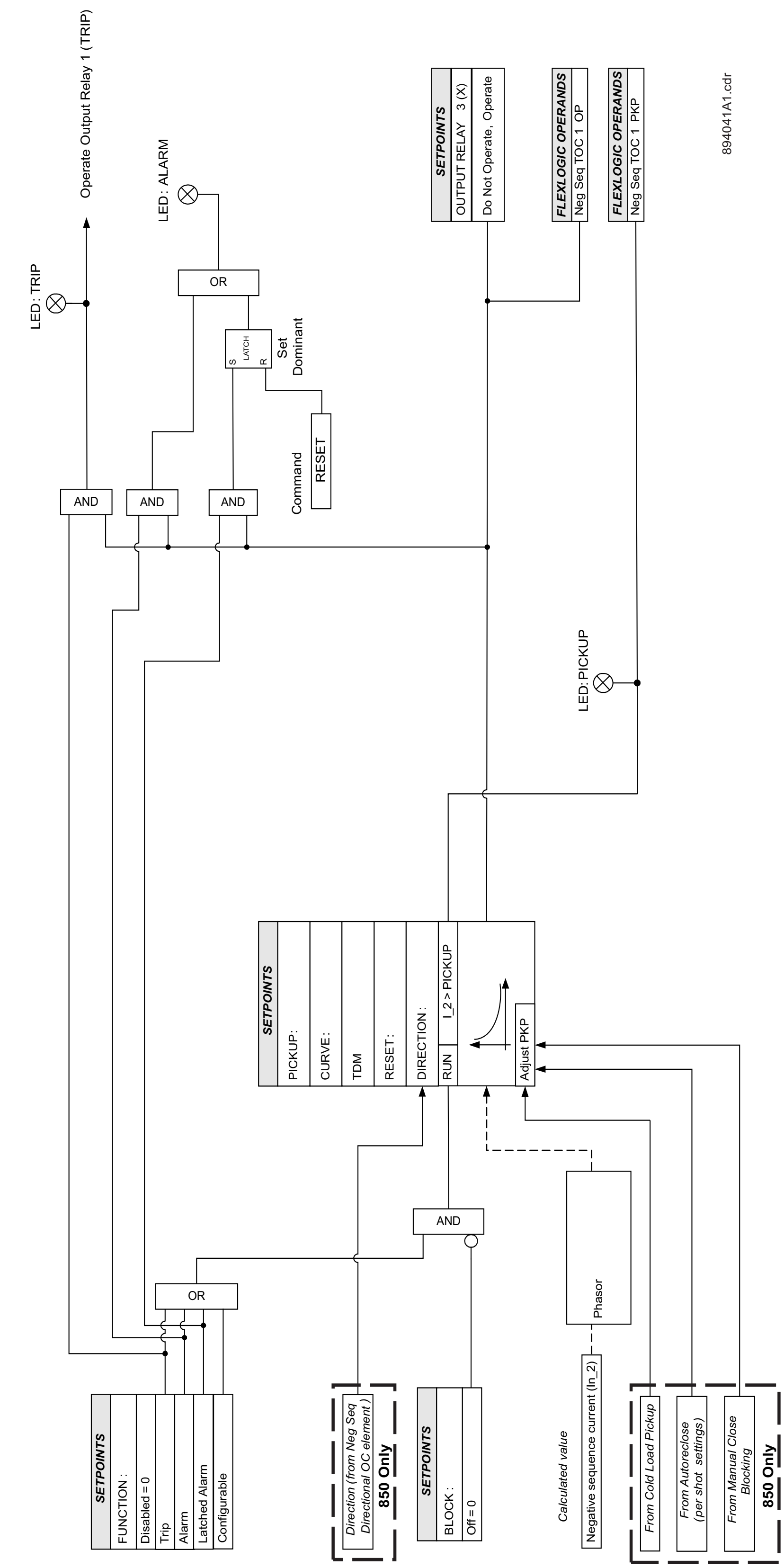
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Self-reset, Latched, Disabled
Default: Self-reset

Figure 6-25: Negative Sequence Time Overcurrent Protection logic diagram



Negative Sequence Instantaneous Overcurrent Protection (50_2)

The 845 relay is equipped with the Negative Sequence Instantaneous Overcurrent protection element. The Negative Sequence Instantaneous Overcurrent element may be used to determine and clear unbalance in the system. The input for computing negative sequence current is the fundamental phasor value. The 845 computes the negative sequence current magnitude |I_2| using the following formula:

$|I\_2|=1/3*|Ia+Ib*(1\angle 240°)+Ic*(1\angle 120°)|$

The element responds to the negative-sequence current 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:

$Iop = |I\_2| - K * |I\_1|$

where $K = 1/8$ and $|I\_1| = 1/3*|Ia+Ib*(1\angle 120°)+Ic*(1\angle 240°)|$

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

- system unbalances under heavy load conditions
- current transformer (CT) transformation errors during three-phase faults
- fault inception and switch-off transients during three-phase faults.

The positive sequence restraint must be considered when testing for Pickup accuracy and response time (multiple of Pickup). The operating quantity depends on the way the test currents are injected into the relay (single-phase injection: Iop = 0.2917 * I_injected; three-phase injection, opposite rotation: Iop = I_injected).

The settings of this function are applied to the calculated negative sequence current to produce Pickup and Trip flags. The Negative Sequence IOC Pickup flag is asserted, when the negative sequence current is above the PKP value. The Negative Sequence IOC Operate flag is asserted if the element stays picked up for the time defined by the Negative Sequence IOC PKP Delay setting. If the Pickup time delay is set to 0.000 seconds, the Pickup and Operate flags are asserted at the same time. The element drops from Pickup without operation if the negative sequence current drops below 97 to 98% of the Pickup value.

Path: **Setpoints > Protection > Group 1(6) > Current > Negative Sequence IOC 1(X)**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

SIGNAL INPUT

Range: dependant upon the order code
Default: CT Bank 1-J1

This setting provides the selection for the current input bank. The default bank names can be changed in: Setpoints > System > Current Sensing > [Name] > CT Bank Name.

PICKUP

Range: 0.050 to 30.000 x CT in steps of 0.001 x CT
Default: 1.000 x CT

PICKUP DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 0.000 s

DROPOUT DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 0.000 s

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

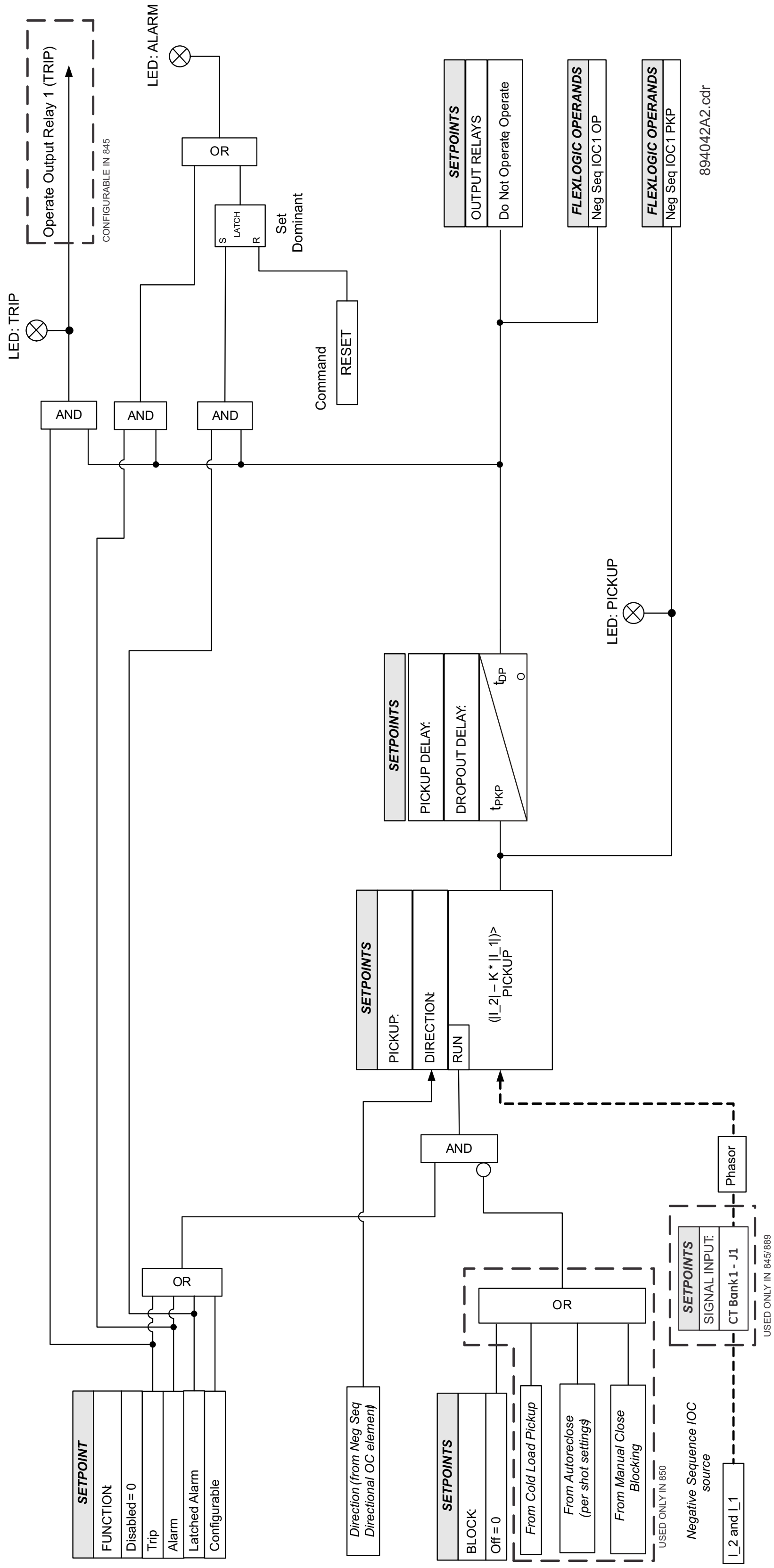
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

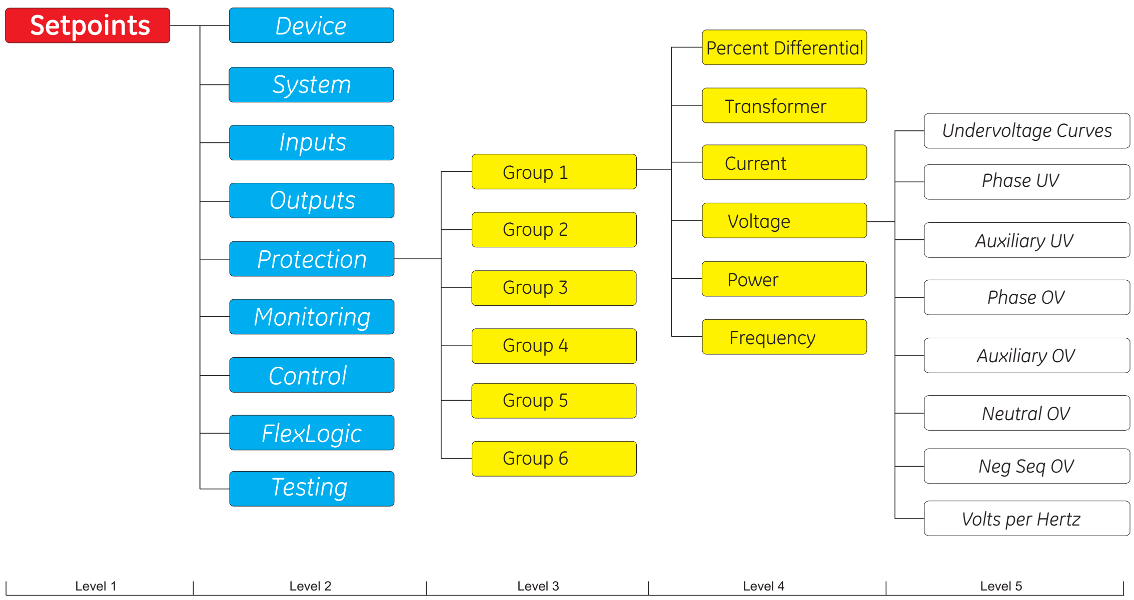
Range: Self-reset, Latched, Disabled
Default: Self-reset

Figure 6-26: Negative Sequence Instantaneous Overcurrent logic diagram



Voltage Elements

Figure 6-27: Voltage Elements Display Hierarchy



Undervoltage Curves

The undervoltage elements can be programmed to have an inverse time delay characteristic. The undervoltage delay setpoint defines a family of curves as shown below.

The operating time is given by:

$T = D/(1 - V/V_{pkp})$

Where:

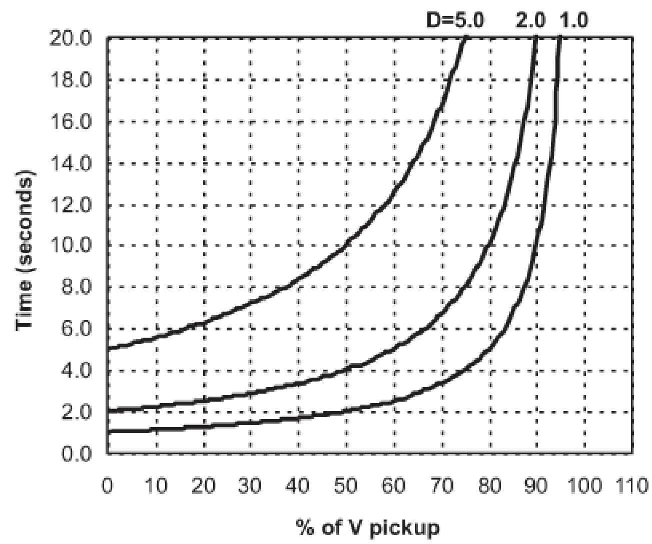
T = Operating Time
D = Undervoltage Pickup Time Delay setpoint (for D = 0.00 operates instantaneously)
V = Voltage as a fraction of the nominal VT Secondary Voltage
V_{pkp} = Undervoltage Pickup Level

The element resets instantaneously if the applied voltage exceeds the dropout voltage. The delay setting selects the minimum operating time of the phase undervoltage.

NOTE

At 0% of Pickup, the operating time equals the Undervoltage Pickup Time Delay setpoint.

Figure 6-28: Inverse Time Undervoltage Curves



If FlexCurves are selected, the operating time determined based on following equation:

$T = Flexcurve (V_{pkp} / V)$

NOTE

FlexCurve reverses the ratio of voltages. The ratio of set pickup value to the measured voltage.

Example: For a Pickup set to 0.9 x VT, when the measured voltage is 0.82 x VT, the ratio would be 0.9/0.8 = 1.1, therefore in the FlexCurve, the corresponding Trip time setting entry is at 1.1 x PKP (not at 0.82 x PKP). On the other hand, when the measured voltage is 1 x VT, the ratio is 0.9/1 = 0.9, therefore, in the FlexCurve, the corresponding Reset time entry is at 0.9 x PKP.

Phase Undervoltage Protection (27P)

The 845 relay is equipped with the Phase Undervoltage (UV) element. The Phase Undervoltage element may be used to protect voltage sensitive loads and system components against sustained undervoltage conditions. This element may be used for permissive functions, initiation of the source transfer schemes, and similar functions.

The Phase Undervoltage element may be set as an instantaneous element with no time delay or as a time delayed element which can be programmed with definite time, inverse time or FlexCurves. The Phase Undervoltage element has programmable minimum operating threshold to prevent some undesired operation when voltage is not available. The input voltages are the three phase to phase voltages from delta connected VTs (PTs) or three phase to ground voltages from wye connected VTs (PTs).

The settings of this function are applied to each of the three voltage inputs to produce Pickup and Trip flags per voltage input. The UV Pickup flag is asserted, when the measured voltage on any of the three voltage inputs is below the PKP value. The UV Trip flag is asserted if the element stays picked up for the time defined by Pickup time delay or for the time defined by the selected inverse curve / FlexCurve, and number of voltages required for operation matches the number of voltages selected in the setting. The element drops from Pickup without operation if the measured voltage rise above 102 to 103% of the Pickup value, before the time for operation is reached.

The minimum voltage setting selects the operating voltage below which the element is blocked (a setting of “0” allows a dead source to be considered a fault condition).

This element may be used to give a desired time delay operating characteristic versus the applied voltage (phase to ground or phase to phase for wye VT connection, or phase to phase for delta VT connection) or as a definite time element. For the inverse time setpoint, the undervoltage delay setpoint defines a family of curves as described in Undervoltage Curves.

Path: **Setpoints > Protection > Group 1(6) > Voltage Elements > Phase UV 1(X)**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable

Default: Disabled

MODE

Range: Phase to Ground, Phase to Phase

Default: Phase to Ground

This setting provides the selection of phase to ground and phase to phase voltages for a Wye VT connection (phase to phase for delta connected VT connection).

NOTICE

Only Phase to Phase mode shall be selected when Delta is programmed for the Phase VT Connection setting under System/Voltage Sensing.

PICKUP

Range: 0.00 to 1.50 x VT in steps of 0.01 x VT

Default: 1.00 x VT

This setting sets the Phase Undervoltage Pickup level specified per times VT.

For example, a Pickup setting of 0.80 x VT with a 13800:115 VT translates into 11.04kV (or 92V secondary). If the mode selection is phase to phase and the Setpoints/System Setup/Voltage Sensing/Phase VT Connection selection is Wye, the previous example translates to the phase to phase voltage value of 11.04kV x 1.732 = 19.12kV.

MINIMUM VOLTAGE

Range: 0.00 to 1.50 x VT in steps of 0.01 x VT

Default: 0.20 x VT

This setting sets the minimum operating voltage for the undervoltage Pickup level specified per times VT.

For example, a PKP setting of 0.20 x VT with 13800:115 VT translates into 2.76kV (or 23V secondary).

If the Mode setting selection is Phase to Phase and the Setpoints/System Setup/Voltage Sensing/Phase VT Connection selection is Wye, the previous example translates to a

Phase to Phase voltage value of 2.76kV x 1.732 = 4.78kV.

PHASES FOR OPERATION

Range: Any One, Any Two, All Three

Default: Any One

This setting defines the number of voltages required for operation of the Phase UV protection function.

UNDERVOLTAGE CURVES

Range: Definite Time, Inverse Time, FlexCurves A/B/C/D

Default: Definite Time

This setting provides the selection of definite time delay or time delay inverse undervoltage curves, or FlexCurves. In the case of FlexCurves, the voltage ratio used is reversed. Refer to the equation and note regarding FlexCurves in the previous section *Undervoltage Curves*.

PICKUP DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s

Default: 1.000 s

If *Inverse Time* is selected as an Undervoltage Curve setpoint, the Pickup Delay value is loaded to variable D in the curve formula. For more information, refer to the previous section *Undervoltage Curves*.

BLOCK

Range: Off, Any FlexLogic operand

Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

EVENTS

Range: Enabled, Disabled

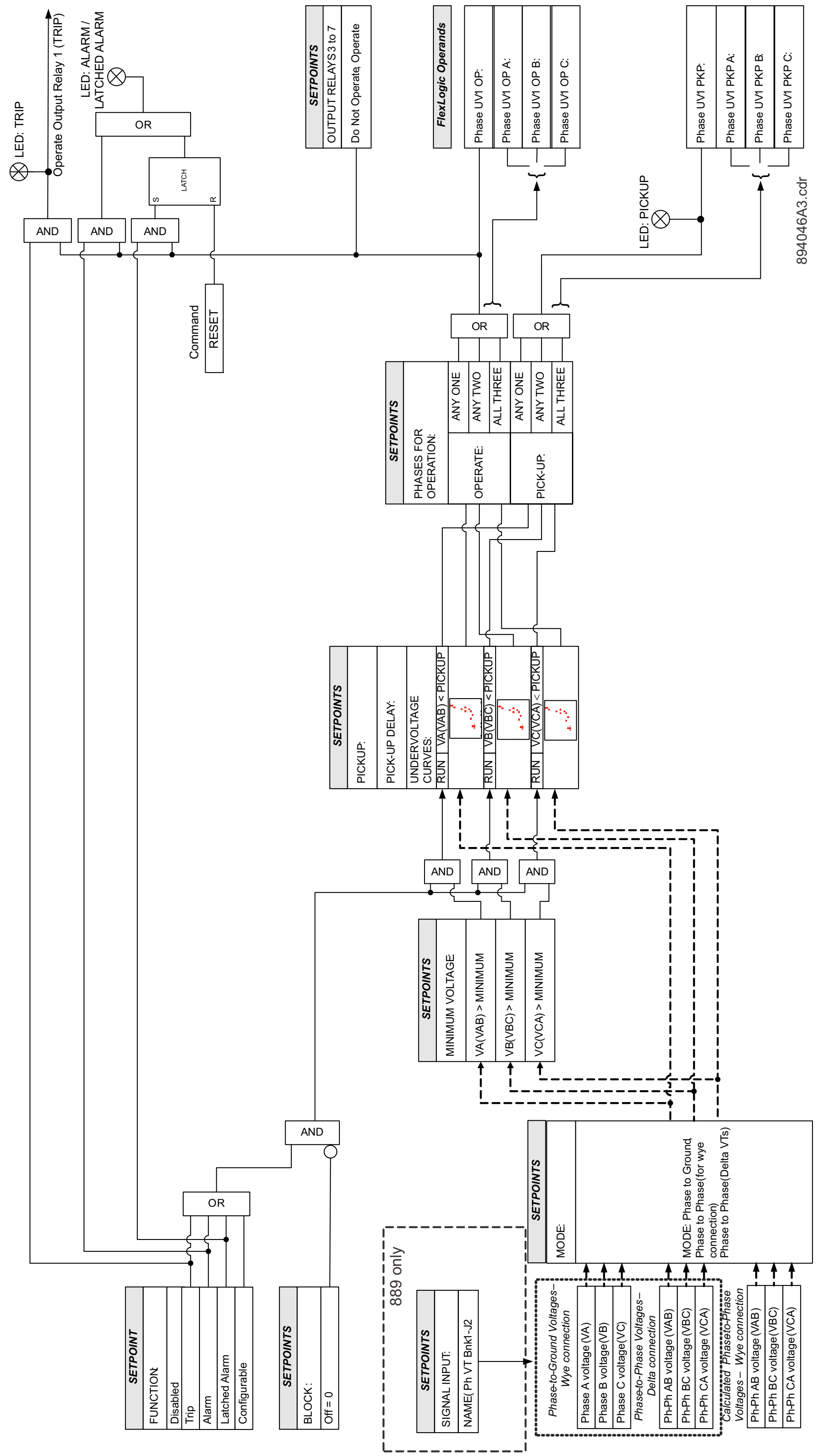
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched

Default: Self-reset

Figure 6-29: Phase Undervoltage Protection logic diagram



Auxiliary Undervoltage (27X)

The 845 relay provides two identical Auxiliary Undervoltage (UV) elements per protection group, or a total of 12 elements. Each Auxiliary Undervoltage element may be used to protect voltage sensitive loads and system components against sustained undervoltage conditions. This element may be used for permissive functions, initiation of the source transfer schemes and similar functions.

The Auxiliary Undervoltage element may be set as an instantaneous element with no time delay or as a time delayed element which can be programmed with definite time, inverse time or FlexCurves. The Auxiliary Undervoltage element has a programmable minimum operating threshold to prevent undesired operation when voltage is not available. The input voltage is the auxiliary voltage.

The settings of this function are applied to auxiliary voltage input to produce Pickup and Trip flags. The Auxiliary UV Pickup flag is asserted when the auxiliary input voltage is below the PKP value. The Auxiliary UV Trip flag is asserted if the element stays picked up for the time defined by Pickup time delay or for the time defined by the selected inverse curve/ FlexCurve. The element drops from Pickup without operation if the measured voltage rises above 102 to 103% of the Pickup value before the time for operation is reached.

The minimum voltage setting selects the operating voltage below which the element is blocked (a setting of "0" will allow a dead source to be considered a fault condition).

This element may be used to give a desired time-delay operating characteristic versus the applied voltage, or as a definite time element. For the inverse time setpoint, the undervoltage delay setpoint defines a family of curves as described in Undervoltage Curves.

Path: **Setpoints > Protection > Group 1(6) > Voltage Elements > Auxiliary UV 1(X)**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable

Default: Disabled

PICKUP

Range: 0.00 to 1.50 x VT in steps of 0.01 x VT

Default: 1.00 x VT

This setting sets the Auxiliary Undervoltage Pickup level specified per times VT. For example, a Pickup setting of 0.80 x VT with a 13800:115 VT translates into 11.04kV (or 92V secondary).

MINIMUM VOLTAGE

Range: 0.00 to 1.50 x VT in steps of 0.01 x VT

Default: 0.20 x VT

This setting sets the minimum operating voltage for the undervoltage Pickup level specified per times VT.

UNDERVOLTAGE CURVES

Range: Definite Time, Inverse Time, FlexCurves A/B/C/D

Default: Definite Time

This setting provides the selection of definite time delay or time delay inverse undervoltage curves. In the case of FlexCurves, the voltage ratio is reversed. For more information refer to the equation and note regarding FlexCurves in Undervoltage Curves.

PICKUP DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s

Default: 1.000 s

If *Inverse Time* is selected as an Undervoltage Curve setpoint, the Pickup Delay value is loaded to variable D in the curve formula. For more information, refer to Undervoltage Curves.

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

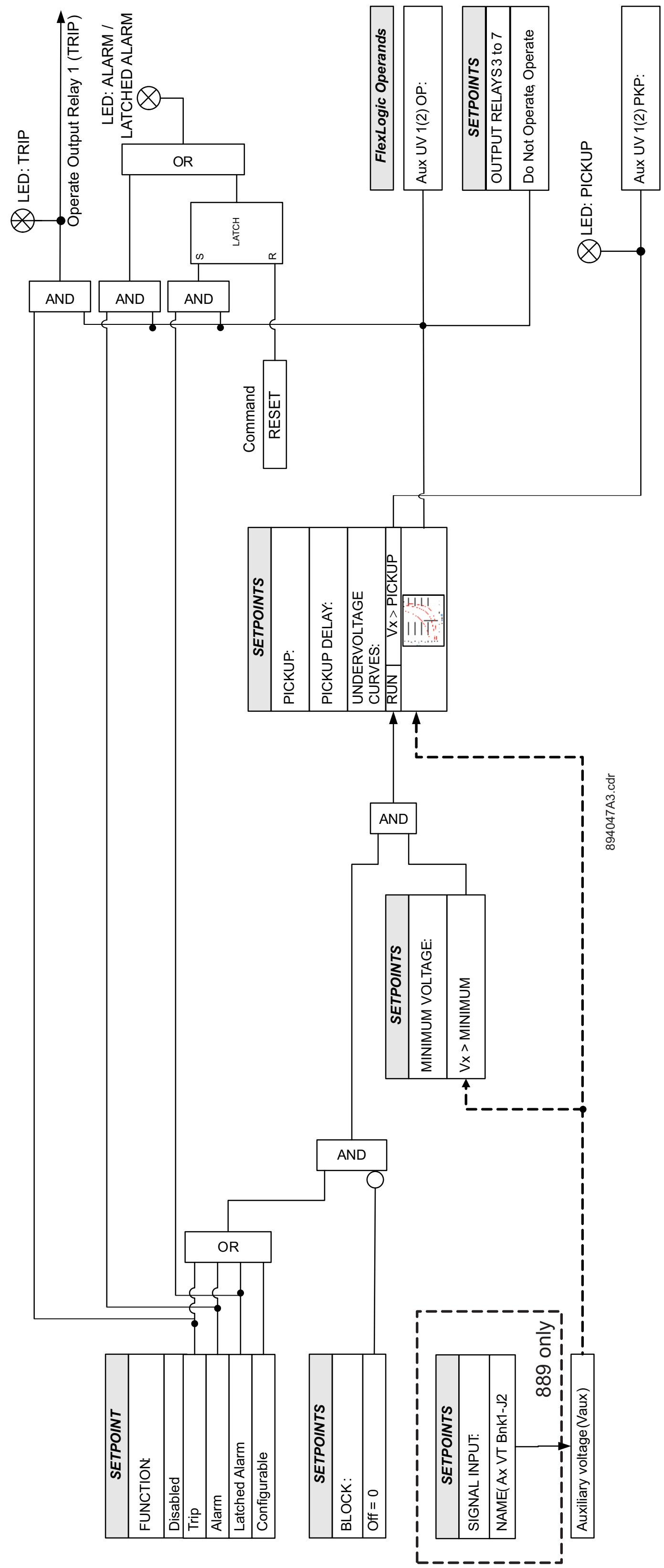
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Self-reset

Figure 6-30: Auxiliary Undervoltage Protection logic diagram



Phase Overvoltage Protection (59P)

The 845 relay provides two identical Phase Overvoltage (OV) elements per protection group, or a total of 12 elements. Each Phase Overvoltage element may be used to protect voltage sensitive loads and system components against sustained overvoltage conditions. The Phase Overvoltage element may be set as an instantaneous element with no time delay or may be set as a definite time element. The input voltages are the three phase to phase voltages from delta connected VTs or three phase to ground voltages from wye connected VTs.

The settings of this function are applied to each of the three voltage inputs to produce Pickup and Trip flags per voltage input. The OV Pickup flag is asserted when the voltage on any voltage input is above the PKP value. The OV Trip flag is asserted if the element stays picked up for the time defined by the Pickup time delay and that number of voltages required for operation is equal to the number defined by voltages required for the operation setting. The element drops from Pickup without operation if the measured voltage drops below 97 to 98% of the Pickup value before the time for operation is reached.

Path: **Setpoints > Protection > Group 1(6) > Voltage > Phase OV 1(X)**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable

Default: Disabled

MODE

Range: Phase to Ground, Phase to Phase

Default: Phase to Ground

This setting provides the selection of phase to ground and phase to phase voltages for a Wye VT connection (phase to phase for delta connected VT connection).

NOTICE

Only Phase to Phase mode shall be selected when the delta is programmed for Phase VT connection under System/Voltage Sensing.

PICKUP

Range: 0.02 to 3.00 x VT in steps of 0.01 x VT

Default: 1.50 x VT

The setting sets the phase overvoltage pickup level to specified per times VT.

For example, a Pickup setting of 1.10 x VT with 13800:115 VT translates into 15.18kV. If the mode selection is phase to phase and Setpoints > System Setup > Voltage Sensing > Phase VT Connection selection is Wye, the previous example translates to the phase to phase voltage value of 15.18kV x 1.732 = 26.29kV.

PHASES FOR OPERATION

Range: Any One, Any Two, All Three

Default: Any One

The setting defines the number of voltages required for operation of the Phase OV protection function.

PICKUP DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s

Default: 1.000 s

DROPOUT DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s

Default: 1.000 s

BLOCK

Range: Off, Any FlexLogic operand

Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

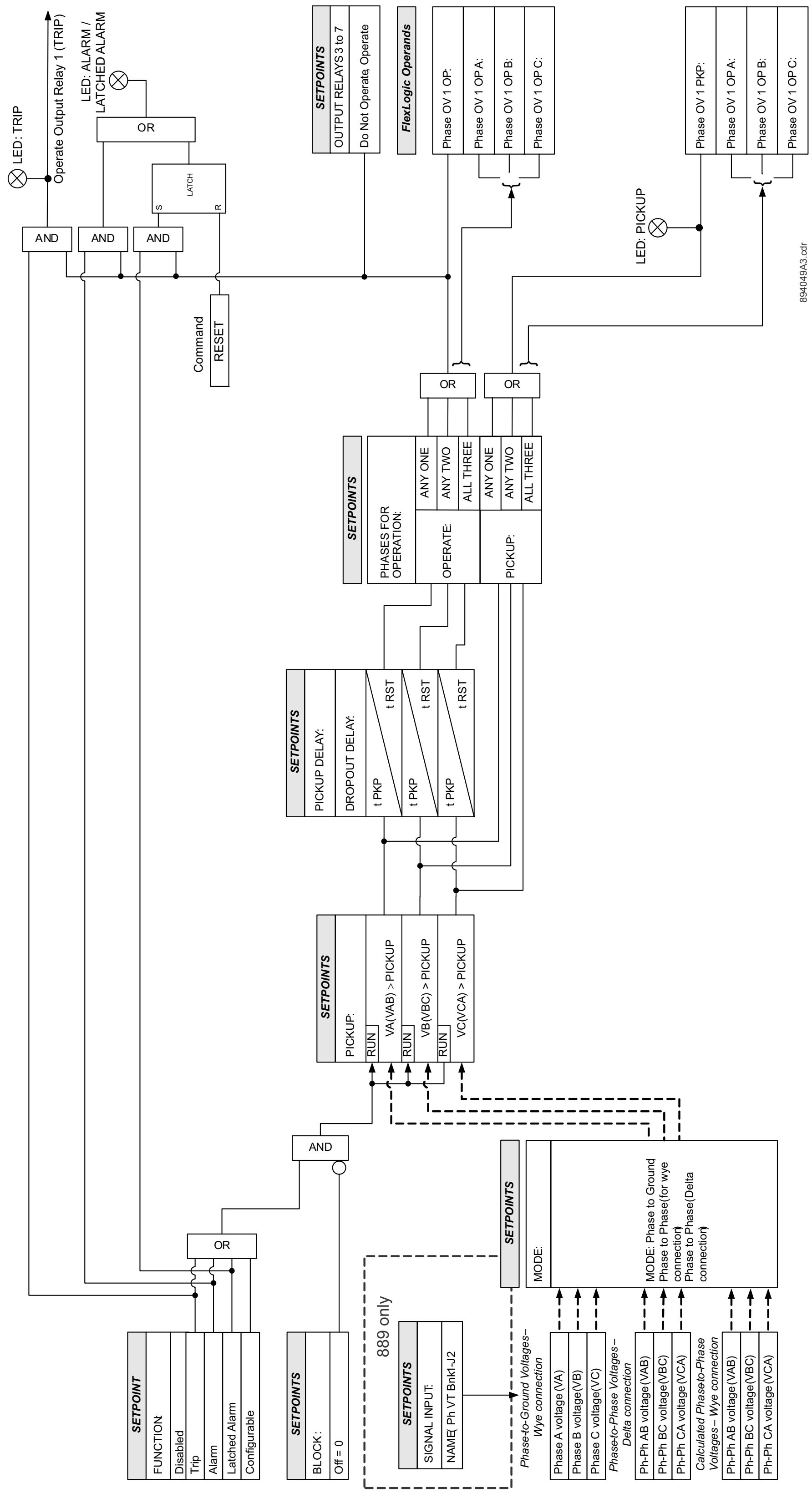
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Self-reset

Figure 6-31: Phase Overvoltage logic diagram



Auxiliary Overvoltage Protection (59X)

The 845 relay provides one Auxiliary Overvoltage (OV) element per protection group, or a total of 6 elements. Each Auxiliary OV element is used to protect voltage sensitive loads and system components against sustained overvoltage conditions. This element can be used for monitoring zero-sequence voltage (from an "open corner delta" VT connection), permissive functions, the source transfer schemes, restoration and similar functions.

The Auxiliary OV element may be set as an instantaneous element with no time delay or may be set as a definite time element, Inverse Time, or with FlexCurves. The input voltage is the auxiliary voltage.

The settings of the Auxiliary OV Protection function are applied to the auxiliary voltage input to produce pickup and trip flags. The Auxiliary OV pickup flag is asserted, when the voltage on auxiliary input is above the PKP value. The Auxiliary OV trip flag is asserted if the element stays picked up for the time defined by pickup time delay, Inverse Time, or FlexCurves. The element drops from pickup without operation, if the measured voltage drops below 97-98% of the pickup value, before the time for operation is reached.

This element may be used to give a desired time-delay operating characteristic versus the applied voltage or as a definite time element. For the inverse time setpoint, the overvoltage pickup delay setpoint defines a family of curves as shown below.

The operating time is given by:

$$T= D/((V/V_{pickup}) - 1) \text{ when } V>V_{pickup}$$

Where:

T = trip time in seconds

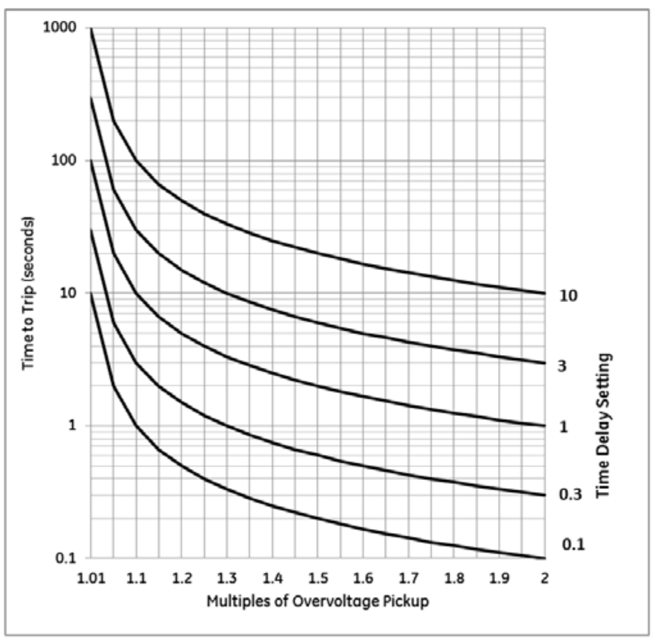
D = Overvoltage Pickup Delay setpoint

V = actual phase-phase voltage

V_{pickup}= Overvoltage Pickup setpoint

The element reset rate is a linear reset time from the threshold of trip.

Figure 6-32: Overvoltage Curves



Path: Setpoints > Protection > Group 1(6) > Voltage > Auxiliary OV

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

PICKUP

Range: 0.00 to 3.00 x VT in steps of 0.01 x VT
Default: 1.50 x VT

This setting sets the auxiliary overvoltage pickup level specified per times VT.

For example, a Pickup setting of 1.10 x VT with 13800:115 VT translates into 15.08kV (or 126.5V secondary).

PICKUP DELAY

Range: 0.000 - 6000.000s in steps of 0.001s
Default: 1.000s

DROPOUT DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 1.000 s

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

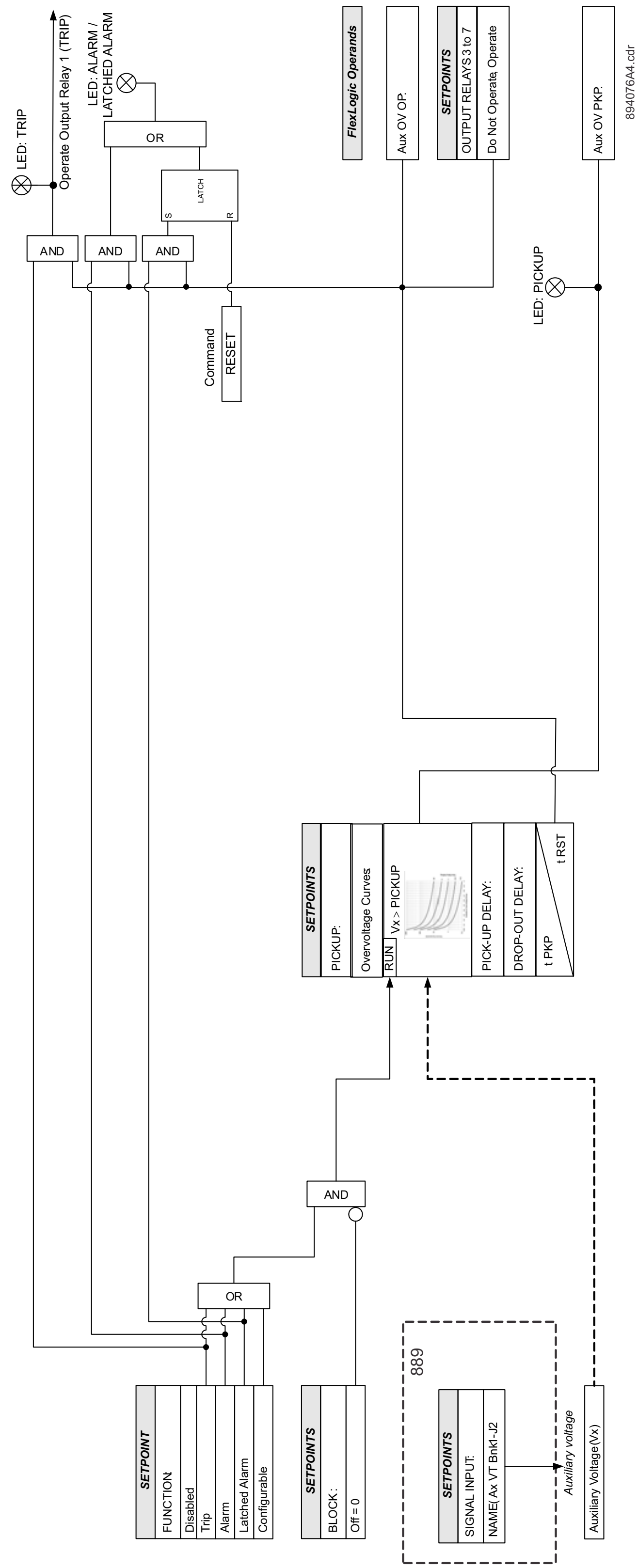
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Self-reset

Figure 6-33: Auxiliary Overvoltage Protection logic diagram



Neutral Overvoltage Protection (59N)

The 845 relay provides one Neutral Overvoltage (also called Neutral Displacement) (Neutral OV) element per protection group.

The Neutral Overvoltage element can be used to detect asymmetrical system voltage conditions caused by a ground fault or the loss of one or two phases of the source. The element responds to the system neutral voltage (3V_0), calculated from the phase voltages. The nominal secondary voltage of the phase voltage channels entered under SETPOINTS/SYSTEM/ VOLTAGE SENSING/PHASE VT SECONDARY is the 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, C or D) or can be used as a definite time element. The source voltage assigned to this element must be configured for a phase VT and phase VTs must be wye connected. VT errors and normal voltage unbalance must be considered when setting this element.

NOTICE

The same curves used for the time overcurrent elements are used for Neutral Displacement. When using the curve to determine the operating time of the Neutral Displacement element, substitute the ratio of neutral voltage to Pickup level for the current ratio shown on the horizontal axis of the curve plot.

Be aware that the Neutral Overvoltage feature should be applied with caution. It would normally be applied to give line-to-ground fault coverage on high impedance grounded or ungrounded systems, which are isolated. This constraint stems from the fact that a measurement of 3V_0 cannot discriminate between a faulted circuit and an adjacent healthy circuit. Use of a time delayed back-up or alarm mode allows other protections an opportunity to isolate the faulted element first.

As indicated above, the relay has one Neutral Overvoltage element per protection group. The settings of this function are applied to 3V_0 calculated from the three phase-to-ground (wye connected VTs) voltage inputs to produce Pickup and Trip flags per 3V_0 calculated voltage. The Neutral OV Pickup flag is asserted when the calculated 3V_0 voltage is above the PKP value. The Neutral OV Trip flag is asserted if the element stays picked up for the time defined by the selected inverse curve and the magnitude of the 3V_0 voltage. The element drops from Pickup without operation, if the calculated voltage drops below 97 to 98% of the Pickup value before the time for operation is reached.

Path: **Setpoints > Protection > Group 1(6) > Voltage Elements > Neutral OV 1(X)**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

PICKUP

Range: 0.02 to 3.00 x VT in steps of 0.01 x VT
Default: 0.30 x VT

CURVE

Range: Definite Time, FlexCurve A, FlexCurve B, FlexCurve C, FlexCurve D.
Default: Definite Time

PICKUP DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 1.000 s

The NEUTRAL OV 1 PICKUP DELAY setting applies only if the NEUTRAL OV 1 CURVE setting is “Definite time”.

DROPOUT DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 1.000 s

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

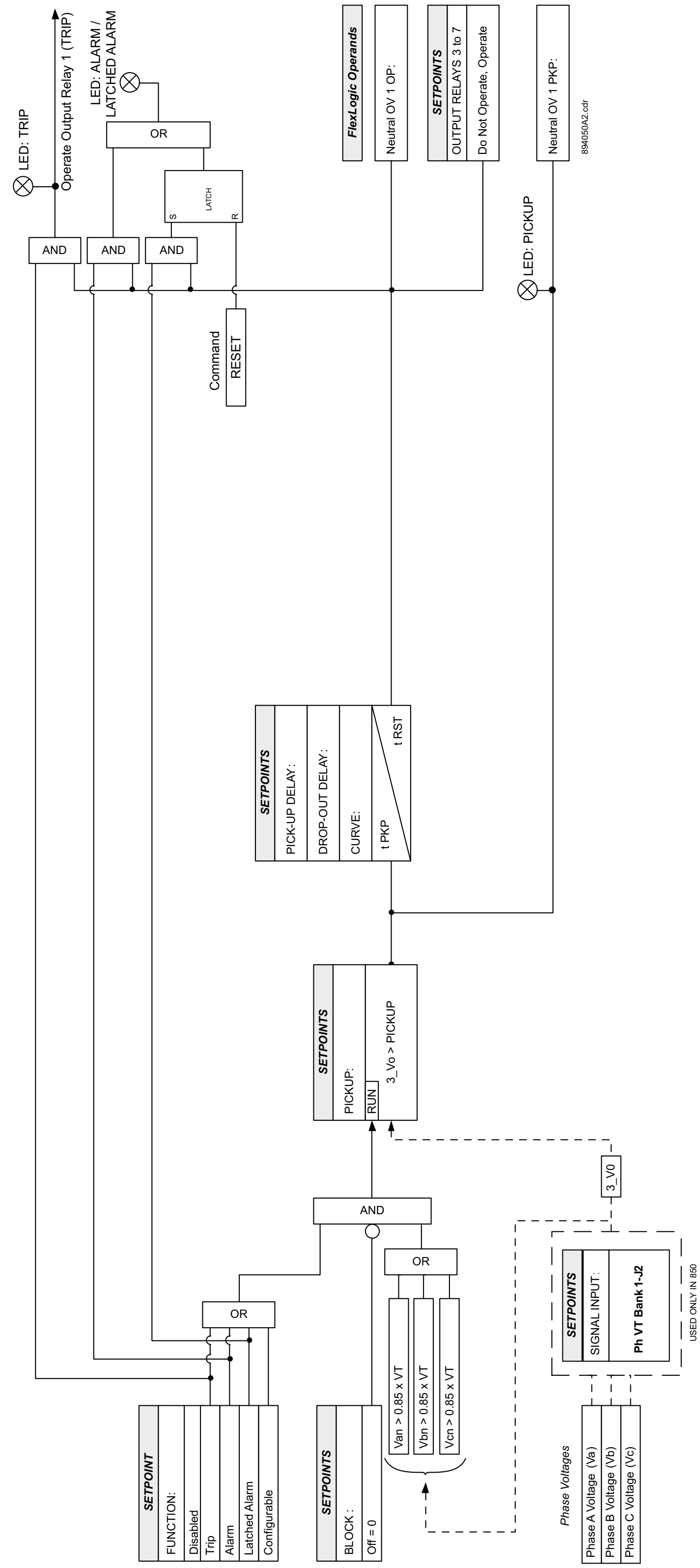
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Self-reset

Figure 6-34: Neutral Overvoltage Protection logic diagram



Negative Sequence Overvoltage Protection (59_2)

The 845 relay provides one Negative Sequence Overvoltage (Negative Sequence OV 1) element per protection group, or a total of 6 elements.

The Negative Sequence Overvoltage element can be used to detect an asymmetrical system voltage condition, loss of one or two phases of the source, or reversed phase sequence of voltages. The element responds to the negative sequence voltage (V_2), calculated from the phase voltages. The Negative Sequence Overvoltage element may be set as an instantaneous element with no time delay, or may be set as a definite time element.

The settings of this function are applied to the calculated Negative Sequence Voltage to produce Pickup and Trip flags. The Negative Sequence OV Pickup flag is asserted when the Negative Sequence Voltage is above the PKP value. The Negative Sequence OV Trip flag is asserted if the element stays picked up for the time defined by Pickup time delay. The element drops from Pickup without operation if the calculated Negative Sequence Voltage drops below 97 to 98% of the Pickup value before the time for operation is reached.

Path: **Setpoints > Protection > Group 1(6) > Voltage > Neg Seq OV 1(X)**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

PICKUP

Range: 0.00 to 3.00 x VT in steps of 0.01 x VT
Default: 1.00 x VT

This setting sets the Negative Sequence Overvoltage Pickup level specified per times VT. For example, a Pickup setting of 0.80 x VT with 13800:115 VT translates into 11.04 kV (or 92 V secondary).

NOTICE

If the 3 phase VT is delta connected, the Negative Sequence Overvoltage pickup level is internally changed to 1/sqrt(3) of the user setting, before being compared to the actual negative sequence voltage.

PICKUP DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 1.000 s

DROPOUT DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 1.000 s

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

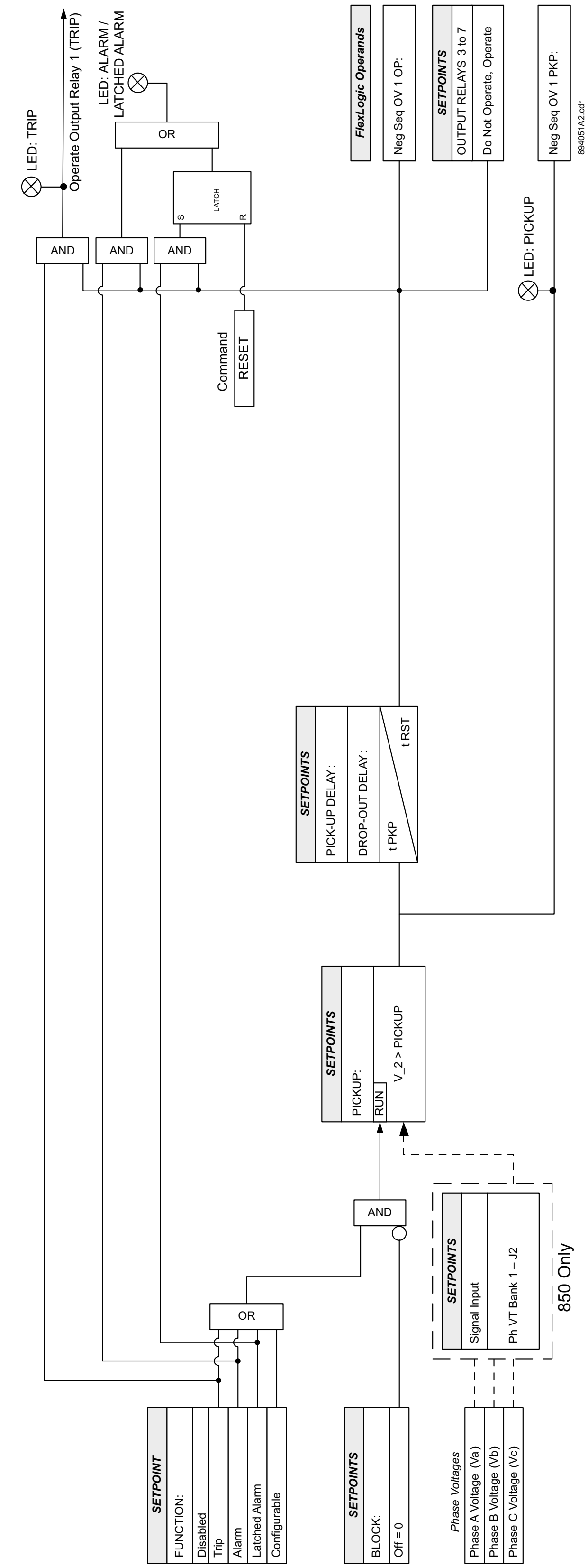
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Self-reset

Figure 6-35: Negative Sequence Overvoltage Protection logic diagram



Volts per Hertz (24)

The per-unit volts-per-Hertz (V/Hz) value is calculated using the maximum of the three-phase voltage inputs or the auxiliary voltage channel Vx input, if the source is not configured with phase voltages. To use the V/Hz element with the auxiliary voltage, set the Signal Input to "Aux VT Bnk1-J2". If there is no voltage on the relay terminals in either case, the per-unit V/Hz value is automatically set to "0". The per unit value is established based on the voltage and nominal frequency power system settings as follows:

1. If the phase voltage inputs defined in the source menu are used for V/Hz operation, then "1 pu" is the selected **Setpoint > System > Voltage Sensing > Ph VT Bnk1-J2 > Voltage 1 > Phase VT Secondary** setting, divided by the **Setpoint > System > Power System > Nominal Frequency** setting.
   For example, if Phase VT Secondary and Nominal Frequency are set as 120 V and 60 Hz, respectively, these set values define the base unit as 1 x (V/Hz). The volts-per-hertz ratio after division of these nominal settings is 120/60 = 2. If the Pickup setpoint from the V/Hz element is set to "1.05 x (V/Hz)", will mean that in order for the element to pick up, the actual volts-per-hertz ratio after division should be 2 *1.05 = 2.1. The ratio of 2.1 can be achieved if for example the measured voltage is 126V and frequency is 60 Hz, or the voltage is constant at 120 V and the frequency is 57.14 Hz, or any other combination of these two values, which after V/Hz division equals 2.1. To check back the pickup setting, we use the base (V/Hz) unit = 120/60 = 2, such that the pickup setting value is 2.1/2 = 1.05 x (V/Hz).
2. When the auxiliary voltage Vx is used (regarding the condition for "None" phase voltage setting mentioned above), then the 1 pu value is the **Setpoint > System > Voltage Sensing > Ph VT Bnk1-J2 > Voltage 1-J2 > Aux. VT Secondary** setting divided by the **Setpoint > System > Power System > Nominal Frequency** setting.
3. If the V/Hz source is configured with both phase and auxiliary voltages, the maximum phase among the three voltage channels at any given point in time is the input voltage signal for element operation, so the per-unit value is calculated as described in item 1, see previous items. If the measured voltage of all three phase voltages is "0", then the per-unit value becomes automatically "0" regardless of the presence of an auxiliary voltage.

The element has a linear reset characteristic. The reset time can be programmed to match the cooling characteristics of the protected equipment. The element will fully reset from the trip threshold in Reset Time seconds. The V/Hz element can be used as an instantaneous element with no intentional time delay or as a Definite or Inverse timed element. The characteristics of the inverse curves are shown as follows.

Path: **Setpoints > Protection > Group 1(6) > Voltage > Volts per Hertz 1(2)**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

This setting enables the Volts per Hertz functionality.

SIGNAL INPUT

Range: dependant on the order code
Default: Ph VT Bnk1-J2

This setting specifies the input voltage used to calculate the per-unit volts-per-Hertz (V/Hz). If three phase voltages are used then set the AC Inputs to "Ph VT Bnk1-J2". To use the V/Hz element with auxiliary voltage, set AC Inputs to "Aux VT Bnk1-J2".

VOLTAGE MODE

Range: Phase-ground, Phase-phase

Default: Phase-ground

If the Phase VT Connection is selected as "Wye", then the Voltage Mode setting further defines the operating quantity and per-unit value for this element. If the Voltage Mode is set as "Phase-phase", then the operating quantity for this element will be phase-to-phase nominal voltage. Likewise, if the Voltage Mode is set to "Phase-ground", then the operating quantity for this element will be the phase-to-ground nominal voltage.

If the Phase VT Connection (set under **Setpoint > System > Voltage Sensing**) is selected as "Delta", then the phase-to-phase nominal voltage is used to define the per-unit value, regardless of the Voltage Mode selection.

PICKUP

Range: 0.80 to 4.00 V/Hz in steps of 0.01

Default: 1.05 V/Hz

Enter the Volts per Hertz value (in V/Hz) above which the Volts per Hertz 1 element will pickup.

CURVE

Range: Definite Time, Inverse A, Inverse B, Inverse C, FlexCurve A, FlexCurve B, FlexCurve C, FlexCurve D

Default: Definite Time

Definite Time:

For the definite time curve, T(s) = TD multiplier. For example, setting the TD multiplier to 20 results in a time delay of 20 seconds to operate when above the Volts/Hz pickup setting. Instantaneous operation can be obtained the same way by setting the TD multiplier to "0".

Inverse Curve A:

The curve for the Volts/Hertz Inverse Curve A shape is derived from the formula:

$$T = \frac{TDM}{\left[\left(\frac{V}{F}\right)\Big/Pickup\right]^2 - 1} \quad when \ \frac{V}{F} > Pickup$$

where: T = Operating Time

TDM= Time Delay Multiplier (delay in seconds)

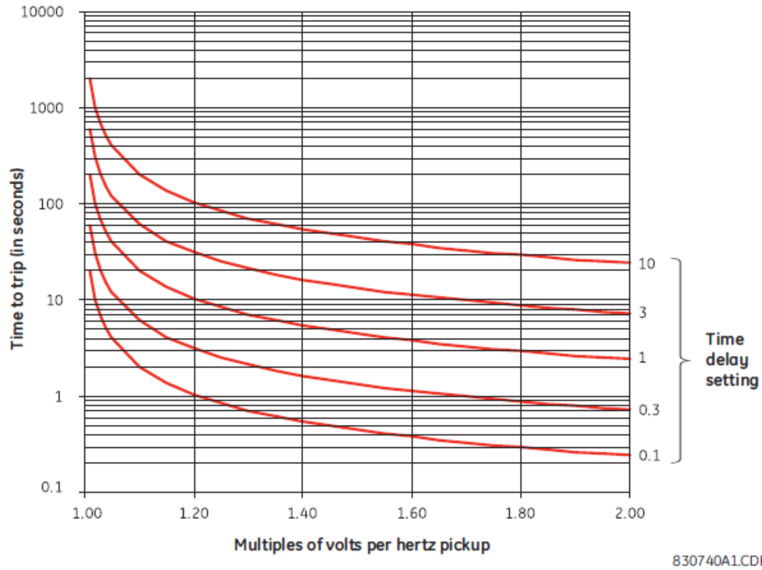
V = fundamental RMS value of voltage (pu)

F = frequency of voltage signal (pu)

Pickup = volts-per-hertz pickup setpoint (pu)

The volts/hertz inverse A curves are shown below.

Figure 6-36: Volts-Per-Hertz Curves for Inverse Curve A



Inverse Curve B:

The curve for the Volts/Hertz Inverse Curve B shape is derived from the formula:

$$T = \frac{TDM}{\left[\left(\frac{V}{F}\right) / Pickup\right] - 1} \quad when \ \frac{V}{F} > Pickup$$

where: T = Operating Time

TDM = Time Delay Multiplier (delay in seconds)

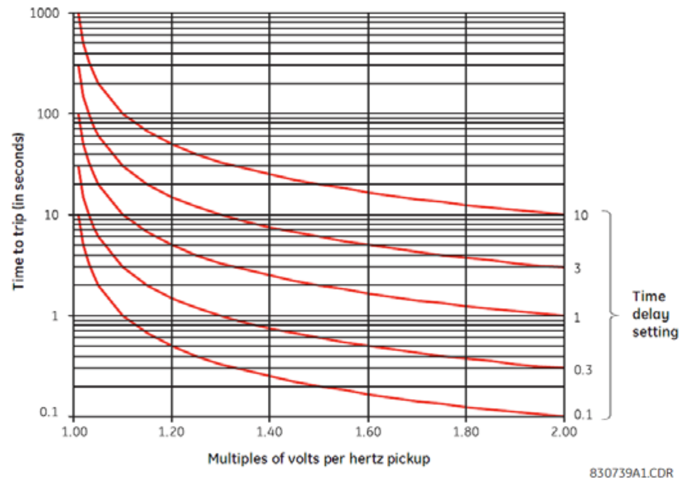
V = fundamental RMS value of voltage (pu)

F = frequency of voltage signal (pu)

Pickup = volts-per-hertz pickup setpoint (pu)

The Volts/Hertz inverse B curves are shown below.

Figure 6-37: Volts-Per-Hertz Curves for Inverse Curve B



Inverse Curve C:

The curve for the Volts/Hertz Inverse Curve C shape is derived from the formula:

$$T = \frac{TDM}{\left[\left(\frac{V}{F}\right)/Pickup\right]^{1/2} - 1} \quad when \; \frac{V}{F} > Pickup$$

where: T = Operating Time

TDM = Time Delay Multiplier (delay in seconds)

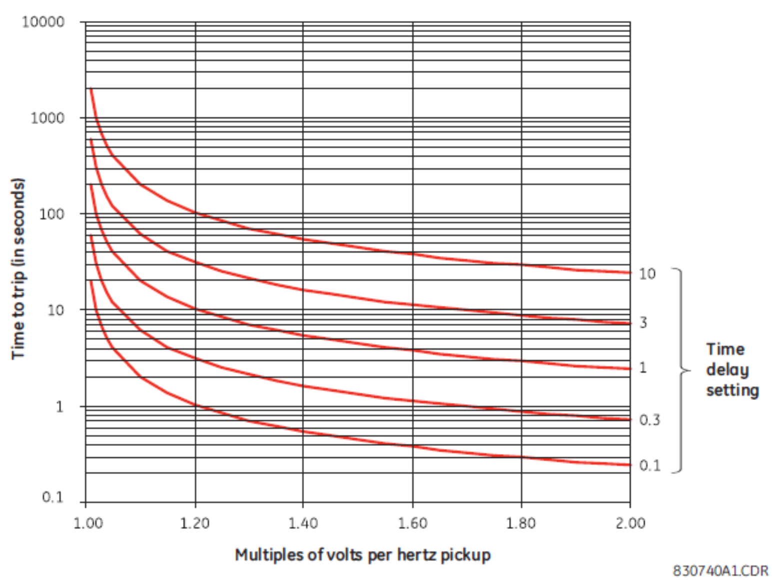
V = fundamental RMS value of voltage (pu)

F = frequency of voltage signal (pu)

Pickup = volts-per-hertz pickup setpoint (pu)

The Volts/Hertz Inverse C curves are shown below.

Figure 6-38: Volts-Per-Hertz Curves for Inverse Curve C



TD MULTIPLIER

Range: 0.05 to 600.00 in steps of 0.01

Default: 1.00

This setting provides a selection for the Time Dial Multiplier which modifies the operating times for the selected inverse curve. When the curve is set to “Definite Time”, T(s) = TD multiplier. For example, setting the TD multiplier to 20 results in a time delay of 20 seconds to operate when above the Volts/Hz pickup setting.

T RESET

Range: 0.00 to 6000.00 in steps of 0.01

Default: 1.00

Enter the time that the Volts per Hertz value must remain below the pickup level before the element resets.

BLOCK

Range: Off, Any FlexLogic Operand

Default: Off

The Volts per Hertz can be blocked by any asserted FlexLogic operand.

OUTPUT RELAY X

For details see Common Setpoints.

EVENTS

Range: Enabled, Disabled

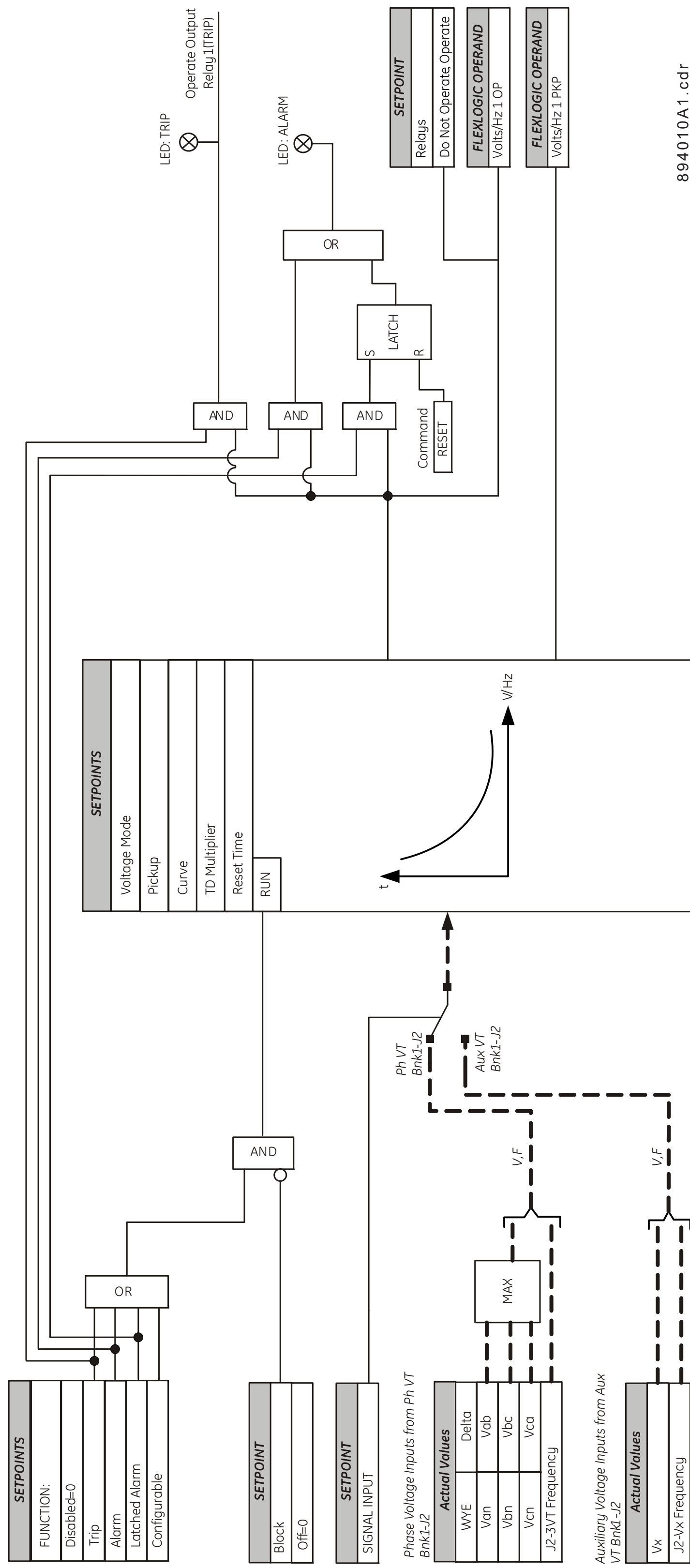
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched

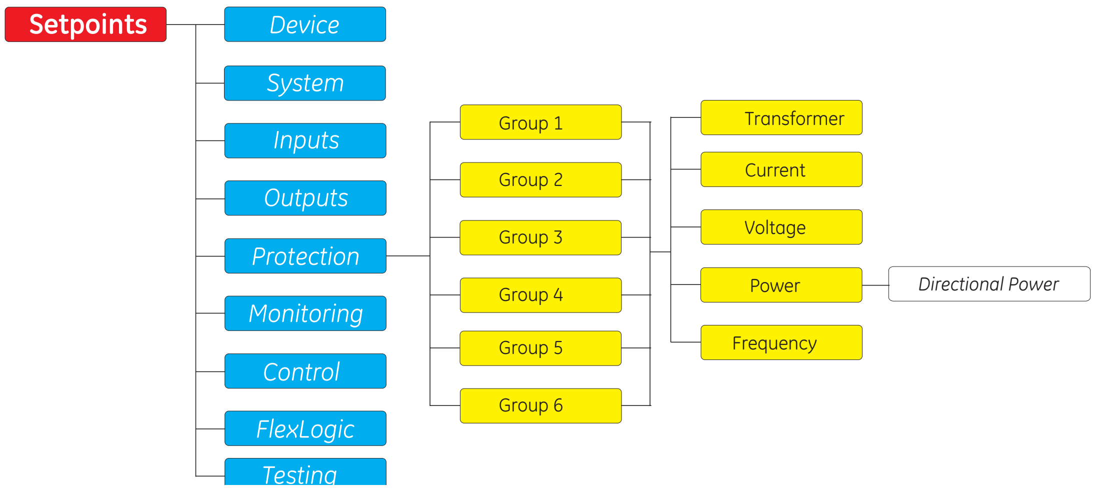
Default: Self-reset

Figure 6-39: Volts per Hertz logic diagram



Power Elements

Figure 6-40: Power Elements Display Hierarchy



Directional Power (32)

The 845 relay provides two identical Directional Power elements per protection group; a total of 12 elements.

The Directional Power element responds to three-phase directional power and is designed for reverse power (32REV) and low forward power (32FWD) applications for synchronous machines or interconnections involving co-generation. The relay 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.

The element has an adjustable characteristic angle and minimum operating power as shown in the Directional Power characteristic diagram. The element responds to the following condition:

$$P\cos\theta + Q\sin\theta > SMIN$$

Where:

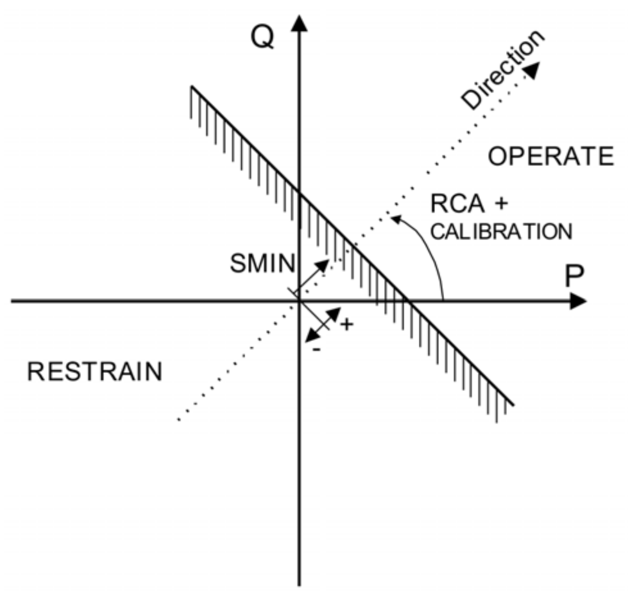
P and Q are active and reactive powers as measured per the metering convention

θ is a sum of the element characteristic (DIR POWER 1 RCA) and calibration (DIR POWER 1 CALIBRATION) angles

SMIN is the minimum operating power.

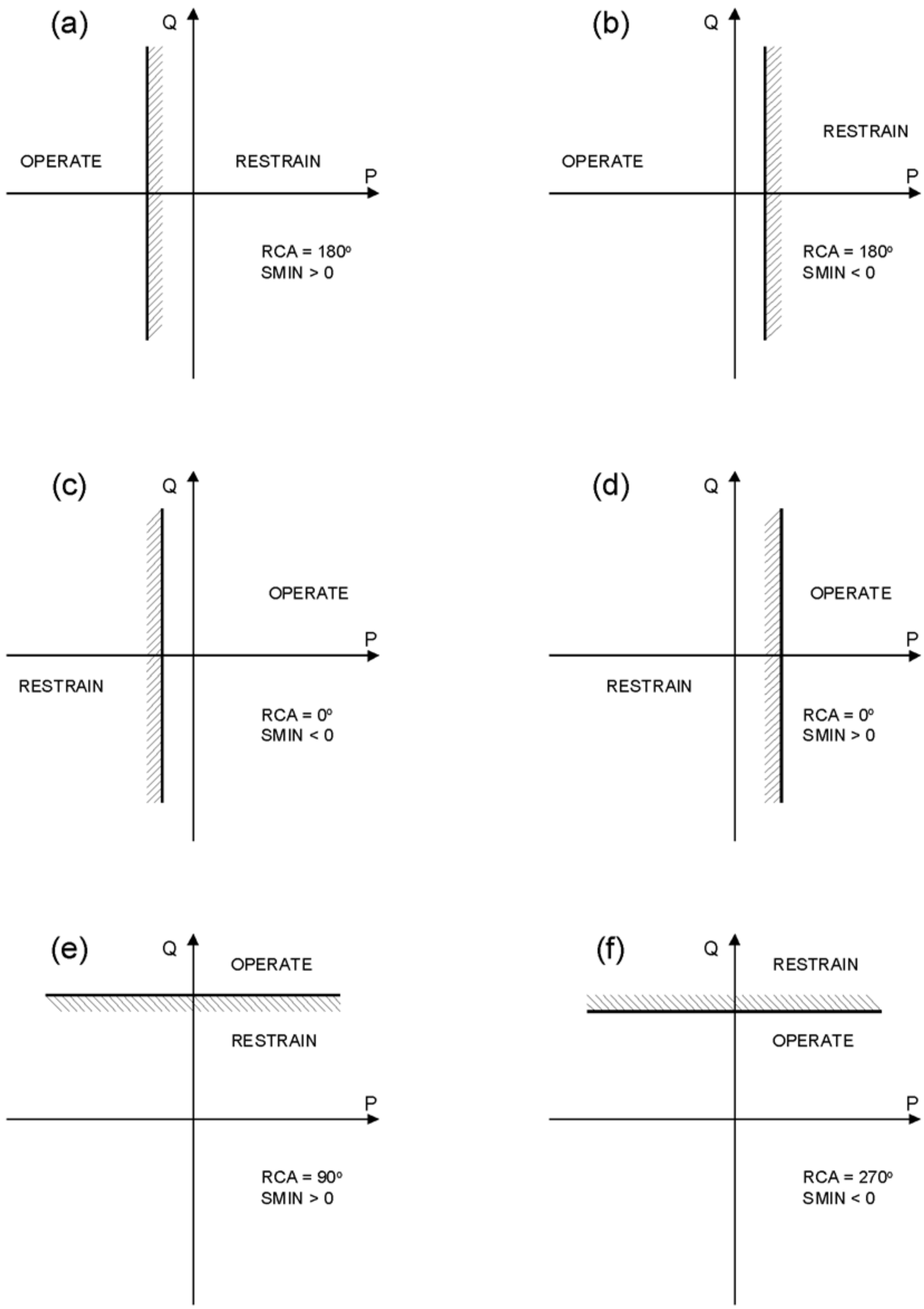
The element has two independent (as to the Pickup and Delay settings) stages for Alarm and Trip, and they can be set separately to provide mixed power protection.

Figure 6-41: Directional Power characteristic



By making the characteristic angle adjustable and providing for both negative and positive values of the minimum operating power, a variety of operating characteristics can be achieved as presented in the figure below. For example, section (a) in the figure below shows settings for reverse power, while section (b) shows settings for low forward power applications.

Figure 6-42: Sample applications of the Directional Power element



Path: **Setpoints > Protection > Group 1(6) > Power > Directional Power 1(X)**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

RCA

Range: 0 to 359° in steps of 1°
Default: 180°

This setting specifies the Relay Characteristic Angle (RCA) for the Directional Power function. Application of this setting is threefold:

1. It allows the element to respond to active or reactive power in any direction (active overpower/underpower, etc.).
2. Together with a precise calibration angle, it allows compensation for any CT and VT angular errors to permit more sensitive settings.
3. It allows for required direction in situations when the voltage signal is taken from behind a delta-wye connected power transformer and phase angle compensation is required.

For example, the active overpower characteristic is achieved by setting DIR POWER 1 RCA to “0°,” reactive overpower by setting DIR POWER 1 RCA to “90°,” active underpower by setting DIR POWER 1 RCA to “180°,” and reactive underpower by setting DIR POWER 1 RCA to “270°”.

CALIBRATION

Range: 0 to 0.95° in steps of 0.05°
Default: 0°

This setting allows the Relay Characteristic Angle 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.

The setting virtually enables calibration of the Directional Power function in terms of the angular error of applied VTs and CTs. The element responds to the sum of the DIR POWER 1 RCA and DIR POWER 1 CALIBRATION settings.

STAGE 1 SMIN

Range: -1.200 to 1.200 x Rated Power in steps of 0.001 x Rated Power
Default: 0.100 x Rated Power

The setting specifies the minimum power as defined along the relay characteristic angle (RCA) for the stage 1 of the element. The positive values imply a shift towards the operate region along the RCA line; the negative values imply a shift towards the restrain region along the RCA line. Refer to the Directional power sample applications figure for details. Together with the RCA, this setting enables a wide range of operating characteristics.

The setting applies to three-phase power and the rated power is as follows:

Rated Power = $3 \times VT_{Secondary\ (phase-neutral)} \times VT_{Ratio} \times CT_{Primary}$ (Wye-connected VT), or
Rated Power = $(3)^{1/2} \times VT_{Secondary\ (phase-phase)} \times VT_{Ratio} \times CT_{Primary}$ (Delta-connected VT)

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 phase-neutral voltage and 10 kA is a primary CT current, the source rated power is 239 MVA, and, SMIN must be set at 4 MW/239 MVA =0.0167 x Rated ≈ 0.017 x Rated. If the reverse power application is considered, RCA = 180° and SMIN = 0.017 x Rated.

The element drops out if the magnitude of the positive-sequence current becomes virtually zero, that is, it drops below the cutoff level.

STAGE 1 DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s

Default: 0.500 s

The setting specifies a time delay for stage 1. For reverse power or low forward power applications for a synchronous machine, stage 1 is typically applied for alarming and stage 2 for tripping.

STAGE 2 SMIN

Range: -1.200 to 1.200 x Rated Power in steps of 0.001 x Rated Power

Default: 0.100 x Rated Power

The setting specifies the minimum power as defined along the relay characteristic angle (RCA) for stage 2 of the element. The setting needs to be coordinated with the setting of stage 1.

STAGE 2 DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s

Default: 20.000 s

The setting specifies a time delay for stage 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: Off, Any FlexLogic operand

Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

EVENTS

Range: Enabled, Disabled

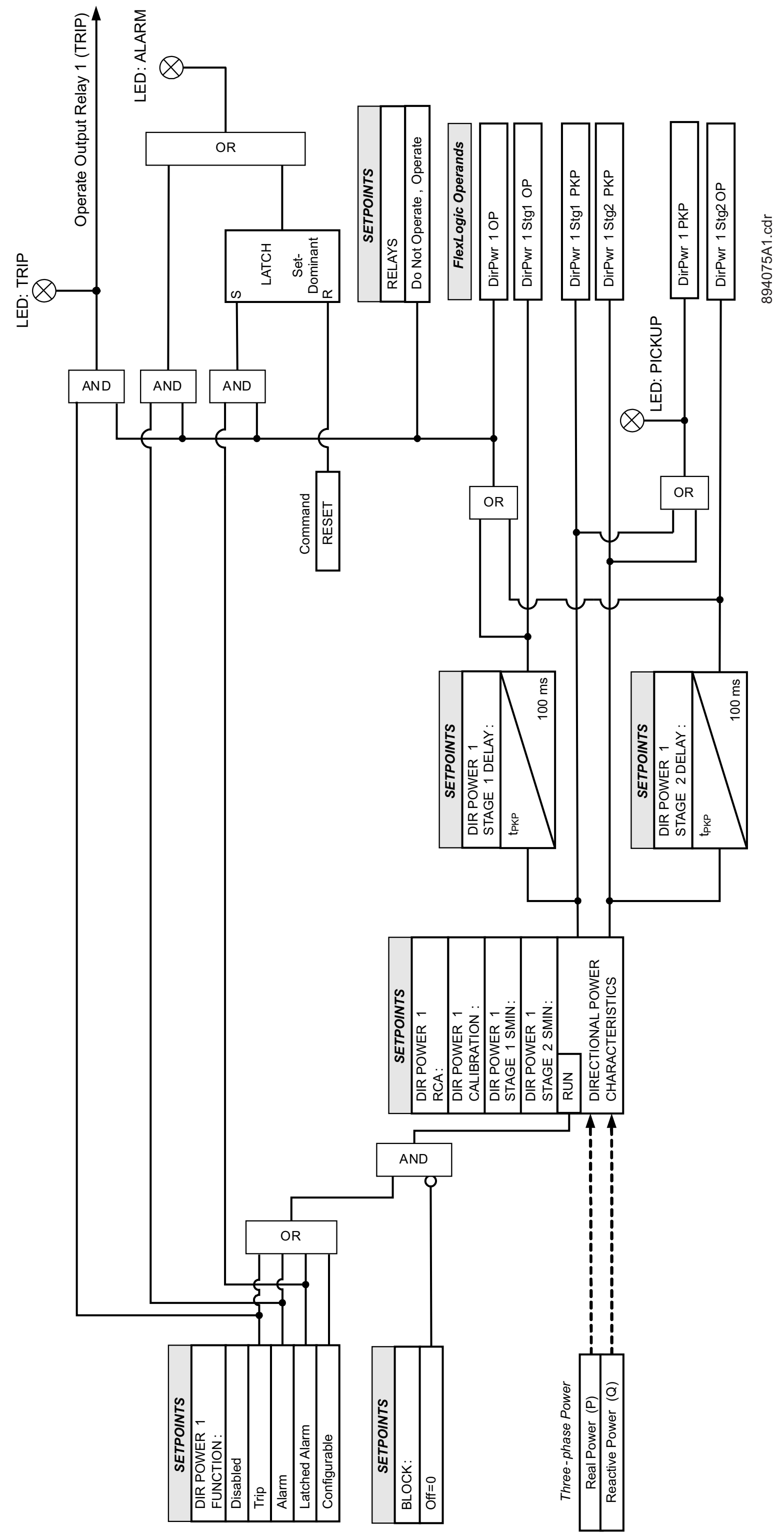
Default: Enabled

TARGETS

Range: Self-reset, Latched, Disabled

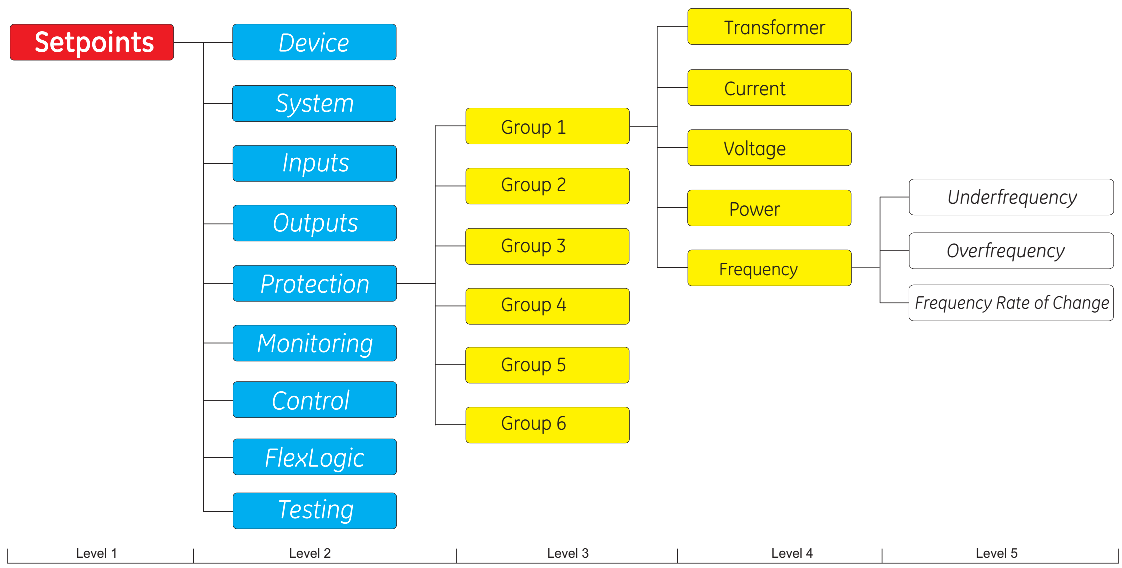
Default: Self-reset

Figure 6-43: Directional Power logic diagram



Frequency Elements

Figure 6-44: Frequency Elements Display Hierarchy



Underfrequency (81U)

The 845 can be used as the primary detecting relay in automatic load-shedding schemes based on underfrequency. The need for such a relay arises if during a system disturbance, an area becomes electrically isolated from the main system and suffers a generation deficiency due to the loss of either transmission or generation facilities. If reserve generation is not available in the area, conditions of low system frequency occur which can lead to a complete collapse. The 845 relay provides four identical Underfrequency (UNDERFREQ) elements per protection group, or a total of 24 elements, which can automatically disconnect sufficient load to restore an acceptable balance between load and generation. The Underfrequency element can be set as an instantaneous element with no time delay or as a definite time delayed element. The Underfrequency element has the programmable minimum operating thresholds to prevent undesired operation during periods of light load or unavailable voltage. The input voltages are the three phase-to-phase voltages from delta connected VTs (PTs), three phase-to-ground voltages from wye connected VTs (PTs), or single phase auxiliary voltage. The input currents are the three phase currents.

The Underfrequency Pickup flag is asserted when the measured frequency of the specified source is below the PKP value and the voltage and current are above the MINIMUM levels. The Underfrequency Trip flag is asserted if the element stays picked up for the time defined by the Pickup time delay. The element drops from Pickup without operation if the measured frequency rises above 0.03Hz of the Pickup value and stays dropped-out for the defined time delay before the time for operation is reached.

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

The minimum operating current setting selects the minimum current below which the element is blocked. Operation during periods of light load are prevented.

Path: **Setpoints > Protection > Group 1(6) > Frequency > Underfrequency 1(X)**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

PICKUP

Range: 20.00 to 65.00 Hz in steps of 0.01 Hz
Default: 59 Hz

PICKUP DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 2.000 s

DROPOUT DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 2.000 s

VT INPUT

Range: dependant upon the order code
Default: Ph VT Bnk1-J2

MINIMUM VOLTAGE

Range: 0.000 to 1.250 x VT in steps of 0.001 x VT
Default: 0.700 x VT

The setting sets the minimum voltage for Underfrequency element operation specified per times VT. The setpoint prevents incorrect operation before energization of the source to the relay location, and during voltage dips.

NOTICE

If the 3-phase VT uses a delta connection and SIGNAL INPUT is set to Ph VT Bnk1-J2, the positive sequence voltage is used as the supervision voltage. In such condition, the true supervision level is internally changed to 1/sqrt(3) of the user setting since the base of VT here is the phase-phase voltage.

CT INPUT

Range: dependant upon the order code
Default: CT Bank 1-J1

MINIMUM CURRENT

Range: 0.000 to 30.000 x CT in steps of 0.001 x CT
Default: 0.200 x CT

The setting sets the minimum value of current required on any phase to allow the Underfrequency element to operate. The setpoint is used to prevent underfrequency tripping during periods of light load, when this action would have an insignificant effect on the system. A setting of zero is suspend current supervision.

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

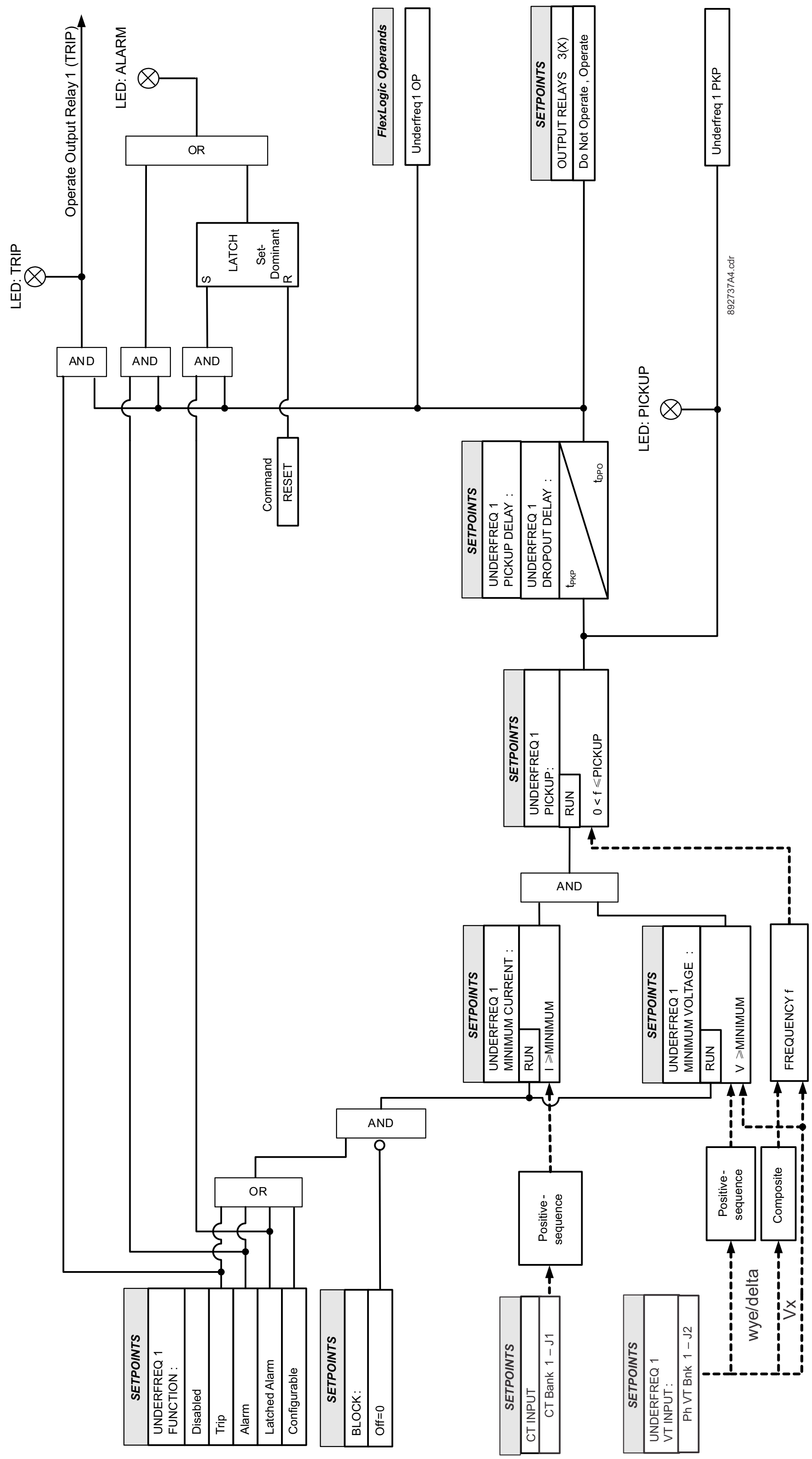
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Self-reset

Figure 6-45: Underfrequency Protection logic diagram



Overfrequency (81O)

The 845 relay provides two identical Overfrequency (OVERFREQ) elements per protection group, or a total of 12 elements.

A significant overfrequency condition, likely caused by a breaker opening and disconnecting load from a particular generation location, can be detected and used to quickly ramp the turbine speed back to normal. If this is not done, the over speed can lead to a turbine trip, which would then subsequently require a turbine start up before restoring the system. If the overfrequency turbine ramp down is successful, the system restoration can be much quicker. The overfrequency monitoring feature of the relay can be used for this purpose at a generating location.

The Overfrequency feature is inhibited from operating unless the magnitude of the positive sequence or auxiliary voltage rises above a threshold. When the supply source is energized, the overfrequency delay timer is allowed to start timing only when the threshold is exceeded and the frequency is above the programmed Pickup level. In the same way, when an overfrequency condition starts the overfrequency delay timer and the voltage falls below the threshold before the timer has expired, the element resets without operating.

The Overfrequency element may be set as an instantaneous element with no time delay, or as a definite time delayed element. The Overfrequency element has a fixed minimum operating threshold to prevent undesired operation during periods of unavailable voltage. The input voltages are the three phase-to-phase voltages from delta connected VTs (PTs), three phase-to-ground voltages from wye connected VTs (PTs), or single phase auxiliary voltage.

The settings of this function are applied to each source to produce Pickup and Operate flags. The Overfrequency Pickup flag is asserted when the measured frequency of the specified source is above the PKP value and the voltage is above the threshold. The Overfrequency Operate flag is asserted if the element stays picked up for the time defined by the Pickup time delay. The element drops from Pickup without operation if the measured frequency decreases below 0.03 Hz of the Pickup value and stays dropped out for the defined time delay before the time for operation is reached.

The minimum operating voltage is set as a threshold below which the element is blocked.

Path: **Setpoints > Protection > Group 1(6) > Frequency > Overfrequency 1(X)**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

SIGNAL INPUT

Range: dependant upon the order code
Default: Ph VT Bnk1-J2

This setting provides selection of the frequency input.

PICKUP

Range: 20.00 to 65.00 Hz in steps of 0.01 Hz
Default: 60.5 Hz

PICKUP DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 2.000 s

DROPOUT DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 2.000 s

MINIMUM VOLTAGE

Range: 0.000 to 1.250 x VT in steps of 0.001 x VT

Default: 0.700 x VT

The setting sets the minimum voltage for Overfrequency element operation specified per times VT.

NOTE

If the 3-phase VT uses a delta connection and FREQUENCY INPUT is set to Ph VT Bnk1-J2, the positive sequence voltage is used as the supervision voltage. In such condition, the true supervision level is internally changed to 1/sqrt(3) of the user setting since the base of VT here is the phase-phase voltage.

BLOCK

Range: Off, Any FlexLogic operand

Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

EVENTS

Range: Enabled, Disabled

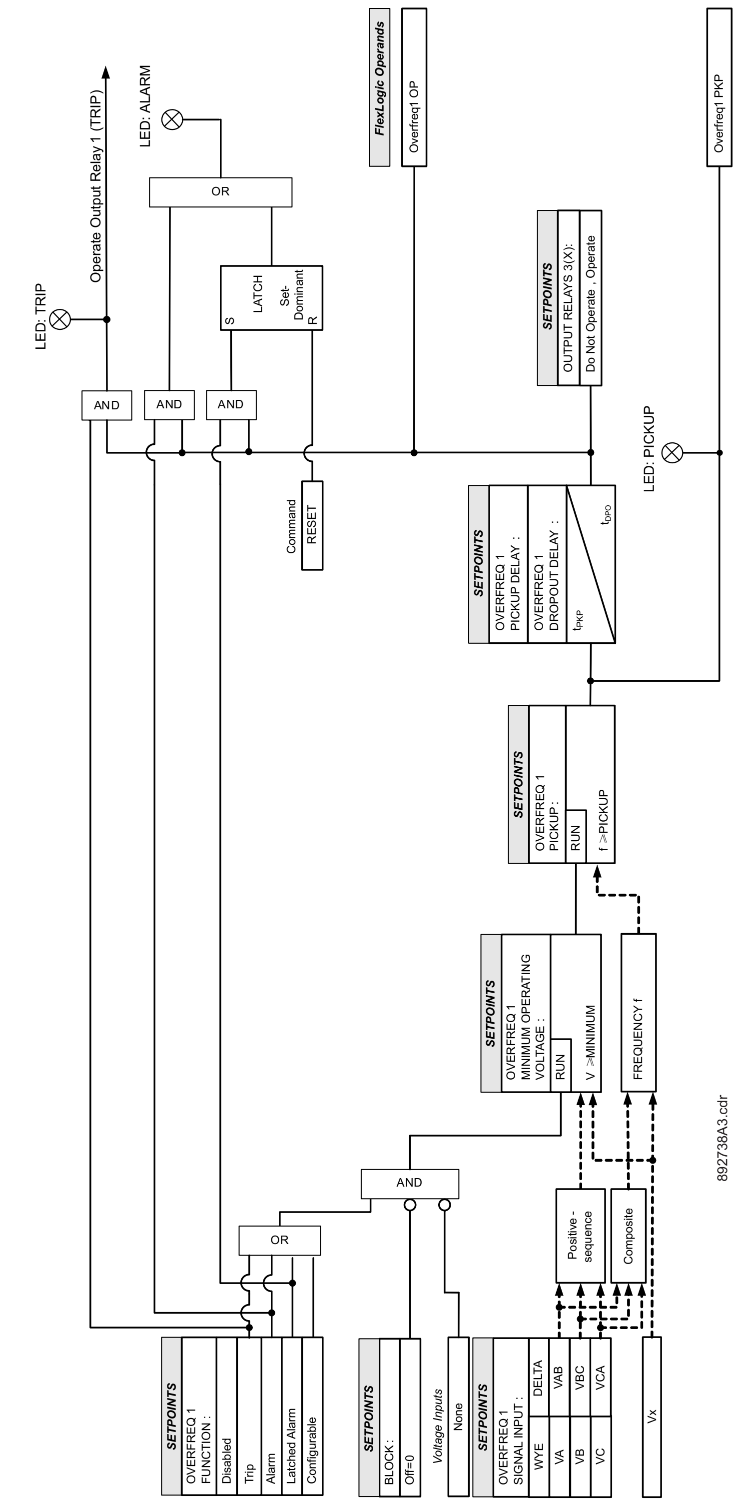
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched

Default: Self-reset

Figure 6-46: Overfrequency Protection logic diagram



Frequency Rate of Change (81R)

There is one Frequency Rate of Change protection element which can respond to rate of change of frequency with voltage, current and frequency supervision.

The Rate of Change element may be set as an instantaneous element with no time delay or as a definite time delayed element. The rate of change element has the programmable minimum operating voltage and current thresholds to prevent undesired operation under specific system conditions.

The settings of this function are applied to each source to produce Pickup and Trip flags.

The Frequency Rate of Change Pickup flag is asserted when the calculated frequency rate of change of the specified source is above the PKP value, the voltage and current are above the MINIMUM levels, and the frequency is within a certain range. The Frequency Rate of Change Trip flag is asserted if the element stays picked up for the time defined by the Pickup time delay. The element instantaneously drops from Pickup without operation, if the frequency rate of change drops below 96% of the Pickup value, before the time for operation is reached.

The minimum voltage and current thresholds select the minimum voltage and current below which the element is blocked.

The minimum and maximum frequencies set the operating frequency range out of which the element is blocked.

Path: **Setpoints > Protection > Group 1(6) > Frequency > Frequency Rate of Change 1(X)**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable

Default: Disabled

The selection of the Trip, Alarm, Latched Alarm, or Configurable setting enables the element.

When the Trip function is selected and the element operates, output relay #1 “Trip” will operate but the “ALARM” LED will not turn on.

When the Alarm function is selected and the element operates, the “ALARM” LED will flash; it will self-reset, when the operating conditions are cleared.

When the Latched Alarm function is selected, and the element operates, the “ALARM” LED will flash during the TOC operating condition, and will be steadily lit after the conditions are cleared. The “ALARM” LED can be cleared by issuing a Reset command. Output relay #1 “Trip” will not operate if the Alarm or Latched Alarm setting is selected.

When the Configurable function is selected, neither the Trip output, nor the ALARM LED will turn on automatically. They must be configured using their own menus and FlexLogic operands.

The selected output relays #3 to #7 will operate if the Trip, Latched Alarm, Alarm or Configurable setting is selected and the element operates

TREND

Range: Decreasing, Increasing, Bi-directional

Default: Decreasing

The setting allows configuring of the element to respond to increasing or decreasing frequency, or to a frequency change in either direction.

PICKUP

Range: 0.10 to 15.00 Hz/sec in steps of 0.01 Hz/sec
Default: 0.50 Hz/sec

The setting specifies an intended Pickup threshold.

For applications monitoring a decreasing trend, set TREND to “Decreasing” and specify the Pickup threshold accordingly. The operating condition is: -df/dt > PKP.

For applications monitoring an increasing trend, set TREND to “Increasing” and specify the pickup threshold accordingly. The operating condition is: df/dt > PKP.

For applications monitoring rate of change of frequency in any direction, set TREND to “Bi-Directional” and specify the Pickup threshold accordingly. The operating condition can be either of the above two conditions.

PICKUP DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 2.000 s

This setting provides a definite Pickup time delay. Instantaneous operation is selected by a Pickup time delay setting of 0.000 s.

MINIMUM FREQUENCY

Range: 20.00 to 80.00 Hz in steps of 0.01 Hz
Default: 45.00 Hz

The setting defines the minimum frequency level required for operation of the element.

The setting may be used to effectively block the feature based on frequency. For example, if the intent is to monitor an increasing trend but only if the frequency is already above certain level, this setting is set to the required frequency level.

MAXIMUM FREQUENCY

Range: 20.00 to 80.00 Hz in steps of 0.01 Hz
Default: 65.00 Hz

The setting defines the maximum frequency level required for operation of the element.

The setting may be used to effectively block the feature based on frequency. For example, if the intent is to monitor a decreasing trend but only if the frequency is already below a certain level (such as for load shedding), this setting is set to the required frequency level.

VT INPUT

Range: dependant upon the order code
Default: Ph VT Bnk1-J2)

This setting provides selection of the frequency input.

MINIMUM VOLTAGE

Range: 0.000 to 1.250 x VT in steps of 0.001 x VT
Default: 0.700 x VT

The setting defines the minimum voltage level required for operation of the element. The supervising function responds to the positive-sequence voltage. Overvoltage supervision is used to prevent operation under specific system conditions such as faults.

NOTICE

If the 3-phase VT uses a delta connection and FREQUENCY INPUT is set to J2-3VT, the positive sequence voltage is used as the supervision voltage. In such condition, the true supervision level is internally changed to 1/sqrt(3) of the user setting since the base of VT here is the phase-phase voltage.

CT INPUT

Range: dependant upon the order code

Default: CT Bank1-J1 or CT Bank1-K1, dependant on order code

This setting provides selection of the frequency input.

MINIMUM CURRENT

Range: 0.000 to 30.000 x CT in steps of 0.001 x CT

Default: 0.200 x CT

This setting defines the minimum current level required for operation of the element. The supervising function responds to the positive-sequence current. Typical application includes load shedding. Set the Pickup threshold to zero if no overcurrent supervision is required. The setting of zero suspends the current supervision.

BLOCK

Range: Off, Any FlexLogic operand

Default: Off

The element will be blocked when the selected operand is asserted.

OUTPUT RELAY X

For details see Common Setpoints.

Each relay can be selected to become either energized or de-energized when operated, and to operate as latched, self-resetting or pulsed.

EVENTS

Range: Enabled, Disabled

Default: Enabled

The selection of the Enabled setting enables the events of the function.

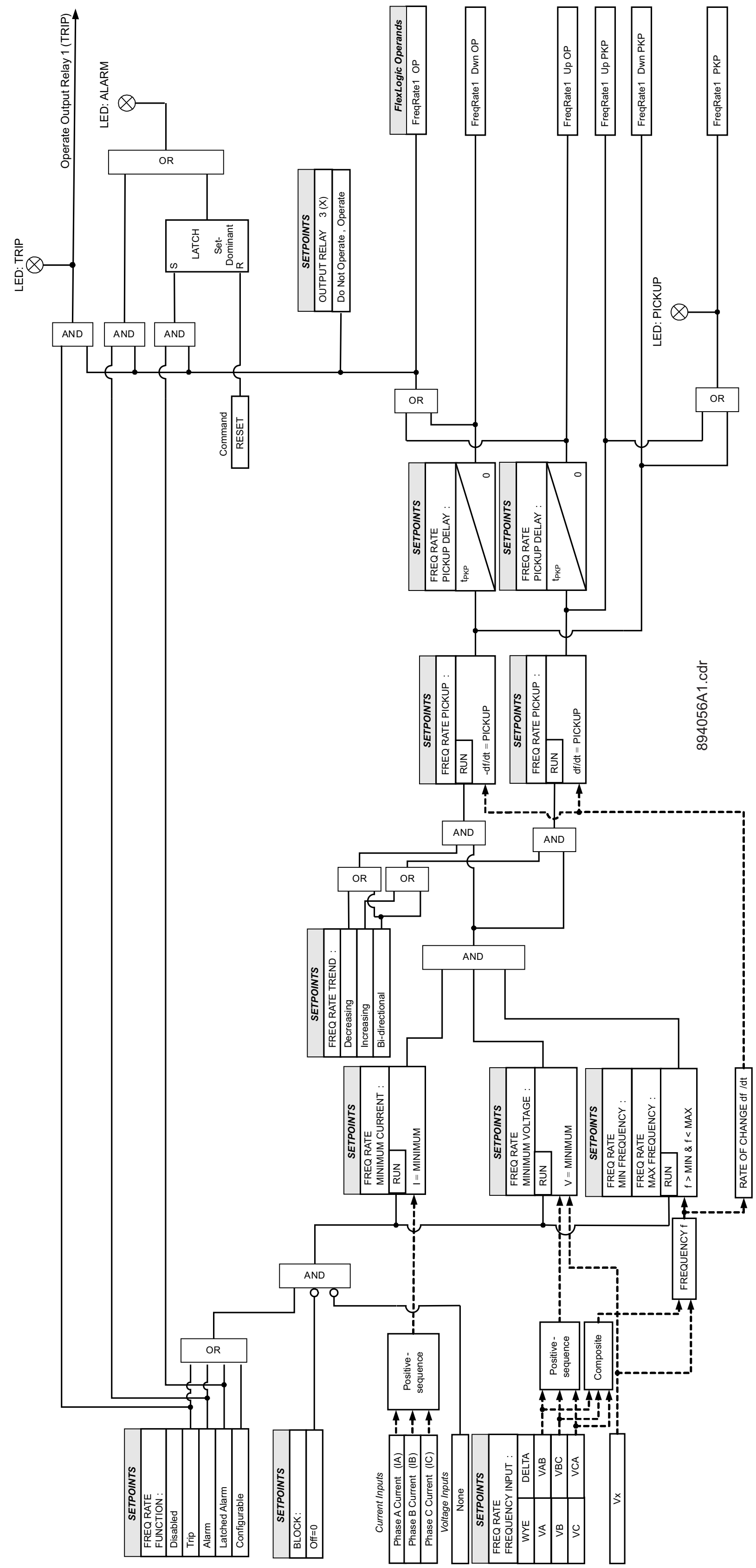
TARGETS

Range: Disabled, Self-reset, Latched

Default: Self-reset

This setting is used to define the operation of an element target message. When set to “Disabled,” no target message is issued upon operation of the element. When set to “Self-Reset,” the target message and its LED indication follow the operate state of the element, and self-reset once the operate element condition clears. When set to “Latched,” the target message will remain visible after the element output returns to logic 0 until a RESET command is received by the relay.

Figure 6-47: Frequency Rate-of-Change Protection logic diagram

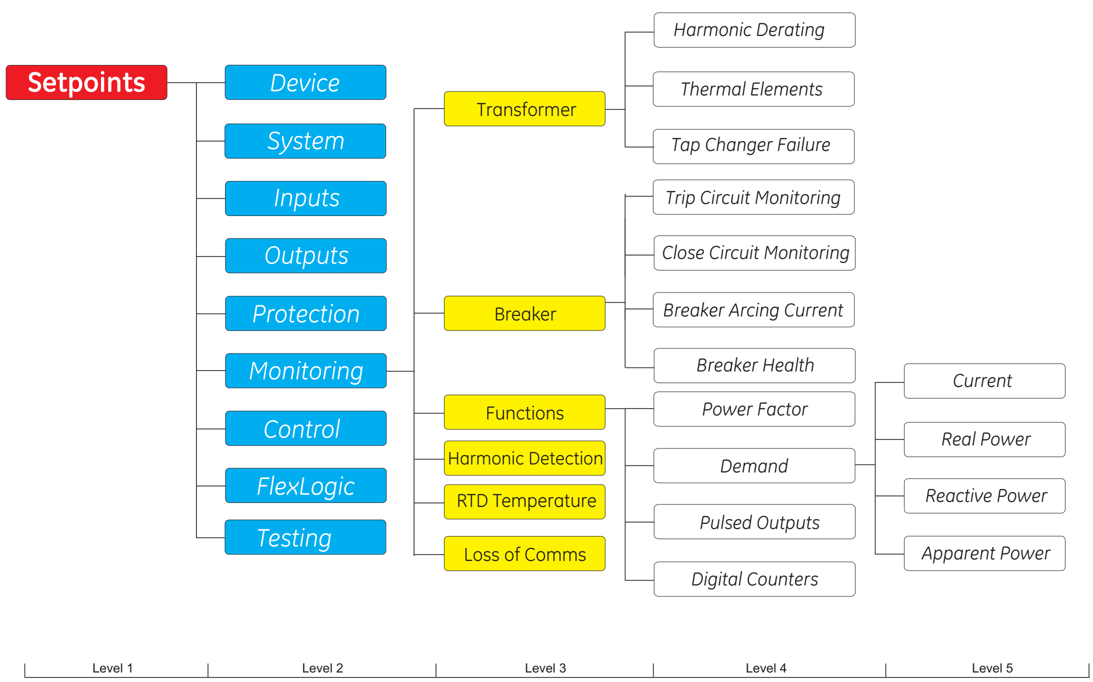


GE
Grid Solutions

845 Transformer Protection System

Chapter 7: Monitoring

Figure 7-1: Monitoring Display Hierarchy



Transformer

Harmonic Derating

The presence of harmonic currents in transformers increases the I^2R losses, stray losses in the core, clamps and structural parts, and eddy current losses in the windings. Of these losses, the eddy current losses are of most concern since they tend to be proportional to the square of the load current and approximately proportional to the square of frequency which, in turn can cause excessive winding loss and abnormal winding temperature rise in transformers when harmonics are present.

The Harmonic Derating element makes use of the harmonic derating factor (HDF) computed by the Series 8 relay, using the harmonic content of the current signals and the transformer data (refer to IEEE C57.110-2008 for the computation method). Once the derating factor falls below a set value, the relay operates accordingly. The derating factor is used to evaluate the load capability of the installed transformer under the non-sinusoidal load currents. Once harmonics are present, the derating factor will decrease from the ideal value of one per unit, which means the load capability is reduced due to harmonics.

The Load-Limit Reduced LED indicator is ON and an operand of 'Load Limit Reduced' is asserted if the HDF of any winding is less than 0.96, regardless of whether the element is disabled or enabled.

NOTE

The following three settings are used in this element:

- **Setpoints > System > Transformer > Transformer Setup > Load Loss at Rated Load**
- **Setpoints > System > Transformer > Transformer Setup > Rated Wndg Temp Rise**
- **Setpoints > System > Transformer > Transformer Setup > Wndg Resistance (3-ph)**

Path: **Setpoints > Monitoring > Transformer > Harmonic Derating > W1(2,3) Harmonic Derating**

FUNCTION

Range: Disabled, Alarm, Latched Alarm, Configurable
Default: Disabled

MINIMUM OPER CURRENT

Range: 0.03 to 1.00 x CT in steps of 0.01 x CT
Default: 0.10 x CT

This setting sets the minimum value for all three-phase currents to allow the Harmonic Derating element to operate.

PICKUP

Range: 0.01 to 0.98 in steps of 0.01
Default: 0.90

PICKUP DELAY

Range: 0 to 60000 s in steps of 1 s
Default: 10 s

BLOCK

Range: Any flexoperand
Default: Off

OUTPUT RELAY X

Range: Do Not Operate, Operate
Default: Do Not Operate

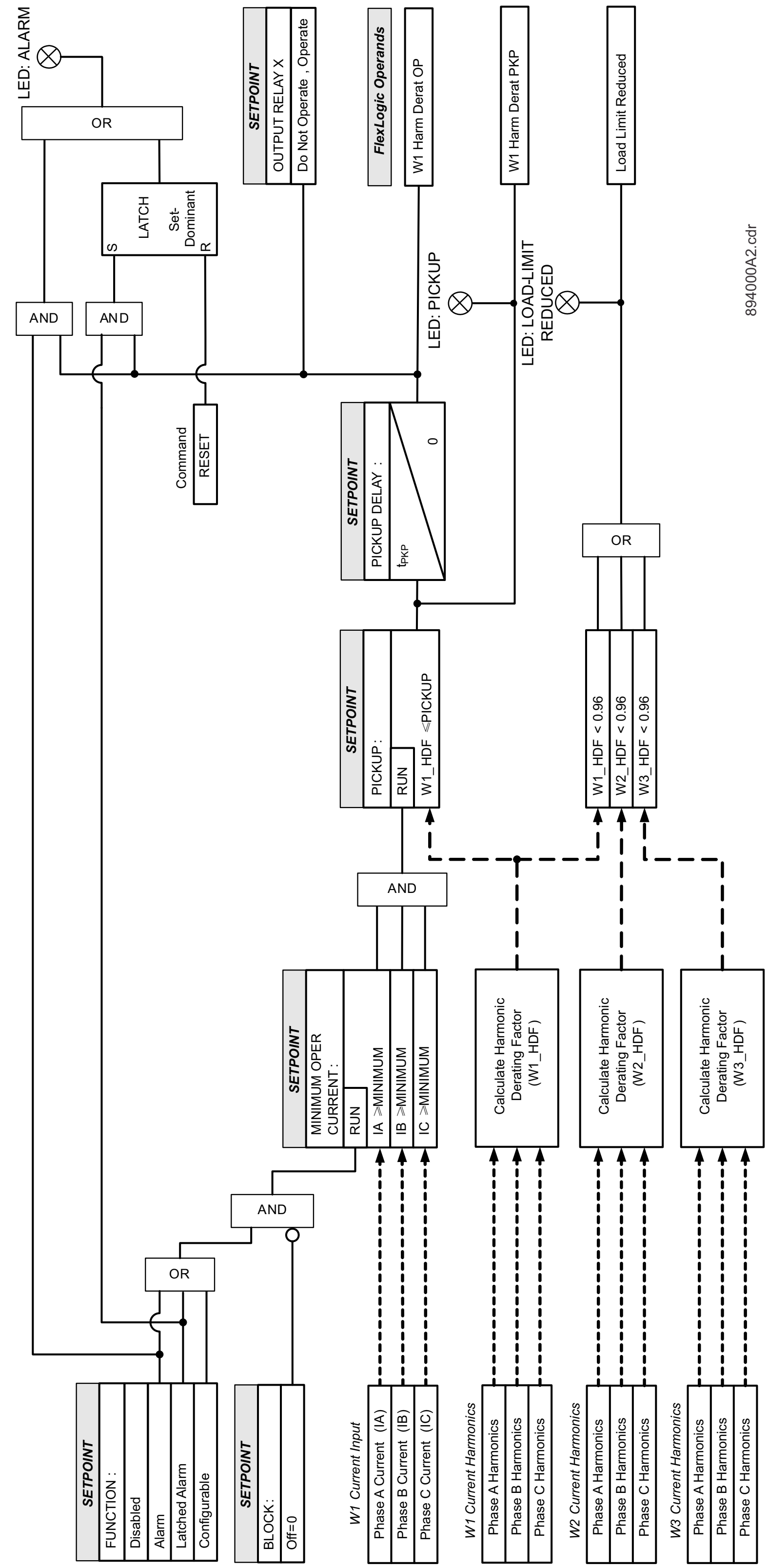
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Self-reset

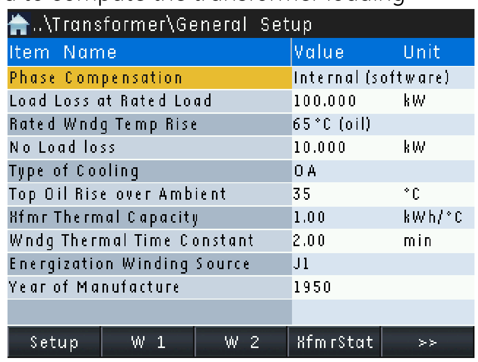
Figure 7-2: Harmonic Derating Logic diagram



Thermal Elements

The 845 thermal elements include Hottest-spot temperature, Aging Factor, and Loss of Life elements. The computation of these elements follows the IEEE standards C57.91-2011 “IEEE Guide for Loading Mineral-Oil-Immersed Transformers”, and C57.96-2013 “IEEE Guide for Loading Dry-Type Distribution Transformers”. The computations are based on transformer loading conditions, ambient temperature, and entered transformer data.

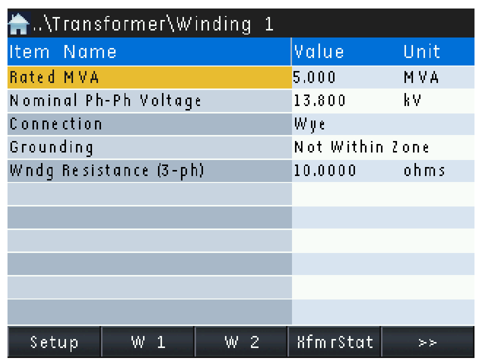
- Refer to **SETPOINTS > SYSTEM > TRANSFORMER > GENERAL** and enter the transformer data used in the computation of Hottest-Spot winding temperature, Aging Factor, and Transformer Loss of Life
- Refer to **SETPOINTS > SYSTEM > TRANSFORMER > WINDING 1(2,3)** and enter the windings data used to compute the transformer loading



..\Transformer\General Setup

Item Name	Value	Unit
Phase Compensation	Internal (software)	
Load Loss at Rated Load	100.000	kW
Rated Wndg Temp Rise	65°C (oil)	
No Load loss	10.000	kW
Type of Cooling	OA	
Top Oil Rise over Ambient	35	°C
Xfmr Thermal Capacity	1.00	kWh/°C
Wndg Thermal Time Constant	2.00	min
Energization Winding Source	J1	
Year of Manufacture	1950	

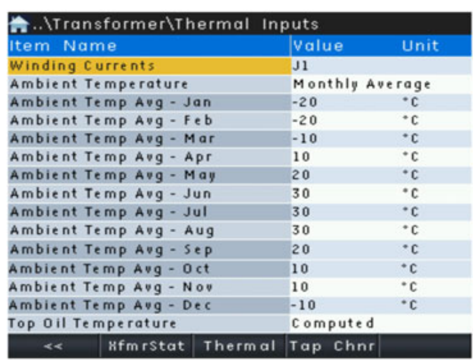
Setup | W 1 | W 2 | XfmrStat | >>



..\Transformer\Winding 1

Item Name	Value	Unit
Rated MVA	5.000	MVA
Nominal Ph-Ph Voltage	13.800	kV
Connection	Wye	
Grounding	Not Within Zone	
Wndg Resistance (3-ph)	10.0000	ohms

Setup | W 1 | W 2 | XfmrStat | >>



..\Transformer\Thermal Inputs

Item Name	Value	Unit
Winding Currents	J1	
Ambient Temperature	Monthly Average	
Ambient Temp Avg - Jan	-20	°C
Ambient Temp Avg - Feb	-20	°C
Ambient Temp Avg - Mar	-10	°C
Ambient Temp Avg - Apr	10	°C
Ambient Temp Avg - May	20	°C
Ambient Temp Avg - Jun	30	°C
Ambient Temp Avg - Jul	30	°C
Ambient Temp Avg - Aug	30	°C
Ambient Temp Avg - Sep	20	°C
Ambient Temp Avg - Oct	10	°C
Ambient Temp Avg - Nov	10	°C
Ambient Temp Avg - Dec	-10	°C
Top Oil Temperature	Computed	

<< | XfmrStat | Thermal | Tap Chnr

The transformer winding settings are used for calculation of the winding nominal current, and the load loss at rated load. The ratio of the actual load to the rated load K is used in the Hottest-spot temperature computation. If the load loss at rated load is not available from the transformer’s test report, use the following formulae to calculate it.

$P_R = I_{n(W)}^2 * R$, where $I_{n(W)}$ is the winding rated current, and R is the three phase series resistance.

- Refer to **Setpoints > System > Transformer > Thermal Inputs** menu, and select the inputs for Ambient temperature and Top-Oil temperature. If no transducer is available to measure Ambient temperature, select the "Monthly Average" setting, and enter the approximate average temperature per month in the monthly calendar menu. If Top-Oil temperature measurement is not available, select the setting "Computed".

..\System\Transformer\Thermal Inputs

Setpoints	Value	Unit
Winding Currents	CT Bank 1-J1	
Ambient Temperature	Monthly Average	
January	-20	° C
February	-20	° C
March	-20	° C
April	7	° C
May	15	° C
June	25	° C
July	30	° C
August	30	° C
September	20	° C
October	17	° C
November	14	° C
December	9	° C
Top-Oil Temperature	Computed	

<< | Status | Thermal | Tap Chan

..\Setpoints\RTD Temperature\RTD 1

Setpoints	Value	Unit
Function	Disabled	
Name	RTD 1	
Type	100 W Platinum	
Trip Temperature	155	º C
Trip Pickup Delay	2	s
Trip Dropout Delay	0	s
Trip Output Relay X	Do Not Operate	
Alarm Function	Disabled	
Alarm Temperature	130	º C
Alarm Pickup Delay	2	s
Alarm Dropout Delay	0	s
Alarm Output Relay X	Do Not Operate	
Sensor Open	None	
Block	Off	
Events	Enabled	
Targets	Latched	

RTD 1 | RTD 2 | RTD 3 | RTD 4 | >>

NOTE

To change the temperature unit, i.e. Fahrenheit, Celsius go to **Setpoints > Device > Front Panel** menu.

The inputs for Ambient Temperature and Top-Oil Temperature from Thermal Inputs menu include selection of RTDs. The selected RTDs must be programmed, for the temperature to be measured on the relay and be included in the calculation for hottest-spot winding temperature.

Winding Hottest

HOTTEST-SPOT TEMPERATURE

The Hottest-Spot Temperature element provides the mechanism for detecting the hottest-spot winding temperatures inside the transformer. It can be set to alarm or trip in cases where the hottest-spot temperature (as computed by the relay) is above the PKP threshold for the specified time, this is considered an overheated transformer.

Path: Setpoints > Monitoring > Transformer > Hottest-Spot Temperature

FUNCTION

Range: Disabled, Alarm, Latched Alarm, Configurable

Default: Disabled

PICKUP

Range: 50 to 300 in steps of 1 degree (in degrees˚F or °C)

Default: 140

Enter the hottest-spot temperature required for operation of the element. This setting must be defined based on the maximum permissible hottest-spot temperature under emergency transformer loading conditions, and the maximum ambient temperature.

PICKUP DELAY

Range: 0 to 60000 min in steps of 1 min

Default: 1 min

This setting is used to select a pickup time delay that is used to delay the operation of the protection.

OUTPUT RELAY 1 (X)

Range: Do Not Operate, Operate

Default: Do Not Operate

The menu includes a list of available output relays to be set for operation or no operation upon protection operation.

BLOCK

Range: Off, Any FlexLogic operand

Default: Off

EVENTS

Range: Enabled, Disabled

Default: Enabled

The selection of the **Enabled** setting enables the events function.

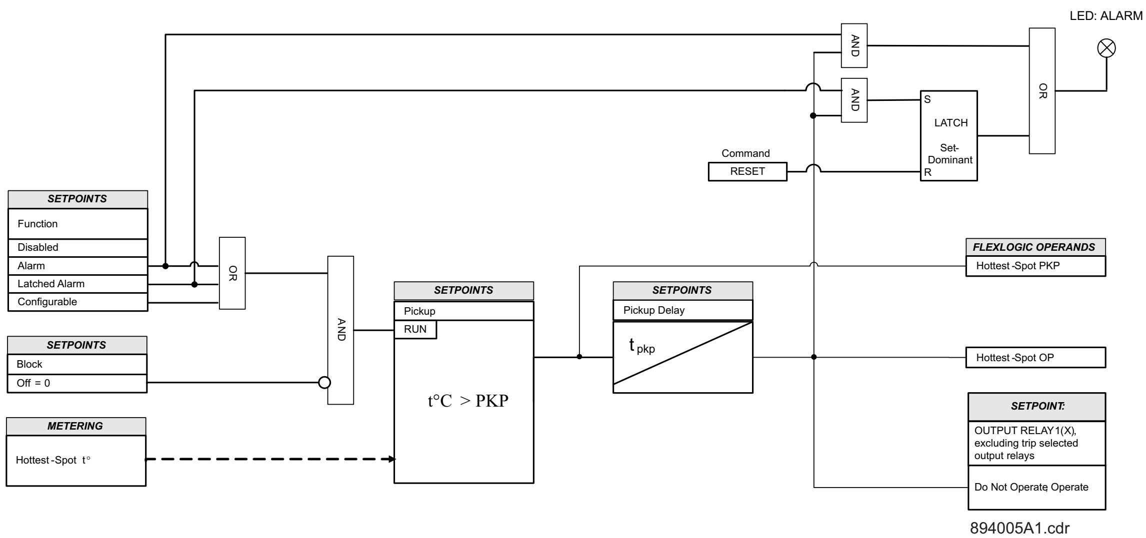
TARGETS

Range: Disabled, Self-reset, Latched

Default: Self-reset

The selection of the **Self-reset** or **Latched** settings enables the target messages of the function.

Figure 7-3: Hottest-Spot Logic diagram



Aging Factor

The Aging Factor element detects the aging of the transformer in per unit normal insulation aging. The element can be set for an alarm or trip, whenever the actual aging factor (as computed by the relay) is bigger than the (defined as acceptable) setting of the aging factor PKP for the specified time delay.

Path: Setpoints > Monitoring > Transformer > Aging Factor

FUNCTION

Range: Disabled, Alarm, Latched Alarm, Configurable

Default: Disabled

PICKUP

Range: 1.1 to 10.0 in steps of 0.1

Default: 2.0

Enter a setting for the aging factor, above which the element will operate. The setting must be above the maximum permissible aging factor under emergency loading conditions, and maximum ambient temperature.

PICKUP DELAY

Range: 0 to 60000 min in steps of 1 min

Default: 10 min

This setting is used to select a pickup time delay that is used to delay the operation of the protection.

OUTPUT RELAY 1 (X)

Range: Do Not Operate, Operate

Default: Do Not Operate

The menu includes a list of available output relays to be set for operation or no operation upon protection operation.

BLOCK

Range: Off, Any FlexLogic operand

Default: Off

The Neutral IOC is blocked when the selected operand is asserted.

EVENTS

Range: Enabled, Disabled

Default: Enabled

The selection of the **Enabled** setting enables the Events function.

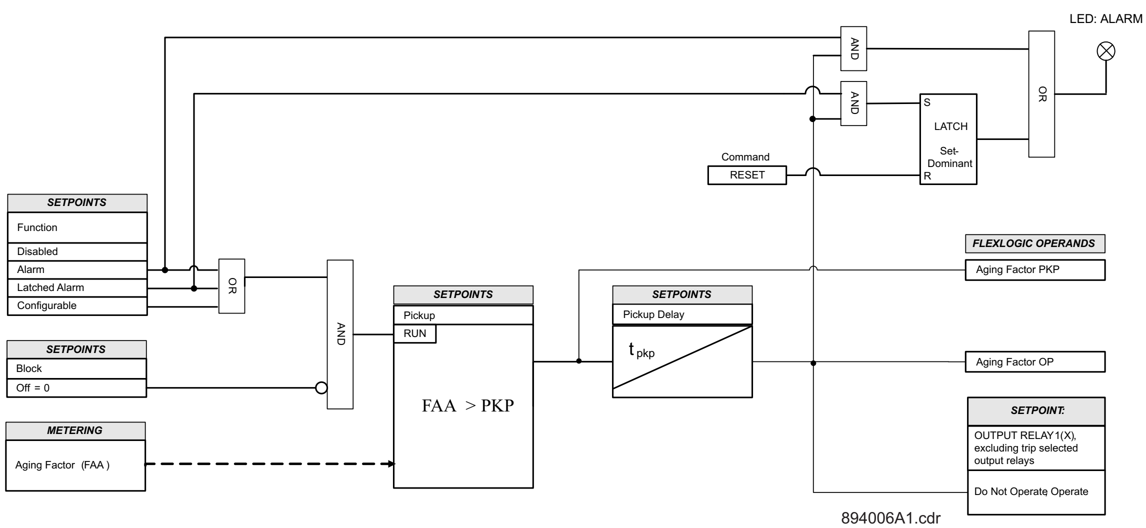
TARGETS

Range: Disabled, Self-reset, Latched

Default: Self-reset

The selection of the **Self-reset** or **Latched** settings enables the target messages of the function.

Figure 7-4: Aging Factor Logic diagram



Loss of Xfmr Life

The Loss of Life (LOL) element provides a mechanism for detecting the accumulated total consumed transformer life. It can be set to issue an alarm or trip, when the actual accumulated transformer loss of life is higher than what is specified by the user loss of life pickup setpoint. For brand new installed transformers, the setting for “XFMR INITIAL LOSS” is “0”, and for already installed transformers, the user must estimate the consumed transformer life in hours, being in service.

Path: **Setpoints > Grouped Elements > Setting Group 1(8) > Transformer > Loss of Xfmr Life**

FUNCTION

Range: Disabled, Alarm, Latched Alarm, Configurable

Default: Disabled

INITIAL XFMR LOL

Range: 1 to 500000 hours in steps of 1 hr

Default: 0 hours

Enter a setting for the consumed transformer life in hours. When the LOL element is enabled, the loss of life computed by the relay is added to the initial loss of life in hours.

PICKUP

Range: 0 to 500000 hours in steps of 1 hr

Default: 200000 hours

Enter the expected life, in hours, required for operation of the element. This setting must be above the total transformer life set as a reference based on nominal loading conditions, and 30° C ambient temperature, as outlined in the IEEE standards.

BLOCK

Range: Off, Any FlexLogic operand

Default: Off

The Neutral IOC is blocked when the selected operand is asserted.

OUTPUT RELAY 1(X)

Range: Do Not Operate, Operate

Default: Do Not Operate

The menu includes a list of available output relays to be set for operation or no operation upon protection operation.

EVENTS

Range: Enabled, Disabled

Default: Enabled

The selection of the **Enabled** setting enables the Events function.

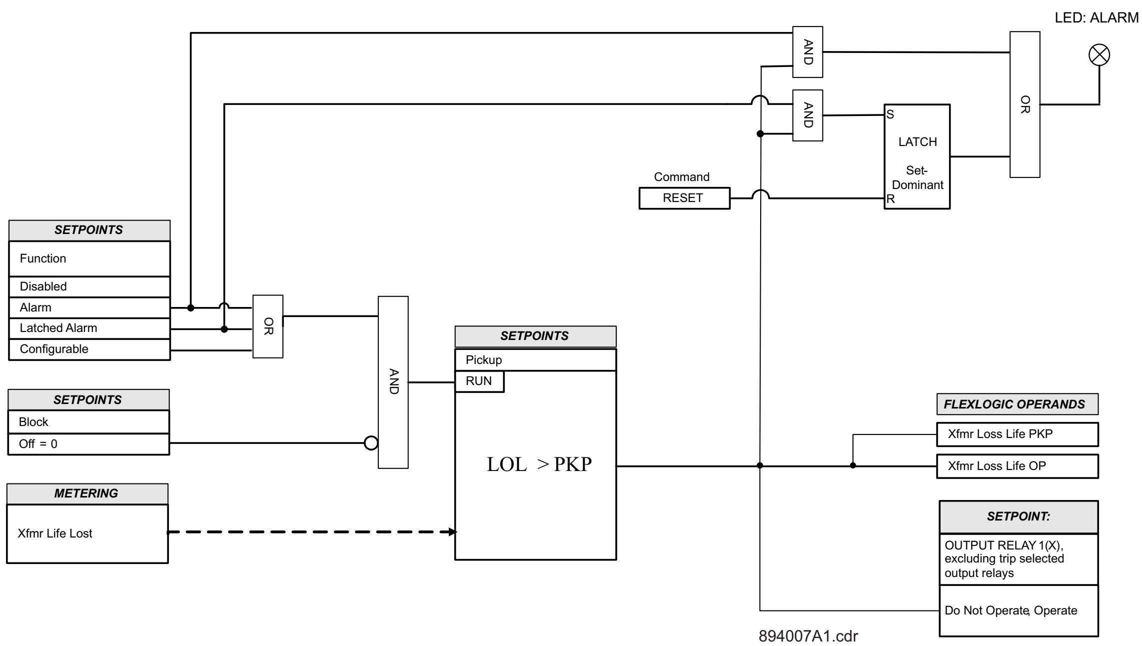
TARGETS

Range: Disabled, Self-reset, Latched

Default: Self-reset

The selection of the **Self-reset** or **Latched** settings enables the target messages of the function.

Figure 7-5: Loss of Life Logic diagram



Tap Changer Failure

The Tap Changer Failure element compares the actual tap changer position with the maximum and minimum set values. The element picks up when the measured tap position actual value exceeds by one tap step the value programmed for maximum tap, or when it is lower by one tap step than the value programmed for minimum tap. The minimum and maximum taps are set in Max Tap and Min Tap setpoints respectively under **Setpoints > System > Transformer > On-load Tap Changer**. If this condition persists for the time selected as a Delay setpoint, the element will operate.

NOTE

The Tap Changer Failure element will not be able to detect tap failure , if the Min Tap and Max Tap setpoints Input from the Tap Changer setup menu are set to the minimum and maximum available values from the range. This applies to any of the three methods used for tap position detection – BCD, DCmA, and Ohms. To be able to successfully detect Tap changer failure, the selected Ohms or DCmA at Tap Min must be bigger than the smallest measured Ohms or DCmA values by a value corresponding to at least one tap step, and the selected Ohms or DCmA values must be smaller than the highest Ohm or DCmA measured value by a value corresponding to at least one tap step

If the Tap position is used for compensation of the differential current due to the new transformation ratio and the tap position is detected below the Minimum, or above the Maximum tap , the relay may show small differential current. If the percent differential protection is set to a very sensitive pickup level, this differential current may cause operation. To avoid such undesired operation, it is wise to de-sensitize the protection until the tap position is detected back in the range between the minimum and maximum tap. For this reason either operand **TC at Min Tap**, or **TC at Max Tap** from the Tap changer Setup, or **The Tap Changer Fail PKP** can be used for setpoint group change, where the Percent differential protection can be enabled with less sensitive settings.

Path: **Setpoints > Monitoring > Transformer > Tap Changer Failure**

FUNCTION

Range: Disabled, Alarm, Latched Alarm, Configurable
Default: Disabled

DELAY

Range: 0.00 to 600.00 s in steps of 0.01 s
Default: 5.00 s

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

OUTPUT RELAYS

Range: Do Not Operate, Operate
Default: Do Not Operate

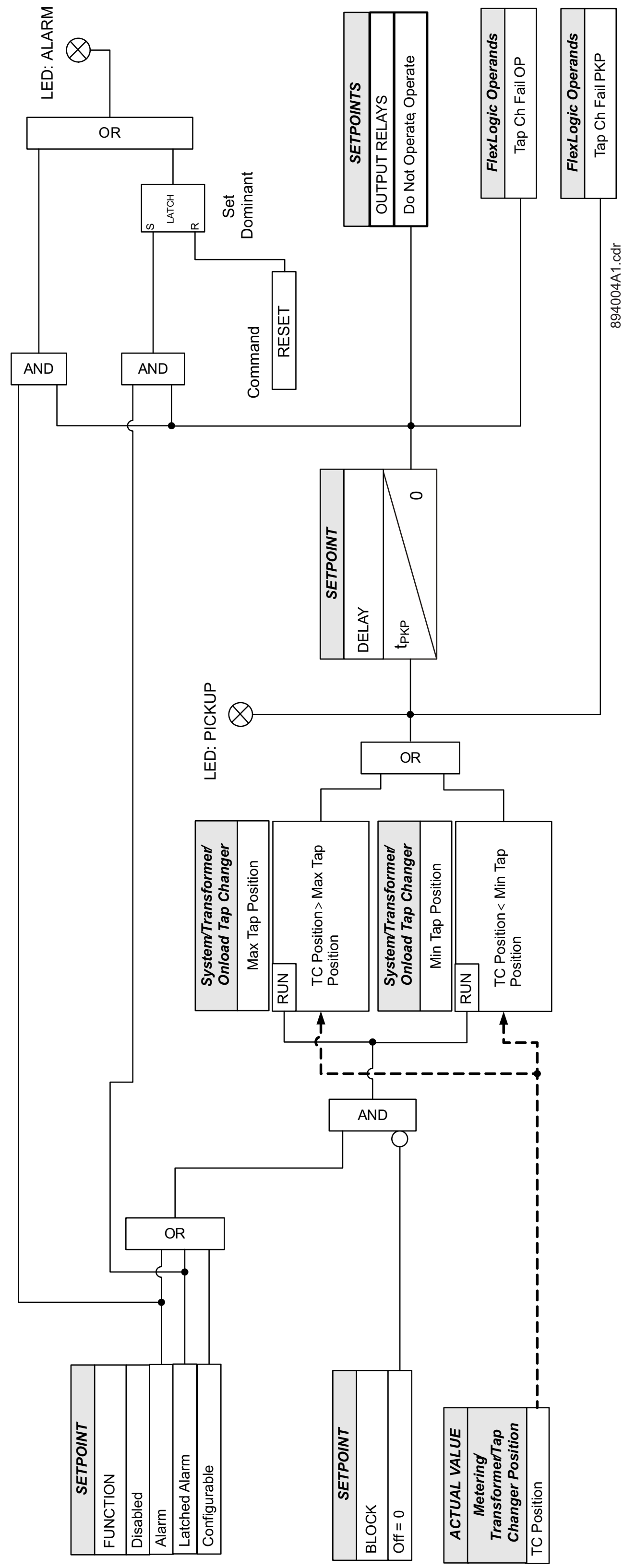
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Latched

Figure 7-6: Tap Changer Failure logic diagram



Trip and Close Circuit Monitoring

The 845 relay provides Trip and Close Circuit Monitoring elements per breaker.

The first and second auxiliary relay outputs from the I/O card on slot "F" are Form-A outputs which include a circuit to monitor the DC voltage across the output contact when it is open. To do that, an external jumper is wired between the "FA_# COM" and "FA_# OPT/V" terminals as shown on the diagrams for Trip and Close breaker circuits. This also applies for the first two auxiliary relays, if the same type I/O card is installed on slot "G"

The monitor contains a level detector whose output is set to logic 1 (ON) when the voltage is above 20 volts. The voltage monitor is used to check the health of the overall trip and closing circuit.

The two figures below show the two different connections of the breaker trip and close coils to the relay's trip and close output relays for either no voltage monitoring and for voltage monitoring of the circuits.

Figure 7-7: Trip Coil Circuit without Monitoring

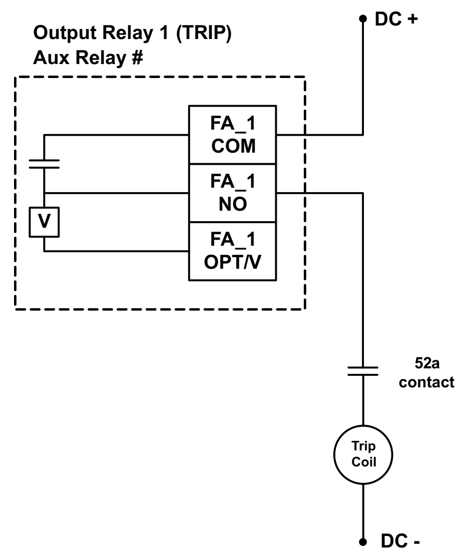


Figure 7-8: Close Coil Circuit without Monitoring

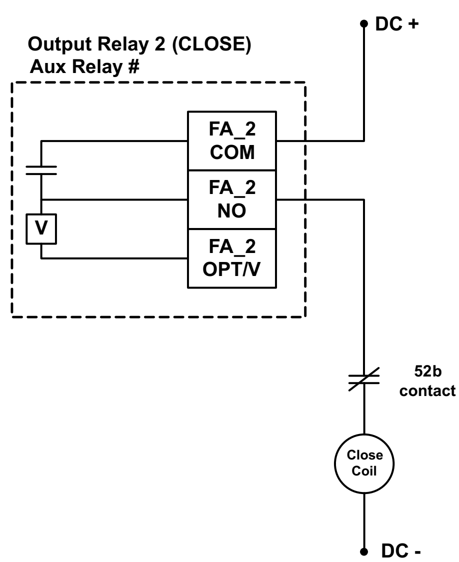


Figure 7-9: Trip Coil Circuit with Monitoring

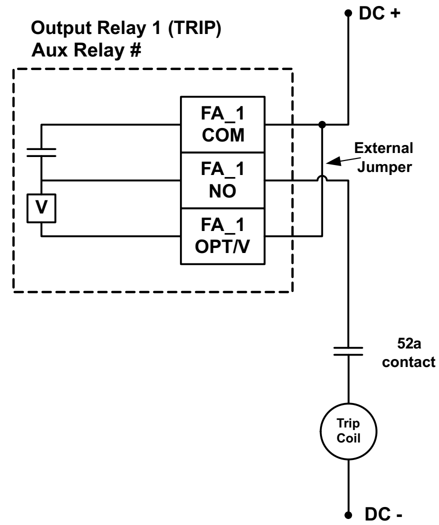
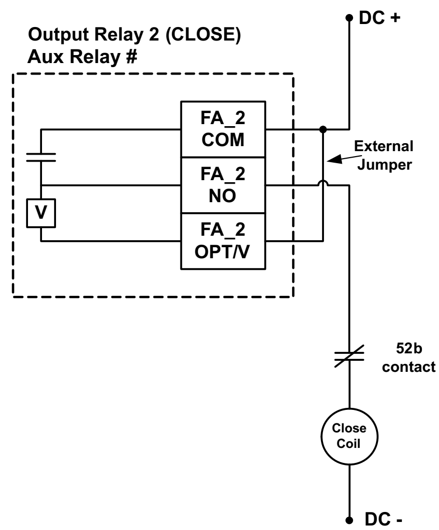
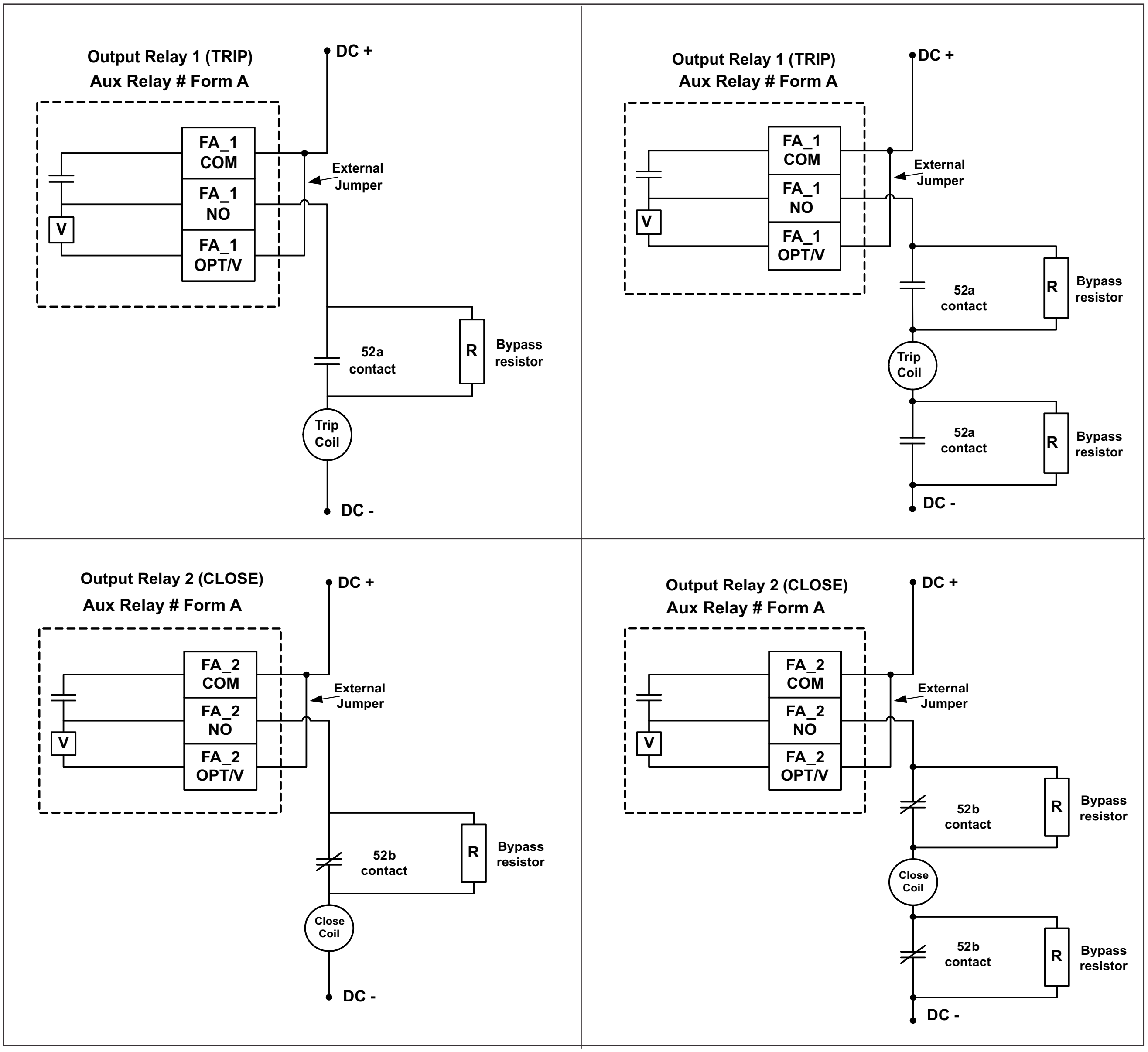


Figure 7-10: Close Coil Circuit with Monitoring



Some applications require monitoring the Trip coil or/and Close coil continuously, regardless of the breaker position (open or closed). This can be achieved by connecting a suitable resistor (see the table *Value of Resistor "R"*) across the breaker auxiliary contact(s) 52a in the trip circuit (across 52b contact(s) for Close coil). With such connections, the trickle current is maintained by the resistor. For these applications the setting for the Bypass Breaker Status should be set to ENABLED.

Figure 7-11: Trip/Close Coil Circuits with Continuous Monitoring



By default when 845 relay is ordered for protection of two-winding transformer, the I/O card from slot "F" is equipped with two form A, and three form C auxiliary relays, and seven contact inputs. The form A auxiliary relays can be used for monitoring of the trip circuits for each of the two transformer breakers. If desired, the 845 can be ordered with a second I/O card on slot "G", which will provide two more form A aux relays for monitoring of the close circuits for both transformer breakers. Please note, that the selected default auxiliary relays for "Trip Output Select" of Breaker 1, and Breaker 2 are Aux Relay 1, and Aux Relay 2 respectively. Form A relays for closing of the breakers are not selected: Close Output Select set to "Off". The assignment of Aux Relays for Trip Output Select, and Close Output Select setpoints per breaker is up to the user.By default when 845 relay is ordered for protection of three-winding transformer, there will be two I/O cards: one on slot "F", and another one from the same type on slot "G". Please note, that the selected default auxiliary relays for "Trip Output Select" of Breaker 1, Breaker 2, and Breaker 3 are Aux Relay 1, Aux Relay 2 and

Auxiliary Relay 9 respectively. Form A relays for closing the breakers are not selected: Close Output Select set to "Off". The user can change the default aux relays, with any other aux relays for Trip and Close per each breaker.

NOTE

The menu for Trip or/and Close Coil Monitoring for any of the transformer breakers is available only if a Form A auxiliary relay is selected for the Trip Output Select and/or Close Output Select setpoints under **Setpoints > System > Breakers > Breaker 1(X)**. The menu for coil monitoring is not available if a normal Form C aux relay is selected.

Table 7-1: Value of Resistor "R"

Power Supply (V DC)	Resistance (Ohms)	Power (Watts)
24	1000	2
48	10000	2
110	25000	5
125	25000	5
220	50000	5

DANGER

Trip and Close Contacts must be considered unsafe to touch when the relay is energized.

TRIP CIRCUIT MONITORING

Path: **Setpoints > Monitoring > Breaker 1 > Trip Circuit Monitoring**

FUNCTION:

Range: Disabled, Latched Alarm, Alarm, Configurable
Default: Disabled

PICKUP DELAY:

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 10.000 s

DROPOUT DELAY:

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 0.000 s

This setting provides selection for reset time delay used to delay the dropout of the detection of the overcurrent condition.

BYPASS BREAKER STATE:

Range: Enabled, Disabled
Default: Disabled

Set the Bypass Breaker State to Enabled when a by-pass resistor is connected across the breaker auxiliary contact for continuous Trip circuit monitoring. The circuits are monitored regardless of breaker position.

BLOCK:

Range: Off, Any FlexLogic operand
Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

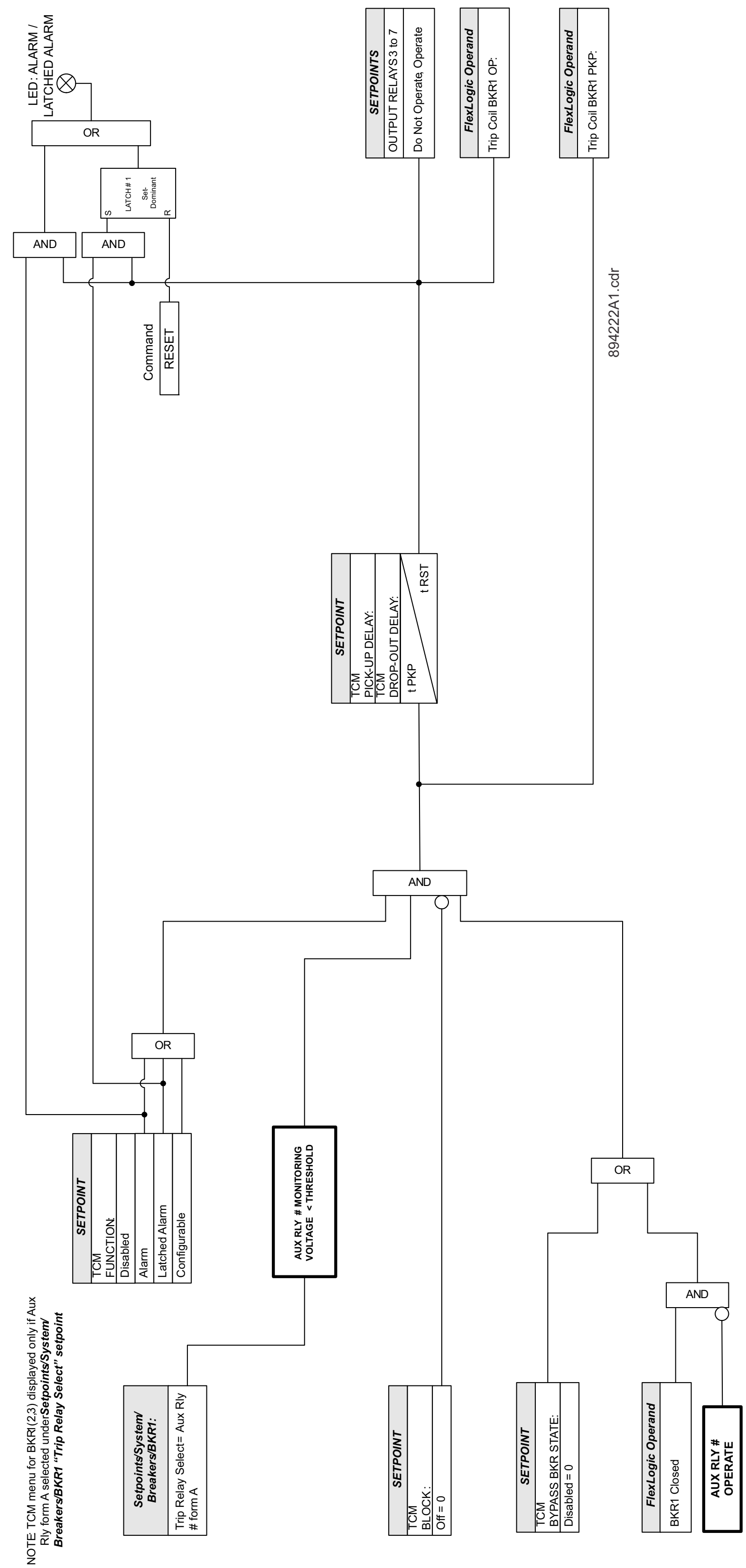
EVENTS:

Range: Disabled, Enabled
Default: Enabled

TARGETS:

Default: Self-reset
Range: Disabled, Self-reset, Latched

Figure 7-12: Trip Circuit Monitoring logic diagram for Breaker 1 (Breaker 2 and Breaker 3)



CLOSE CIRCUIT MONITORING

Path: Setpoints > Monitoring > Breaker 1 > Close Circuit Monitoring

FUNCTION:

Range: Disabled, Latched Alarm, Alarm, Configurable
Default: Disabled

PICKUP DELAY:

Default: 10.000 s
Range: 0.000 to 6000.000 s in steps of 0.001 s

DROPOUT DELAY:

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 0.000 s

BYPASS BREAKER STATE:

Range: Enabled, Disabled
Default: Disabled

Set the Bypass Breaker State to Enabled when a by-pass resistor is connected across the breaker auxiliary contact for continuous Close circuit monitoring. The circuits are monitored regardless of breaker position.

OUTPUT RELAY X

Range: Do Not Operate, Operate
Default: Do Not Operate

BLOCK:

Default: Off
Range: Off, Any FlexLogic operand

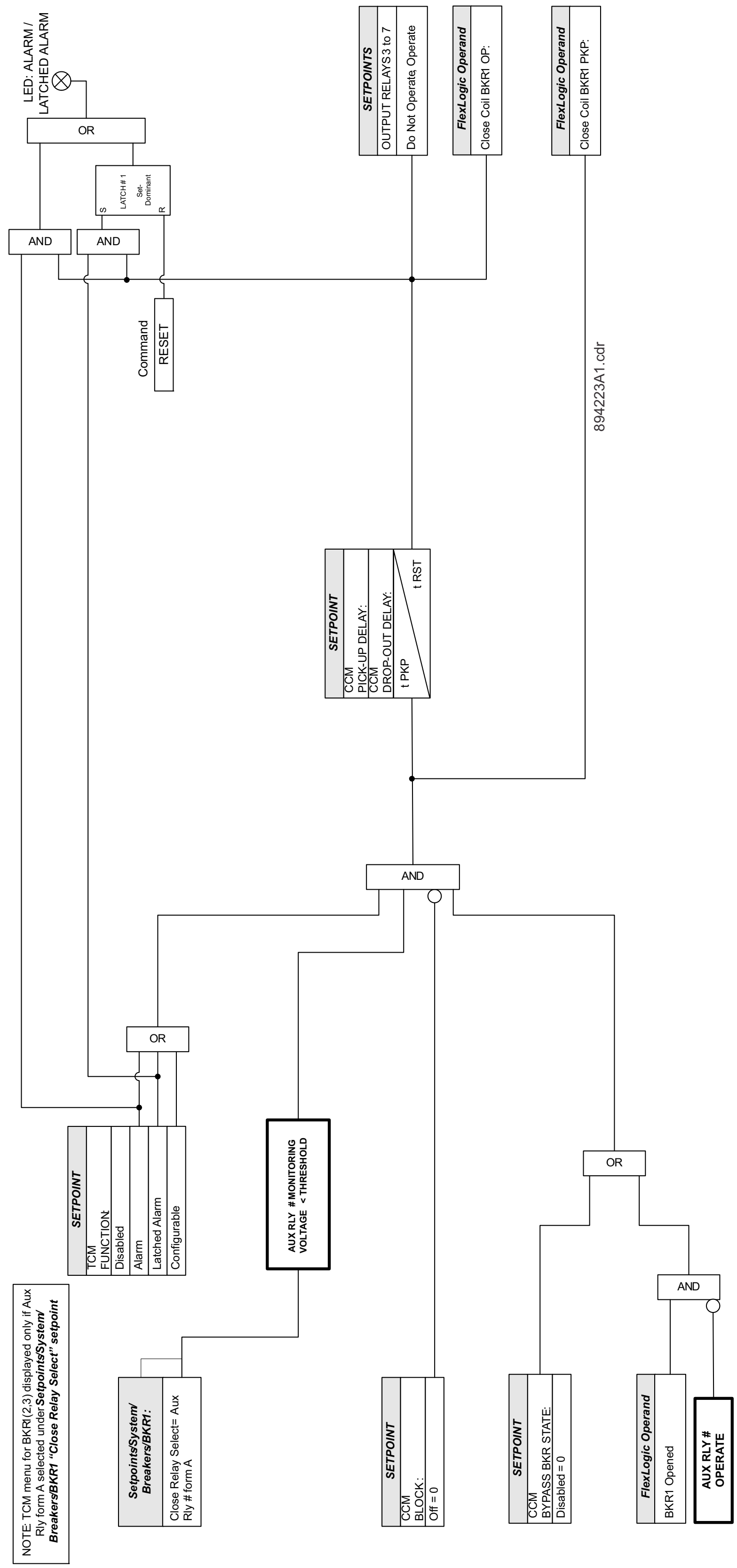
EVENTS:

Range: Disabled, Enabled
Default: Enabled

TARGETS:

Range: Disabled, Self-reset, Latched
Default: Self-reset

Figure 7-13: Close Circuit Monitoring Diagram

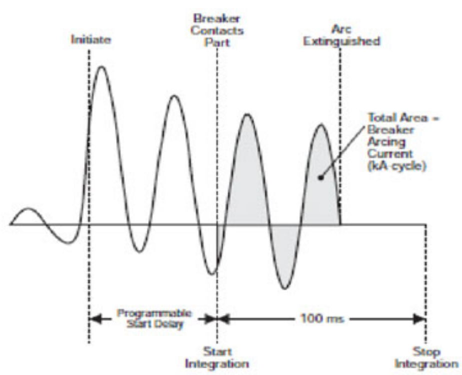


Breaker Arcing Current

The 845 relay provides one Breaker Arcing Current element.This element calculates an estimate of the per-phase wear on the breaker contacts by measuring and integrating the current squared passing through the breaker contacts as an arc. These per-phase values are added to accumulated totals for each phase and compared to a programmed threshold value. When the threshold is exceeded in any phase, the relay can set an output operand and set an alarm. The accumulated value for each phase can be displayed as an actual value.

The same output operands that are selected to operate the Trip output relay that is used to trip the breaker indicating a tripping sequence has begun, are used to initiate this feature. A time delay is introduced between initiation and starting of integration to prevent integration of current flow through the breaker before the contacts have parted. This interval includes the operating time of the output relay, any other auxiliary relays and the breaker mechanism. For maximum measurement accuracy, the interval between the change-of-state of the operand (from 0 to 1) and contact separation should be measured for the specific installation. Integration of the measured current continues for 100 ms, which is expected to include the total arcing period.

Figure 7-14: Breaker Arcing Current Measurement



Path: **Setpoints > Monitoring > Breaker > BKR 1 Monitor > BKR 1 Arcing Current**

FUNCTION

Range: Disabled, Alarm, Latched Alarm, Configurable
Default: Disabled

SIGNAL INPUT

Range: dependant upon the order code
Default: CT Bank1-J1

INITIATION

Range: Off, Any FlexLogic operand
Default: Off

The setpoint selects the FlexLogic operand, digital input, virtual input or remote input that initiates the Breaker Arcing Current scheme, typically the Trip signals from internal protection functions.

DELAY

Range: 0.000 to 6000.00 s in steps of 0.001 s
Default: 0.030 s

The setpoint provides a delay interval between the time the tripping sequence is initiated and the time the breaker contacts are expected to part, starting the integration of the measured current.

ALARM LEVEL

Range: 0 to 50000 kA2-c in steps of 1 kA2-c
Default: 1000 kA2-c

The setpoint specifies the threshold value (kA2-cycle) above which the output operand is set.

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

OUTPUT RELAYS X

For details see Common Setpoints.

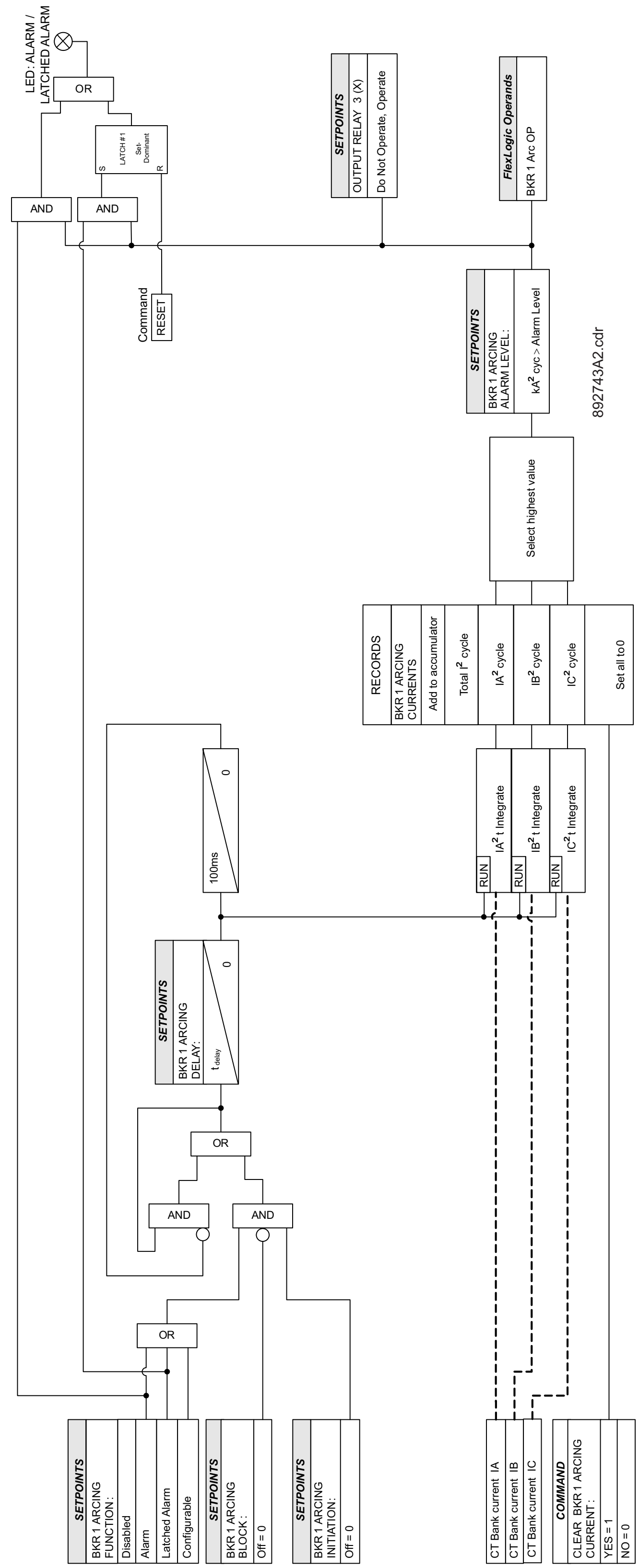
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Self-reset, Latched, Disabled
Default: Self-reset

Figure 7-15: Breaker Arcing Current logic diagram



Breaker Health

The 845 relay provides breaker health information by monitoring and analyzing the operation count, arcing energy of breaking current, arcing time, tripping time, closing time and spring charging time if applicable. The breaker health status depends on many factors, such as permissible operation number, magnitude of breaking current, mechanical wear and contact wear.

The operation count is able to give direct information by comparing it with the permissible operation number. The longer tripping time and closing time can provide an approximate estimation of trip/close coils and mechanical wear. The increasing spring charging time may imply developing problems in motor and spring mechanisms. Meanwhile, the increase in arcing energy of the breaking current may reflect the possibility of contact wear. Longer arcing time may suggest the loss of dielectric strength in the arc chamber. If the arcing energy or any of the time intervals is above the related Pickup levels for the use-defined times, the ALARM LED is lit.

The scheme is equipped with three incomplete sequence timers for Trip/Close time, arc time and spring charge time respectively. So it automatically resets the related time interval after the programmed delay.

A breaker operation function is also included, where breaker operation failure is caused by either of the following conditions:

- The breaker does not respond to a Trip command within the programmed breaker operation delay time.
- The breaker does not respond to a Close command within the programmed time.

Path: **Setpoints > Monitoring > Breaker 1 > Breaker Health**

FUNCTION

Range: Disabled, Alarm, Latched Alarm, Configurable

Default: Disabled

MODE

Range: Detection, Monitoring

Default: Detection

The Breaker Health has two running modes: detection and monitoring. Since the monitored time intervals differ for different breaker types and manufacturers, the detection mode can be used to help set the Pickup settings based on the historical true values. The operation count, arcing energy of the breaking current, arcing time, tripping time, closing time and spring charging time are measured and displayed in 'Records/ Breaker Health,' But the element does not pick up when in detection mode. Monitoring mode is the normal mode, wherein measurements are analyzed and the element may pick up accordingly.

PRESET TRIP COUNTER

Range: 0 to 100000 in steps of 1

Default: 0

This setting pre-sets the actual operation number when the relay is starting in service or the record is cleared.

TRIP TRIGGER

Range: Off, Any FlexLogic operand

Default: Off

This setting assigns the trip initiation signal.

CLOSE TRIGGER

Range: Off, Any FlexLogic operand
Default: Off

This setting assigns the close initiation signal.

OPEN STATUS

Range: Off, Any FlexLogic operand
Default: Off

The setting selects the signal to show the open status of the breaker. If the contact input is not configured, the detection of open status is delayed by an extra debouncing time.

CLOSE STATUS

Range: Off, Any FlexLogic operand
Default: Off

The setting selects the signal to show the close status of the breaker. If the contact input is not configured, the detection of close status is delayed by an extra debouncing time.

SPRING CHARGE STATUS

Range: Off, Any FlexLogic operand
Default: Off

The setting selects the signal to show the status of Spring Charge. Normally, the contact input connected to the auxiliary contact of the limit switch can be used.

TRIP TIME PICKUP

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 0.050 s

The setting sets the Pickup level of the Trip time. The Trip time interval is initiated by the TRIP TRIGGER signal and stopped by the OPEN STATUS signal.

CLOSE TIME PICKUP

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 0.050 s

The setting sets the Pickup level of the Close time. The Close time interval is initiated by the CLOSE TRIGGER signal and stopped by the CLOSE STATUS signal.

INCOMPLETE TRP/CLS TIME

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 0.100 s

The setting declares a breaker operation failure condition if the breaker does not respond within this time delay. The setting should be greater than the Trip time PKP value and Close time PKP value.

ARC TIME PICKUP

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 0.100 s

The setting sets the Pickup level of the Arc time. The Arc time is initiated by the OPEN STATUS signal and stopped when the current samples in one cycle are less than 0.02 CT. Then the Arc time is equal to the calculated time interval minus one cycle.

INCOMPLETE ARC TIME

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 0.300 s

The setting declares an Arc time failure condition if there are currents flowing through the breaker after this time delay. This setting should be greater than the Arc time PKP value.

SPRING CHARGE TIME PICKUP

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 15.000 s

This setting sets the Pickup level of the Spring Charge time. The Spring Charge time is measured from the pulse duration of the SPRING CHARGE STATUS.

INCOMPLETE CHARGE TIME

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 45.000 s

The setting declares a Charge time failure condition if the spring charging process is not finished after this time delay. The setting should be greater than the Charge time PKP value.

ARC ENERGY PICKUP

Range: 1 to 100000 kA2-c in steps of 1 kA2-c
Default: 1000 kA2-c

The setting sets the Pickup level of the arc energy. The arc energy value is calculated in the Breaker Arcing Current element.

NOTICE

The ACR ENERGY is calculated by the breaker arcing current element. If the breaker arcing current element is disabled, the ACR ENERGY is not calculated and this setting should not be used. The ACR ENERGY used here is the individual value for each trip and not the accumulated value recorded in the Breaker Arcing Current element.

ALARM COUNTER

Range: 1 to 100 in steps of 1
Default: 5

The setting sets the alarm counter level. One counter is used to accumulate the Pickup data from all monitoring quantities. If the counter value is above the alarm counter level, the LED is lit and one operand is asserted.

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

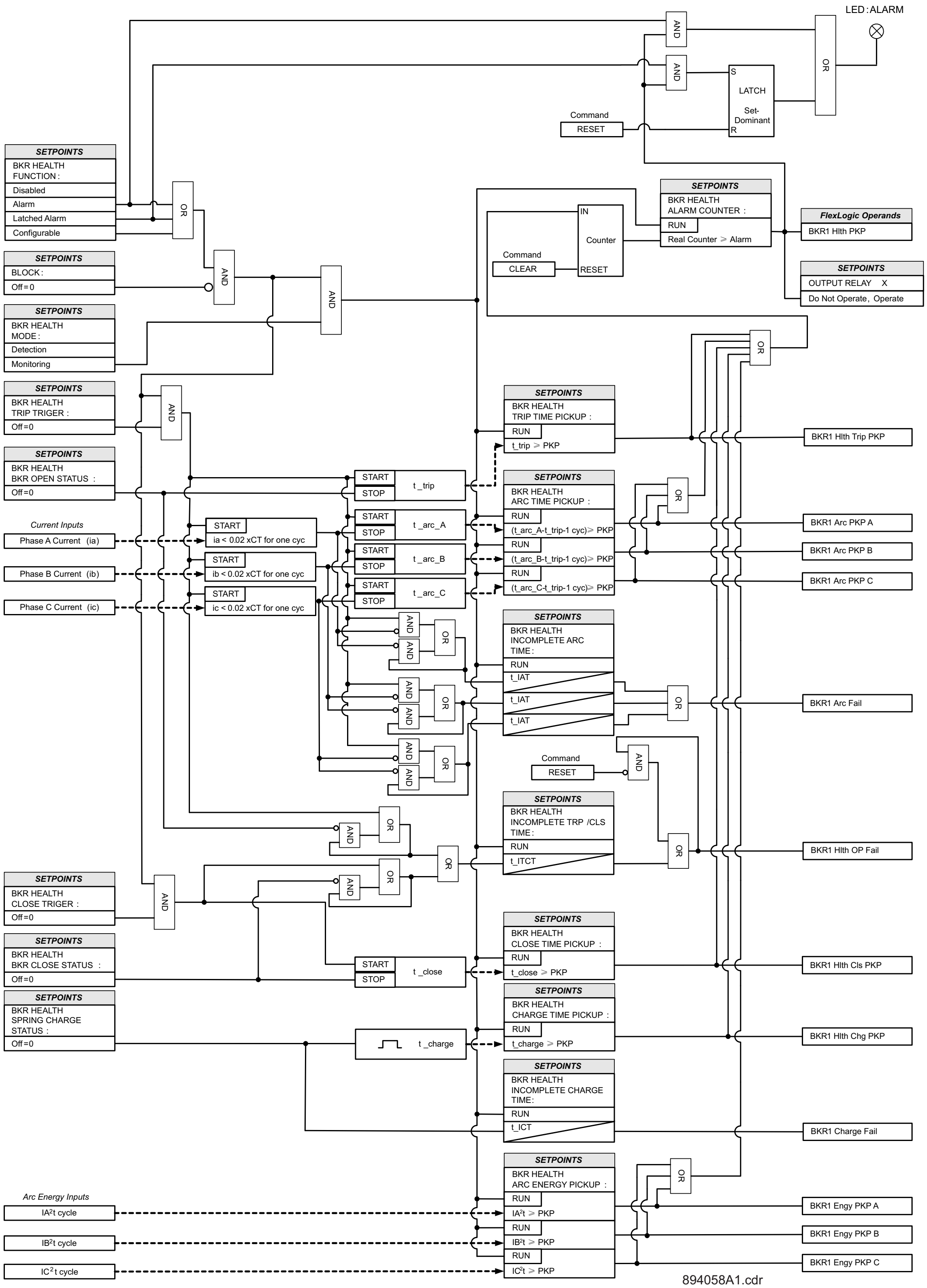
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Self-reset

Figure 7-16: Breaker Health and Operation logic diagram



Functions

Power Factor (55)

It is generally desirable for a system operator to maintain the Power Factor as close to unity as possible to minimize both costs and voltage excursions. Since the Power Factor is variable on common non-dedicated circuits, it is advantageous to compensate for low (lagging) Power Factor values by connecting a capacitor bank to the circuit when required. The relay allows two stages of capacitance switching for Power Factor compensation.

The relay calculates the average Power Factor in the three phases as follows:

Average Power Factor = Total 3-Phase Real Power / Total 3-Phase Apparent Power

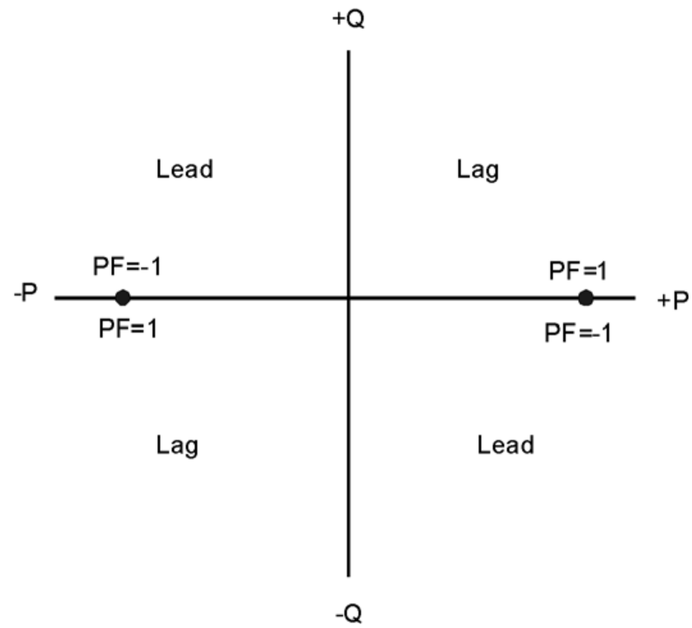
When the measured Power Factor becomes more lagging or leading (depending on the user setting) than the Switch-In level, the relay operates a user-selected output contact. This output can be used to control a switching device which connects capacitance to the circuit, or to signal an alarm to the system operator. After entering this state, when the Power Factor becomes less lagging or leading than the Power Factor Switch-Out level for a time greater than the set delay, the relay resets the output contact to the non-operated state.

For delta-connected VTs, the Power Factor feature is inhibited from operating unless all three voltages are above a threshold and one or more currents are above 0.002 × CT. Power Factor element delay timers are only allowed to time when the voltage threshold is exceeded on all phases and the Power Factor remains outside of the region between the programmed Switch-In and Switch-Out levels. In the same way, when a Power Factor condition starts the Power Factor delay timer, if all three phase voltages fall below the threshold before the timer has timed-out, the element resets without operating. A loss of voltage during any state returns the Power Factor element(s) to the Reset state.

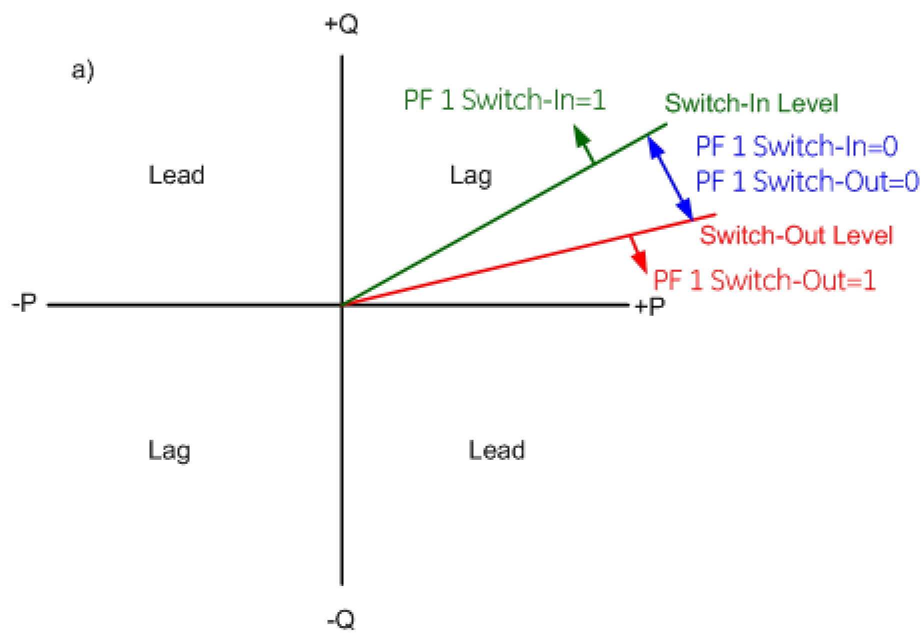
For wye-connected VTs, the power factor value is calculated from the valid phase(s) with a voltage that is above a user-selected threshold and a current that is above 0.002 × CT. Power Factor element delay timers are only allowed to time when the supervision conditions are met and the Power Factor remains outside of the region between the programmed Switch-In and Switch-Out levels. In the same way, when a Power Factor condition starts the Power Factor delay timer, if one or more valid phases no longer satisfy the supervision conditions, the power factor will be re-calculated based on the still valid phase(s). If the element is continuously asserted with the new power factor value, the timer will continue timing, otherwise, the element will reset without operating.

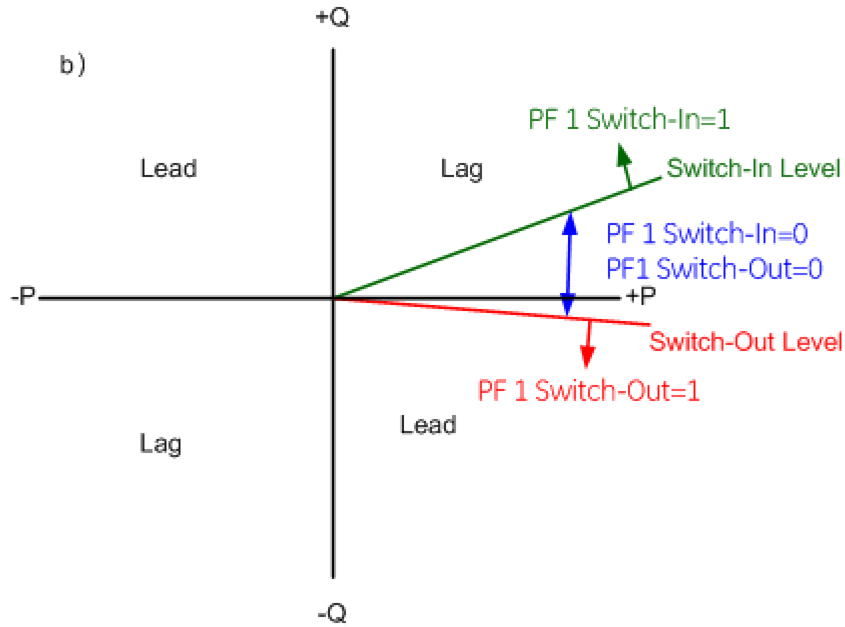
The following figure illustrates the conventions established for use in 845 relays, where the negative value means the lead power factor, and the positive value means the lag power factor.

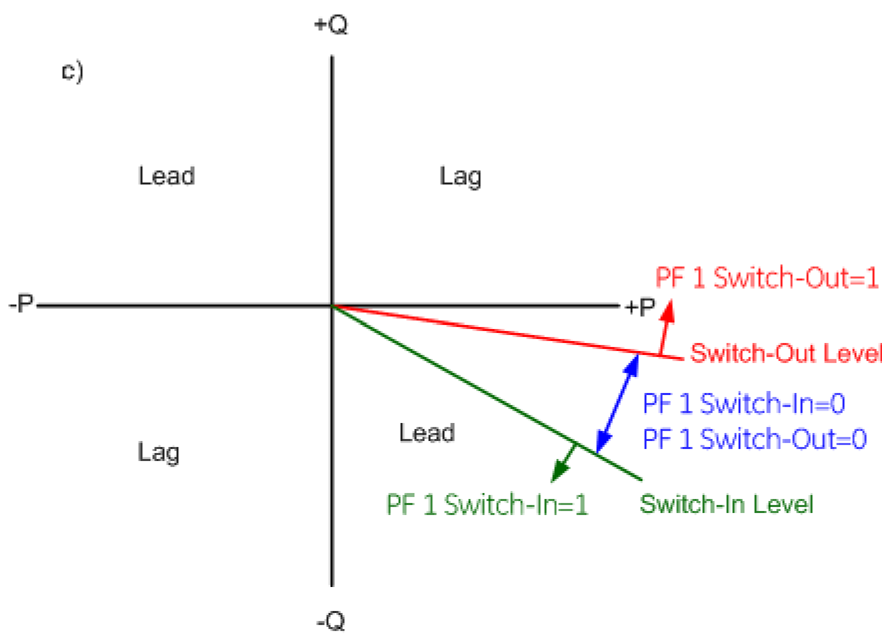
Figure 7-17: Conventions for Power Factor

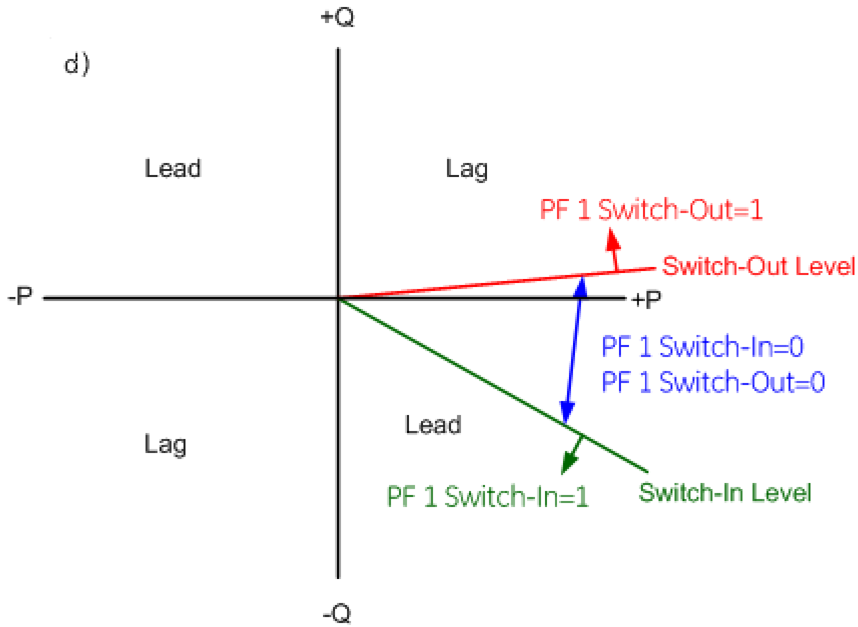


For example, the applications of Switch-In and Switch-Out levels are shown in the figures below.




+Q
b)
PF 1 Switch-In=1
Lead
Lag
Switch-In Level
PF 1 Switch-In=0
PF1 Switch-Out=0
-P
+P
Switch-Out Level
PF 1 Switch-Out=1
Lead
Lag
-Q


+Q
c)
Lead
Lag
PF 1 Switch-Out=1
-P
+P
Switch-Out Level
PF 1 Switch-In=0
PF 1 Switch-Out=0
Lead
Lag
PF 1 Switch-In=1
Switch-In Level
-Q



The settings of this function produces Switch-In, Switch-Out and Operate flags. The Power Factor Switch-In flag is asserted when the absolute value of the calculated Power Factor is below the Switch-In value, and supervision conditions are satisfied. The Power Factor Operate flag in the Switch-In level is asserted if the element stays switched-in for the time defined by the time delay. After the element drops from Switch-In, the Power Factor Switch-Out flag is asserted when the Power Factor passes the Switch-Out value. The Power Factor Operate flag in the Switch-Out level is asserted if the element stays switched out for the time defined by the time delay.

The minimum operating voltage is set as a threshold below which the element is reset.

Path: **Setpoints > Monitoring > Functions > Power Factor 1(X)**

FUNCTION

Range: Disabled, Alarm, Latched Alarm, Configurable
Default: Disabled

SWITCH-IN

Range: -0.01 to -0.99, 1, 0.99 to 0.01 (for 8 Series Enervista Setup software: 0.01 Lead, 0.02 Lead, ..., 0.98 Lead, 0.99 Lead, 1, 0.99 Lag, 0.98 Lag, ..., 0.02 Lag, 0.01 Lag)
Default: 0.08 Lag

The setting sets the Power Factor Switch-In level. The negative value is used to denote the lead power factor, and the positive value is used for the lag power factor.

SWITCH-OUT

Range: -0.01 to -0.99, 1, 0.99 to 0.01 (for 8 Series Enervista Setup software: 0.01 Lead, 0.02 Lead, ..., 0.98 Lead, 0.99 Lead, 1, 0.99 Lag, 0.98 Lag, ..., 0.02 Lag, 0.01 Lag)
Default: 1.00

The setting sets the Power Factor Switch-Out level. The negative value is used to denote the lead power factor, and the positive value is used for the lag power factor.

NOTICE

SWITCH-IN and SWITCH-OUT are mutually exclusive settings. See the application examples above which show no common zone in which both SWITCH-IN and SWITCH-OUT are asserted.

DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 50.000 s

The setting provides the definite Switch-In and Switch-Out time delay. Instantaneous operation is selected by the time delay setting of 0.000 s.

MINIMUM VOLTAGE

Range: 0.00 to 1.25 x VT in steps of 0.01 x VT
Default: 0.30 x VT

The setting sets the minimum voltage for Power Factor element operation specified per times VT.

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

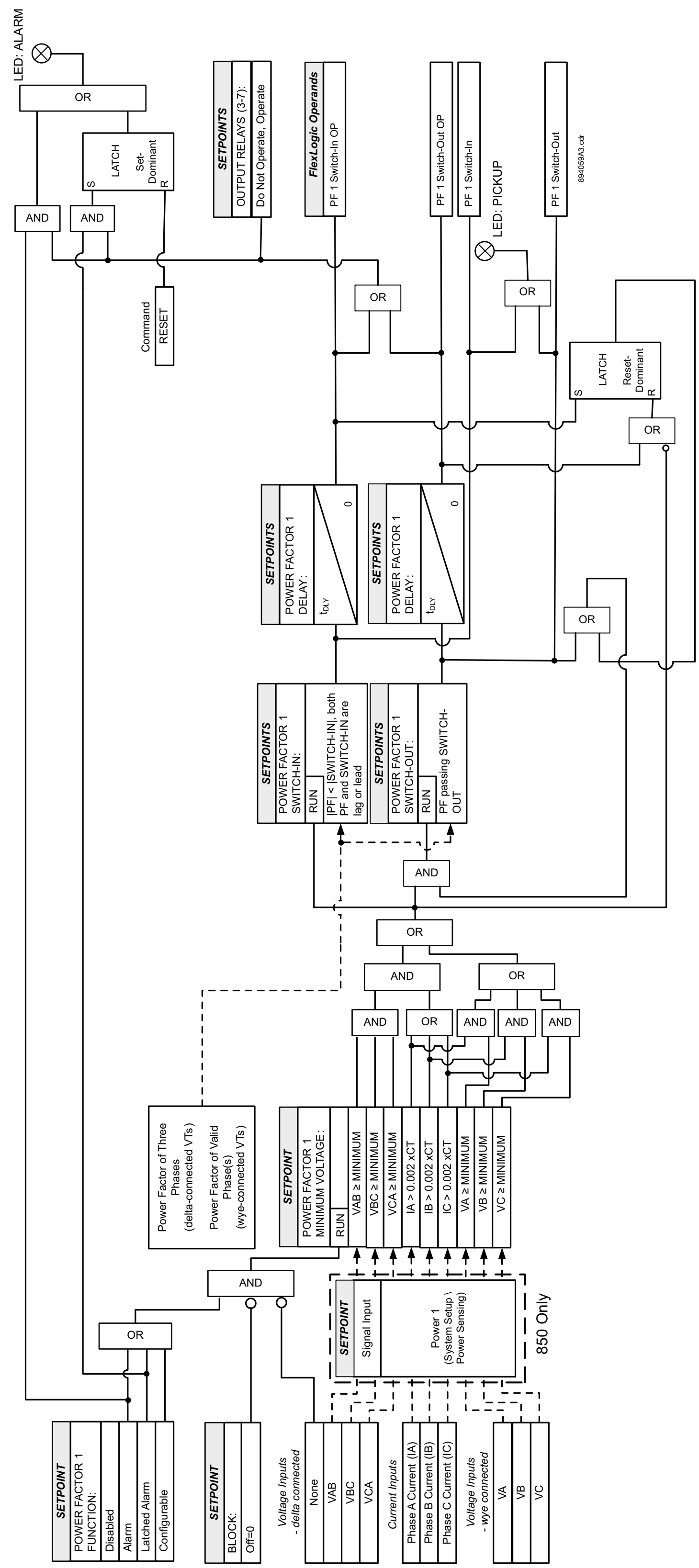
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Self-reset

Figure 7-18: Power Factor logic diagram



Demand

Current Demand is measured on each phase, and on three phases for real, reactive, and apparent power. Setpoints allow emulation of some common electrical utility demand measuring techniques for statistical or control purposes.

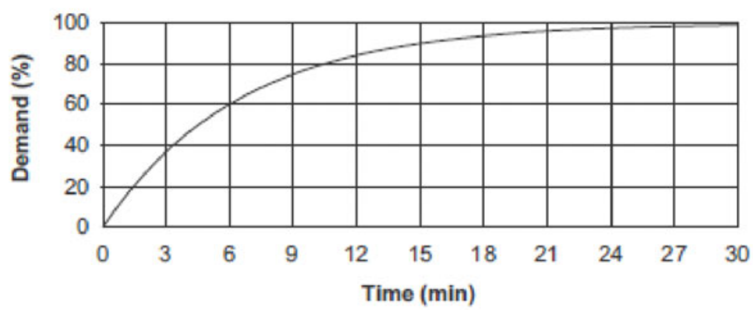
NOTICE

The relay is not approved as, or intended to be, a revenue metering instrument. If used in a peak load control system, the user must consider the accuracy rating and method of measurement employed, and the source VTs and CTs, in comparison with the electrical utility revenue metering system.

The relay can be set to calculate Demand by any of three methods.

- **Thermal Exponential**: This selection emulates the action of an analog peak recording Thermal Demand meter. The relay measures the quantity (RMS current, real power, reactive power, or apparent power) on each phase every second, and assumes the circuit quantity remains at this value until updated by the next measurement. It calculates the Thermal Demand equivalent based on:
  $d(t) = D(1 - e^{-kt})$
  Where:
  d = demand value after applying input quantity for time t (in minutes),
  D = input quantity (constant),
  k = 2.3/thermal 90% response time.

Figure 7-19: Thermal Demand Characteristic (15 min response)



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

- **Block Interval**: This selection calculates a linear average of the quantity (RMS current, real power, reactive power, or apparent power) over the programmed Demand time interval, starting daily at 00:00:00 (i.e. 12 am). The 1440 minutes per day is divided into the number of blocks as set by the programmed time interval. Each new value of Demand becomes available at the end of each time interval.
- **Rolling Demand**: This selection calculates a linear average of the quantity (RMS current, real power, reactive power, or apparent power) over the programmed Demand time interval, in the same way as Block Interval. The value is updated every minute and indicates the Demand over the time interval just proceeding the time of update.

Current Demand

The Current Demand for each phase is calculated individually, and the Demand for each phase is monitored by comparison with a single Current Demand Pickup value. If the Current Demand Pickup is equalled or exceeded by any phase, the relay can cause an alarm or signal an output relay.

Path: **Setpoints > Monitoring > Functions > Demand > Current Demand 1(X)**

FUNCTION

Range: Disabled, Alarm, Latched Alarm, Configurable
Default: Configurable

SIGNAL INPUT

Range: dependant upon the order code
Default: CT Bank 1-J1

This setting provides the selection for the current input bank. The bank names can be changed in: Setpoints > System > Current Sensing > [Name] > CT Bank Name.

MEASUREMENT TYPE

Range: Blk Interval, Exponential, Rolling Dmd
Default: Blk Interval

This setting sets the measurement method. Three methods can be applied.

THERMAL 90% RESPONSE TIME

Range: 5 min, 10 min, 15 min, 20 min, 30 min
Default: 15 min

This setpoint sets the time required for a steady state current to indicate 90% of the actual value to approximately match the response of the relay to analog instruments. The setpoint is visible only if MEASUREMENT TYPE is “Thermal Exponential”.

TIME INTERVAL

Range: 5 min, 10 min, 15 min, 20 min, 30 min
Default: 20 min

This setpoint sets the time period over which the current demand calculation is to be performed. The setpoint is visible only if MEASUREMENT TYPE is “Block Interval” or “Rolling Demand”.

PICKUP

Range: 10 to 10000 A in steps of 1 A
Default: 1000 A

This setpoint sets the Current Demand Pickup level.

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

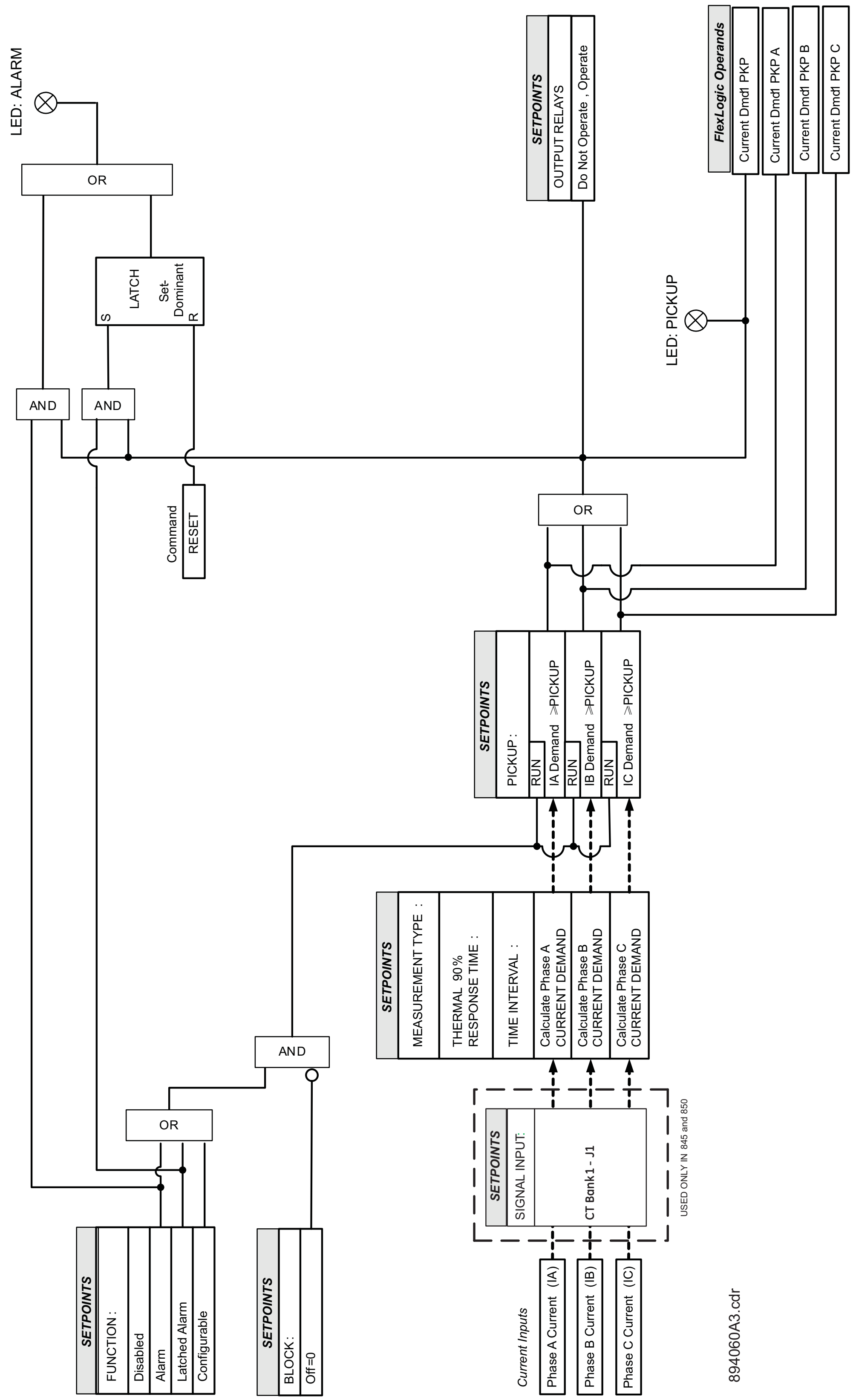
EVENTS

Range: Enabled, Disabled
Default: Disabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Disabled

Figure 7-20: Current Demand logic diagram



Real Power Demand

The Real Power Demand is monitored by comparing it to a Pickup value. If the Real Power Demand Pickup is ever equalled or exceeded, the relay can be configured to cause an alarm or signal an output relay.

Path: **Setpoints > Monitoring > Functions > Demand > Real Power Demand 1(X)**

FUNCTION

Range: Disabled, Alarm, Latched Alarm, Configurable
Default: Configurable

MEASUREMENT TYPE

Range: Blk Interval, Exponential, Rolling Dmd
Default: Blk Interval

This setting sets the measurement method. Three methods can be applied.

THERMAL 90% RESPONSE TIME

Range: 5 min, 10 min, 15 min, 20 min, 30 min
Default: 15 min

This setpoint sets the time required for steady-state Real Power to indicate 90% of the actual value to approximately match the response of the relay to analog instruments. The setpoint is visible only if MEASUREMENT TYPE is “Thermal Exponential”.

TIME INTERVAL

Range: 5 min, 10 min, 15 min, 20 min, 30 min
Default: 20 min

This setpoint sets the time period over which the Real Power Demand calculation is to be performed. The setpoint is visible only if MEASUREMENT TYPE is “Block Interval” or “Rolling Demand”.

PICKUP

Range: 0.1 to 300000.0 kW in steps of 0.1 kW
Default: 1000.0 kW

This setting sets the Real Power Demand Pickup level. The absolute value of real power demand is used for the Pickup comparison.

RESET DEMAND

Range: Off, Any FlexLogic operand
Default: Off

Any FlexLogic operand can be used to reset the minimum and maximum real power demand from the current value to zero. These values are reset to zero at the rising edge of the set operand. After reset to zero, calculation of minimum and maximum real power demand values continues until the next rising edge of the reset operand.

The Reset Demand operand doesn’t reset the current value of the demand used by the Real Power Demand function.

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

OUTPUT RELAYS X

For details see Common Setpoints.

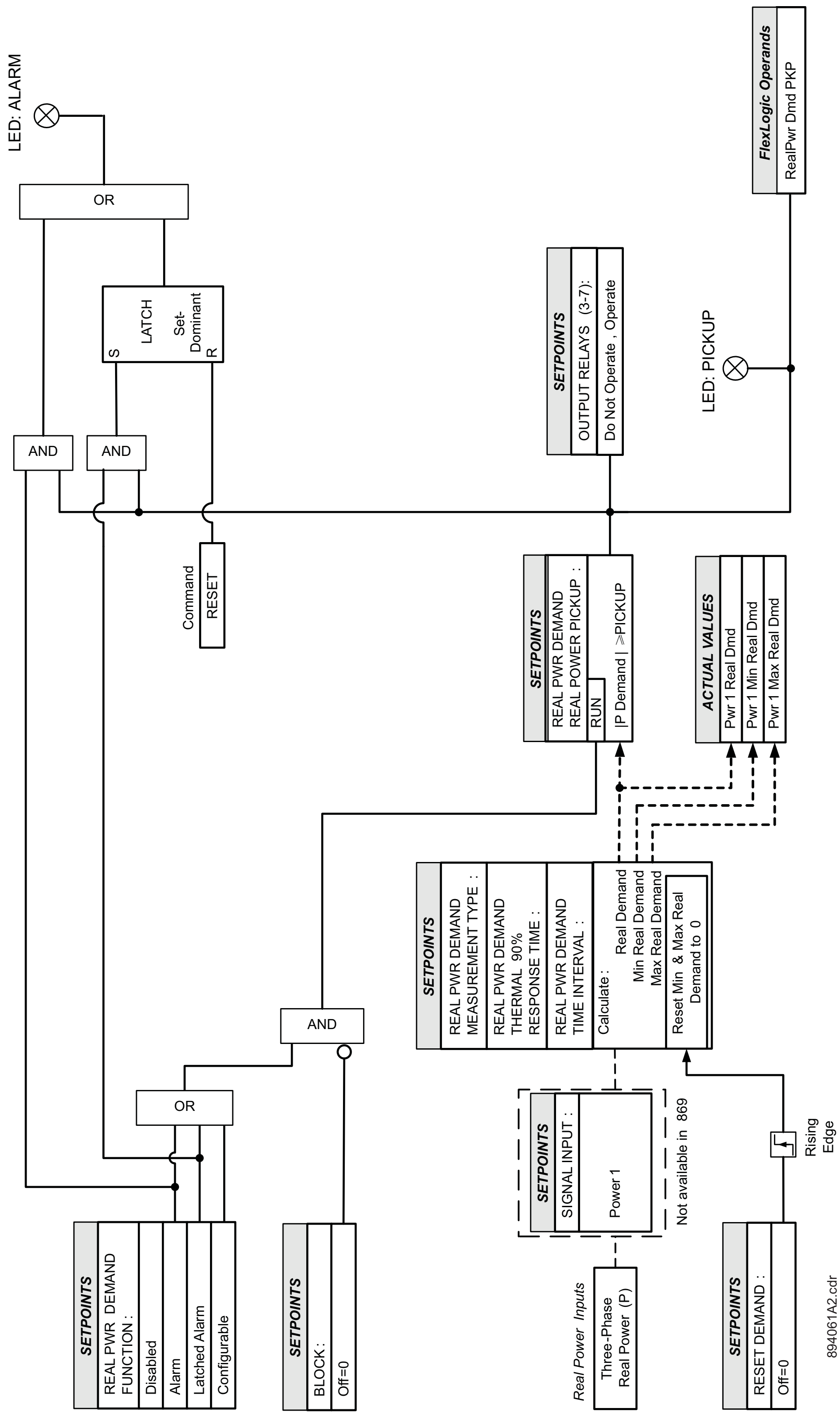
EVENTS

Range: Enabled, Disabled
Default: Disabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Disabled

Figure 7-21: Real Power Demand logic diagram



Reactive Power

The Reactive Power Demand is monitored by comparing to a Pickup value. If the Reactive Power Demand Pickup is ever equalled or exceeded, the relay can be configured to cause an alarm or signal an output relay.

Path: **Setpoints > Monitoring > Functions > Demand > Reactive Power Demand 1(X)**

FUNCTION

Range: Disabled, Alarm, Latched Alarm, Configurable
Default: Configurable

MEASUREMENT TYPE

Range: Blk Interval, Exponential, Rolling Dmd
Default: Blk Interval

The setting sets the measurement method. Three methods can be applied.

THERMAL 90% RESPONSE TIME

Range: 5 min, 10 min, 15 min, 20 min, 30 min
Default: 15 min

The setpoint sets the time required for a steady state Reactive Power to indicate 90% of the actual value to approximately match the response of the relay to analog instruments. The setpoint is visible only if MEASUREMENT TYPE is "Thermal Exponential".

TIME INTERVAL

Range: 5 min, 10 min, 15 min, 20 min, 30 min
Default: 20 min

The setpoint sets the time period over which the Reactive Power Demand calculation is to be performed. The setpoint is visible only if MEASUREMENT TYPE is "Block Interval" or "Rolling Demand".

PICKUP

Range: 0.1 to 300000.0 kvar in steps of 0.1 kvar.
Default: 1000.0 kvar

Any FlexLogic operand can be used to reset the accumulated reactive power demand from its current value to zero. The accumulated value resets at the rising edge of the set operand. After reset to zero, the reactive power demand element continues calculating the demand until the next rising edge of the reset operand.

RESET DEMAND

Range: Off, Any FlexLogic operand
Default: Off

Any FlexLogic operand can be used to reset the minimum and maximum reactive power demand from its current value to zero. The minimum and maximum values reset at the rising edge of the set operand. After reset to zero, calculation of minimum and maximum reactive power demand values continues until the next rising edge of the reset operand.

The Reset Demand operand doesn't reset the current value of the demand used by the Reactive Power Demand function.

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

OUTPUT RELAY X

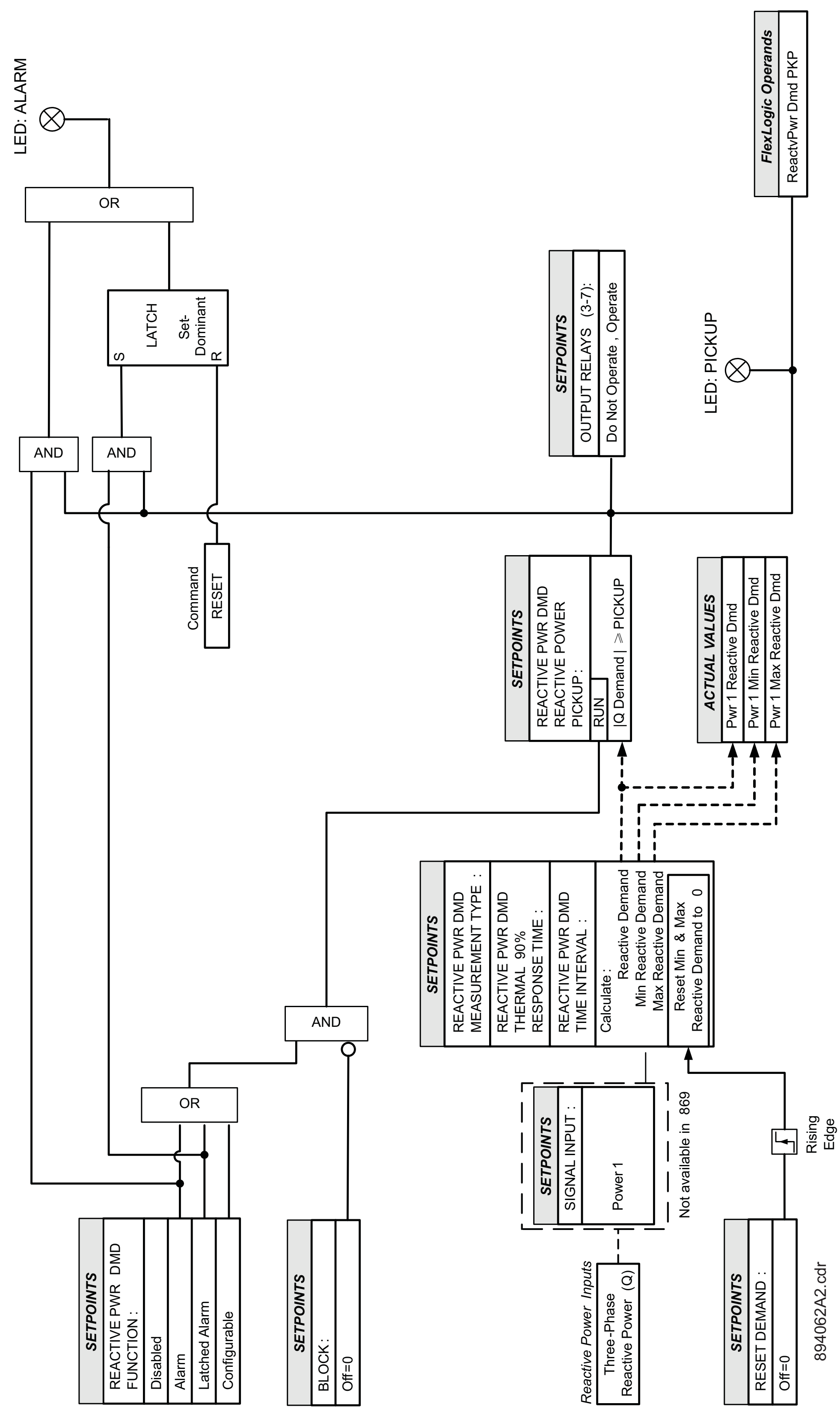
For details see Common Setpoints.

EVENTS

Range: Enabled, Disabled
Default: Disabled

TARGETS
Range: Disabled, Self-reset, Latched
Default: Disabled

Figure 7-22: Reactive Power Demand logic diagram



Apparent Power Demand

The Apparent Power Demand is monitored by comparing to a Pickup value. If the Apparent Power Demand Pickup is ever equalled or exceeded, the relay can be configured to cause an alarm or signal an output relay.

Path: **Setpoints > Monitoring > Functions > Demand > Apparent Power Demand 1(X)**

FUNCTION

Range: Disabled, Alarm, Latched Alarm, Configurable
Default: Configurable

MEASUREMENT TYPE

Range: Blk Interval, Exponential, Rolling Dmd
Default: Blk Interval

The setting sets the measurement method. Three methods can be applied.

THERMAL 90% RESPONSE TIME

Range: 5 min, 10 min, 15 min, 20 min, 30 min
Default: 15 min

The setpoint sets the time required for a steady state Apparent Power to indicate 90% of the actual value to approximately match the response of the relay to analog instruments. The setpoint is visible only if MEASUREMENT TYPE is "Thermal Exponential".

TIME INTERVAL

Range: 5 min, 10 min, 15 min, 20 min, 30 min
Default: 20 min

The setpoint sets the time period over which the Apparent Power Demand calculation is to be performed. The setpoint is visible only if MEASUREMENT TYPE is "Block Interval" or "Rolling Demand".

PICKUP

Range: 0.1 to 300000.0 kVA in steps of 0.1 kVA
Default: 1000.0 kVA

The setting sets the Apparent Power Demand Pickup level.

RESET DEMAND

Range: Off, Any FlexLogic operand
Default: Off

Any FlexLogic operand can be used to reset the minimum and maximum apparent power demand from its current value to zero. The minimum and maximum values reset at the rising edge of the set operand. After reset to zero, calculation of minimum and maximum apparent power demand values continues until the next rising edge of the reset operand.

The Reset Demand operand doesn't reset the current value of the demand used by the Apparent Power Demand function.

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

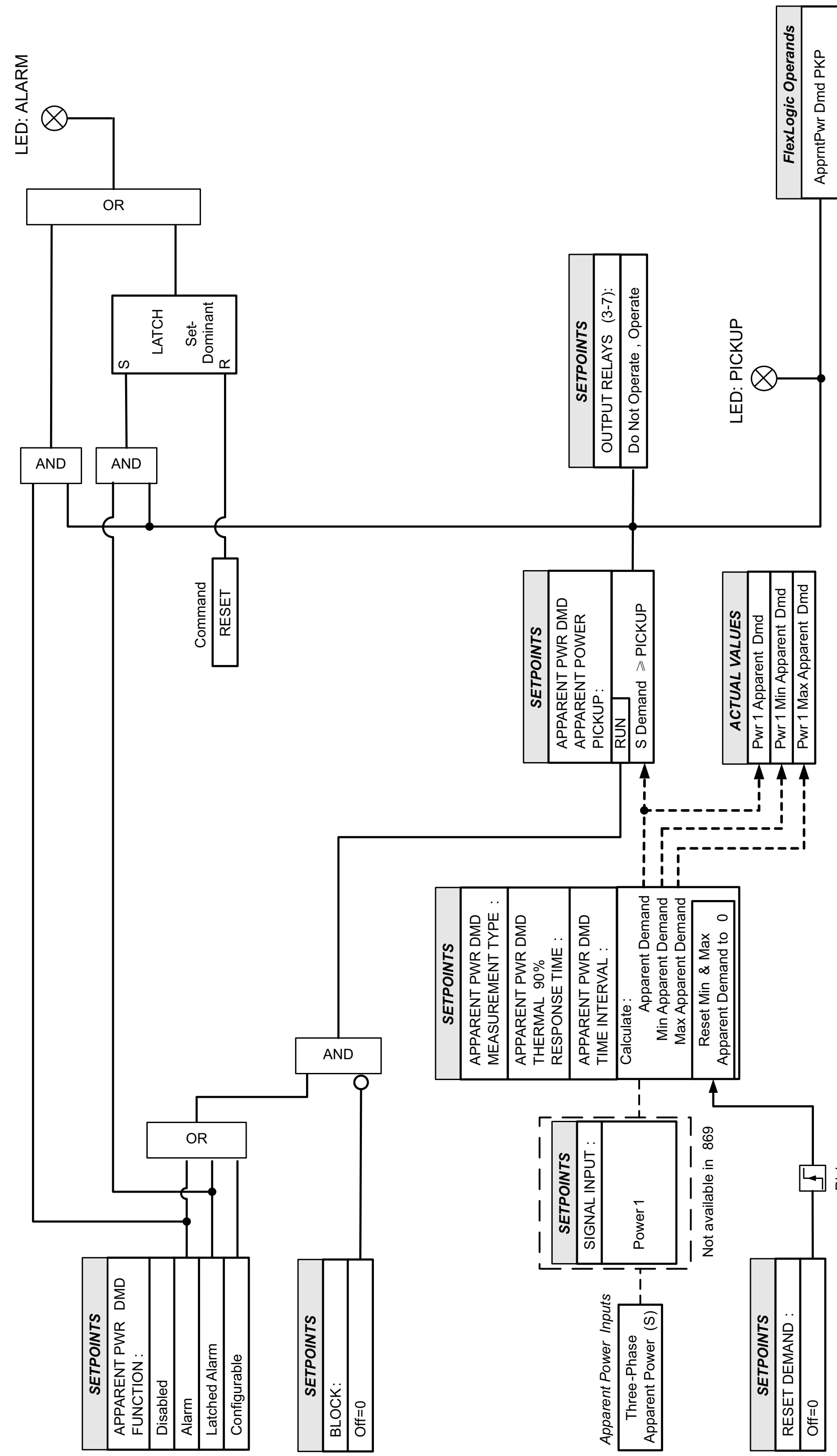
EVENTS

Range: Enabled, Disabled
Default: Disabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Disabled

Figure 7-23: Apparent Power Demand logic diagram



Pulsed Outputs

The 845 relay provides a Pulse Output element for four energy measurements. The element can operate auxiliary relays after an adjustable energy increment for the quantities of positive and negative MWatthours and positive and negative MVARhours.

Pulses occur at the end of each programmed energy increment. Upon power-up of the relay, the Pulse Output function, if enabled, continues from where it was at the time of loss of control power. For example, if control power is removed when the positive Watthours stored at last pulse was 24.000 MWh, when control power is re-applied a pulse occurs at 34.000 MWh if the energy increment is set at 10.000 MWh.

NOTICE

1. The Auxiliary Output relay(s) used for this element must be set to "Self-Resetting" under Aux Output relays. The pulses consist of a one second on-time and a one second off-time. This feature is programmed such that no more than one pulse per two seconds is required.
2. The 845 is not a revenue class meter and cannot be used for billing purposes.

Energy quantities are displayed in MWh and MVarh, with resolutions of 1 kWh and 1 kVarh respectively.

Path: **Setpoints > Monitoring > Functions > Pulsed Outputs**

FUNCTION

Range: Disabled, Enabled
Default: Disabled

POS WHS PULSE INCREMENT

Range: 0.000 to 1000.000 MWh in steps of 0.001 MWh
Default: 10.000 MWh

The setpoint specifies the positive Watthours threshold pulse increment after which the output pulse and output operand are set.

POS WHS PULSE RELAY X

For details see Common Setpoints.

NEG WHS PULSE INCREMENT

Range: 0.000 to 1000.000 MWh in steps of 0.001 MWh
Default: 10.000 MWh

The setpoint specifies the negative Watthours threshold pulse increment after which the output pulse and output operand are set.

NEG WHS PULSE RELAY X

For details see Common Setpoints.

POS VARHS PULSE INCREMENT

Range: 0.000 to 1000.000 MVARh in steps of 0.001 MVARh
Default: 10.000 MVARh

The setpoint specifies the positive VARhours threshold pulse increment after which the output pulse and output operand are set.

POS VARHS PULSE RELAY X

For details see Common Setpoints.

NEG VARHS PULSE INCREMENT

Range: 0.000 to 1000.000 MVARh in steps of 0.001 MVARh
Default: 10.000 MVARh

The setpoint specifies the positive VARhours threshold pulse increment after which the output pulse and output operand are set.

NEG VARHS PULSE RELAY X

For details see Common Setpoints.

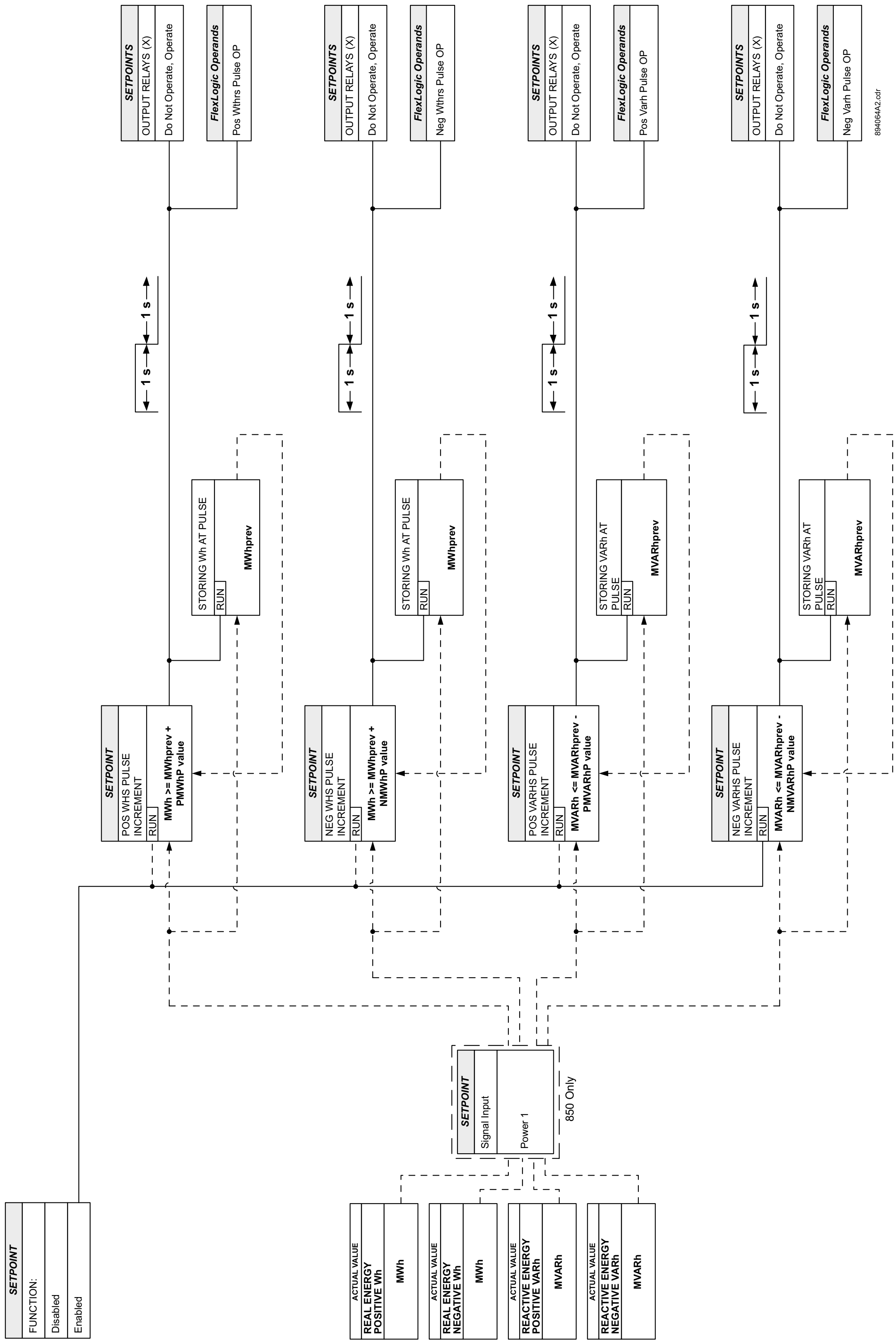
EVENTS

Range: Disabled, Enabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Self-Reset

Figure 7-24: Pulsed Outputs logic diagram



Digital Counters

The 845 relay provides sixteen identical Digital Counters. A Digital Counter counts the number of state transitions from logic 0 to logic 1.

The Digital Counters are numbered from 1 to 16. The counters are used to count operations such as the Pickups of an element, the changes of state of an external contact (e.g. breaker auxiliary switch), or the pulses from a watt-hour meter.

Path: **Setpoints > Monitoring > Functions > Digital Counters > Digital Counter 1 (16)**

FUNCTION

Range: Disabled, Enabled
Default: Disabled

NAME

Range: Any 13 alphanumeric characters
Default: Counter 1

UNITS

Range: Any 5 alphanumeric characters
Default: Units

Assigns a label to identify the unit of measure with respect to the digital transitions to be counted. The units label will appear in the metering corresponding Actual Values Status under RECORDS/DIGITAL COUNTERS.

PRE-SET

Range: -2147483648, 0, +2147483647
Default: 0

The setpoint sets the count to a required pre-set value before counting operations begin, as in the case where a substitute relay is installed in place of an in-service relay, or while the Counter is running.

COMPARE

Range: -2147483648, 0, +2147483647
Default: 0

The setpoint sets the value to which the accumulated count value is compared. Three FlexLogic output operands are provided to indicate if the present value is 'more than (HI)', 'equal to (EQL)', or 'less than (LO)' the set value.

UP

Range: Off, Any FlexLogic operand
Default: Off

The setpoint selects the FlexLogic operand for incrementing the Counter. If an enabled UP input is received when the accumulated value is at the limit of +2147483647, the counter rolls over to -2147483648 and shows the alarm 'Digital Counter 1 at Limit'.

DOWN

Range: Off, Any FlexLogic operand
Default: Off

The setpoint selects the FlexLogic operand for decrementing the Counter. If an enabled DOWN input is received when the accumulated value is at the limit of +2147483647, the counter rolls over to -2147483648 and shows the alarm 'Digital Counter 1 at Limit'.

SET TO PRE-SET

Range: Off, Any FlexLogic operand
Default: Off

The setpoint selects the FlexLogic operand used to set the counter to the pre-set value. The counter is set at pre-set value in the following situations:

1. When the Counter is enabled and Digital Counter 1 Set to Pre-Set operand has value 1 (when the Counter is enabled and Digital Counter 1 Set to Pre-Set operand has value 0, the Counter will be set to 0).
2. When the Counter is running and Digital Counter 1 Set to Pre-Set operand changes the state from 0 to 1 (Digital Counter 1 Set to Pre-Set changing from 1 to 0 while the Counter is running has no effect on the count).
3. When a reset or reset/freeze command is sent to the Counter and Digital Counter 1 Set to Pre-Set operand has the value 1 (when a reset or reset/freeze command is sent to the Counter and Digital Counter 1 Set to Pre-Set operand has the value 0, the Counter will be set to 0).

RESET

Range: Off, Any FlexLogic operand
Default: Off

The setpoint selects the FlexLogic operand for setting the count, either 0 or the pre-set value depending on the state of the Counter 1 Set to Pre-set operand.

FREEZE/RESET

Range: Off, Any FlexLogic operand
Default: Off

The setpoint selects the FlexLogic operand for freezing (capturing) the accumulating count value into a separate register with the associated date and time of the operation while resetting the count to either 0 or the pre-set value depending on the state of the "Counter 1 Set to Pre-set" operand.

FREEZE/COUNT

Range: Off, Any FlexLogic operand
Default: Off

The setpoint selects the FlexLogic operand for freezing (capturing) the accumulating count value into a separate register with the associated date and time of the operation while continuing counting. The present accumulated value and frozen (captured) value with the associated date/time stamp are available as STATUS values. If control power is interrupted, during the power-down operation, the accumulated and frozen (captured) values are saved into non-volatile memory.

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

HI OUTPUT RELAY X

For details see Common Setpoints.

EQL OUTPUT RELAY X

For details see Common Setpoints.

LO OUTPUT RELAY X

For details see Common Setpoints.

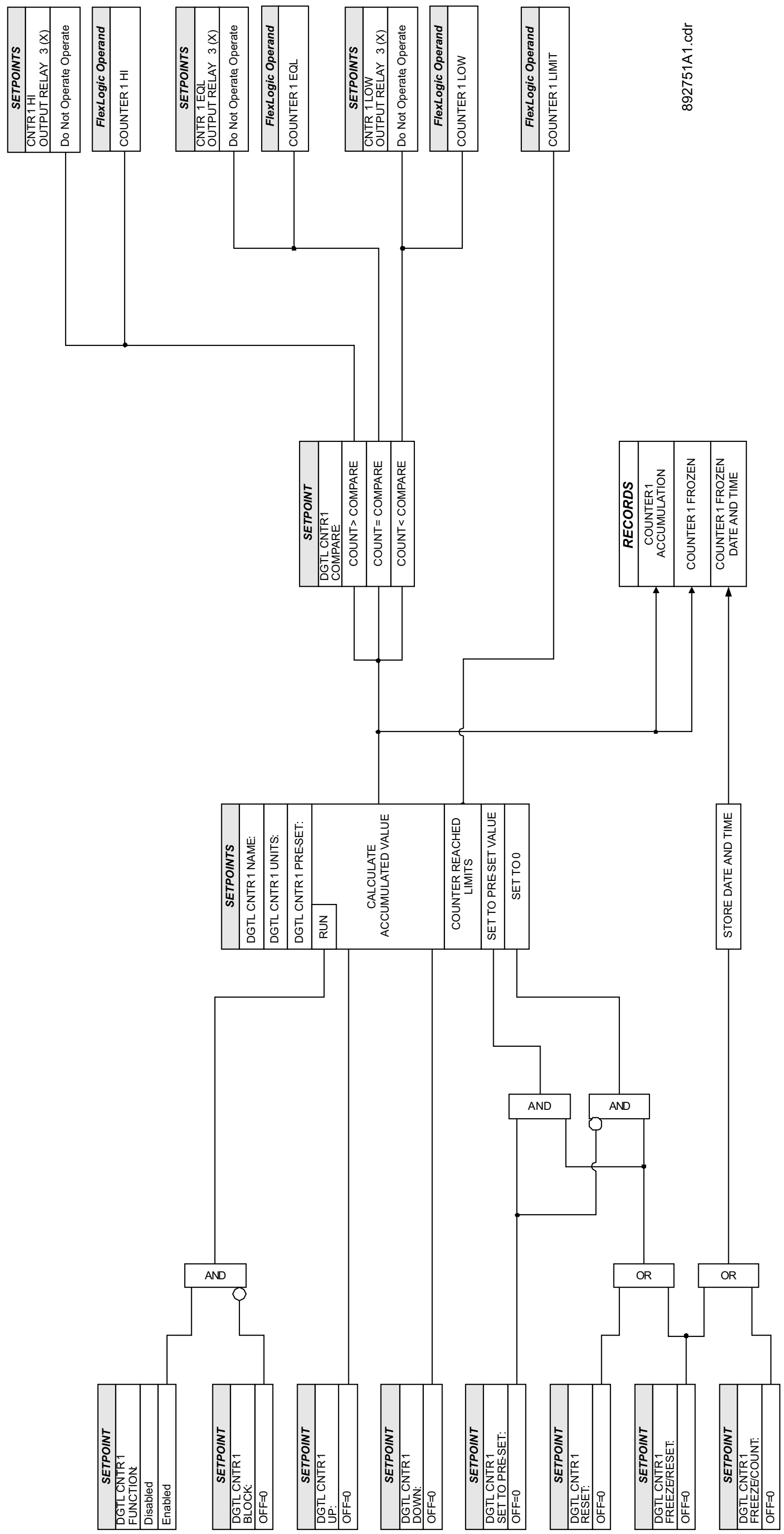
EVENTS

Range: Disabled, Enabled
Default: Enabled

NOTE

The counter accumulated value can be reset to zero either by asserting an operand programmed under Reset from the counter menu, executing the clear Digital Counters command under the Records/Clear menu, or by setting the function of the counter to "Disabled".

Figure 7-25: Digital Counter logic diagram



Harmonic Detection

The Harmonic detection 1(6) element monitors the selected 2nd to 5th harmonic or Total Harmonics Distortion (THD), which is present in the phase currents. The relay provides six identical Harmonic Detection elements.

During transformer energization or motor starts, the inrush current present in phase currents can impact some sensitive elements, such as negative sequence overcurrent. Therefore, the ratio of the second harmonic to the fundamental magnitude per phase is monitored, while exceeding the settable pickup level, an operand is asserted, which can be used to block such sensitive elements.

During startup or shutdown of generator connected transformers, or following a load rejection, the transformer can experience an excessive ratio of volts to hertz, that is, become overexcited. Similarly, the ratio of the fifth harmonic to the fundamental magnitude can be monitored to detect the overexcitation condition.

NOTE

The harmonics monitored in this element is calculated from the phase currents, unlike the second or fifth harmonic differential current used in the transformer differential element.

NOTE

The harmonics are updated every protection pass. The THD is updated every three cycles, which is not recommended as a blocking signal.

Path: **Setpoints > Monitoring > Harmonic Detection > Harmonic Detection 1(X)**

FUNCTION

Range: Disabled, Alarm, Latched Alarm, Configurable
Default: Disabled

SIGNAL INPUT

Range: dependant upon the order code
Default: CT Bank 1–J1

HARMONIC

Range: 2nd, 3rd, 4th, 5th, THD
Default: 2nd

This setting selects the specified harmonic or THD to be monitored. The harmonic or THD is expressed in percent relative to the fundamental magnitude.

PICKUP

Range: 0.1 to 100.0% in steps of 0.1%
Default: 20.0%

PICKUP DELAY

Range: 0.000 to 60000.000 s in steps of 0.001 s
Default: 0.000 s

PHASES FOR OPERATION

Range: Any One, Any Two, All Three, Average
Default: Any One

This setting defines the phases required for operation, and the detail is explained below:

- ANY ONE: At least one phase picked up.
- ANY TWO: Two or more phases picked up.
- ANY THREE: All three phases picked up.

- AVERAGE: The average of three-phase harmonics or THDs picked up.

If set to AVERAGE, the relay calculates the average level of the selected harmonic and compares this level against the pickup setting. Averaging of the selected harmonic follows an adaptive algorithm depending on the fundamental current magnitude per-phase. If the fundamental magnitude on any of the three phases goes below the current cut-off level, the selected harmonic current from that phase is dropped (zeroed) from the equation for averaging, and the divider is decreased from 3 to 2. The same happens if the magnitude of the fundamental magnitude on one of remaining two phases drops below the cut-off level. In this case the selected harmonic on this phase is dropped from summation, and the divider is decreased to 1.

MIN OPER CURRENT

Range: 0.03 to 1.00 x CT in steps of 0.01
Default: 0.10 x CT

This setting sets the minimum value of current required to allow the Harmonic Detection element to operate.

If PHASES FOR OPERATION is set to AVERAGE, the average of three-phase currents is used for supervision. A similar adaptive average algorithm is applied to calculate the average of operation current magnitude.

OUTPUT RELAY X

For details see Common Setpoints.

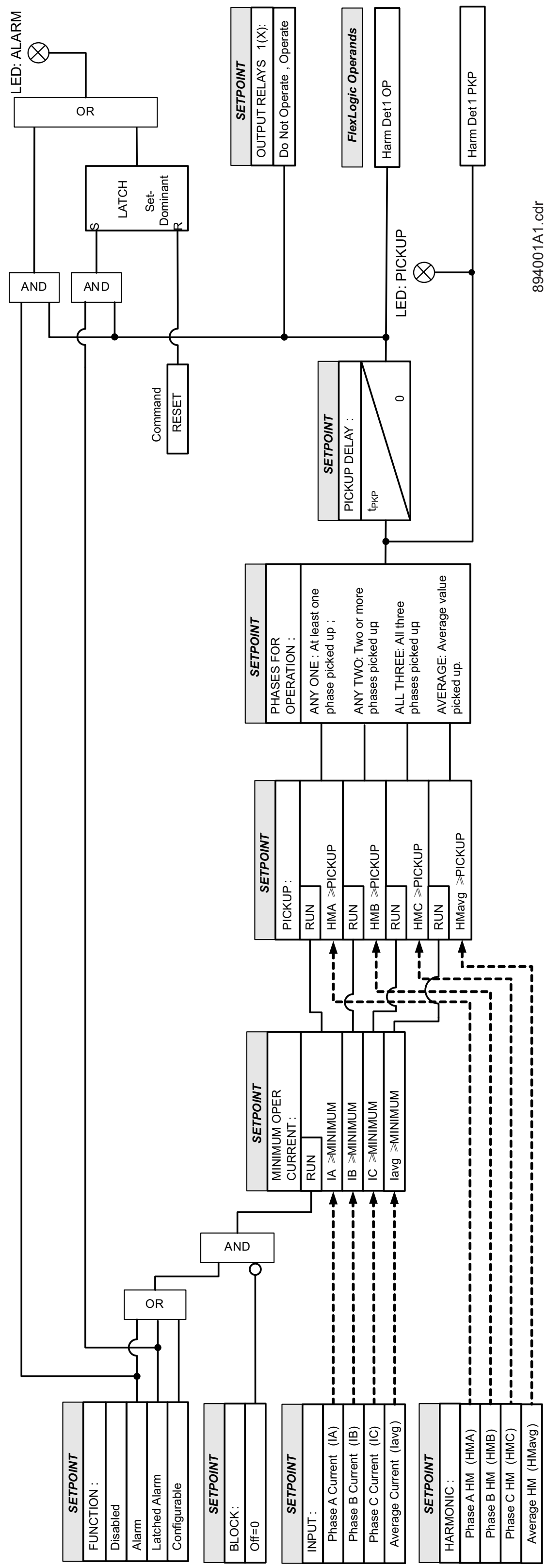
EVENTS

Range: Disabled, Enabled
Default: Enabled

TARGETS

Range: Self-reset, Latched, Disabled
Default: Latched

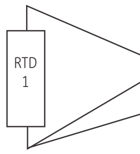
Figure 7-26: Harmonic Detection logic diagram



RTD Temperature

RTD Wiring Diagram

Figure 7-27: RTD Wiring diagram



Terminal	Signal	RTD
B1	HOT	RTD 1
B2	COMP	
B3	RETURN	RTD 1/2
B4	HOT	RTD 2
B5	COMP	
B6	HOT	RTD 3
B7	COMP	
B8	RETURN	RTD 3/4
B9	SHIELD	
B10	HOT	RTD 4
B11	COMP	
B12	HOT	RTD 5
B13	COMP	
B14	RETURN	RTD 5/6
B15	HOT	RTD 6
B16	COMP	
B17	SHIELD	
B18	RESERVED	

Terminal	Signal	RTD
C1	HOT	RTD 7
C2	COMP	
C3	RETURN	RTD 7/8
C4	HOT	RTD 8
C5	COMP	
C6	HOT	RTD 9
C7	COMP	
C8	RETURN	RTD 9/10
C9	SHIELD	
C10	HOT	RTD 10
C11	COMP	
C12	HOT	RTD 11
C13	COMP	
C14	RETURN	RTD 11/12
C15	HOT	RTD 12
C16	COMP	
C17	SHIELD	
C18	RESERVED	

894219A1.cdr

NOTE

To enhance the accuracy of the RTD, ensure all 3 cables are of the same length and gauge. In addition, the Compensation and Return wires must be connected on the RTD side and not on the relay side.

RTD Inputs

The 845 has two methods of supporting RTD inputs. I/O cards installed in the relay can supply up to 13 RTDs, as described below. An optional CANBUS-based RMIO unit can also be installed, which can monitor up to 12 additional RTDs (referred to as RRTDs). The RMIO unit supports 6, 9, or 12 RRTDs.

Hardware and software is provided to receive signals from external Resistance Temperature Detectors (RTDs) and convert these signals into a digital format for use as required. These channels are intended to be connected to any of the RTD types in common use.

Depending on the order code (Advanced Monitoring option selected), the 845 relay is packaged with one combo card consisting of one RTD input, one Ohms input, four DCmA inputs and seven DCmA outputs. Additionally, the relay can be furnished with up to two optional RTD cards, each of them having 6 RTD input channels. Only slots “B” and “C” can accept the optional RTD cards.

NOTE

If only one RTD card is ordered at the time the relay is ordered, this RTD card is always shown in slot B. The order code selection does not allow for an RTD card in slot C, if no RTD card is ordered in slot B.

NOTE

An I/) card L ordered in Slot G will contain an additional RTD input on the card. It will be the highest RTD number shown (i.e. if 1 additional RTD card is used, then the LVIO RTD will be RTD #7).

An alphanumeric name is assigned to each channel; this name is included in the channel actual values. It is also used to reference the channel as the input parameter to features designed to measure this type of parameter. Selecting the type of RTD connected to the channel configures the channel. The conversion chart is shown in the RTD Temperature vs. Resistance table.

Table 7-2: RTD Temperature vs. Resistance

TEMPERATURE		RESISTANCE (IN OHMS)			
°C	°F	100 Ω PT (IEC 60751)	120 Ω NI	100 Ω NI	10 Ω CU
–40	–40	84.27	92.76	77.30	7.49
–30	–22	88.22	99.41	82.84	7.88
–20	–4	92.16	106.15	88.45	8.26
–10	14	96.09	113.00	94.17	8.65
0	32	100.00	120.00	100.00	9.04
10	50	103.90	127.17	105.97	9.42
20	68	107.79	134.52	112.10	9.81
30	86	111.67	142.06	118.38	10.19
40	104	115.54	149.79	124.82	10.58
50	122	119.40	157.74	131.45	10.97
60	140	123.24	165.90	138.25	11.35
70	158	127.08	174.25	145.20	11.74
80	176	130.90	182.84	152.37	12.12
90	194	134.71	191.64	159.70	12.51
100	212	138.51	200.64	167.20	12.90
110	230	142.29	209.85	174.87	13.28
120	248	146.07	219.29	182.75	13.67
130	266	149.83	228.96	190.80	14.06
140	284	153.58	238.85	199.04	14.44
150	302	157.33	248.95	207.45	14.83
160	320	161.05	259.30	216.08	15.22
170	338	164.77	269.91	224.92	15.61
180	356	168.48	280.77	233.97	16.00
190	374	172.17	291.96	243.30	16.39
200	392	175.86	303.46	252.88	16.78
210	410	179.53	315.31	262.76	17.17
220	428	183.19	327.54	272.94	17.56
230	446	186.84	340.14	283.45	17.95
240	464	190.47	353.14	294.28	18.34
250	482	194.10	366.53	305.44	18.73

NOTE

RTD type copper (Cu) is only available when order code option 'S' is chosen for Slot B or C.

RTD Protection

The 845 relay can monitor up to 13 RTDs and 12 RRTDs, each of which can be configured to have a trip temperature and an alarm temperature. The RTD Temperature protection menu will be seen on the relay upon availability of RTD input/inputs. The RRTD Temperature protection setpoints can be seen only if the 845 has the RMIO module installed and validated. The minimum RTD Temperature requirement is to set the setpoint "Type". The default value for "Type", for each RTD is "100 Ω Platinum". The protection RTD Trip, and RTD Alarm from the menu are optional. They respond to directly measured RTD temperature. The Alarm temperature is set slightly above the normal measured temperature for the transformer top-oil, bottom-oil, or LTC oil. The Trip temperature is normally set at the maximum permissible oil temperatures defined as dangerous for the transformer and the transformer insulation.

This element also monitors the RTD broken connection and blocks the RTD trip and alarm functions if the RTD connection is detected as Open or Shorted and generates RTD Open and RTD Shorted FlexLogic operands. An RTD is detected as Open when the RTD connection is either open or the temperature is greater than 250°C. An RTD is detected as Shorted when the RTD connection is either shorted or the temperature is equal to less than -40°C.

NOTE

The RTD input is active regardless of whether or not, the RTD Trip, or/and RTD Alarm functions are enabled.

Path: **Setpoints > RTD Temperature > RTD 1[X]**

Path: **Setpoints > RRTD Temperature > RRTD 1[X]**

TRIP FUNCTION

Range: Disabled, Trip, Configurable
Default: Disabled

If a trip is not required from the RTD, select “Configurable”. The “Configurable” setting enables the RTD without producing a trip.

NAME

Range: Up to 13 alphanumeric characters
Default: RTD 1

TYPE

Range: 100 Ω Platinum, 100 Ω Nickel, 120 Ω Nickel
Default: 100 Ω Platinum

Selects the type of the RTD used.

TRIP TEMPERATURE

Range: 1°C to 250°C in steps of 1°C (33°F to 482°F in steps of 2°F)
Default: 155°C (311°F)

TRIP PICKUP DELAY

Range: 0 s to 600 s in steps of 1 s
Default: 2 s

TRIP DROPOUT DELAY

Range: 0 s to 600 s in steps of 1s
Default: 0 s

TRIP OUTPUT RELAY X

For details see Common Setpoints.

ALARM FUNCTION

Range: Disabled, Alarm, Latched Alarm
Default: Disabled

ALARM TEMPERATURE

Range: 1°C to 250°C in steps of 1°C (33°F to 482°F in steps of 2°F)
Default: 130°C (266°F)

ALARM PICKUP DELAY

Range: 0 s to 600 s in steps of 1 s
Default: 2 s

ALARM DROPOUT DELAY

Range: 0 s to 600 s in steps of 1 s
Default: 0 s

ALARM OUTPUT RELAY X

For details see Common Setpoints.

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

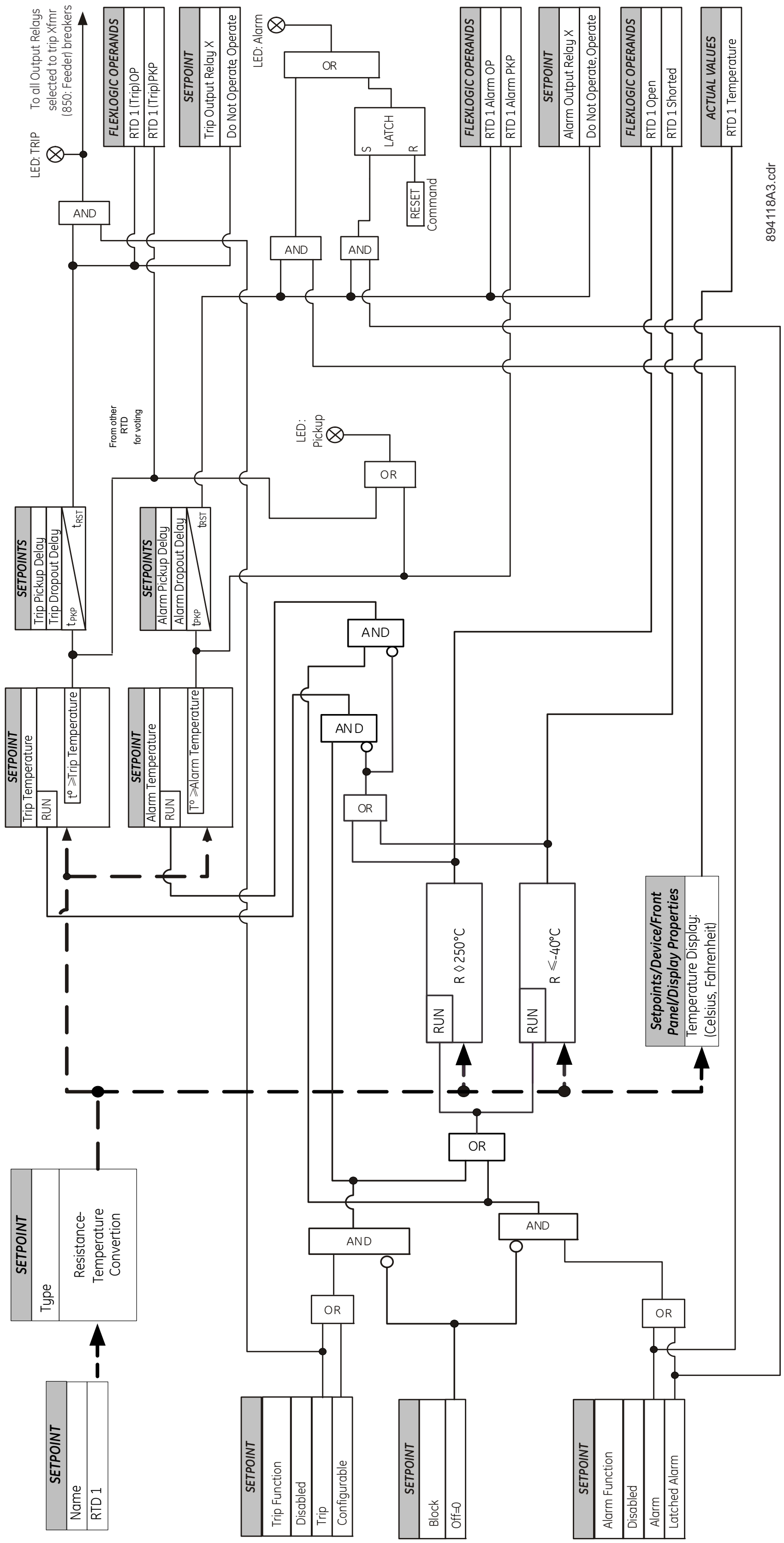
EVENTS

Range: Disabled, Enabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Latched

Figure 7-28: RTD Protection logic diagram



RTD Trouble

When set to Alarm or Latched Alarm, this element monitors all the RTDs that are either programmed as Alarm or Trip or Configurable and generates an alarm if any of the RTDs are detected as Open or Shorted. Upon detection of an RTD Open or Shorted condition, the element also asserts the RTD Trouble PKP and RTD Trouble OP and operates the assigned output relay. Both RTDs and RRTDs can be monitored using this element.

Path: **Setpoints > Monitoring > RTD Trouble**

FUNCTION

Range: Disabled, Alarm, Latched Alarm

Default: Disabled

ALARM OUTPUT RELAY X

For details see Common Setpoints.

EVENTS

Range: Disabled, Enabled

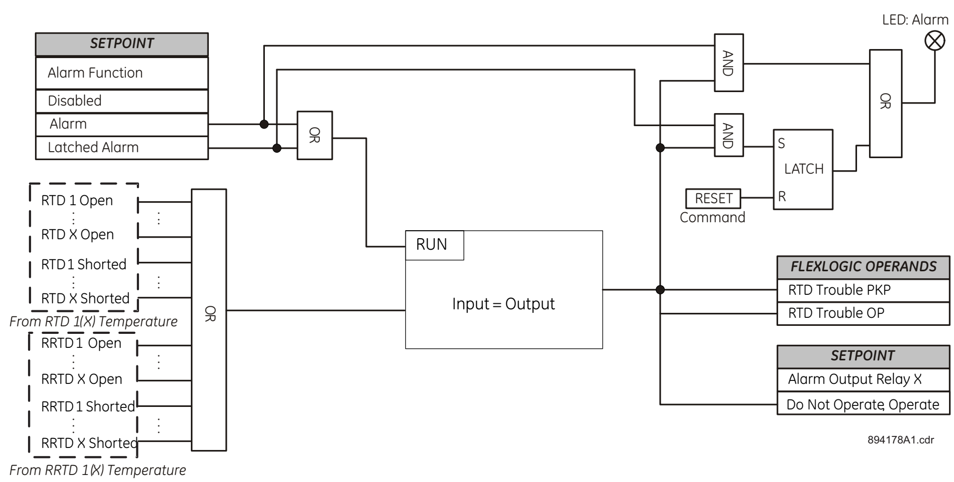
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched

Default: Latched

Figure 7-29: RTD Trouble logic diagram



Loss of Communications

Introduction

This section covers the functionality of the 8 Series Loss of Communications element.

The 8 Series device monitors activity on an interface via the configured protocol for this interface. The communications status is set for each protocol.

If communications is lost, the enabled interface will issue a “Loss of Comms” event and operate a combination of output relays / states.

Path: **Setpoints > Monitoring > Loss of Comms**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

INTERFACE

Range: Serial, Serial + Ethernet, Ethernet, All
Default: Serial

Only the protocols associated with the selected interface are shown in this screen as options. For example, if “Ethernet” is selected, select the Ethernet protocols to monitor. The Ethernet protocols selection is defined as EthernetProtocolBitmask bitmasks.

MODBUS

Range: Off, On
Default: Off

PICKUP DELAY

Range: 0 to 600 s in steps of 1
Default: 2 s

OUTPUT RELAY X

For details see Common Setpoints.

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

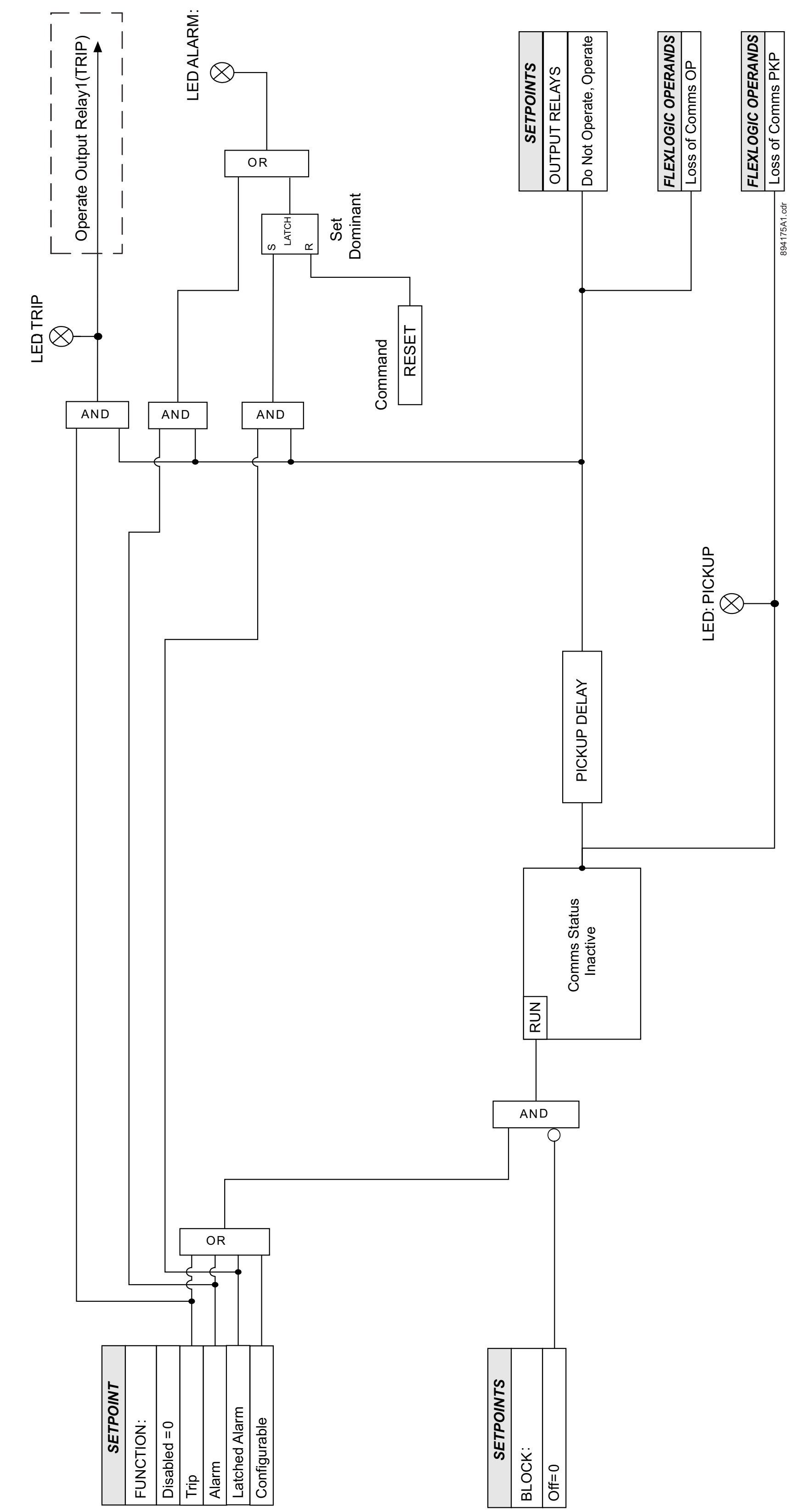
EVENTS

Range: Disabled, Enabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Latched

Figure 7-30: Loss of Communications logic diagram



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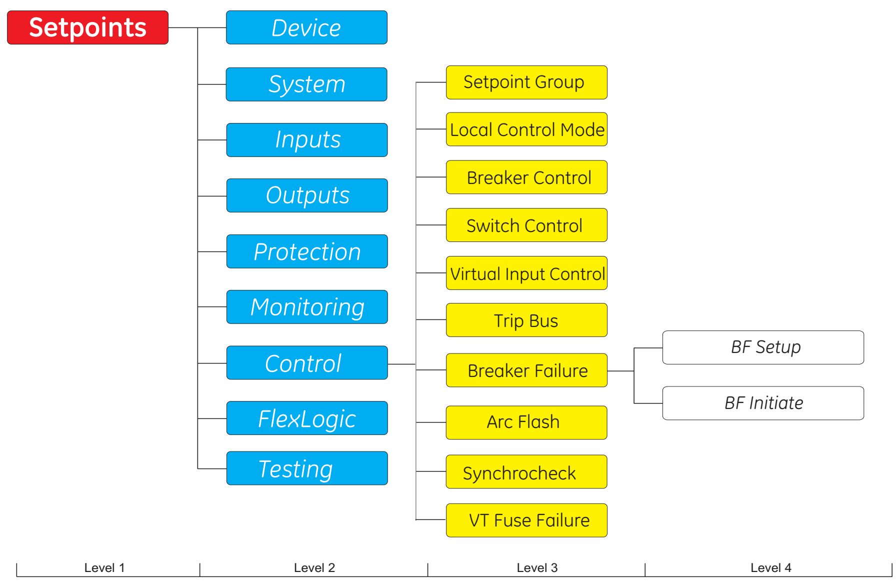
845 Transformer Protection System

Chapter 8: Control

Figure 8-1: Control Display Hierarchy



Setpoint Group

The 845 relay provides six setpoint groups. All setpoints contained under the protection setpoints are reproduced in six groups, identified as Setpoint Groups 1, 2, 3, 4, 5 and 6. These multiple setpoints provide the capability for both automatic and manual switching to protection settings for different operating situations. Automatic (adaptive) protection setpoint adjustment is available to change settings when the power system configuration is altered.

Automatic group selection can be initiated from the autoreclose, SETPOINT GROUPS and by use of a SET GROUP x ACTIVE setpoint input. The group selection can be initiated by this input from any FlexLogic operands, inputs, pushbuttons or communications.

Group 1 is the default for the "Active Group" and is used unless another group is requested to become active. The active group can be selected with the ACTIVE SETPOINT GROUP setpoint, by SET ACTIVE x GROUP input or inputs from autoreclose, SETPOINT GROUPS. If there is a conflict in the selection of the active group, between a setpoint, inputs and inputs from functions, the higher numbered group is made active. For example, if the inputs for Group 2, 4, and 6 are all asserted the relay uses Group 6. If the logic input for Group 6 then becomes de-asserted, the relay uses Group 4. Some application conditions require that the relay does not change from the present active group. This prevention of a setpoint group change can be applied by setting Change Inhibit inputs (1 to 16). If needed, typically this change inhibit is done when any of the overcurrent (phase, neutral, ground, or negative sequence), overvoltage, bus or line undervoltage, or underfrequency elements are picked-up.

Path: **Setpoints > Control > Setpoint Groups**

ACTIVE SETPOINT GROUP

Range: 1,2,3,4,5,6
Default: 1

The Active Setpoint Group setting is used for manual selection of the Active Setpoint Group by setting.

SET GROUP 2 (3,4,5,6) ACTIVE

Range: Off, Any FlexLogic operand
Default: Off

The setpoint selects the FlexLogic operand that initiates change of the Active Setpoint Group.

GROUP CHANGE INHIBIT 1 (UP TO 16)

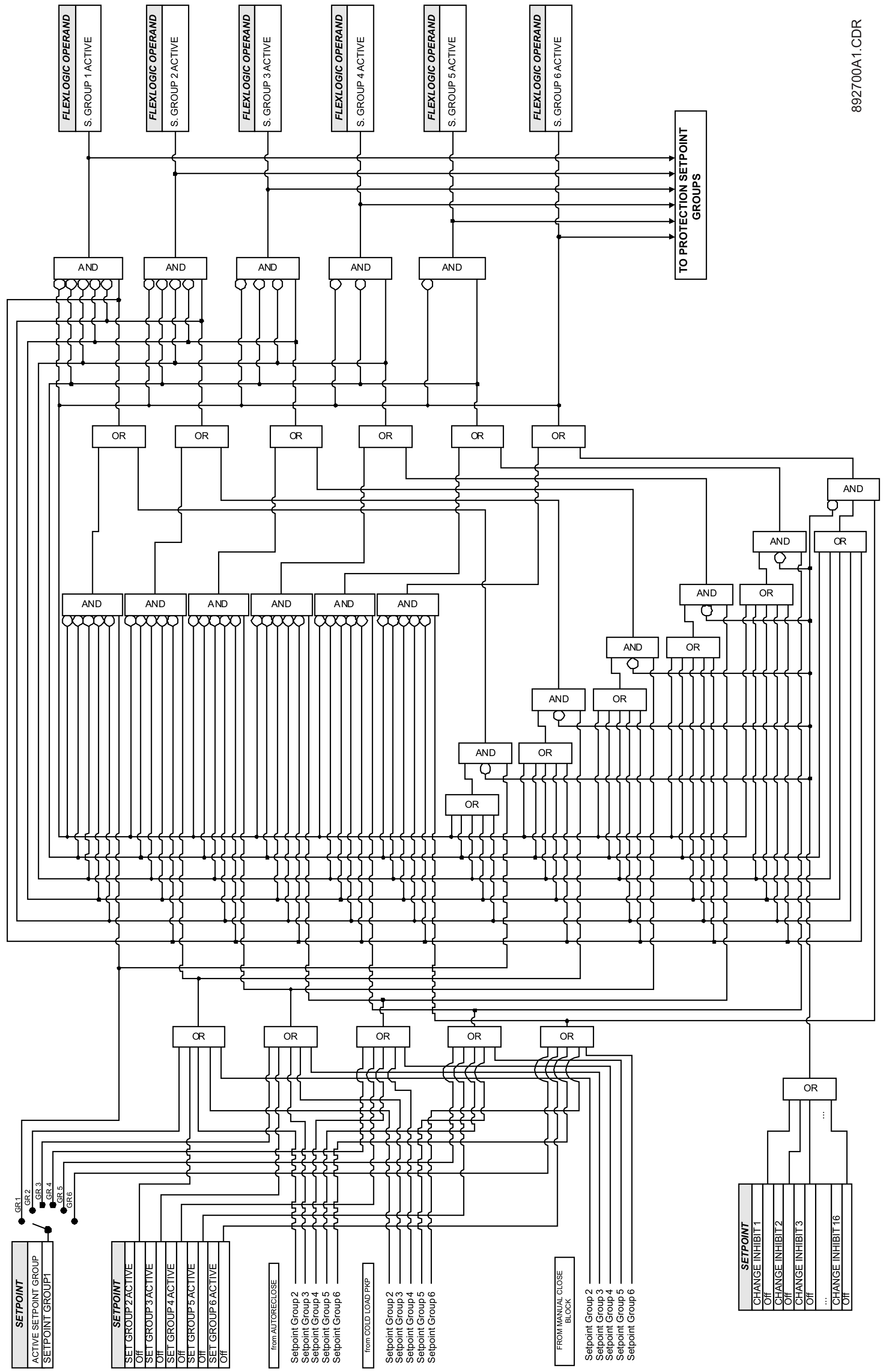
Range: Off, Any FlexLogic operand
Default: Off

The setpoint selects the FlexLogic operand that inhibits change of the active setpoint group.

EVENTS

Range: Disabled, Enabled
Default: Enabled

Figure 8-2: Setpoint Groups logic diagram



Local Control Mode (breakers and switches)

Local – when the setpoint "Local Mode" is enabled, Open and Close control of breakers and switches is performed using relay pushbuttons (PBs), or contact inputs from PBs installed in close proximity to the relay (such as on the relay panel, or in the relay cubicle).

The addition of contact inputs for closing and opening the breaker, or switch while in local mode provides the flexibility to use PBs mounted near the relay. Please note that one pair of PBs is used for breaker control, and another pair of PBs is used for switch control. If contact inputs are used while the Select Before Operate (SBO) mechanism is enabled, the breaker or the switch shall first be selected using the relay PBs, and then opened or closed using the designated relay panel or cubicle PBs. (The "Select Before Operate" setpoint is only available for relays supporting a single breaker.) If the SBO mechanism is disabled while the relay supports configurable single line diagrams (SLDs), only the breaker PBs either on the relay front panel or mounted nearby will work. The menu setpoints for local switch Open and Close are hidden and deactivated.

If the relay does not support configurable SLD, the setpoints for local switch Open and Close are omitted from the menu.

While in Local Mode, the letters **LM** are displayed on the relay display banner. In addition, an LED can be programmed to turn ON when the relay is set to Local Mode. By default the relay comes with one LED programmed to show Local Mode.

In Local Mode, control for the breakers and disconnect switches can be accessed from the relay front panel (PBs programmed for Open and Close) or by contact inputs for Open and Close from PBs installed near the relay. Hardcoded SLD PBs are designated for Tag, Block and Bypass Block for each component upon selection. In this mode, the Local Open and Local Close setpoints for Breaker Control or Switch Control (see the respective logic) are active.

Remote – when Remote Mode is enabled, the switches are controlled (open/close) from any assigned FlexLogic operand, contact input, virtual input, virtual output, remote input, or via communication. The Control Mode menu is designed to switch the control for both breakers and switches to either REMOTE MODE ("Local Mode" setpoint set to Off, or the selected "Local Mode" input de-asserted), or LOCAL MODE (Local Mode setpoint asserted).

Breaker Mode defaults

The default value for 845 relays is **Local**.

Navigation

The 8 Series front panel provides navigation pushbuttons (PBs) which highlight the component (breaker or disconnect switch) from the single line diagram. As shown in Figure 8-3:Navigation and SLD component selection, the navigation PBs (Up/Down or Up/Down/Left/Right depending on relay front panel model), are used to browse through the SLD components. These PBs are used for SLD navigation only. The navigation starts with highlighting the first breaker, and then goes through all other components in sequence, until the last one (breaker or switch). Only the breakers and switches included in the SLD from the display will be browsed (navigated).

Select Before Operate

Once the breaker or the switch is highlighted in the SLD using the navigation PBs, the component must be selected before open or close action is performed. The selection of the component is performed by pressing "ENTER" key from the front panel (see Figure 8-3:Navigation and SLD component selection). A flash message " BKR # Selected", or "Sw # Selected" appears on the screen to denote the selection. Once selected, the text from the first three tabs from the display corresponding to the PBs 1, 2, and 3 changes to "Tag", "Block", and "Bypass". At this stage, the selected breaker or switch can be Opened or Closed using the programmed PBs, and Tagged/Blocked/Bypassed using the SLD PBs.

For PBs supporting one breaker only, the Local Control Mode menu includes the setpoint "Select Before Operate", which can be set to either Enabled or Disabled. When it is set to Disabled, tagging, blocking and block bypassing commands are disabled from both Local and Remote control. In this mode the breaker can be controlled directly by the programmed Open and Close PBs. The local control for the disconnect switches is suspended. In this mode they can only be controlled remotely, i.e. using pre-programmed contact inputs, virtual inputs, comms, or any selected FlexLogic operand for closing and opening commands. The remote block and block bypass flags are also suspended. With Select Before Operate set to Disabled the relay behaves similar to some other legacy relays, where when in Local mode the breaker is directly controlled by pressing the Open and Close PBs without additional confirmation, and when in Remote mode the breaker is directly controlled by executing the remote open and close commands from the configured setpoints.

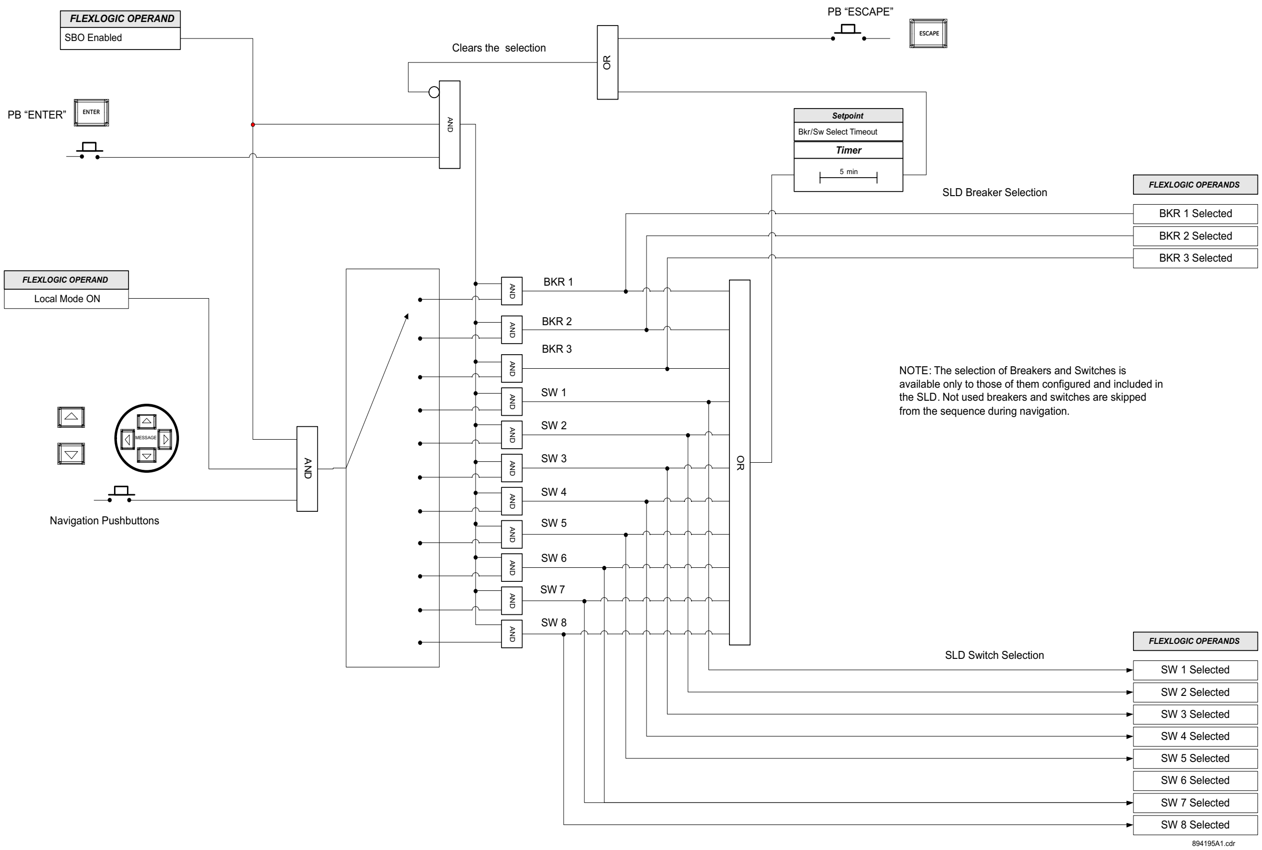
When the "Select Before Operate" setpoint is set to Enabled, the navigation, the breaker or switch selection, as well as the blocking, bypassing and tagging are operational when in Local mode. When switched to Remote mode, the remote blocking and bypassing will be operational as well.

NOTICE

The selected component from SLD will be deselected if either the time programmed in setpoint "Bkr/Sw Select Timeout" expires, or the PB "ESCAPE" is pressed. The "HOME" button will not de-select the selected object. To navigate to home page, the component must be first de-selected on the SLD page.

The programmed PBs for breaker or switch Open and Close can be used only in local mode when an active object is selected in the SLD. The selected device can be opened or closed provided it is not blocked or tagged. If no operation is detected, the selection is removed, and the selected PB must be pressed again to enable the selection. The local mode breaker selection and operation is only active if the user has proper level security access.

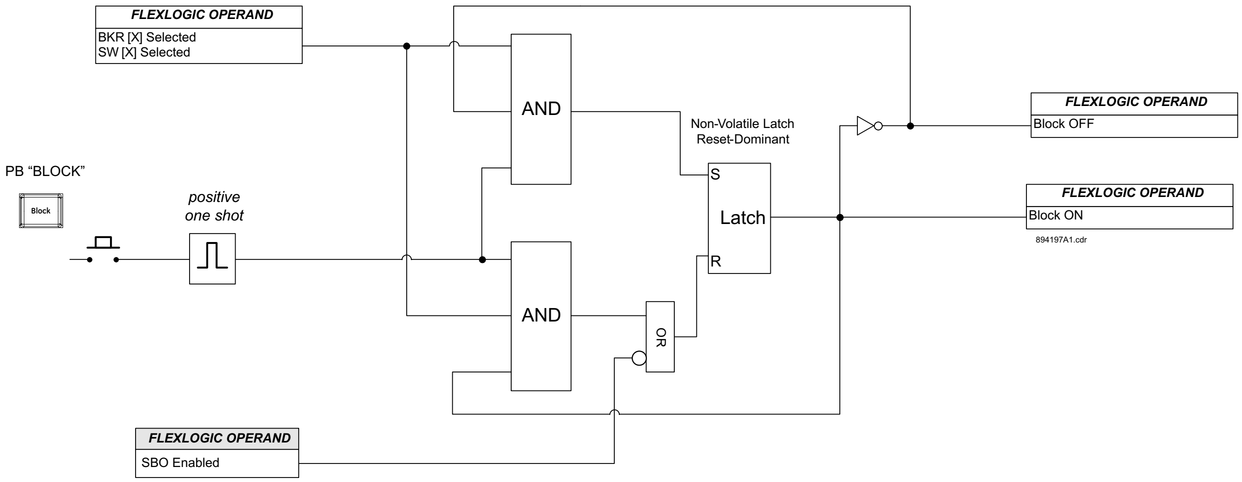
Figure 8-3: Navigation and SLD component selection



PB "Block" (Hardcoded SLD Pushbutton)

Blocking of a breaker or switch can be used for simply inhibiting the close or open operation while in Local Mode. The selected breaker or disconnect switch can be blocked. If block was not applied to the selected component, pressing "Block" PB will block either the Open or Close command depending on the existing state (see Figure 8-4:SLD Pushbutton "Block" logic diagram). For example, if the selected component is in opened state, pressing the PB "Block" will block the closing command, and vice versa (see figures: Local Control for breakers/Local Control for switches). When the block is active, the letter "B" appears in the SLD next to the controlled component

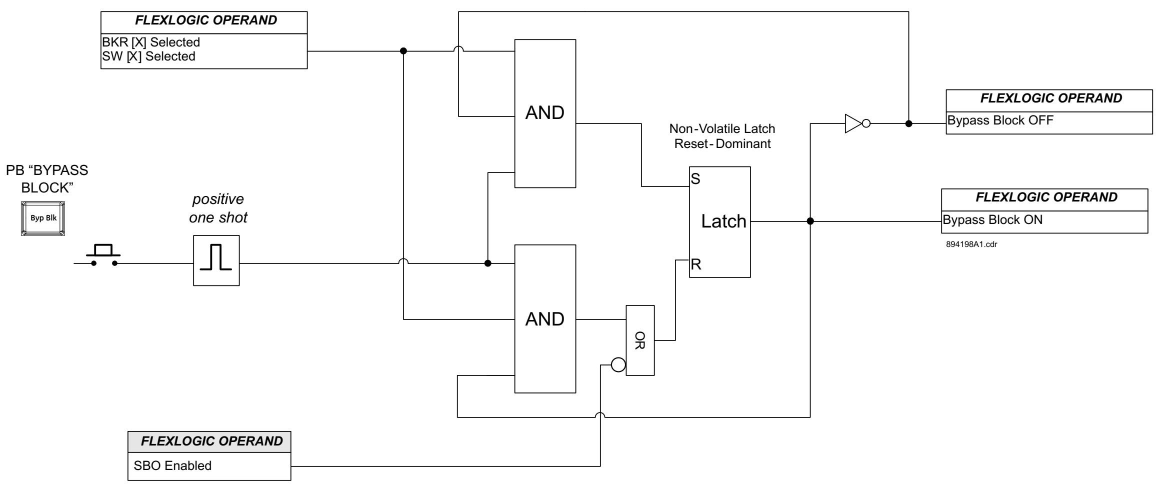
Figure 8-4: SLD Pushbutton "Block" logic diagram



PB "Bypass" (Hardcoded SLD Pushbutton)

Blocking of the command can be bypassed using the SLD pushbutton "Bypass" (see Figure 8-5:SLD Pushbutton "Bypass Block" logic diagram). When pressed, the previously applied block is bypassed (see figures: Local Control for breakers/Local Control for contactor). For example if the block was applied when the Breaker/Switch was opened, pressing the PB "Bypass" will allow closing command. If the bypass is active for the selected breaker or switch, a letter "By" appears next to the symbol in the SLD.

Figure 8-5: SLD Pushbutton "Bypass Block" logic diagram

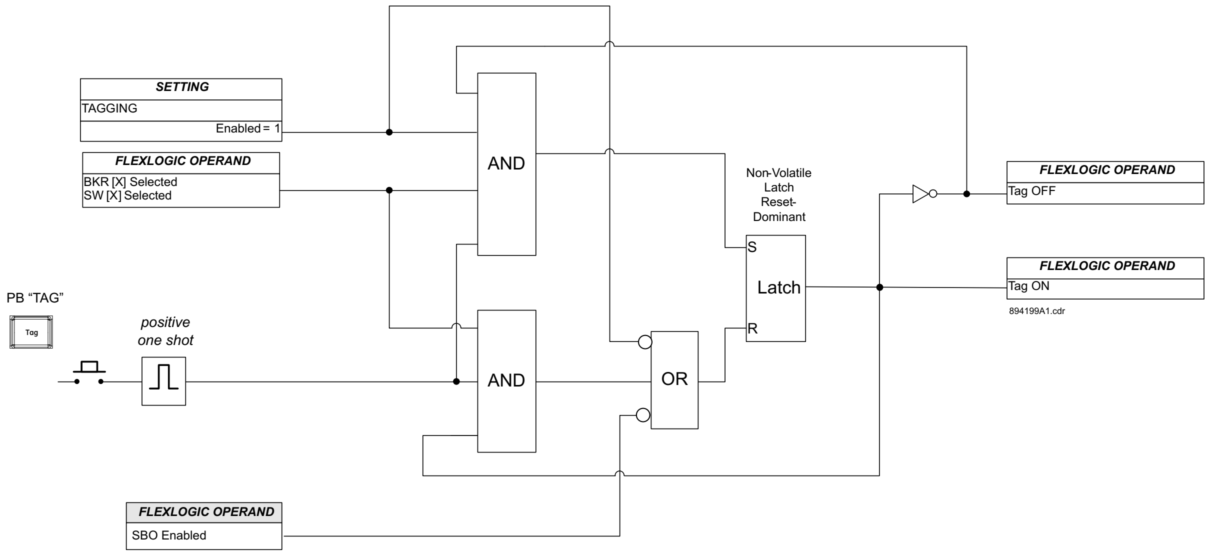


PB "Tag" (hardcoded SLD pushbutton)

Lockout/Tagout is a practice and procedure to safeguard employees from unexpected energization or startup of machinery and equipment, or hazardous energy during service or maintenance activities. If a breakeror disconnect switch is tagged, the open and close controls are inhibited.

Both remote and local control commands are blocked if the tagged operand BKR# Tag ON, or SW# Tag ON is active for the selected particular breaker or switch respectively. The breaker or switch is tagged by pressing the SLD pushbutton "Tag". If the selected switching device is tagged, a letter "T" appears under its symbol. Tagging can be achieved in local mode using the front panel control from the configurable SLD screens. The Pushbutton "Tag" logic diagram shows the tagging logic diagram for a switch. The logic applies to one breaker or switch at the time in the single line diagram.

Figure 8-6: Pushbutton "Tag" logic diagram



NOTICE

The pushbuttons, Tag, Block and Bypass Block are used for both breakers and switches when selected in the SLD. Only one component at the time can be selected in the SLD.

NOTICE

Tagging, blocking, or bypassing block can be performed in Local Mode, and only when the component (breaker or switch) is selected in the SLD. The applied action of tagging, blocking or bypassing block is retained for this component after it's been deselected. To change the status of the applied action, the component need be reselected.

NOTICE

The Local Mode control allows programming of separate pair of PBs for Open and Close commands to breakers and for Open and Close commands to switches. If desired, one pair of pushbuttons can be programmed for Open and Close commands to both breakers and switches.

Figure 8-7: Local Control for breakers

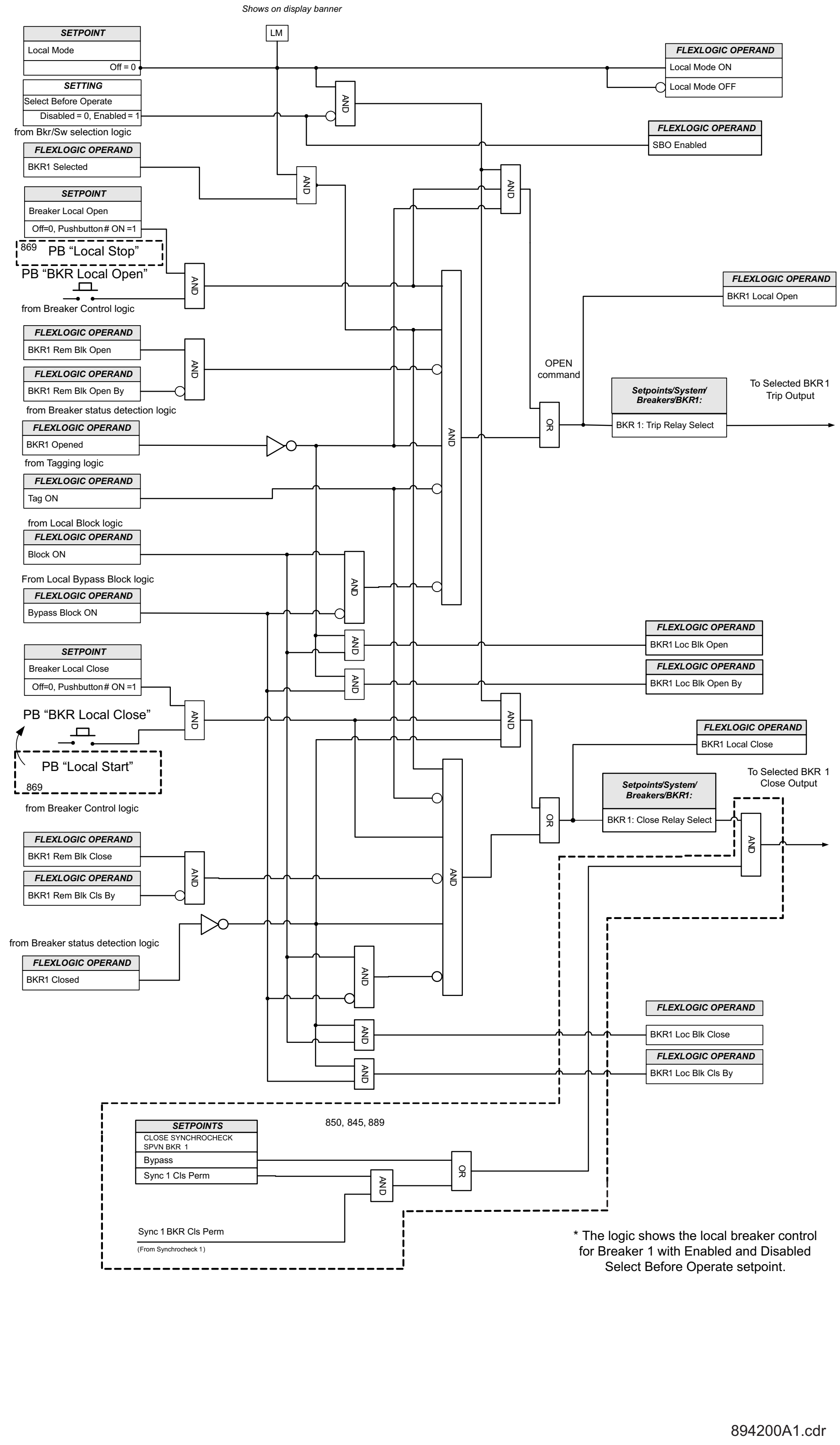
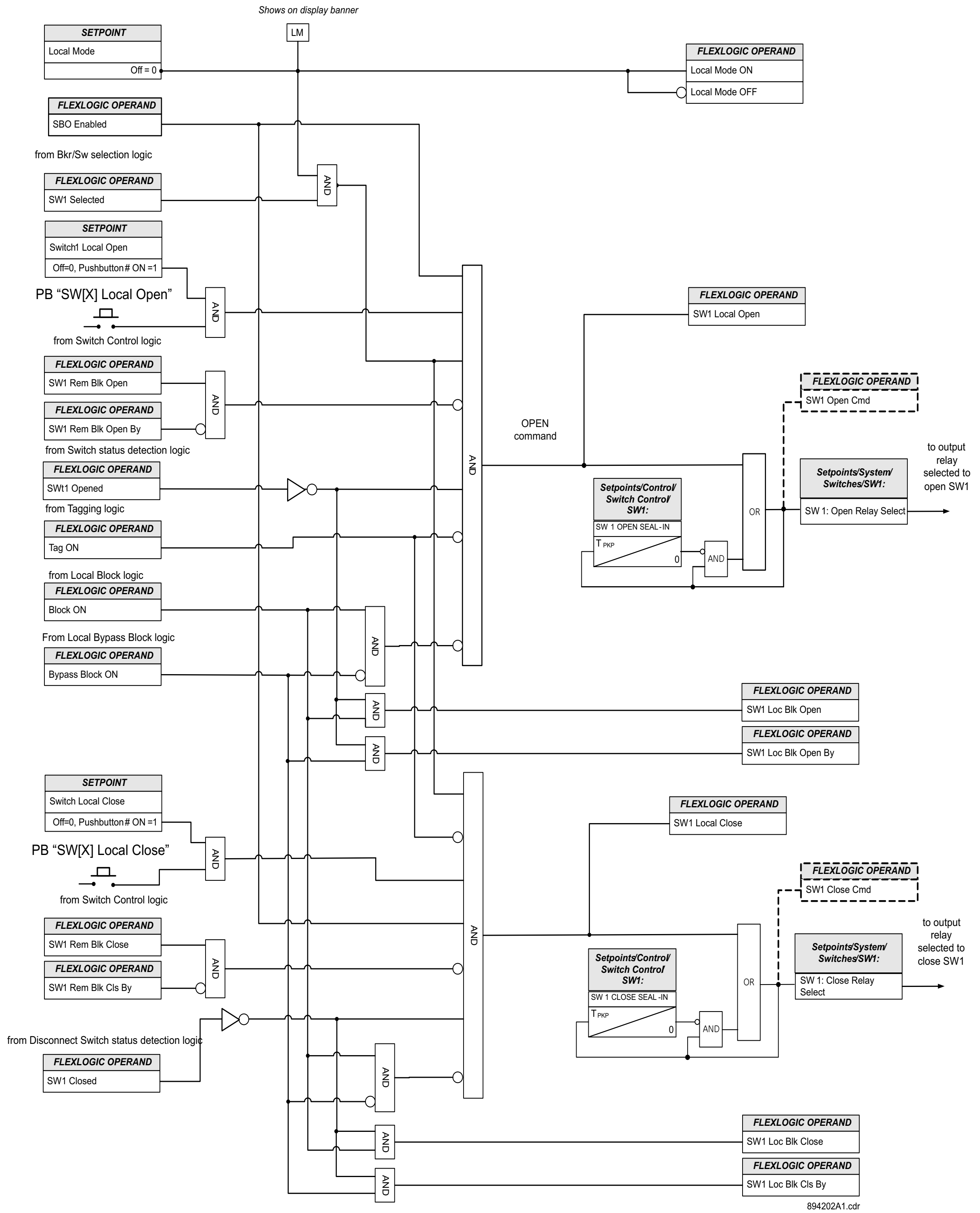


Figure 8-8: Local Control for Switches



* The logic shows the local control for Disconnect Switch 1 when Select Before Operate setpoint is set to Enabled. The local switch control is not available when SBO is set to Disabled.

Path: **Setpoints > Control > Local Control Mode**

For this path the HMI menus vary depending on the order code and the number of breakers selected.

NOTE

For relays supporting single breaker control, the SW Local Open and SW Local Close setpoints appear in the menu only if the relay is ordered with Advanced SLD; and the "Select Before Operate" setpoint is set to "Enabled". In all other cases, these setpoints are hidden and inactive.

LOCAL MODE

Range: Off, On, Any FlexLogic operand

Default: order code dependant (On or Pushbutton 5 OFF)

For the 10 PB faceplate 11-A

Range: Off, On, Any FlexLogic operand

Default: Pushbutton 5 Off

The LOCAL MODE setting places the relay in local mode. The relay is in Remote mode, if not forced into Local mode by this setpoint (i.e. LOCAL mode set to Disabled, or the selected input de-asserted). When in Local Mode, both Breakers and Disconnect switches can be controlled using the faceplate pushbuttons and SLD pushbuttons.

BKR /SW SELECT TIMEOUT

Range: 1 to 10 min in steps of 1 min

Default: 5 min

This setting specifies the available time for open/close commands, after a breaker or a disconnect switch has been selected in the single line diagram.

BKR LOCAL OPEN

Range: Off, Pushbutton 1 ON,.......Pushbutton 10 ON, Contact Input X

Default: Pushbutton 2 ON

This setpoint is active, when Local Mode is activated. The breaker open command can be initiated by the selected faceplate pushbutton.

BKR LOCAL CLOSE

Range: Off, Pushbutton 1 ON,.......Pushbutton 10 ON, Contact Input X

Default: Pushbutton 1 ON

This setpoint is active, when Local Mode is activated. The breaker close command can be initiated by the selected faceplate pushbutton.

SW LOCAL OPEN

Range: Off, Pushbutton 1 ON,.......Pushbutton 10 ON, Contact Input X

Default: Pushbutton 2 ON

This setpoint is active, when Local Mode is activated. The switch open command can be initiated by the programmed faceplate pushbutton. The setpoint appears in the Local Control Mode menu only when advanced SLD is selected when ordering the relay.

SW LOCAL CLOSE

Range: Off, Pushbutton 1 ON,.......Pushbutton 10 ON, Contact Input X

Default: Pushbutton 1 ON

This setpoint is active, when Local Mode is activated. The switch close command can be initiated by the programmed faceplate pushbutton. The setpoint appears in the Local Control Mode menu only when advanced SLD is selected when ordering the relay.

TAGGING

Range: Enabled, Disabled

Default: Enabled

When enabled, tagging control is enabled and the TAG key is displayed on the front panel interface. When a breaker or a switch is tagged both the local and remote control of the device is inhibited.

NOTICE

Tagging is applied only from the TAG key and is mostly used for maintenance purposes, and in general when either the open or close control must be inhibited. The tagging cannot be bypassed and can only be disabled (untagged) by pressing the TAG key again.

EVENTS

Range: Disabled, Enabled

Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched

Default: Self-reset

Breaker Control (3)

While the Local breaker control is generic as the same front panel pushbuttons are used for control of each selected breaker from the SLD, the remote breaker control requires programming of setpoints for each individual breaker. When the relay is in Remote mode (Local Mode set to Off, or the assigned operand de-asserted), the setpoint "Remote Block Open" and "Remote Block Close" from the breaker menu can be used. These setpoints can be used to provide Interlocking to the breaker control by assigning appropriate operands. The control for each breaker can be programmed to have Bypass Remote Block Open and Bypass Remote Block Close inputs. These inputs can be programmed if temporary permission for open or close is required.

The remote breaker open and close controls, as well as the blocking and bypassing the block commands are executed as per the programmed setpoints form the Breaker Control menu.

NOTICE

The breaker "Remote Block Open", "Remote Block Close", "Bypass Rem Blk Open" and "Bypass Rem Blk Close" flags are inhibited, when the setpoint Select Before Operate residing under Local Control Mode menu is set to Disabled. The breaker remote open and close commands are operational.

NOTICE

The 845 relay provides control of up to three breakers, depending on the order code. An additional remote breaker status is available for HMI status only.

Path: **Setpoints > Control > Breaker Control > BKR1(X)**

REMOTE OPEN

Range: Off, Any FlexLogic operand

Default: Off

The setting specifies the input which, when asserted, initiates a Trip command to output relay #1 TRIP. When the selected input is asserted, the Trip contact is energized and stays energized until the input drops off, the breaker opens, and the selected Trip seal-in time expires. This setpoint provides the flexibility to operate the Trip output relay by selecting an operand from the list of FlexLogic operands, contact inputs, virtual inputs, or remote inputs. For example the operand "Trip Bus 1 Op" can be selected to activate this output according to the Trip conditions configured under the Trip Bus 1 menu.

REMOTE CLOSE

Range: Off, Any FlexLogic operand

Default: Off

The setting specifies the input which, when asserted, initiates a Close command to the output relay selected to close the breaker. This setpoint provides flexibility to operate the output relay by selecting an operand from the list of FlexLogic operands.

REMOTE BLOCK OPEN

Range: Off, Any FlexLogic operand

Default: Off

The assertion of the operand assigned to this setpoint prevents the breaker from opening/tripping.

REMOTE BLOCK CLOSE

Range: Off, Any FlexLogic operand

Default: Off

The assertion of the operand assigned to this setpoint prevents the breaker from closing.

BYPASS REM BLK OPEN

Range: Off, Any FlexLogic operand
Default: Off

This setting specifies selection of an input which when asserted bypasses the asserted remote block open signal. Open command is permitted for the breaker.

BYPASS REM BLK CLOSE

Range: Off, Any FlexLogic operand
Default: Off

This setting specifies selection of an input which when asserted bypasses the asserted remote block close signal. Close command is permitted for the breaker.

CLOSE SYNC SPVN BKR

Range: Bypass, Sync 1 Cls Perm
Default: order code dependant (e.g. Bypass or Sync 1Cls Perm)

This setpoint selects whether or not the closing of the breaker is supervised by the synchrocheck function. For this purpose the Synchrocheck element must be enabled.

NOTICE

If the supervision is not bypassed and Close is applied for an application where the breaker is located on radial feeders, or the line is powered by one source only, the DEAD SOURCE PERM setpoint from the Synchrocheck menu shall not be disabled.

NOTICE

The 845 relay has one three-phase voltage inputs, a single auxiliary voltage input, and one Synchrocheck element. It is strongly recommended to connect the relay voltage inputs to three-phase VTs and an Aux VT installed across a breaker on the same side of the transformer winding. With this condition in place, select the Synchrocheck Close Permission only for that breaker. Do not select the Synchrocheck Close Permission for the breakers on the other transformer windings.

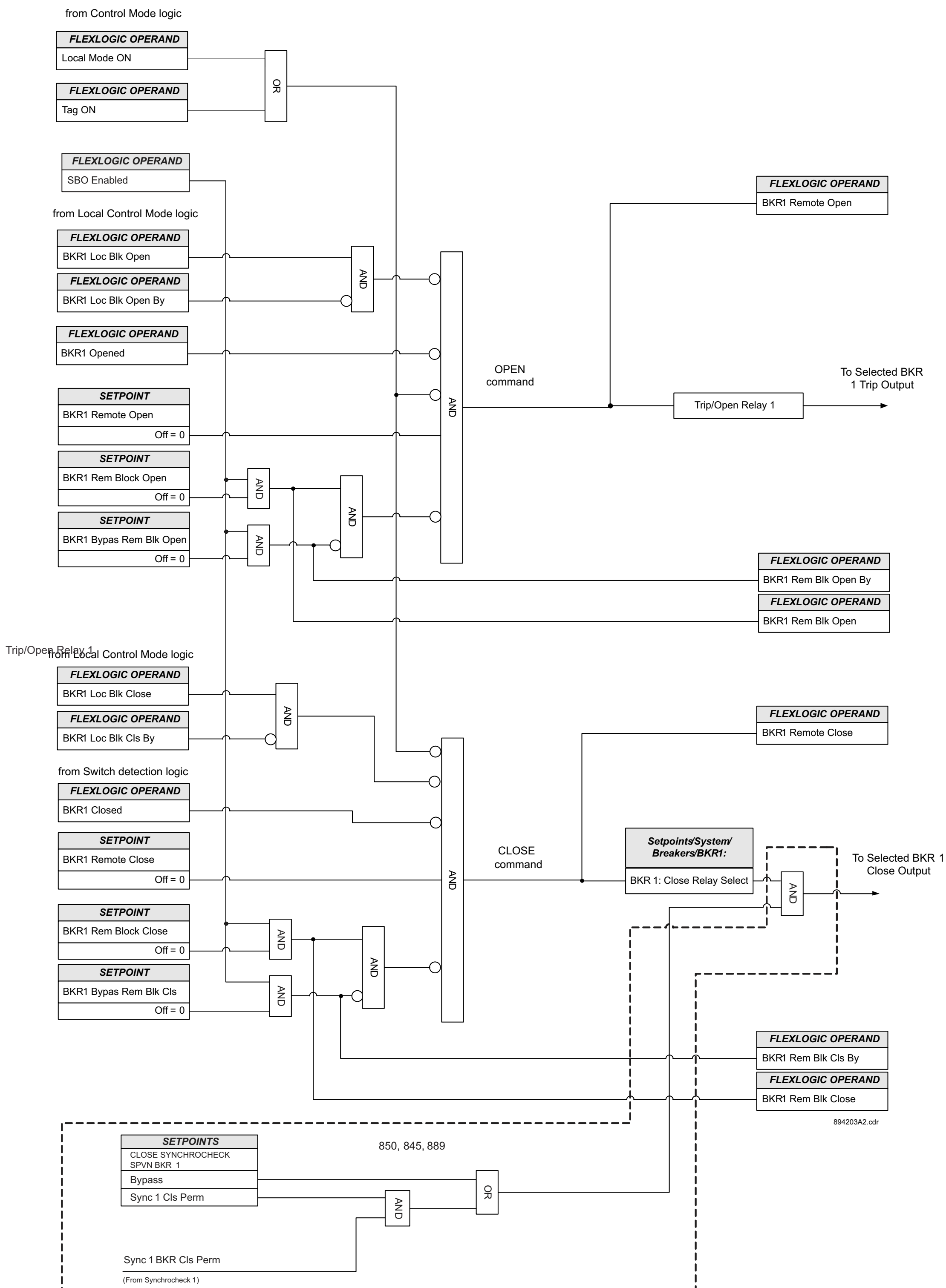
EVENTS

Range: Disabled, Enabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Self-reset

Figure 8-9: Breaker Control logic diagram



Switch Control (89)

Description

The disconnect switch control provides local and remote opening and closing of the switches. The local control (Open, Close, Tag, Block, Bypass Block) is performed from the relay front panel pushbuttons when Local Mode is active, and the switch is selected from the displayed single line diagram. The remote switch open and close controls, as well as the blocking and bypassing the block commands are executed as per the programmed setpoints form the Switch Control menu. While the Local switch control is generic and the same front panel pushbuttons are used for every selected component from the SLD, the remote switch control requires programming of setpoints per each individual switch. These settings are defined in the menu of each individual switch control. When the relay is in Remote mode (Local Mode set to Off, or the assigned operand de-asserted), the setpoint "Remote Block Open" and "Remote Block Close" from the Switch Control menus can be used. These setpoints can be used to provide Interlocking to the switch control by assigning appropriate operands. The control for each disconnect switch can be programmed to have Bypass Remote Block Open and Bypass Remote Block Close inputs. These inputs can be programmed if temporary permission for open or close is required.

NOTICE

The switch "Remote Block Open", "Remote Block Close", "Bypass Remote Block Open" and "Bypass Remote Block Close" flags are inhibited, when the setpoint Select Before Operate residing under Local Control Mode menu is set to Disabled. The remote open and close commands are still operational.

Path: **Setpoints > Control > Switch Control > SW 1(X) Control**

REMOTE OPEN

Range: Off, Any FlexLogic operand
Default: Off

This setting specifies an input which when asserted initiates the open command to the switch. This setpoint is active only when the operand assigned for Local Mode is de-asserted, or Local Mode is set to "Off".

REMOTE CLOSE

Range: Off, Any FlexLogic operand
Default: Off

This setting specifies an input which when asserted initiates the close command to the switch. This setpoint is active only when the operand assigned for Local Mode is de-asserted, or Local Mode is set to "Off".

OPEN SEAL-IN

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 0.000 s

This setting specifies the seal-in time of the open commands due to an operator initiated manual or remote open command to the disconnect switch.

CLOSE SEAL-IN

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 0.000 s

This setting specifies the seal-in time of the open commands due to an operator initiated manual or remote close command to the disconnect switch.

NOTICE

To maintain the close/open command for a certain time, do so by either using the seal-in timers Open Seal-In and Close Seal-In, or the setpoint "Seal-in" from the output relays, or FlexLogic.

REMOTE BLOCK OPEN

Range: Off, Any FlexLogic operand
Default: Off

The assertion of the operand assigned to this setpoint prevents the disconnect switch from opening.

REMOTE BLOCK CLOSE

Range: Off, Any FlexLogic operand
Default: Off

The assertion of the operand assigned to this setpoint prevents the disconnect switch from closing.

BYPASS REM BLK OPEN

Range: Off, Any FlexLogic operand
Default: Off

This setting specifies the selection of an input which when asserted bypasses the block to the disconnect open control. The Open command is permitted.

BYPASS REM BLK CLOSE

Range: Off, Any FlexLogic operand
Default: Off

This setting specifies the selection of an input which when asserted bypasses the block to the disconnect close control. The Close command is permitted.

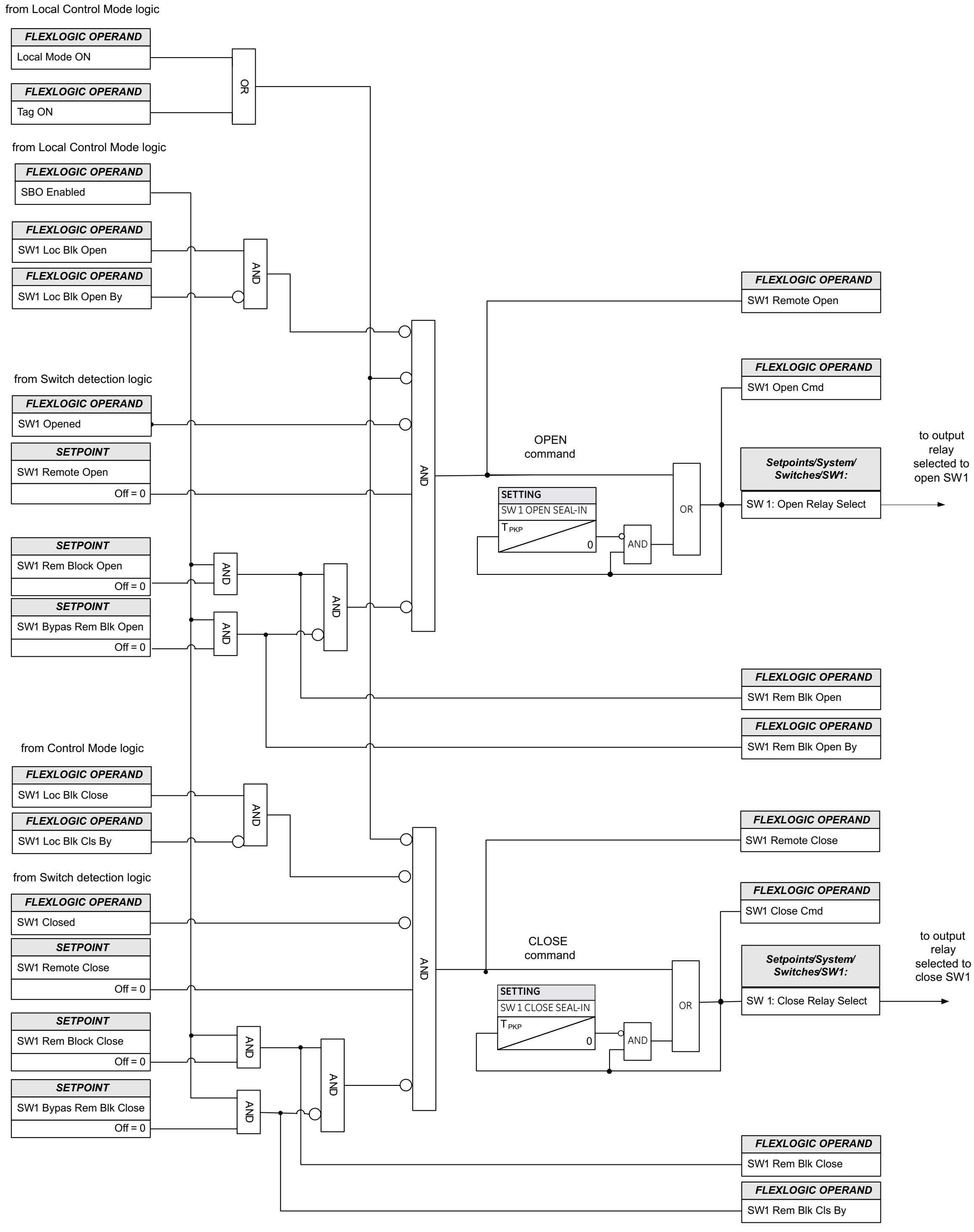
EVENTS

Range: Disabled, Enabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Self-reset

Figure 8-10: Switch Control logic diagram



* The logic shows the remote control logic for SW 1. The same logic applies to each switch by programming its individual setpoints for remote control.

Virtual Input Control

Path: **Setpoints > Control > Virtual Input Control**

FORCE VIRTUAL INPUT 1 (64)

Range: Off, On

Default: Off

The states of up to 64 Virtual Inputs are changed here. The current or selected status of the Virtual Input is also shown here. The status is a state OFF (logic 0) or ON (logic 1). If the corresponding Virtual Input selected under Setpoints/Inputs/Virtual Inputs is set to “Latched,” the “On” command initiated from this menu stays “On” and the status of this Virtual Input is also “On” until the “Off” command is received. If the Virtual Input type is “Self-Reset,” the command and status of this Virtual Input reverts to “Off” after one evaluation of the FlexLogic™ equations.

Trip Bus

The 845 relay provides six identical Trip Bus elements. The Trip Bus element allows aggregating outputs of protection, control elements, inputs without using FlexLogic and assigning them in a simple and effective manner. Each Trip Bus can be assigned to trip, alarm or the other logic actions. Simple trip conditioning such as latch, delay, and seal-in delay are available.

Path: **Setpoints > Control > Trip Bus 1(X)**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

INPUT 1 to 16

Range: Off, Any FlexLogic operand
Default: Off

These settings select a FlexLogic operand to be assigned as an input to the Trip Bus.

LATCHING

Range: Enabled, Disabled
Default: Disabled

The setting enables or disables latching of the Trip Bus output. This is typically used when lockout is required or user acknowledgement of the relay response is required.

RESET

Range: Off, Any FlexLogic operand
Default: Off

The trip bus output is reset when the operand assigned to this setting is asserted.

PICKUP DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 0.000 s

DROPOUT DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 0.000 s

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

EVENTS

Range: Enabled, Disabled
Default: Enabled

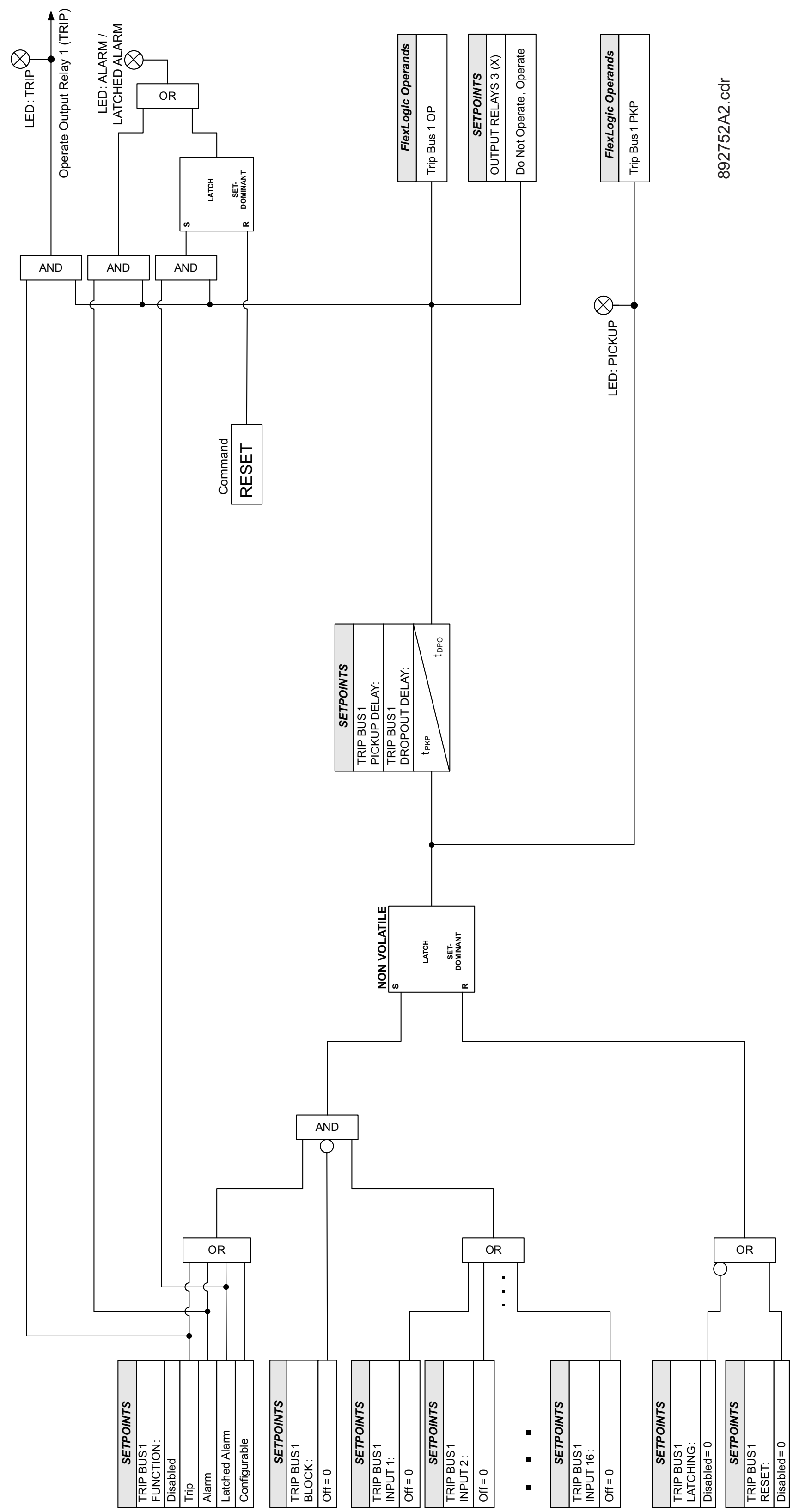
TARGETS

Range: Self-reset, Latched, Disabled
Default: Self-reset

NOTE

The *Any Trip* operand must not be programmed as an input for the Trip Bus function.

Figure 8-11: Trip Bus logic diagram



Breaker Failure (50BF)

The Breaker Failure element determines that a breaker signaled to Trip has not cleared a fault within a definite time. The Breaker Failure scheme must Trip all breakers that can supply current to the faulted zone. Operation of a breaker Failure element causes 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 can affect system safety and stability, a very high level of security is required.

The Breaker Failure function monitors phase and neutral currents and/or status of the breaker while the protection trip or external initiation command exists. If Breaker Failure is declared, the function operates the selected output relays, forces the autoreclose scheme to lockout and raises FlexLogic operands.

The operation of a Breaker Failure element consists of three stages: initiation, determination of a Breaker Failure condition, and outputs.

Initiation of a Breaker Failure

The protection signals initially sent to the breaker or external initiation (FlexLogic operand that initiates Breaker Failure) initiates the Breaker Failure scheme.

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 can result from a declaration of a failed breaker.

Determination of a Breaker Failure condition

The schemes determine a Breaker Failure condition supervised by one of the following:

Current supervision only

Breaker status only

Both (current and breaker status)

Each type of supervision 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 delays are associated with breaker failure timers 1, 2, and 3.

Timer 1 logic is supervised by current level only. If fault current is detected after the delay interval, an output is issued. The continued presence of current indicates that the breaker has failed to interrupt the circuit. This logic detects a breaker that opens mechanically but fails to interrupt fault current.

Timer 2 logic is supervised by both current supervision and breaker status. 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.

Timer 3 logic is supervised by a breaker auxiliary contact only. There is no current level check in this logic as it is intended to detect low magnitude faults. External logic may be created to include control switch contact used to indicate that the breaker is in out-of-service mode, disabling this logic when the breaker is out-of-service for maintenance.

Timer 1 and 2 logic provide two levels of current supervision - high-set and low-set - that allow the supervision level to change (for example: 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 the timeout of timer 1 or 2, along with a timer low-set delay 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.

Outputs

The outputs from the schemes are:

- Re-trip of the protected breaker

- FlexLogic operand that reports on the operation of the portion of the scheme where high-set or low-set current supervision is used
- FlexLogic operand that reports on the operation of the portion of the scheme where 52b status supervision is used only
- FlexLogic operand that initiates tripping required to clear the faulted zone. The Breaker Failure output can be sealed-in for an adjustable period
- Target message indicating a failed breaker has been declared.

Setup

Path: **Setpoints > Control > Breaker Failure > BF1(X) > BF1(X) Setup**

FUNCTION

Range: Disabled, Retrip, Latched Alarm, Alarm, Configurable

Default: Disabled

When the **Retrip** function is selected and Breaker Failure is initiated (with re-trip current supervision), the output relay #1 "Trip" operates but the "ALARM" LED does not turn on.

SIGNAL INPUT

Range: dependant upon the order code

Default: CT Bank 1-J1

PH RETRIP SUPERV PICKUP

Range: 0.050 to 30.000 x CT in steps of 0.001 x CT

Default: 1.000 x CT

The setpoint specifies the phase current Retrip level, which when exceeded after Breaker Failure initiation, will Retrip its own breaker. The setting is set to detect the lowest expected fault current on the protected circuit.

NTRL RETRIP SUPERV PICKUP

Range: 0.050 to 30.000 x CT in steps of 0.001 x CT

Default: 1.000 x CT

This setpoint specifies the neutral current Retrip level, which when exceeded after Breaker Failure initiation, will Retrip its own breaker. The setting detects the lowest expected fault current on the protected circuit. Neutral Retrip current supervision is used to provide increased sensitivity.

SUPERVISION

Range: Current, 52b & Current, 52b

Default: Current

The setpoint specifies the type of supervision of the Breaker Failure element. There are three options: current only, breaker status only, or both.

BREAKER CLOSED

Range: Off, Any FlexLogic operand

Default: Off

The setpoint selects the FlexLogic operand (auxiliary switch contact) to indicate that the circuit breaker is closed.

T1 PICKUP DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s

Default: 0.120 s

The setting provides a delay for Timer 1 logic which is supervised with current supervision only. The timer is set to the expected opening time of the circuit breaker, plus a safety margin intended to overcome the relay measurement and timing errors as well as relay processing time and current supervision reset time. In a microprocessor relay this time is not significant. In the 845 relay, the current magnitude ramps-down to zero in ¾ of a power cycle after the current is interrupted.

NOTICE

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.

T2 PICKUP DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s

Default: 0.120 s

The setting provides a delay for Timer 2 logic which is supervised with current supervision and breaker status (52b indication). The timer is set to the expected opening time of the circuit breaker, plus a safety margin intended to overcome the relay measurement and timing errors, relay processing time, current supervision reset time, and the time required for the breaker auxiliary contact to open.

T3 PICKUP DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s

Default: 0.120 s

The setting provides a delay for Timer 3 logic which is supervised with breaker status only (52b indication). The timer is set to the expected opening time of the circuit breaker, plus a safety margin intended to overcome the relay timing errors, and the time required for the breaker auxiliary contact to open.

PHASE HIGHSET PICKUP

Range: 0.050 to 30.000 x CT in steps of 0.001 x CT

Default: 1.000 x CT

The setpoint specifies the phase current output supervision level. The setting detects the lowest expected fault current on the protected circuit.

NEUTRAL HIGHSET PICKUP

Range: 0.050 to 30.000 x CT in steps of 0.001 x CT

Default: 1.000 x CT

The setpoint specifies the neutral current output supervision level. The setting detects the lowest expected fault current on the protected circuit. Neutral current supervision is used to provide increased sensitivity.

LOWSET DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s

Default: 0.000 s

The setting provides the lowest current supervision Pickup. The setting is used in applications where a change in supervision current level is required (for example: breakers with opening resistors).

The lowest delay (interval between high-set and low-set) is the expected breaker opening time.

PHASE LOWSET PICKUP

Range: 0.050 to 30.000 x CT in steps of 0.001 x CT

Default: 1.000 x CT

The setpoint specifies the phase current output supervision level. The setting detects the lowest expected fault current on the protected circuit where significant change in current level is expected (for example: breakers with opening resistors).

NEUTRAL LOWSET PICKUP

Range: 0.050 to 30.000 x CT in steps of 0.001 x CT

Default: 1.000 x CT

The setpoint specifies the neutral current output supervision level. The setting detects the lowest expected fault current on the protected circuit where significant change in current level is expected (for example: breakers with opening resistors). Neutral current supervision is used to provide increased sensitivity.

DROPOUT DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s

Default: 0.100 s

The setting is used to set the period of time for which the Breaker Fail 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 for longer than the reclaim time.

BLOCK

Range: Off, Any FlexLogic operand

Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

EVENTS

Range: Disabled, Enabled

Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched

Default: Self-reset

Initiate

Path: **Setpoints > Control > Breaker Failure 1(X) > BF1(X) Initiate**

EXTERNAL INITIATE

Range: Off, Any FlexLogic operand

Default: Off

The setpoint selects the FlexLogic operand that initiates the Breaker Failure scheme; typically the trip signals from external devices.

NOTICE

The trip signals from internal protection functions may be used with the help of FlexLogic, but for easier setting the Breaker Failure function is provided with a BF1 INITIATE submenu.

INITIATE IN1(15)

Range: Off, Any FlexLogic operand

Default: Ph TOC 1 OP

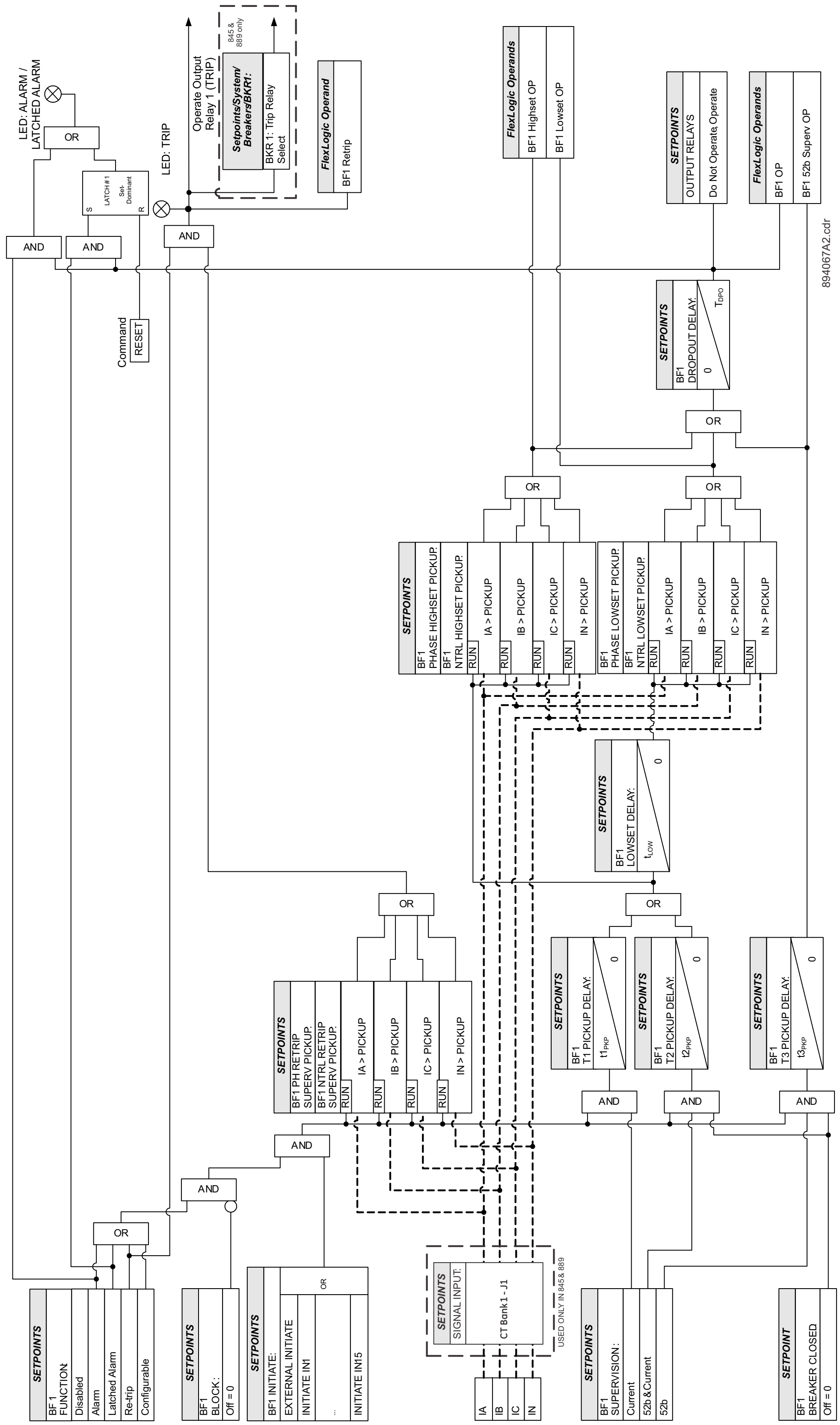
The setpoint selects the FlexLogic operand that initiates the Breaker Failure scheme; typically the trip signals from internal protection functions.

NOTICE

The default setting includes the following protection functions:

Ph TOC 1 OP
Ph TOC 2 OP
Ph IOC 1 OP
Ph IOC 2 OP
Ntrl TOC 1 OP
Ntrl TOC 2 OP
Ntrl IOC 1 OP
Ntrl IOC 2 OP
GND TOC 1 OP
GND IOC 1 OP

Figure 8-12: Breaker Failure logic diagram



Arc Flash Protection

The Arc Flash Protection module supports fast and secure protection against an arc flash event for a safe working environment.

Arc Flash protection utilizes a total of four light detection fiber sensors and dedicated high-speed instantaneous overcurrent element with secure Finite Response Filtering. Light from the light sensor AND logic with high-speed overcurrent ensures fast and secure operation. Further enhancement includes continuous monitoring of individual light sensors with self-test trouble indication. Four Arc Flash elements with self-test from the individual light sensors can be used to design flexible Arc Flash protection schemes for different configurations depending upon the physical locations of the sensors. Each individual element can also provide a higher level of redundancy/reliability of the system.

In case any issues with the sensors are detected (i.e. failure of a self-test), the corresponding light sensor trouble operands (i.e. “Light Sensor # Trouble” and “Light Sensor Trouble”) are asserted. Very fast detection of the Arc flash light event is also possible using Light as the only detection parameter for alarm purposes. In addition, customized logic can be designed using individual “AF1 Light # PKP” and “Arc Flash 1 S# OP” operands from different light sensors in the FlexLogic engine.

Path: **Setpoints > Control > Arc Flash > Arc Flash 1**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable

Default: Disabled

The selection of Trip, Alarm, Latched Alarm or Configurable setting enables the HS Phase/Ground IOC function.

HS PHASE PKP

Range: 0.050 to 30.000 x CT in steps of 0.001 x CT

Default: 2.000 x CT

HS GROUND PKP

Range: 0.050 to 30.000 x CT in steps of 0.001 x CT

Default: 1.000 x CT

NOTE

The value of HS Gnd PICKUP can be set to a very high value, when only the HS Phs element needs to be applied for Arc Flash detection.

NOTE

The HS Ground PKP setting is not available if the order code is selected to have just one sensitive ground current input on the J1-Bank (4-0B in the order code).

LIGHT SENSOR 1(4)

Range: Disabled, Enabled

Default: Disabled

BLOCK

Range: Off, Any FlexLogic operand

Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

EVENTS

Range: Disabled, Enabled

Default: Enabled

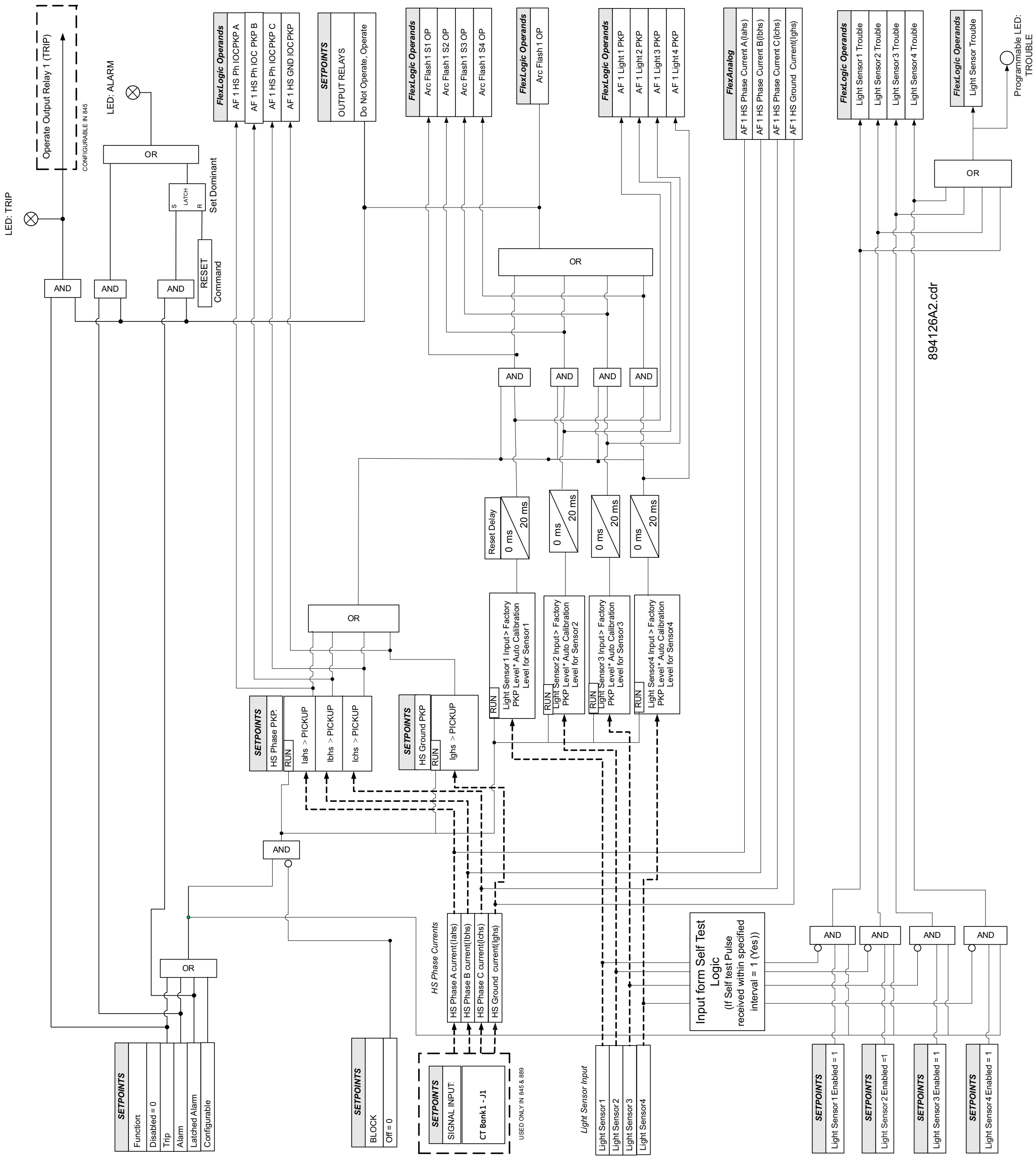
This setting enables or disables the events of the Arc Flash function.

TARGETS

Range: Self-reset, Latched, Disabled

Default: Latched

Figure 8-13: Arc Flash logic diagram



Synchrocheck (25)

The 845 relay provides one Synchrocheck element.

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

If a breaker can be a paralleling point between two generation sources, it is common practice to automatically perform a check to ensure the sources are within allowable voltage limits before permitting closing of the breaker. Synchrocheck provides this feature by checking that the bus and line input voltages are within the programmed differentials of voltage magnitude, phase angle position, and frequency. If this feature is enabled, the check will be performed before either manual close or automatic reclose signals can operate the Close Output Relay. The Synchrocheck programming can allow permitted closing if either or both of the sources are de-energized.

Synchrocheck verifies that the voltages (BUS and LINE) on the two sides of the supervised circuit breaker are within set limits of magnitude, angle and frequency difference. The time during which the two voltages remain within the admissible angle difference is determined by the setting of the phase angle difference ΔΦ (without angle compensation) and the frequency difference ΔF (slip frequency). It can be defined as the time it would take the voltage phasor, BUS or LINE, to traverse an angle equal to 2 × ΔΦ at a frequency equal to the frequency difference ΔF. This time can be calculated by:

$$T = \frac{1}{\frac{360^\circ}{2 \times \Delta\Phi} \times \Delta F}$$

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

Example:

For the values of ΔΦ = 30° and ΔF = 0.1 Hz, the time during which the angle between the two voltages is less than the set value is:

$$T = \frac{1}{\frac{360}{2 \times 30} \times 0.1} = 1.66 \text{ sec}$$

As a result the breaker closing time must be less than this computed time, to successfully close and connect both energized sides.

If one or both sides of the synchronizing breaker are de-energized, the Synchrocheck programming can allow for closing of the circuit breaker using undervoltage control to by-pass the Synchrocheck measurements (dead source function).

The measured bus and line input voltage magnitudes, angles and frequencies, and calculated differential values of angle magnitude and frequency are available as actual values under **Metering > Synchrocheck 1**.

NOTE

The Synchrocheck from the 845 relay works correctly if programmed with voltage inputs from Phase and Aux VTs placed across the breaker on same side of the transformer winding. The Synchrocheck will not work correctly if the Phase and Aux VTs are placed on two different windings.

The selection of "Aux VT Connection" under **Setpoints > System > Voltage Sensing** determines the voltage used for Synchrocheck as derived from the three-phase voltages available on the relay. For example, if the Aux VT Connection is selected as Vab, and the three-phase VTs are connected in "Wye", the relay computes delta voltage Vab as well, and uses it for Synchrocheck.

⚠WARNING

The Synchrocheck cannot be performed if the three-phase VTs are Delta connected, and the Wye single voltage input is selected under "Aux VT connection". "Wye" voltages cannot be calculated from Delta connected VTs.

If both Line and Bus sides are three-phase VTs, the VT types must match, i.e. either both Line and Bus Volt inputs are Delta or both are Wye. If both sides are single-phase Aux VT inputs, then both Aux VT connection types must match, i.e. if the Line side Aux VT type is Vab, then the Bus side Aux VT type must be Vab. Aux VT connection "Vn" is not a valid type for synchrocheck.

⚠CAUTION

If the VT types on the Line and Bus side do not match, as specified above, the Sunchrocheck does not run even when the Function is set to Enabled.

⚠WARNING

Once the Synchrocheck function is programmed, it will perform a voltage input selection check, to determine that the voltage magnitudes are not different by more than 5%. This check depends only on the settings entered for phase and auxiliary VTs under Setpoints > System > Voltage Sensing. If the difference between the selected voltage inputs by calculation is bigger than 5%, the Synchrocheck will not work. For example, the phase VT can be set to Wye connection with secondary voltage of 66.4V. The Aux. VT can be connected between phase A to B with the secondary voltage set to 115V. Then, one of the Synchrocheck inputs can be set as the Wye connected phase voltage bank, and the other input can be the Aux. VT with voltage V_{ab}. Since the difference between the computed V_{ab} input and the Aux. VT setting is 0%, the Synchrocheck will work. However, if this difference is bigger than 5%, the Synchrocheck will not work.

Path: **Setpoints > Control > Synchrocheck 1(X)**

FUNCTION

Range: Disabled, Enabled

Default: Disabled

BUS VOLTS INPUT

Range: dependant upon the order code

Default: Ph VT Bnk1-J2

The setting provides selection of the Bus Volts input; either three-phase voltages from the three-phase VTs connected to the relay, or a single voltage from the Auxiliary VT also connected to the relay Aux VT input. The setup of these VTs is outlined under **Setpoints > System > Voltage Sensing**.

LINE VOLTS INPUT

Range: dependant upon the order code

Default: Ax VT Bnk1-J2

The setting provides selection of the Line Volts input; either three-phase voltages from the three-phase VTs connected to the relay, or a single voltage from the Auxiliary VT also connected to the relay Aux VT input. The setup of these VTs is outlined under **Setpoints > System > Voltage Sensing**.

MAX FREQ DIFFERENCE

Range: 0.01 to 5.00 Hz in steps of 0.01 Hz

Default: 0.20 Hz

The setting selects the maximum frequency difference in 'Hz' between the two sources. A frequency difference between the two input voltage systems below this value is within the permissible limit for synchronism.

MAX ANGLE DIFFERENCE

Range: 1 to 100° in steps of 1°

Default: 20°

The setpoint selects the maximum angular difference in degrees between the two sources. An angular difference between the two input voltage phasors below this value is within the permissible limit for synchronism.

MAX VOLT DIFFERENCE

Range: 10 to 600000 V in steps of 1 V

Default: 2000 V

The setpoint selects the maximum primary voltage difference in volts between the two sources. A primary voltage magnitude difference between the two input voltages below this value is within the permissible limit for synchronism.

MAX FREQ HYSTERESIS

Range: 0.01 to 0.10 Hz in steps of 0.01 Hz

Default: 0.05 Hz

The setpoint specifies the required hysteresis for the maximum frequency difference condition. The condition becomes satisfied when the frequency difference becomes lower than SYNC1 MAX FREQ DIFFERENCE. Once the Synchrocheck element has operated, the frequency difference must increase above the SYNC1 MAX FREQ DIFFERENCE + SYNC1 MAX FREQ HYSTERESIS sum to drop out (assuming the other two conditions, voltage and angle, remain satisfied).

DEAD SOURCE PERM

Range: Disabled, LB & DL, DB & LL, DB & DL, DB OR DL, DB XOR DL

Default: Disabled

The setpoint 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 (Bus Voltage or/and Line Voltage) are below the maximum voltage threshold. A dead or live source is declared by monitoring the voltage level. Six options are available.

The voltage levels that determine whether a source is dead or live are configurable in the four setpoints following this one.

The DEAD SOURCE PERMISSION range is as follows:

"Disabled": Dead source permissive is disabled.

"LB & DL": Live Bus AND Dead Line."DB & LL": Dead Bus AND Live Line.

"DB & DL": Dead Bus AND Dead Line.

"DB OR DL": Dead Bus OR Dead Line.

"DB XOR DL": Dead Bus XOR Dead Line (one source is Dead and one is Live).

NOTICE

For an application where the breaker is located on radial feeders, or line is powered by one source only, the DEAD SOURCE PERM setpoint shall not be disabled.

LIVE BUS VOLTS MIN

Range: 0.00 to 1.50 x VT in steps of 0.01 x VT

Default: 0.80 x VT

The setpoint establishes a minimum voltage magnitude for the Bus Voltage. Above this magnitude, the Bus Voltage input used for Synchrocheck is considered “Live” or energized.

LIVE LINE VOLTS MIN

Range: 0.00 to 1.50 x VT in steps of 0.01 x VT

Default: 0.80 x VT

The setpoint establishes a minimum voltage magnitude for the Line Voltage. Above this magnitude, the Line Voltage input used for Synchrocheck is considered “Live” or energized.

DEAD BUS VOLTS MAX

Range: 0.00 to 1.50 x VT in steps of 0.01 x VT

Default: 0.20 x VT

The setpoint establishes a maximum voltage magnitude for the Bus Voltage. Below this magnitude, the Bus Voltage input used for Synchrocheck is considered “Dead” or de-energized.

DEAD LINE VOLTS MAX

Range: 0.00 to 1.50 x VT in steps of 0.01 x VT

Default: 0.20 x VT

This setpoint establishes a maximum voltage magnitude for the Line Voltage. Below this magnitude, the Line Voltage input used for Synchrocheck is be considered “Dead” or de-energized.

SYNCCHECK BYPASS

Range: Off, Any FlexLogic operand

Default: Off

The Synchrocheck is bypassed when the selected operand is asserted. Typically BKR(X) Disconnected is used to bypass Synchrocheck.

BLOCK

Range: Off, Any FlexLogic operand

Default: Off

The Synchrocheck is blocked when the selected operand is asserted. Typically 52a (the circuit breaker closed) contact is used to block Synchrocheck (Synchrocheck is needed only when the circuit breaker is open). Synchrocheck can be also blocked when the relay is tripping.

OUTPUT RELAY X

For details see Common Setpoints.

EVENTS

Range: Enabled, Disabled

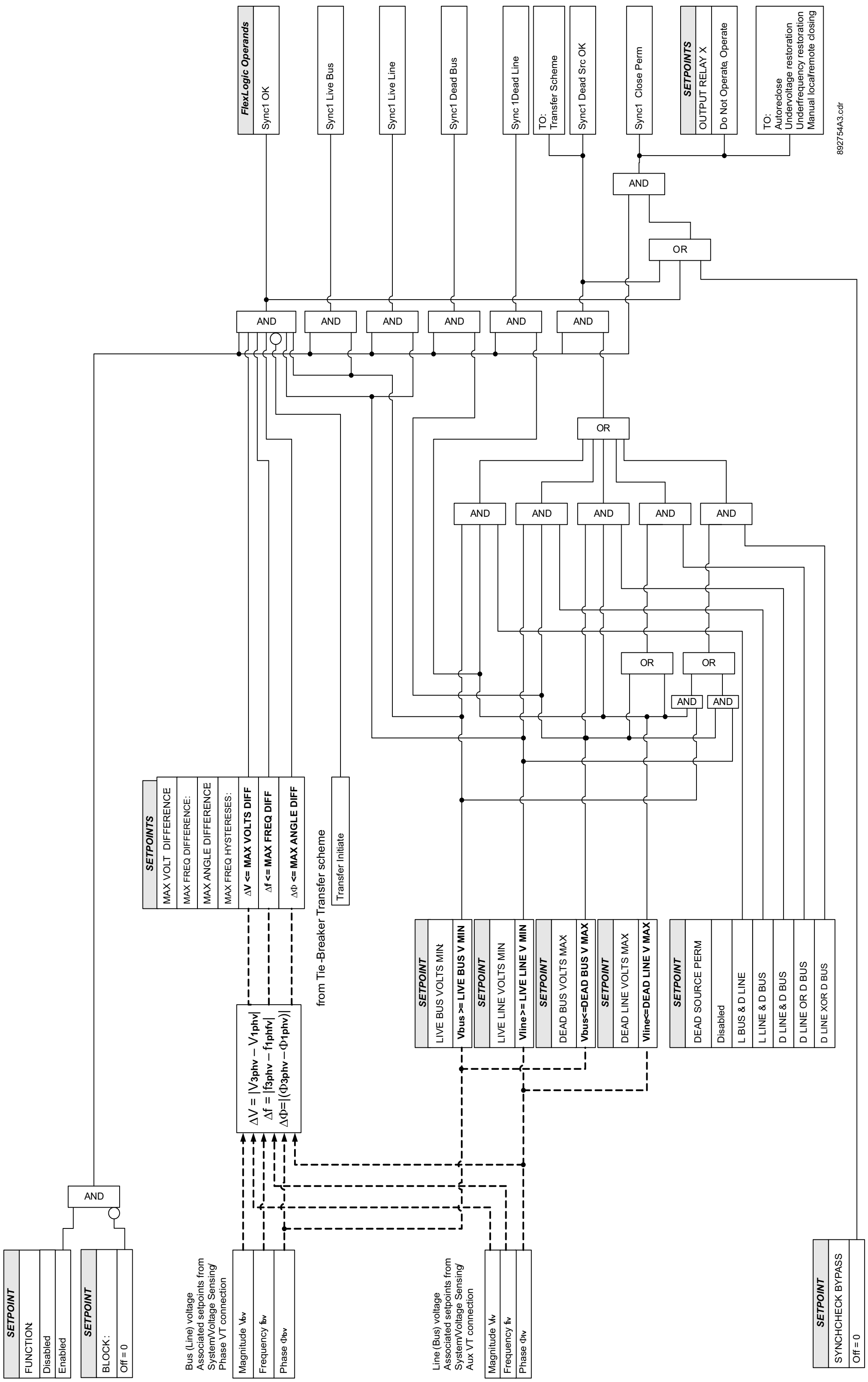
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched

Default: Self-reset

Figure 8-14: Synchrocheck logic diagram



VT Fuse Failure (VTFF)

The 845 relay provides one VT Fuse Failure. The VT Fuse Failure detector can be used to raise an alarm and/or block elements that may operate incorrectly for a full or partial loss of AC potential caused by one or more blown fuses. Some elements that might be blocked (via the BLOCK input) are voltage restrained overcurrent, directional current, power functions. This loss can be caused by a blown primary voltage transformer fuse (or fuses), or by voltage transformer secondary circuit protection fuse failure.

There are two classes of fuse failure that may occur:

1. Class A: loss of one or two phases
2. Class B: loss of all three phases.

Different means of detection are required for each class. An indication of a Class A failure is a significant level of negative sequence voltage, whereas an indication of a Class B failure is the presence of positive sequence current and 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.

The settings of this function are applied to three-phase voltage input (supervised with positive, negative and zero sequence current components) to produce an Operate flag.

Path: **Setpoints > Control > VT Fuse Failure 1 (2)**

FUNCTION

Range: Disabled, Alarm, Latched Alarm, Configurable
Default: Disabled

CT INPUT

Range: DDependant upon the order code
Default: CT Bnk1-J1

OUTPUT RELAY X

For details see Common Setpoints.

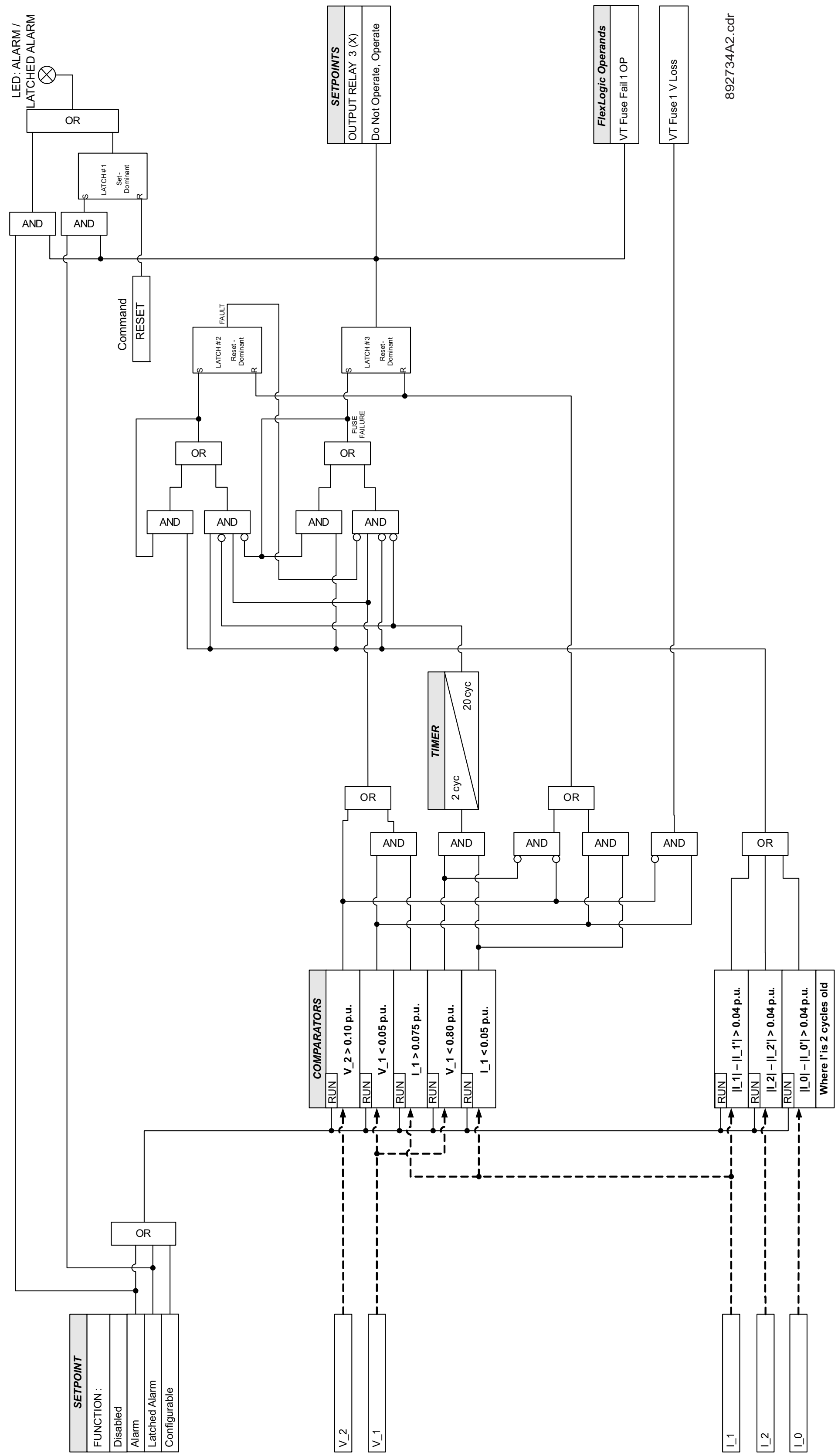
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Self-reset

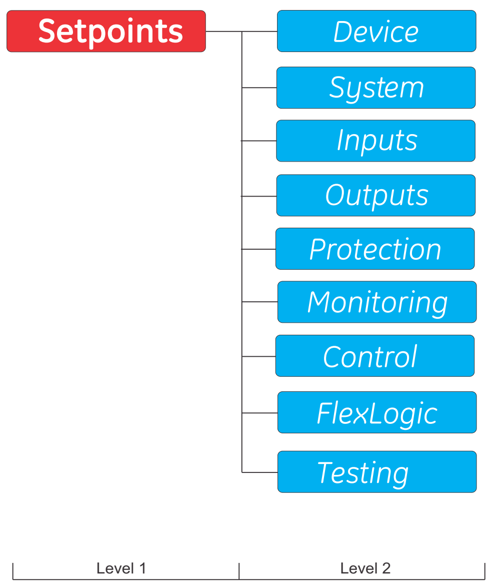
Figure 8-15: VT Fuse Failure logic diagram



845 Transformer Protection System

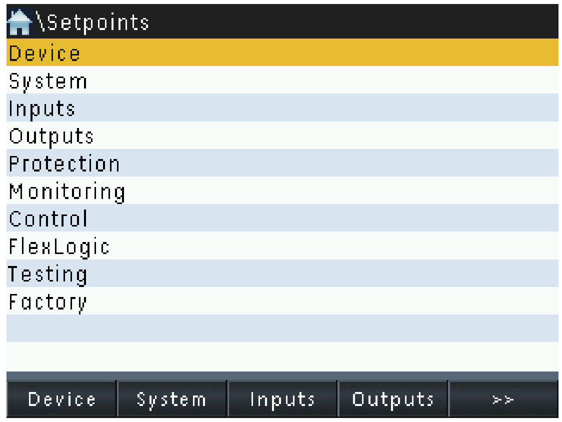
Chapter 9: FlexLogic and Other Setpoints

Figure 9-1: Main Setpoints Display Hierarchy



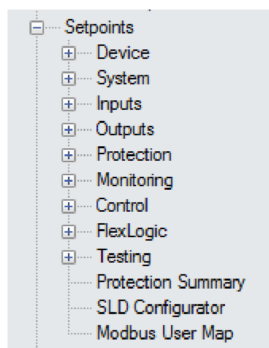
This chapter describes the FlexLogic and Testing setpoints in detail. Flexlogic setpoints provide access to the variable logic used with the relay. Testing setpoints include simulated current and voltage inputs, and test operations for LEDs, input contacts, and output relays.

Figure 9-2: Main Setpoints HMI Screen



Factory setpoints, as seen in the HMI Main Setpoints Screen, are for GE internal use only. These cannot be accessed by users.

Figure 9-3: Enervista 8 Series Setup software Setpoints Menu



The Protection Summary page, as seen in the EnerVista 8 Series Setup software Setpoints menu, is described in detail in Protection Summary.

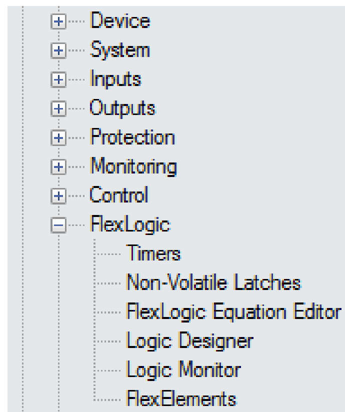
The SLD Configurator, as seen in the EnerVista 8 Series Setup software Setpoints menu, is described in detail in SLD Configurator.

The Modbus User Map, as seen in the EnerVista 8 Series Setup software Setpoints menu, is described in detail in the *8 Series Communication Guide* that can be downloaded from http://www.gegridsolutions.com/.

FlexLogic

To provide maximum flexibility, the arrangement of internal digital logic combines fixed and user-programmed parameters. Logic upon which individual features are designed is fixed, and all other logic, from 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 then uses FlexLogic to produce analog and digital outputs.

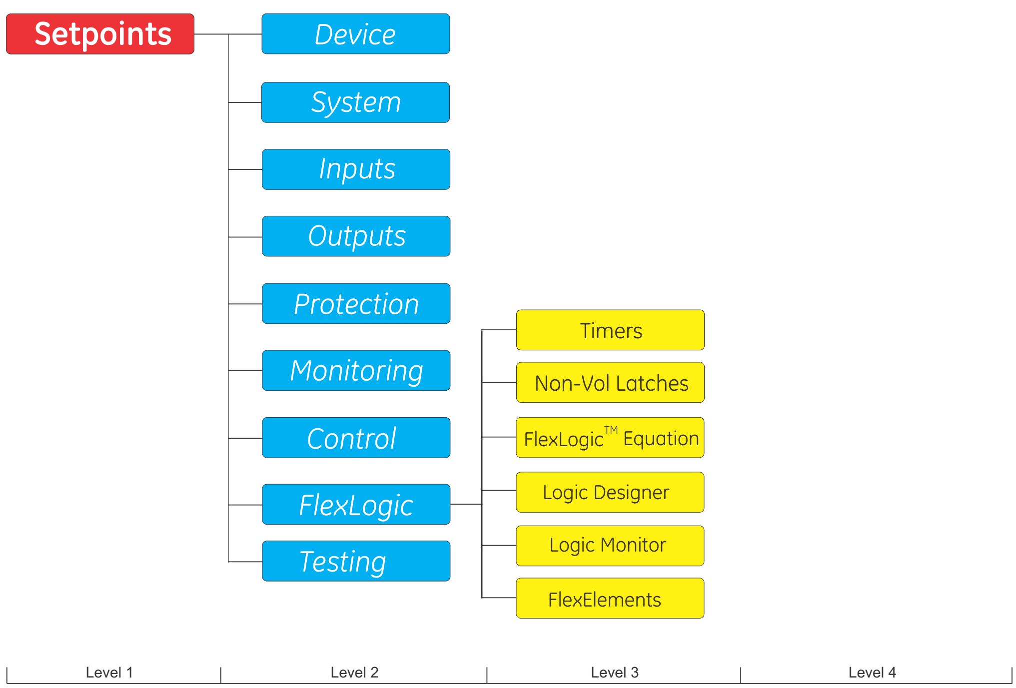
The major sub-systems of a generic 8 Series relay involved in this process are shown as follows.



NOTE

For information on the Logic Designer and Logic Monitor menu items, see *Help > User Manual > Logic Designer & Monitor* in the EnerVista 8 Series Setup software.

Figure 9-4: FlexLogic Display Hierarchy



The states of all digital signals used in the 845 are represented by flags (FlexLogic™ operands). A digital “1” is represented by a 'set' flag. Any external contact change-of-state can be used to block an element from operating, as an input to a control feature in a

FlexLogic™ equation, or to operate an output relay. The state of the contact input can be displayed locally or viewed remotely via the communications facilities provided. In a simple scheme where a contact input is used to block an element is desired, this selection is made within the menu of the element. This applies to other features that set flags: elements, virtual inputs, remote inputs, schemes, and human operators.

When more complex logic than the one presented above is required, the FlexLogic tool should be used. For example, if it is desired to block the operation of a Phase Time Overcurrent element by the closed state of a contact input, and the operated state of a Phase Undervoltage element, the two input states need be programmed in a FlexLogic equation. This equation ANDs the two inputs to produce a virtual output which then must be programmed within the menu of the Phase Time Overcurrent as a blocking input. Virtual outputs can be created only 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 customization of the relay through a series of equations that consist of operators and operands. The operands are the states of inputs, elements, schemes and outputs. The operators are logic gates, timers and latches (with set and reset inputs). A system of sequential operations allows any combination of specified operands to be assigned, as inputs to specified operators, to create an output. The final output of an equation is a numbered register called a 'Virtual Output'. Virtual Outputs can be used as an input operand in any equation, including the equation that generates the output, as a seal-in or other type of feedback.

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

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

Table 9-1: 845 FlexLogic Operands

ELEMENT	OPERANDS	EVENT DESCRIPTION
Aging Factor	Aging Factor PKP Aging Factor OP	The Aging factor element has picked up The Aging factor element has operated
Analog Input	Anlg Ip Trip PKP Anlg Ip Trip OP Anlg Ip Alarm PKP Anlg Ip Alarm OP Anlg Ip 2 to 4	Analog Input 1 trip has picked up Analog Input 1 trip has operated Analog Input 1 alarm has picked up Analog Input 1 alarm has operated Similar to Analog Input 1 operands above
Annunciator	Reset Annunctr OP (MNUL) Reset Annunctr OP (OPRD)	Annunciator reset manually (pushbutton or PC software) Annunciator reset by operand (set under Setpoints\Device\Resetting\Reset Annunciator or Setpoints\Device\Front Panel\Annunciator\Annunciator Setup\Reset Annunciator)

ELEMENT	OPERANDS	EVENT DESCRIPTION
Arc Flash 1	AF 1 Light 1 PKP	Light sensor 1 has detected light above threshold
	AF 1 Light 2 PKP	Light sensor 2 has detected light above threshold
	AF 1 Light 3 PKP	Light sensor 3 has detected light above threshold
	AF 1 Light 4 PKP	Light sensor 4 has detected light above threshold
	AF 1 HS Ph IOC PKP A	High speed IOC of phase A has picked up
	AF 1 HS Ph IOC PKP B	High speed IOC of phase B has picked up
	AF 1 HS Ph IOC PKP C	High speed IOC of phase C has picked up
	AF 1 HS GND IOC PKP	High speed IOC of Ground has picked up
	Arc Flash 1 S1 OP	Arc Flash event is detected due to detection of light in sensor 1 above threshold AND HS Phs/Gnd IOC element picked up
	Arc Flash 1 S2 OP	Arc Flash event is detected due to detection of light in sensor 2 above threshold AND HS Phs/Gnd IOC element picked up
	Arc Flash 1 S3 OP	Arc Flash event is detected due to detection of light in sensor 3 above threshold AND HS Phs/Gnd IOC element picked up
	Arc Flash 1 S4 OP	Arc Flash event is detected due to detection of light in sensor 4 above threshold AND HS Phs/Gnd IOC element picked up
	Arc Flash 1 OP	Arc Flash event is detected by at least one of the sensor elements AND HS Phs/Gnd IOC elements
	Light Sensor 1 Trouble	Detection of any trouble in light sensor 1 or corresponding fiber
	Light Sensor 2 Trouble	Detection of any trouble in light sensor 2 or corresponding fiber
	Light Sensor 3 Trouble	Detection of any trouble in light sensor 3 or corresponding fiber
	Light Sensor 4 Trouble	Detection of any trouble in light sensor 4 or corresponding fiber
	Light Sensor Trouble	Detection of any trouble in any of the 4 light sensors or corresponding fibers
Auxiliary OV	Aux OV PKP	Auxiliary overvoltage element has picked up
	Aux OV OP	Auxiliary overvoltage element has operated
Auxiliary UV	Aux UV 1 PKP	Auxiliary undervoltage element 1 has picked up
	Aux UV 1 OP	Auxiliary undervoltage element 1 has operated
	Aux UV 2	The same set of operands as per Aux UV 1
Breaker	BKR[X] Opened	Breaker state is detected opened
	BKR[X] Closed	Breaker state is detected closed
	BKR[X] Unkwn State	Close or Open breaker state cannot be detected
	BKR[X] Connected	Breaker has been connected to the power system
	BKR[X] Disconnected	Breaker has been detached from the power system
	BKR[X] Configured	Breaker status contact is configured
	BKR[X] Not Configured	Breaker status contact is not configured
	BKR[X] Trolley Bad Status	Breaker Trolley Status Bad status mode detected
		[X] - the element number.
Breaker Arcing	BKR1 Arc OP	Breaking arcing 1 element operated
	BKR 2, BKR 3	Same set of operands as for BKR 1
Breaker Control	BKR[X] Remote Open	Breaker Open command is initiated to Breaker 1
	BKR[X] Remote Close	Breaker Close command is initiated to Breaker 1
	BKR[X] Rem Blk Open	The Open command to Breaker 1 is blocked
	BKR[X] Rem Blk Close	The Close command to Breaker 1 is blocked
	BKR[X] Remote Blk Opn By	The block open signal to Breaker 1 is bypassed
	BKR[X] Remote Blk Cls By	The block close signal to Breaker 1 is bypassed
		[X] - the element number.
Breaker Failure	BF1 Retrip	Breaker failure 1 re-trip operated
	BF1 Highset OP	Breaker failure 1 operated with high level current supervision (includes breaker status supervision if set)
	BF1 Lowset OP	Breaker failure 1 operated with low level current supervision (includes breaker status supervision if set)
	BF1 52b Superv OP	Breaker failure 1 operated with breaker status only
	BF1 OP	Breaker failure 1 operated
	BF 2, BF 3	Same set of operands as for BF 1
Breaker Health	BKR1 Hlth PKP	Breaker health has picked up
	BKR1 Hlth Trip PKP	Trip time of breaker health has picked up
	BKR1 Hlth Cls PKP	Close time of breaker health has picked up
	BKR1 Hlth Chg PKP	Spring charge time of breaker health has picked up
	BKR1 Arc PKP A	Arc time of phase A of breaker health has picked up
	BKR1 Arc PKP B	Arc time of phase B of breaker health has picked up
	BKR1 Arc PKP C	Arc time of phase C of breaker health has picked up
	BKR1 Engy PKP A	Arc energy of phase A of breaker health has picked up
	BKR1 Engy PKP B	Arc energy of phase B of breaker health has picked up
	BKR1 Engy PKP C	Arc energy of phase C of breaker health has picked up
	BKR1 Hlth OP Fail	Breaker trip or close operation has failed
	BKR1 Arc Fail	Breaker arc time has failed
	BKR1 Charge Fail	Spring charge time has failed
	Breaker 2 Health, Breaker 3 Health	Same set of operands as for Breaker Health 1

ELEMENT	OPERANDS	EVENT DESCRIPTION
Close Circuit Monitoring	Cls Coil Mon 1 PKP Cls Coil Mon 1 OP	Close Coil 1 Monitoring element has picked up. Close Coil 1 Monitoring element has operated for an amount of time greater than the Close Circuit Monitor Pick-up Delay Time.
Contact Inputs	CI # On CI # Off	# – any contact input number
Critical Failure Relay	Critical Fail OP	The critical failure relay operated
Demand	Current Dmd PKP Current Dmd PKP A Current Dmd PKP B Current Dmd PKP C RealPwr Dmd PKP ReactvPwr Dmd PKP ApprntPwr Dmd PKP	At least one phase from current demand element has picked up Phase A from current demand element has picked up Phase B from current demand element has picked up Phase C from current demand element has picked up Real power demand has picked up Reactive power demand has picked up Apparent power demand has picked up
Digital Counters	Counter 1 HI Counter 1 EQL Counter 1 LO Counter 1 at Limit Counter 2 to Counter 16	Digital counter 1 output is 'more than' comparison value Digital counter 1 output is 'equal to' comparison value Digital counter 1 output is 'less than' comparison value Digital counter 1 reached limit Same set of operands as for Counter 1
Directional Power	DirPwr 1 Stg1 PKP DirPwr 1 Stg2 PKP DirPwr 1 PKP DirPwr 1 Stg1 OP DirPwr 1 Stg2 OP DirPwr 1 OP DirPwr 2	Stage 1 of the directional power element 1 has picked up Stage 2 of the directional power element 1 has picked up The directional power element has picked up Stage 1 of the directional power element 1 has operated Stage 2 of the directional power element 1 has operated The directional power element has operated The same set of operands per DirPwr 1
Frequency Rate-Of-Change	FreqRate1 PKP FreqRate1 OP FreqRate1 Up PKP FreqRate1 Up OP FreqRate1 Dwn PKP FreqRate1 Dwn OP	The frequency rate of change 1 element has picked up The frequency rate of change 1 element has operated The frequency rate of change 1 element has picked up on raising frequency The frequency rate of change 1 element has operated on raising frequency The frequency rate of change 1 element has picked up on lowering frequency The frequency rate of change 1 element has operated on lowering frequency
Front Panel, Targets, LEDs, Pushbuttons	Any Target ^^ PB[X] On ^^ PB[X] Off Testing On Testing Off	Generated upon activation of any target message Pushbutton [X] has been turned on Pushbutton [X] has been turned off Testing is enabled Testing is disabled ^^ - content between the two ^ changes according to what is programmed in the noted Operand Custom Text register
FlexElements	FlexEl 1 PKP FlexEl 1 OP FlexEl 2 to 8	The FlexElement 1 has picked up The FlexElement 1 has operated The FlexElements 2 to 8 is the same as Flexelement.
Ground TOC	GND TOC 1 PKP GND TOC 1 OP Ground TOC 2, Ground TOC 3	Ground time overcurrent 1 has picked up Ground time overcurrent 1 has operated Same set of operands as shown for Ground TOC 1
Ground IOC	GND IOC 1 PKP GND IOC 1 OP Ground IOC 2, Ground IOC 6	Ground instantaneous overcurrent 1 has picked up Ground instantaneous overcurrent 1 has operated Same set of operands as shown for Ground IOC 1
Ground Directional OC	Gnd Dir OC FWD Gnd Dir OC REV	Ground directional overcurrent forward has operated Ground directional overcurrent reverse has operated
Harmonic Detection	Harm Det 1 PKP Harm Det 1 OP Harmonic Detection 2 to 6	Harmonic Detection 1 has picked up Harmonic Detection 1 has operated The same set of operands as per Harmonic Detection 1
Harmonic Derating	W1 Harm Derat PKP W1 Harm Derat OP W2 Harm Derat PKP W2 Harm Derat OP W3 Harm Derat PKP W3 Harm Derat OP Load Limit Reduced	Harmonic Derating W1 has picked up Harmonic Derating W1 has operated Harmonic Derating W2 has picked up Harmonic Derating W2 has operated Harmonic Derating W3 has picked up Harmonic Derating W3 has operated Harmonic Derating has detected load limit reduced

ELEMENT	OPERANDS	EVENT DESCRIPTION
Hottest Spot	Hottest-Spot PKP Hottest-Spot OP	The Hottest-spot temperature element has picked up The Hottest-spot temperature element has operated
IEC 61850 Mapping	Setting Changed Setting File Reject Any Major Error Any Minor Error Port 4 Ethernet Fail Port 5 Ethernet Fail Firmware Upgd In-Service Any Trip Any Alarm Any PKP	Any change in settings from Front Panel, Enervista or File Transfer Method Setting file is rejected due to not programmed condition or FlexLogic error See the Relay Major Self-Test errors table See the Relay Minor Self-Test errors table The failure of Ethernet Port 4 The failure of Ethernet Port 5 Any successful change in the Firmware upgrade state The relay is In-Service Any operated element with Function selected as "Trip" Any operated element with Function selected as "Alarm" Any enabled protection or control element pickup
Local Control Mode	SBO Enabled Local Mode ON Local Mode OFF BKR[X] Local Open BKR[X] Local Close BKR[X] Loc Blk Open BKR[X] Loc Blk Close BKR[X] Loc Blk Open By BKR[X] Loc Blk Cls By BKR[X] Tag On BKR[X] Tag Off BKR[X] Selected SW[X] Local Open SW[X] Local Close SW[X] Loc Blk Open SW[X] Loc Blk Close SW[X] Loc Blk Open By SW[X] Loc Blk Cls By SW[X] Tag On SW[X] Tag Off SW[X] Selected	Select Before Operate control mode is enabled Local mode is ON (shows LM in display banner) Local mode is OFF Local Open command has been initiated to BKR[X] Local Close command has been initiated to BKR[X] Open command to BKR[X] is blocked Close command to BKR[X] is blocked Open command to BKR[X] is permitted, Block Open signal is bypassed command to BKR[X] is permitted, Block Close signal is bypassed The selected breaker is tagged The selected breaker is untagged Breaker BKR[X] has been selected in SLD Local Open command has been initiated to SW[X] Local Close command has been initiated to SW[X] Open command to the switch is blocked Close command to the switch is blocked Open switch command is permitted, Block Open signal is bypassed Close switch command is permitted, Block Close signal is bypassed The selected breaker/switch is tagged The selected breaker/switch is untagged Disconnect Switch 1(8) has been selected in SLD [X] - the element number.
Loss of Communications	Loss Of Comms PKP Loss Of Comms OP	Loss Of Comms has picked up Loss Of Comms has operated
Neutral TOC	Ntrl TOC 1 PKP Ntrl TOC 1 OP Neutral TOC 2 Neutral TOC 2, Neutral TOC 3	Neutral time overcurrent 1 has picked up Neutral time overcurrent 1 has operated The same set of operands as per Neutral TOC 1
Neutral IOC	Ntrl IOC 1 PKP Ntrl IOC 1 OP Ntrl IOC 2 Neutral IOC 2 to Neutral IOC6	Neutral IOC 1 has picked up Neutral IOC 1 has operated The same set of operands as per Neutral IOC 1
Neutral Directional OC	Ntrl Dir OC FWD Ntrl Dir OC REV	Neutral directional overcurrent forward has operated Neutral directional overcurrent reverse has operated
Neutral OV	Ntrl OV 1 PKP Ntrl OV 1 OP	Neutral overvoltage element 1 has picked up Neutral overvoltage element 1 has operated
Negative sequence OV	NegSeq OV 1 PKP NegSeq OV 1 OP	Negative-sequence overvoltage element 1 has picked up Negative-sequence overvoltage element 1 has operated
Negative Sequence TOC	NegSeq TOC 1 PKP NegSeq TOC 1 OP Neg Seq TOC 2, Neg Seq TOC 3	Negative Sequence TOC 1 has picked up Negative Sequence TOC 1 has operated Same set of operands as shown for Negative Sequence TOC 1
Negative Sequence IOC	NegSeq IOC 1 PKP NegSeq IOC 1 OP Neg Seq IOC 2, Neg Seq IOC 3	Negative Sequence IOC has picked up Negative Sequence IOC 1 has operated Same set of operands as shown for Negative Sequence IOC 1
Negative Sequence Directional OC	NegSeq DirOC FWD NegSeq DirOC REV	Negative Sequence directional overcurrent forward has operated Negative Sequence directional overcurrent reverse has operated
Non-Volatile Latch 1 to 16	NV Latch 1 ON NV Latch 1 OFF Any PKP Any OP Any Trip Any Alarm NV Latch 2 to 16	The output of non-volatile latch 1 is On The output of non-volatile latch 1 is Off Any enabled protection or control element pickup Any enabled protection or control element operated Any operated element with Function selected as "Trip" Any operated element with Function selected as "Alarm" The same set of operands as per Non-Volatile Latch 1

ELEMENT	OPERANDS	EVENT DESCRIPTION
Output Relays	Trip ON Close ON Aux Relay [X] ON BKR [X] Manual Open BKR [X] Manual Close	Trip command to Relay 1 (TRIP) has been issued Close command to Relay 2 (CLOSE) has been issued Command to Aux Relay [X] has been issued Either Local (using PBs) Open or Remote Open command has been issued to the output relay selected under BKR[X] Trip Relay Select setpoint Either Local (using PBs) Close or Remote Close command has been issued to the output relay selected under BKR[X] Close Relay Select setpoint
Over-Frequency	Overfreq 1 PKP Overfreq 1 OP Overfreq 2	Overfrequency 1 has picked up Overfrequency 1 has operated The same set of operands as per Overfreq 1
Overload	W1 Overload PKP W2 Overload PKP W3 Overload PKP Overload PKP Overload OP	Winding 1 Transformer overload has picked up Winding 2 Transformer overload has picked up Winding 3 Transformer overload has picked up At least one Winding Transformer overload has picked up Transformer overload has operated
Percent Differential	Percent Diff PKP A Percent Diff PKP B Percent Diff PKP C Percent Diff PKP Percent Diff OP A Percent Diff OP B Percent Diff OP C Percent Diff OP Percent Diff Warn Percent Diff Blocked Percent Diff Sat A Percent Diff Sat B Percent Diff Sat C Percent Diff Sat Percent Diff Dir A Percent Diff Dir B Percent Diff Dir C Percent Diff Dir 2nd Harm Diff A 2nd Harm Diff B 2nd Harm Diff C 5th Harm Diff A 5th Harm Diff B 5th Harm Diff C	Percent A differential has picked up Percent B differential has picked up Percent C differential has picked up At least one Percent differential element has picked up Phase A differential has operated Phase B differential has operated Phase C differential has operated At least one Percent differential element has operated Percent differential current exceeded 0.5 x PKP for 10 seconds Percent differential protection has been blocked Percent differential flag triggered on phase A Percent differential flag triggered on phase B Percent differential flag triggered on phase C Percent differential flag triggered Percent differential directional flag triggered on phase A Percent differential directional flag triggered on phase B Percent differential directional flag triggered on phase C Percent differential directional flag triggered 2^{nd} harmonic Phase A diff. current block detected 2^{nd} harmonic Phase B diff. current block detected 2^{nd} harmonic Phase C diff. current block detected 5^{th} harmonic Phase A diff. current block detected 5^{th} harmonic Phase B diff. current block detected 5^{th} harmonic Phase C diff. current block detected
Phase TOC	Ph TOC 1 PKP A Ph TOC 1 PKP B Ph TOC 1 PKP C Ph TOC 1 PKP Ph TOC 1 OP A Ph TOC 1 OP B Ph TOC 1 OP C Ph TOC 1 OP PHASE TOC 2 PHASE TOC 2, PHASE TOC 3	Phase A of phase time overcurrent 1 has picked up Phase B of phase time overcurrent 1 has picked up Phase C of phase time overcurrent 1 has picked up At least one phase of phase time overcurrent 1 has picked up Phase A of phase time overcurrent 1 has operated Phase B of phase time overcurrent 1 has operated Phase C of phase time overcurrent 1 has operated At least one phase of phase time overcurrent 1 has operated The same set of operands as per Phase TOC 1
Phase IOC	Ph IOC 1 PKP A Ph IOC 1 PKP B Ph IOC 1 PKP C Ph IOC 1 PKP Ph IOC 1 OP A Ph IOC 1 OP B Ph IOC 1 OP C Ph IOC 1 OP Ph IOC 2 PHASE IOC 2 to PHASE IOC6	Phase A of phase IOC 1 has picked up Phase B of phase IOC 1 has picked up Phase C of phase IOC 1 has picked up At least one phase of phase IOC overcurrent 1 has picked up Phase A of phase IOC 1 has operated Phase B of phase IOC 1 has operated Phase C of phase IOC 1 has operated At least one phase of phase IOC 1 has operated The same set of operands as per Phase IOC 1
Phase Directional OC	Ph Dir OC REV A Ph Dir OC REV B Ph Dir OC REV C Ph Dir OC REV	Phase A current in reverse direction Phase B current in reverse direction Phase C current in reverse direction At least one phase current in reverse direction

ELEMENT	OPERANDS	EVENT DESCRIPTION
Phase UV	Ph UV 1 PKP Ph UV 1 PKP A Ph UV 1 PKP B Ph UV 1 PKP C Ph UV 1 OP Ph UV 1 OP A Ph UV 1 OP B Ph UV 1 OP C Ph UV 2	At least one phase of phase undervoltage 1 has picked up Phase A of phase undervoltage 1 has picked up Phase B of phase undervoltage 1 has picked up Phase C of phase undervoltage 1 has picked up At least one phase of phase undervoltage 1 has operated Phase A of phase undervoltage 1 has operated Phase B of phase undervoltage 1 has operated Phase C of phase undervoltage 1 has operated The same set of operands as per Phase UV 1
Phase OV	Ph OV 1 PKP Ph OV 1 PKP A Ph OV 1 PKP B Ph OV 1 PKP C Ph OV 1 OP Ph OV 1 OP A Ph OV 1 OP B Ph OV 1 OP C Ph OV 2	At least one phase of phase overvoltage 1 has picked up Phase A of phase overvoltage element 1 has picked up Phase B of phase overvoltage element 1 has picked up Phase C of phase overvoltage element 1 has picked up At least one phase of phase overvoltage 1 has operated Phase A of phase overvoltage element 1 has operated Phase B of phase overvoltage element 1 has operated Phase C of phase overvoltage element 1 has operated The same set of operands as per Phase OV 1
Power Factor	PF 1 Switch-In PF 1 Switch-Out PF 1 Switch-In OP PF 1 Switch-Out OP PF 2	The measured power factor has crossed the Switch-in setpoint The measured power factor has crossed the Switch-Out setpoint The PF1 Switch-In element operated The PF1 Switch-Out element operated The same set of operands as per PF 1
Programmable Pushbuttons	PB 1 ON PB 1 OFF Pushbuttons 2 and 3	Pushbutton 1 ON state has been asserted Pushbutton 1 OFF state has been asserted The same set of operands as shown for Pushbutton 1
Pulse Output	Pos Wthrs Pulse OP Neg Wthrs Pulse OP Pos Varh Pulse OP Neg Varh Pulse OP	Positive Watthours pulse occurs at the end of the programed energy increment Negative Watthours pulse occurs at the end of the programed energy increment Positive VARhours pulse occurs at the end of the programed energy increment Negative VARhours pulse occurs at the end of the programed energy increment
Relay Service	In-Service	The relay is In-Service
Remote Input	Rem Ip # ON Rem Ip # OFF	# – any remote input number
Remote Modbus Device	FlexLogic Operand [X] On FlexLogic Operand [X] Off	[X] - the element number. Note the operand name will change depending on what is programmed. NOTE: Although the Remote Modbus Device names can be edited, the list of FlexLogic operands may use the names found in the default BSG3 profile. These operand names are Status 1-9, Warning 1-9, Alarm 1-9 and Remote MB Device 28-32.
Resetting	Reset OP Reset OP (PB) Reset OP (Operand) Reset OP (Comms)	Reset command Reset command initiated from a front panel pushbutton Reset command initiated from a FlexLogic operand Reset command initiated via communications
Restricted Ground Fault	RGF 1 PKP RGF 1 OP RGF 1 Superv ON RGF 2 and RGF 3	Restricted Ground Fault 1 has picked up Restricted Ground Fault 1 has operated The Restricted Ground Fault supervision has operated Same set of operands as for RGF1
RRTD Temperature	RRTD 1 PKP RRTD 1 OP RRTD 1 Alarm PKP RRTD 1 Alarm OP RRTD 1 Open RRTD 1 Shorted	RRTD 1 Trip has picked up. RRTD 1 Trip has operated. RRTD 1 Alarm has picked up RRTD 1 Alarm has operated RRTD 1 sensor is detected open RRTD 1 sensor is detected shorted
	RRTD 2 to RTD 12	Similar to RRTD 1
	Hot RRTD	Any RRTD Alarm PKP operand has picked up.

ELEMENT	OPERANDS	EVENT DESCRIPTION
RTD Temperature	RTD 1 PKP RTD 1 OP RTD 1 Alarm PKP RTD 1 Alarm OP RTD 1 Open RTD 1 Shorted	RTD 1 Trip has picked up. RTD 1 Trip has operated. RTD 1 Alarm has picked up RTD 1 Alarm has operated RTD 1 sensor is detected open RTD 1 sensor is detected shorted
	RTD 2 to RTD 12	Similar to RTD 1
	Hot RTD	Any RTD Alarm PKP operand has picked up.
RTD Trouble	RTD Trouble PKP RTD Trouble OP	RTD Trouble has picked up RTD Trouble has operated
Security	ROLE ADMIN ACT ROLE OPERATOR ACT ROLE OBSERVER ACT	Administrator role is active and is set to true when that is the case Operator role is active and is set to true when that is the case Observer role is active and is set to true when that is the case
Self-Test Error	Any Minor Error Any Major Error	see the Relay Minor Self-Test errors table see the Relay Major Self-Test errors table
Setpoint Access	Setpoints Access OP	An access to change setpoints has been granted
Setpoints Group Control	Group 1 Active Group 2 Active ... Group 6 Active	Setpoint group 1 is active Setpoint group 2 is active ... Setpoint group 6 is active
Status Detection	Xfmr Energized Xfmr De-Energized Not Configured	The Transformer is detected Energized The Transformer is detected De-Energized The Xfmr status detection is not configured
Switches	SW[X] Opened SW[X] Closed SW[X] Intermittent SW[X] Discrepancy SW[X] Not Configured	Disconnect Switch [X] state is detected opened Disconnect Switch [X] state is detected closed Intermittent state between 89a and 89b contacts programmed for SW[X] during opening or closing Discrepancy between 89a and 89b contact inputs programmed for SW[X] is detected No contact Input 89a or 89b is programmed to reflect the status of SW[X] [X] - the element number. Note the operand name will change depending on what is programmed.
Switch Control	SW[X] Open Cmd SW[X] Close Cmd SW[X] Remote Open SW[X] Remote Close SW[X] Rem Blk Open SW[X] Rem Blk Close SW[X] Rem Blk Open Byp SW[X] Rem Blk Close Byp	Local or Remote Open command initiated to Switch [X] Local or Remote Close command initiated to Switch [X] Remote Open command is initiated to Switch [X] Remote Close command is initiated to Switch [X] The Open command to Switch [X] is blocked The Close command to Switch [X] is blocked The block open signal for Switch [X] is bypassed The block close signal for Switch [X] is bypassed [X] - the element number.
Synchrocheck	Sync1 OK Sync1 Live Bus Sync1 Live Line Sync1 Dead Bus Sync1 Dead Line Sync1 Dead Src OK Sync1 Close Perm	Synchrocheck 1 permission is given Synchrocheck 1 bus voltage is live Synchrocheck 1 line voltage is live Synchrocheck 1 bus voltage is dead Synchrocheck 1 line voltage is dead Synchrocheck 1 dead source permission is given Synchrocheck 1 breaker closing permission is given
Tab Pushbuttons	TAB PB [X] ON TAB PB [X] OFF TAB PB [X] PRESS	Tab Pushbutton [X] is ON Tab Pushbutton [X] is OFF Tab Pushbutton [X] is Pressed Down
Tap Changer Setup	TC at Min Tap ON TC at Ntrl Tap ON TC at Max Tap ON TC at Min Tap OFF TC at Ntrl Tap OFF TC at Max Tap OFF	Tap Changer has reached Minimum Tap Tap Changer has reached Neutral Tap Tap Changer has reached Maximum Tap Tap Changer position is not at Minimum Tap Tap Changer position is not at Neutral Tap Tap Changer position is not at Maximum Tap
Tap Changer Failure	Tap Ch Fail PKP Tap Ch Fail OP Tap Ch Fail Alarm PKP Tap Ch Fail Alarm OP	Tap Changer Fail has picked up Tap Changer Fail has operated Tap Changer Failure Alarm has picked up Tap Changer Failure Alarm has operated
Targets	Active Target	At least one target is detected active

ELEMENT	OPERANDS	EVENT DESCRIPTION
Trip Bus	Trip Bus 1 PKP Trip Bus 1 OP Trip Bus 2 to 6	Asserted when the trip bus 1 element picks up Asserted when the trip bus 1 element operates The same set of operands as per Trip Bus 1
Trip Circuit Monitoring	TripCoil Mon 1 PKP TripCoil Mon 1 OP	Trip Coil 1 Monitoring element has picked up. Trip Coil 1 Monitoring element has operated for an amount of time greater than the Close Circuit Monitor Pick-up Delay Time.
Under-Frequency	Underfreq 1 PKP Underfreq 1 OP Underfreq 2 to 4	Underfrequency 1 has picked up Underfrequency 1 has operated The same set of operands as per Underfreq 1
Virtual Input 1 to 32	VI # ON VI # OFF	# – any virtual input number
Virtual Outputs 1 to 32	VO # ON VO # OFF	Flag is set, logic = 1 Flag is set, logic=0
Volts per Hertz 1	V/Hz 1 PKP V/Hz 1 OP	The Volts per Hertz element 1 has picked up The Volts per Hertz element 1 has operated
Volts per Hertz 2	V/Hz 2 PKP V/Hz 2 OP	The Volts per Hertz element 2 has picked up The Volts per Hertz element 2 has operated
VT Fuse Failure	VT Fuse Fail1 OP VT Fuse1 V Loss	VT fuse failure detector 1 has operated VT fuse 1 failure has lost voltage signals (V2 below 10% AND V1 below 5% of nominal)
Xfmr Loss Life	Xfmr Loss Life PKP Xfmr Loss Life OP	Xfmr Loss Life element has picked up Xfmr Loss Life element has operated

NOTE

If Phase to Phase mode is selected in this protection element, in “EVENT DESCRIPTION” column, “Phase A” becomes “Voltage AB”, “Phase B” becomes “Voltage BC” and “Phase C” becomes “Voltage CA”.

Some operands can be re-named. These are the names of the breakers in the breaker control feature, the ID (identification) of contact inputs, the ID of virtual inputs, and the ID of virtual outputs. If the default name or ID of any of these operands are changed, the assigned name appears in the relay list of operands. The default names are shown in the FlexLogic Operands table above.

Table 9-2: 845 FlexLogic Operators

TYPE	SYNTAX	DESCRIPTION	NOTES
Editor	INSERT	Insert a parameter in an equation list.	
	DELETE	Delete a parameter from an equation list.	
End	END	The first END encountered signifies the last entry in the list of processed FlexLogic™ parameters.	
One-shot	POSITIVE ONE SHOT	One shot that responds to a positive going edge.	A ‘one shot’ refers to a single input gate that generates a pulse response to an edge on the input. The output from a ‘one shot’ is True (positive) for only one pass through the FlexLogic equation. There is a maximum of 64 ‘one shots’.
	NEGATIVE ONE SHOT	One shot that responds to a negative going edge.	
	DUAL ONE SHOT	One shot that responds to both the positive and negative going edges.	

TYPE	SYNTAX	DESCRIPTION	NOTES
Logic gate	NOT	Logical NOT	Operates on the previous parameter.
	OR(2)↓ OR(16)	2 input OR gate↓ 16 input OR gate	Operates on the 2 previous parameters. ↓Operates on the 16 previous parameters.
	AND(2)↓ AND(16)	2 input AND gate↓ 16 input AND gate	Operates on the 2 previous parameters. ↓Operates on the 16 previous parameters.
	NOR(2)↓ NOR(16)	2 input NOR gate↓ 16 input NOR gate	Operates on the 2 previous parameters. ↓Operates on the 16 previous parameters.
	NAND(2)↓ NAND(16)	2 input NAND gate↓ 16 input NAND gate	Operates on the 2 previous parameters. ↓Operates on the 16 previous parameters.
	XOR(2)	2 input Exclusive OR gate	Operates on the 2 previous parameters.
	LATCH (S,R)	Latch (set, reset): reset-dominant	The parameter preceding LATCH(S,R) is the reset input. The parameter preceding the reset input is the set input.
Timer	TIMER 1↓ TIMER 32	Timer set with FlexLogic™ timer 1 settings. ↓ Timer set with FlexLogic™ timer 32 settings.	The timer is started by the preceding parameter. The output of the timer is TIMER #.
Assign virtual output	= Virt Op 1↓ = Virt Op 32	Assigns previous FlexLogic™ operand to virtual output 1.↓ Assigns previous FlexLogic™ operand to virtual output 96.	The virtual output is set by the preceding parameter

The characteristics of the logic gates are tabulated below, and the operators available in FlexLogic are listed in the FlexLogic operators table.

Table 9-3: FlexLogic Gate Characteristics

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

FLEXLOGIC RULES

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

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

FLEXLOGIC EVALUATION

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

FlexLogic provides latches which by definition have a memory action, remaining in the set state after the set input has been asserted. However, they are volatile; that is, they reset on the re-application of control power.

When making changes to settings, all FlexLogic equations are re-compiled whenever any new setting value is entered, so all latches are automatically reset. If it is necessary to re-initialize FlexLogic during testing, for example, it is suggested to power the unit down then back up.

Timers

Path: **Setpoints > FlexLogic > Timers**

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

TIMER 1 TYPE

Range: Milliseconds, Seconds, Minutes
Default: Milliseconds

The setpoint is used to select the time measuring unit.

TIMER 1 PICKUP DELAY

Range: 0 to 60000 s in steps of 1 s
Default: 0 s

The setpoint sets the time delay to Pickup. If a Pickup delay is not required, set this function to "0".

TIMER 1 DROPOUT DELAY

Range: 0 to 60000 s in steps of 1 s
Default: 0 s

The setpoint sets the time delay to Dropout. If a Dropout delay is not required, set this function to "0".

Non-volatile Latches

The purpose of a Non-volatile Latch is to provide a permanent logical flag that is stored safely and does not reset when the relay reboots after being powered down. Typical applications include sustaining operator commands or permanently blocking relay functions such as Autorecloser, until a deliberate HMI action resets the latch.

Operation of the element is summarized in the following table:

<table>
<tr><th>LATCH 1 TYPE</th><th>LATCH 1 SET</th><th>LATCH 1 RESET</th><th>LATCH 1 ON</th><th>LATCH 1 OFF</th></tr>
<tr><td rowspan="4">Reset Dominant</td><td>On</td><td>Off</td><td>On</td><td>Off</td></tr>
<tr><td>Off</td><td>Off</td><td>Previous State</td><td>Previous State</td></tr>
<tr><td>On</td><td rowspan="2">On</td><td rowspan="2">Off</td><td rowspan="2">On</td></tr>
<tr><td>Off</td></tr>
<tr><td rowspan="4">Set Dominant</td><td rowspan="2">On</td><td>Off</td><td rowspan="2">On</td><td rowspan="2">Off</td></tr>
<tr><td>On</td></tr>
<tr><td>Off</td><td>Off</td><td>Previous State</td><td>Previous State</td></tr>
<tr><td>Off</td><td>On</td><td>Off</td><td>On</td></tr>
</table>

Path: Settings > FlexLogic > Non-volatile Latches > Latch 1(16)

NV LATCH 1 FUNCTION

Range: Disabled, Enabled
Default: Disabled

The setpoint enables or disables the Non-volatile Latch function.

NV LATCH 1 TYPE

Range: Reset-Dominant, Set-Dominant
Default: Reset-Dominant

The setting characterizes NV LATCH 1 to be set- or reset-dominant.

NV LATCH 1 SET

Range: Any FlexLogic operand
Default: Off

If asserted, this specified FlexLogic operand 'SET' NV LATCH 1.

LATCH 1 RESET

Range: Any FlexLogic operand
Default: Off

If asserted, this specified FlexLogic operand 'RESET' NV LATCH 1.

FlexLogic Equation

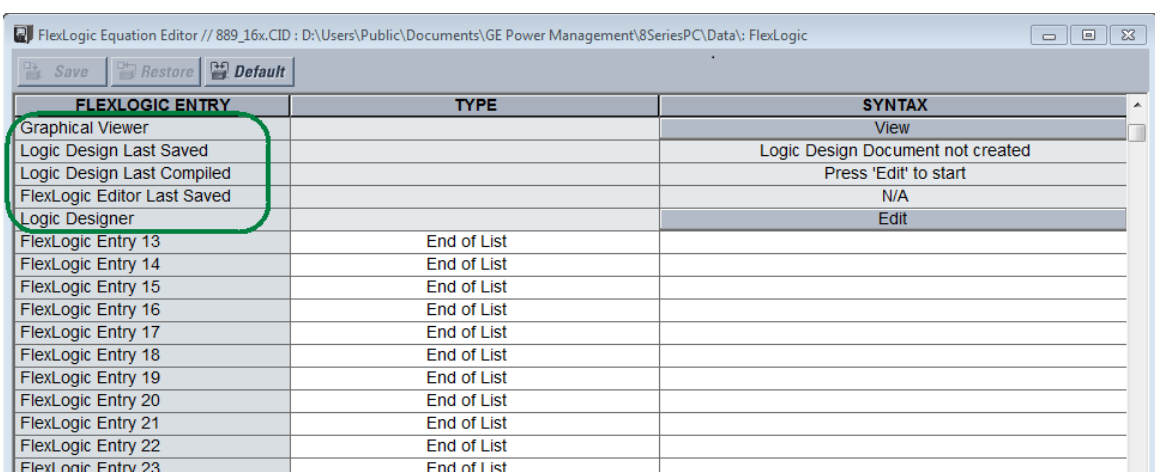
Path: Setpoints > FlexLogic > FlexLogic Equation

The FlexLogic Equation screen (see following figure from EnerVista 8 Series Setup software) is one of two options available to configure FlexLogic. The other option is Logic Designer.

Three new time stamp variables: Logic Design Last Saved, Logic Design Last Compiled and FlexLogic Editor Last Saved, have been included in this screen. Look at the time stamps to easily see which of the options: FlexLogic Editor or Logic Designer is currently being used.

There are 1024 FlexLogic entries available, numbered from 1 to 1024 (i.e. FlexLogic Entry X – where X ranges from 1 to 1024) with default END entry settings. If a "Disabled" Element is selected as a FlexLogic entry, the associated state flag is never set to 1.

Figure 9-5: FlexLogic Equation Editor Screen



The FlexLogic entries are defined as follows.

Graphical Viewer: Clicking on the View button enables the FlexLogic equation to be presented in graphical format (Read-only). Refer to the "Viewing FlexLogic Graphics" section for more details.

Logic Design Last Saved, Logic Design Last Compiled, and FlexLogic Editor Last Saved: Each of these three read-only variables holds the time stamp that represents the time that the operation (of the respective variable) was performed.

1. When no Logic (New file creation) is present these timestamps are set to default text representations.
2. Time stamps are displayed in the format 'Mon DD YYYY HH:MM:SS' [Jun 22 1981 14:20:00]
3. Each time a 'Save' operation is performed in the 'FlexLogic Equation Editor' screen, the 'FlexLogic Editor Last Saved' entry gets updated.
4. Based on the values present at each launch of the 'FlexLogic Equation Editor' screen, internal validation prompts the relevant messages. These prompts must be followed to ensure that the 'FlexLogic' configuration is synchronized with the 'Logic Designer'. These three variables are shown in color in the FlexLogic Equation Editor based on timestamps. Color is used to indicate the change (non-synchronization if any) of FlexLogic between the FlexLogic Editor and Logic Designer Screens.

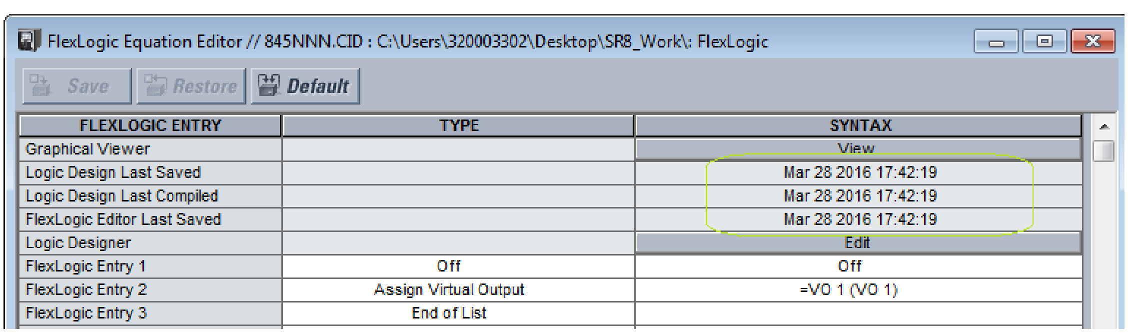
File Conversion and Handling of Time Stamps: When File Conversion is applied the three time stamps are processed (either carry forwarded, defaulted, updated with latest PC time) based on the Source and Destination File versions and Order code supported.

The following cases depict the nature of the three time stamps after a file conversion.

Source Version	Target Version	Is FlexLogic Change Detected?	Time Stamps [LDLs, LDLc, FELs]**
>= 160	>= 160	YES	[0^ , 0 , PCTime**]
>= 160	>=160	NO	*Existing time stamps are copied to the converted file
< 160	>= 160	YES	[0 , 0 , PCTime]
< 160 (& > 120***)	>= 160	NO	[PCTime, PCTime, PCTime,]

**	LDLs – Logic Designer Last Saved, LDLc– Logic Designer Last Compiled and FELs – FlexLogic Editor Last Saved
** PCTime	The time that the file conversion took place
^ 0	Indicates the time stamps are being defaulted
***	There is no support for Logic Designer [Graphical Editor] below version 130
*	For each specific case, the source files for Logic Designer (Graphical) content will also get copied "as is" to the destination folder. This enables the user to retain old content "as is".

In a typical scenario where both the FlexLogic Designer and FlexLogic Editor are used for configuring FlexLogic, the updated time stamps appear as shown in the following figure.



Logic Designer: This entry can be used to initiate the launch of the 'Logic Designer' screen. Once chosen, the existing 'FlexLogic Equation Editor' screen is set to Read-only and then the 'Logic Designer' screen launch is initiated.If the user wants to re-visit the FlexLogic Editor Screen, any existing read-only screen has to be closed first. Then, the screen has to be re-opened. The FlexLogic Editor screen is now editable, again.

In order to maintain synchronization of FlexLogic, the following update rules are defined.

For example, when a user tries to open the 'FlexLogic Equation Editor' of a particular device or file.

- If the 'Logic Designer' screen is open and in Edit mode, a message prompts to save any changes. The 'FlexLogic Equation Editor' is not launched.
- If the 'Logic Designer' is open and in saved mode (no edits to save or compile), the 'Logic Designer' screen is closed and then the 'FlexLogic Equation Editor' launch is initiated.

Viewing FlexLogic Graphics

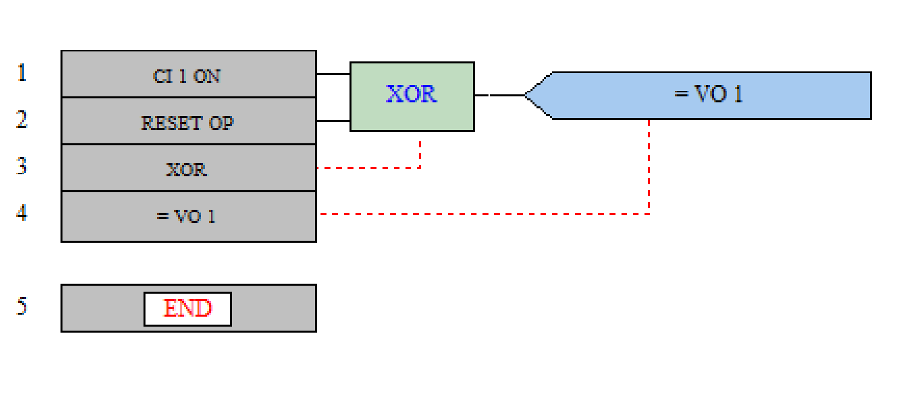
To verify that the FlexLogic equation(s) and its selected parameters produce the desired logic, the expression can be viewed by converting the derived equation into a graphic diagram. It is strongly recommended and helpful to view an equation as a graphic diagram before it is saved to the 845 device in order to troubleshoot any possible error in the equation.

To View the FlexLogic Graphic

Click on the View button at the top of the Type column in the FlexLogic Equation screen, see previous figure. Provided the equation is entered correctly, this generates a graphical representation of the expression previously entered. If any operator inputs are missing or any FlexLogic rules have been violated, the EnerVista 8 Series Setup software displays a message box indicating any problems in the equation when the view feature is attempted.

The expression is also listed to the left of the diagram to demonstrate how the diagram was created. The End statement is added as parameter 5 (End of list).

Figure 9-6: FlexLogic Graphic Example



FlexElements

There are 8 identical FlexElements™. A FlexElement is a universal comparator, that can be used to monitor any analog actual value measured or calculated by the relay, or a net difference of any two analog actual values of the same type. Depending on how the FlexElement is programmed, the effective operating signal could be either a signed signal ("Signed" selected for Input Mode), or an absolute value ("Absolute" selected for Input Mode).

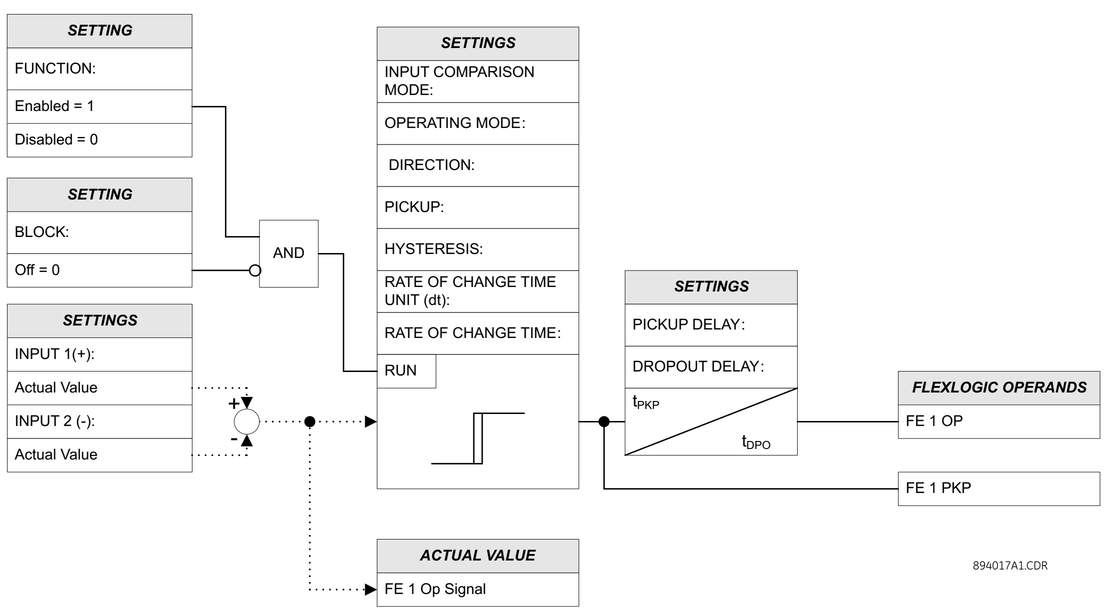
The element can be programmed to respond either to a signal level or to a rate-of-change (delta) over a pre-defined period of time. The output operand is asserted when the operating signal is higher than a threshold or lower than a threshold chosen.

When programming a FlexElement, one must keep in mind the following limitations:

1. The analog inputs for any FlexElement must be from the same "gender":
   - current and current (in any combination, phase-symmetrical, phase-phase, kA-A, differential, restraint, etc.)
   - voltage and voltage (as above)
   - active power and active power (Watts and Watts)
   - reactive power and reactive power (Vars and Vars)
   - apparent power and apparent power (VA and VA)
   - angle and angle (any, no matter what signal, for example angle of voltage and angle of current are a valid pair)
   - % and % (any, for example THD and harmonic content is a valid pair)
   - V/Hz and V/Hz
   - °C and °C
   - I^2t and I^2t
   - FlexElement actual and FlexElement actual

   For all the other combinations, the element displays 0.000 or N/A and will not assert any output operand.
2. The analog value associated with one FlexElement can be used as an input to another FlexElement "Cascading".

Figure 9-7: FlexElement logic diagram



Path: **Setpoints > FlexLogic > FlexElements > FlexElement 1**

FUNCTION

Range: Disabled, Enabled
Default: Disabled

NAME

Range: Up to 13 alphanumeric characters
Default: FlexEl 1

INPUT 1 (+)

Range: Off, any FlexAnalog signal
Default: Off

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

INPUT 2 (-)

Range: Off, any FlexAnalog signal
Default: Off

This setting specifies the second input (inverted) to the FlexElement. Zero is assumed as the input if this setting is set to “Off”. For proper operation of the element at least one input must be selected. Otherwise, the element will not assert its output operands.

This input should be used to invert the signal if needed for convenience, or to make the element respond to a differential signal such as for a top-bottom oil temperature differential alarm.

A warning message is displayed and 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.

PICKUP

Range: -30.000 to 30.000 pu in steps of 0.001 pu
Default: 1.000

This setting specifies the operating threshold for the effective operating signal of the element.

If the “Over” direction is set, the element picks up when the operating signal exceeds the PICKUP value.

If the “Under” direction is set, the element picks up when the operating signal falls below the PICKUP value.

The HYSTERESIS setting controls the element drop out.

Notice that both the operating signal and the pickup threshold can be negative when facilitating applications such as reverse power alarms.

The FlexElement can be programmed to work with all analog values measured or computed by the relay. The PICKUP setting is entered in pu values using the following definitions of the base units:

Table 9-4: Definitions of the Base Unit for the FLEXELEMENT

Measured or calculated analog value related to:	**Base Unit**
Voltage	V_{BASE} = maximum nominal primary RMS value of the Input 1(+) and input 2(-) inputs
Current	I_{BASE} = maximum nominal primary RMS value of the Input 1(+) and input 2(-) inputs
Power	P_{BASE} = maximum value of V_{BASE} * I_{BASE} for the Input 1(+) and input 2(-) inputs
Power Factor	PF_{BASE} = 1.00

Measured or calculated analog value related to:	Base Unit
Phase Angle	DegBASE = 360 deg
Harmonic Content	H_{BASE} = 100% of nominal
THD	THD_{BASE} = 100%
Frequency	f_{BASE} = nominal frequency as entered under the SYSTEM SETUP menu
Volt/Hz	BASE = 1.00
dcmA	BASE = DCMA INPUT MAX (setting under the DCMA menu). If two DCMA signals are used by the FlexElement, the maximum of the above setting among the two elements is used as the base.
RTDs	BASE = 100.00°C
I^2t (arcing Amps)	BASE = 2000 kA^2*cycle
Differential and Restraint currents (Percent Differential)	I_{BASE} = CT primary from the CT bank selected for Winding 1 (the same base as the one for 87T element)
Differential and Restraint currents (RGF)	I_{BASE} = CT primary from the CT bank selected for the RGF element (the same base as the one for RGF element)
Winding Hottest-Spot	BASE = 100°C
Loss of Transformer Life	LOL_{BASE} = 180000 hours
Daily Rate Loss of Life	$DRLOL_{BASE}$ = 1000 hours
Aging Factor	AAF_{BASE} = 1.00
Harmomic Derating	HDF_{BASE} = 1.00
Xfmr Overload	OL_{BASE} = 100%
Tap Position	TC_{BASE} = 1

HYSTERESIS

Range: 0.1 to 50.0% in steps of 0.1%

Default: 3.0%

This setting defines the pickup – drop out relation of the element by specifying the width of the hysteresis loop as a percentage of the pickup value as shown above in the *Direction, Pickup, and Hysteresis setpoints* figure.

RATE OF CHANGE TIME UNIT (dt)

Range: millisecond, second, minute

Default: milliseconds

This setting specifies the time base dt when programming the FlexElement as a rate of change element.

The setting is applicable only if the Operating Mode is set to "Delta".

RATE OF CHANGE TIME

Range: 40 to 65535 in steps of 1

Default: 40

This setting specifies the duration of the time interval for the rate of change mode of operation.

The setting is applicable only if the Operating Mode is set to "Delta".

EXAMPLES

13.8 kV power system:

- Phase VT Connection: Wye
- Phase VT Secondary: 66.4 V
- Phase VT Ratio: 120:1 (phase to neutral primary voltage = 120*66.4 = 7968 V)
- Aux VT Connection: Vab
- Aux VT Secondary: 115 V

- Aux VT Ratio: 120:1(phase-phase primary voltage = 13800V)
- Phase CTs Primary: 2000 A
- Ground CT Primary: 500 A
- Frequency: 60Hz

Detecting voltage difference:

The voltage difference between calculated phase-phase voltage derived from Wye connected phase VTs, and the directly measured phase-phase voltage from auxiliary VT can be monitored by programming a FlexElement.

FlexElement settings:

- Input 1(+): J2 Vab RMS
- Input 2 (-): J2 Vaux RMS (input from VT connected between phases A and B)
- Operating Mode: Absolute
- Input Comparison Mode: Level
- Direction: Over

The analog input J2 Vab is phase-phase voltage computed by the relay based on three-phase Wye voltages. As per the Phase VT setup, the primary RMS nominal voltage for J2 Vab input is 66.4 V *120 = 7.968kV.

The analog input J2 Vaux is directly measured phase-phase voltage and its primary RMS nominal voltage is 115V *120 = 13.8kV

V_{BASE} = max (7.968kV, 13.8kV) = 13.8kV.

If we want to detect 2% voltage difference (2% @13.8kV = 276V) between the computed phase to phase Vab voltage, and the measured Vaux voltage from a VT connected between phases A and B, the pickup per-unit setting for the FlexElement can be set as follows:

Pickup = 276V/13800V = 0.02 pu

If the voltage difference between the selected inputs becomes bigger than 276 Volts, the FlexElement will pickup, and operate, which can be used to energize contact, or initiate alarm, or trip.

Detecting current difference between Neutral and Ground currents:

In a balanced system, the computed neutral and the measured ground currents is 0 Amps. However, during ground faults their values are not zero. More specifically if the phase and ground CTs are located on the same transformer winding, such that the ground CT is installed on the grounded neutral of the winding, their values supposed to be the same during external fault, and would be different during internal fault. The FlexElement can be used for detecting the differential signal between these quantities. For example the following condition can be made:

I_{BASE} = max (2000A, 500A) = 2000A

FlexElement settings:

- Input 1(+): J1
- InInput 2 (-): J1 Ig
- Operating Mode: Absolute
- Input Comparison Mode: Level
- Direction: Over
- Pickup = 200A/2000A: 0.1 pu

When no CT saturation conditions exist, if the difference between the neutral current and the ground current becomes more than 200 Amps primary, this can be treated as an indication of an internal ground fault, which should be cleared. With I_{BASE} = max (2000A, 500A) = 2000A, the pickup can be set as follows: Pickup = 200A/2000A = 0.1 pu

Detecting Low 3-ph Apparent Power:

V_{BASE} = 7.968kV

I_{BASE} = 1000 A

$P_{BASE} = V_{BASE} * I_{BASE}$ = 7968 V *2000A = 15.936MVA

The FlexElement can be set to detect under-power conditions and produce alarm, or trip if the apparent power is less than 500kVA. In this case the pickup setting for the FlexElement can be computed as follows:

Pickup = 0.5MVA / 15.936 MVA = 0.0313 pu

FlexElement settings:

- Input 1(+): Pwr1 Apparent
- Input 2(-): Off
- Operating Mode: Absolute
- Input Comparison Mode: Level
- Direction: Under
- Pickup: 0.0313 pu

Power Factor Cap Bank Switch-In Example

PF_{BASE} = 1.00

FlexElement can be programmed to switch-in cap bank, if for example the measured 3Ph Power Factor has negative value(lag), and drops below the pickup of -0.7 pu. Programming the Hysteresis setpoint to the desired percentage can define the PF value at which the cap bank can be switched off. For example, if the cap bank is required to be switched off at PF value of -0.9, than the percent hysteresis is computed as:

% hysteresis = ((abs(-0.9)-abs(-0.7))/ PFBASE)*100 = 20%

NOTICE

The minimum pickup should not be less than 0.01 pu, as the measurement resolution for the Power Factor is 0.01.

- Input 1(+): Pwr1 PF
- Input 2(-): Off
- Operating Mode: Signed
- Input Comparison Mode: Level
- Direction: Under
- Pickup: -0.700 pu
- Hysteresis: 20.0 %

Detecting high THD (Total Harmonic Distortion)

THD_{BASE} = 100%

A FlexElement can be programmed to detect excessive amount of harmonics in the system, and Alarm, Trip, or switch-in/out an equipment to suppress the high amount of harmonics. The Total Harmonic Distortion is an estimation of how the AC signals are distorted and as shown above, it can be used as an input for the FlexElement.

For example if an operation from a FlexElement is desired when the THD for the phase A voltage exceeds 20%, then having a base of 100%, the pickup setting should be set to 0.200 pu.

- Input 1(+): J2 Phase A THD
- Input 2(-): Off
- Operating Mode: Absolute
- Input Comparison Mode: Level
- Direction: Over
- Pickup: 0.200 pu

NOTICE

The harmonics and THD values are measured as percentage of the fundamental signal, and have resolution of 0.01%. However for the minimum pickup setting of 0.001 pu, this would mean percentage step of 0.1%.

Simple V/Hz ratio detection for protected equipment

V/Hz_{BASE} = 1.00High V/Hz ratios in the power system are harmful for the insulation of the protected equipment – transformer, generator, or elsewhere in the power system. If not detected, it can lead to excessive heat and degradation of the insulation which will damage the equipment. A FlexElement can be used for simple detection of V/Hz values, and to issue an Alarm, or Trip, if detected above Pickup setting. Since the base unit for V/Hz = 1.00, programming of the pickup setpoint is straight forward for the desired FlexElement operation. For the example given here, a value of 1.200 pu has been selected.

- Input 1(+): Volts Per Hertz 1Input 2(-): OffOperating Mode: AbsoluteInput Comparison Mode: LevelDirection: OverPickup: 1.200 puHysteresis: 8.3 %

Now, if the FlexElement is needed to drop down when the V/Hz ratio becomes equal to 1.1, the hysteresis can be calculated as:1.2pu-1.1pu = 0.1 puHysteresis = (0.1*100)/1.2 = 8.3%

High Breaker Arcing current detection

High breaker arcing current can be detected by using a FlexElement during the opening of a breaker. One or more FlexElements can be configured for detecting levels of maximum arcing current during the tripping of a particular breaker, and give an indication for the health of the breaker.

The base unit for the breaker arcing current is programmed in the relay as: BASE = 2000 kA^2*cycle

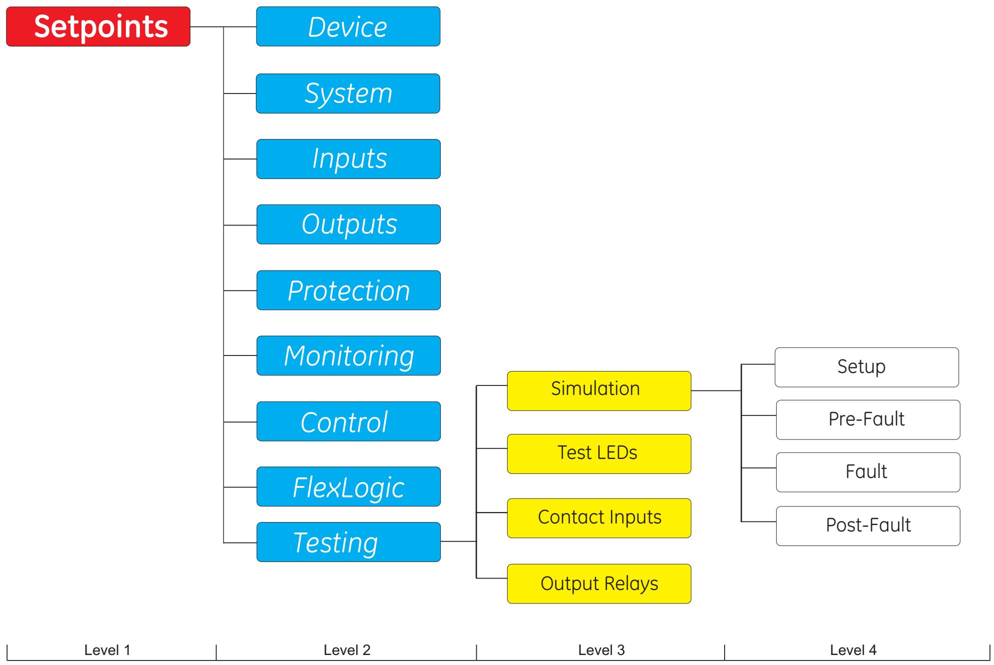
- Input 1(+): Total Arcing Current
- Input 2(-): Off
- Operating Mode: Absolute
- Input Comparison Mode: Level
- Direction: Over
- Pickup: 2.500 pu
- Hysteresis: 0.0 %

To configure the pickup setpoint for a total arcing current of 5000kA^2/cycle, the per-unit pickup value can be calculated as follows:

Pickup = 5000kA^2 *cycle/2000 kA^2*cycle = 2.500 pu

Testing

Figure 9-8: Testing Display Hierarchy



Path: **Setpoints > Testing**

- Simulation
- Test LEDs
- Contact Inputs
- Output Relays

The 8 Series can simulate current and voltage inputs when the Simulation feature is enabled. Other test operations are also possible such as the LED lamp test of each color, contact input states and testing of output relays.

Simulation

Path: Setpoints > Testing > Simulation

- Setup
- Pre-Fault
- Fault
- Post-Fault

The Simulation feature is provided for testing the functionality of the 8 Series in response to programmed conditions, without the need of external AC voltage and current inputs. First time users will find this to be a valuable training tool. System parameters such as currents, voltages and phase angles are entered as setpoints. When placed in simulation mode, the relay suspends reading actual AC inputs, generates samples to represent the programmed phasors, and loads these samples into the memory to be processed by the relay. Normal (pre-fault), fault and post-fault conditions can be simulated to exercise a variety of relay features. There are three sets of input parameters used during simulation, each provides a particular state of the system as follows.

NOTE

All Simulation setpoints revert to default values at power-up.

Testing of Arc Flash functionality is not possible with the Simulation feature.

Setup

Path: Setpoints > Testing > Simulation > Setup

- Simulation State
- Pre-Fault to Fault Trigger
- Force Relays
- Force LEDs

SIMULATION STATE

Range: Disabled, Prefault State, Fault State, Postfault State
Default: Disabled

Program the Simulation State to “Disabled” if actual system inputs are to be monitored.

If programmed to any other value, the relay is in test mode and actual system parameters are not monitored, including Current, Voltage, and Contact Inputs. The system parameters simulated by the relay are those in the following section that correspond to the programmed value of this setpoint. For example, if programmed to “Fault”, then the system parameters are set to those defined by the Fault setpoint values.

NOTE

While in test mode, Contact Input states are automatically forced to the values set in Setpoints > Testing > Contact Inputs.

When the Fault State is set as the Simulation State and a Trip occurs, the Simulation State automatically transitions to the Postfault State.

PRE-FAULT TO FAULT TRIGGER

Range: Off, On, Any FlexLogic Operand
Default: Off

FORCE RELAYS

Range: Disabled, Enabled

Default: Disabled

When in test mode, and Force Relays is "Enabled", relay states can be forced from the **Setpoints > Testing > Output Relays** menu, this overrides the normal operation of the output contacts. When in test mode, and Force Relays is "Disabled", the relay states maintain their normal operation. Forcing of output relay states is not performed when the Simulation State is "Disabled".

FORCE LEDS

Range: Disabled, Enabled

Default: Disabled

When in test mode, and Force LEDs is "Enabled", LED states and colors can be forced from the **Setpoints > Testing > Test LEDs** menu, this will override the normal operation of the LEDs. When in test mode, and Test LEDs is "Disabled", the LED states and colors will maintain their normal operation. Forcing of LEDs is not performed when the Simulation State is "Disabled".

Pre-Fault

This state is intended to simulate the normal operating condition of a system by replacing the normal input parameters with programmed pre-fault values. For proper simulation, values entered here must be below the minimum trip setting of any protection feature.

Voltage magnitudes and angles are entered as Wye values only. The voltage setpoints are not available if the corresponding VT Bank PHASE VT CONNECTION setpoint is Delta. Voltages are set in secondary VT units.

The CT and VT Bank availability is dependent on the installed Order Code options.

Path: Setpoints > Testing > Simulation > Pre-Fault

J2 Prefault Van(Vbn,Vcn,Vx) Voltage:

Range: 0.00 to 300.00 V in steps of 0.01

Default: 0.00 V

J2 Prefault Van(Vbn,Vcn,Vaux) Angle:

Range: -359.9° to 0.0° in steps of 0.1

Default: 0.0°

J1(K1,K2) Prefault Phase Ia(Ib,Ic):

Range: 0.000 to 46.000 x CT in steps of 0.001 x CT

Default: 0.000 x CT

Phase current magnitudes are entered as a multiple of the corresponding CT Bank PHASE CT PRIMARY setpoint.

J1(K1,K2) Prefault Phase Ig:

Range:

For Ground CT: 0.000 to 46.000 x CT in steps of 0.001 x CT

Default: 0.000 x CT

The ground current magnitude setpoint range is dependent on the ground CT type as defined in the Order Code options. For Ground CT, the magnitude is entered as a multiple of the corresponding CT Bank GROUND CT PRIMARY setpoint.

J1(K1,K2) Prefault Ia(Ib,Ic,Ig) Angle:

Range: -359.9° to 0.0° in steps of 0.1

Default: 0.0°

Fault

The Fault state is intended to simulate the faulted operating condition of a system by replacing the normal input parameters with programmed fault values.

Voltage magnitudes and angles are entered as Wye values only. The voltage setpoints are not available if the corresponding VT Bank PHASE VT CONNECTION setpoint is Delta. Voltages are set in secondary VT units.

The CT and VT Bank availability is dependent on the installed Order Code options.

Path: Setpoints > Testing > Simulation > Fault

J2 Fault Van(Vbn,Vcn,Vx) Voltage:
Range: 0.00 to 300.00 V in steps of 0.01
Default: 0.00 V

J2 Fault Van(Vbn,Vcn,Vaux) Angle:
Range: -359.9° to 0.0° in steps of 0.1
Default: 0.0°

J1(K1,K2) Fault Phase Ia(Ib,Ic):
Range: 0.000 to 46.000 x CT in steps of 0.001 x CT
Default: 0.000 x CT

J1(K1,K2) Fault Phase Ig:
Range:
For Ground CT: 0.000 to 46.000 x CT in steps of 0.001 x CT
Default: 0.000 x CT

J1(K1,K2) Fault Ia(Ib,Ic,Ig) Angle:
Range: -359.9° to 0.0° in steps of 0.1
Default: 0.0°

Post-Fault

The Post-fault state is intended to simulate a system that has tripped by replacing the normal input parameters with programmed post-fault values.

Voltage magnitudes and angles are entered as Wye values only. The voltage setpoints are not available if the corresponding VT Bank PHASE VT CONNECTION setpoint is Delta. Voltages are set in secondary VT units.

The CT and VT Bank availability is dependent on the installed Order Code options.

Path: Setpoints > Testing > Simulation > Post-Fault

J2 Postfault Van(Vbn,Vcn,Vx) Voltage:
Range: 0.00 to 300.00 V in steps of 0.01
Default: 0.00 V

J2 Postfault Van(Vbn,Vcn,Vaux) Angle:
Range: -359.9° to 0.0° in steps of 0.1
Default: 0.0°

J1(K1,K2) Postfault Phase Ia(Ib,Ic):
Range: 0.000 to 46.000 x CT in steps of 0.001 x CT
Default: 0.000 x CT

J1(K1,K2) Postfault Phase Ig:
Range:
For Ground CT: 0.000 to 46.000 x CT in steps of 0.001 x CT
For Sensitive Ground CT: 0.000 to 4.600 x CT in steps of 0.001 x CT
For CBCT: 0.000 to 15.000 A in steps of 0.001
Default: 0.000 x CT

J1(K1,K2) Postfault Ia(Ib,Ic,Ig) Angle:
Range: -359.9° to 0.0° in steps of 0.1
Default: 0.0°

Test LEDs

The Test LEDs setting is used to program the state and color of each LED when in test mode and Force LEDs is “Enabled”.

NOTE

Test LEDs setpoints here (in test mode) will revert to default values at power-up.

Path: **Setpoints > Testing > Test LEDs**

LED 1 (17)

Range: Off, Red, Green, Orange

Default: Off

Selects the color of each LED when the relay is in test mode (Simulation State is not set to “Disabled”) and Force LEDs is “Enabled”. The setpoints Simulation State and Force LEDs are found under **Setpoints > Testing > Simulation > Setup**.

Contact Inputs

The Contact Inputs section is used to program the state of each contact input when in test mode. The number of Contact Inputs available is dependent on the installed Order Code options.

NOTE

Contact Inputs setpoints here (in test) will revert to default values at power-up.

Path: **Setpoints > Testing > Contact Inputs**

CI 1(X):

Range: Off, On

Default: Off

The item name displays the user configurable name for the contact input.

Output Relays

The Output Relays section is used to program the state of each output relay when the device is in test mode and Force Relays is “Enabled”.

Select “Off” to force the output relay to the de-energized state, or select “On” to force the output relay to the energized state.

The number of Output Relays available is dependent on the installed Order Code options.

NOTE

Output Relays setpoints here (in test mode) will revert to default values at power-up.

Path: **Setpoints > Testing > Output Relays**

OUTPUT RELAY X

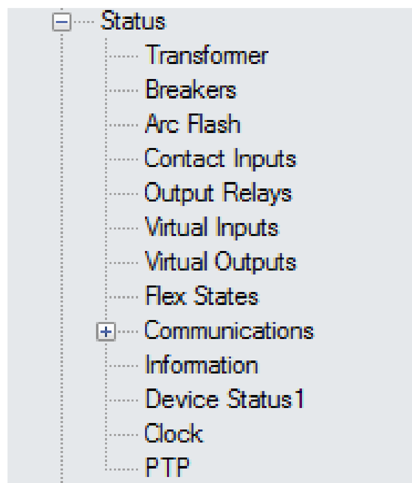
Range: Off, On

Default: Off

845 Transformer Protection System

Chapter 10: Status

Figure 10-1: Main Status Screen

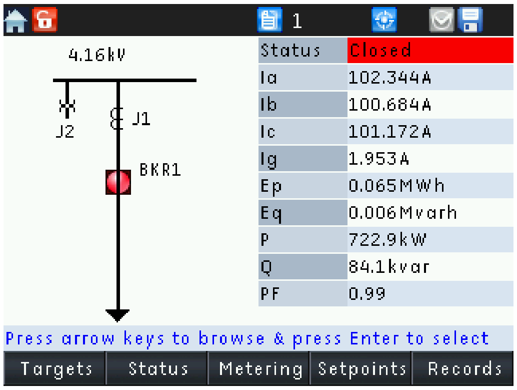


Summary

Configurable SLD

The status of each SLD screen is displayed under **Status > Summary > Configurable SLDs > SLD1(X)**.

Figure 10-2: Sample SLD



Path: Status > Summary > Configurable SLDs > SLD 1(X)

Once in the SLD screen, by default no breaker/switch is highlighted or selected. Pressing the Up/Dn (or Up/Dn/Left/Right) navigation keys highlights BKR1 and navigates through BKR1, 2, 3, etc. and then through Switch1, 2, 3, etc.

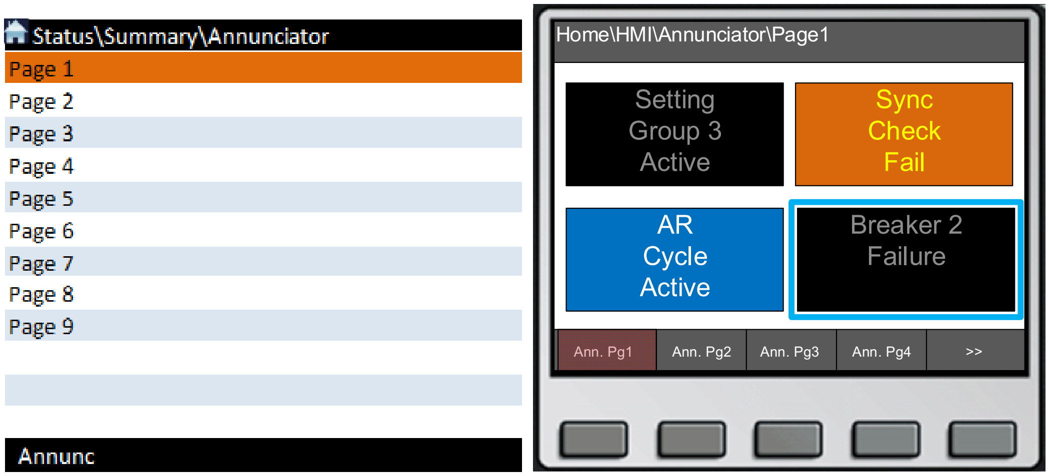
If the Up/Dn/Left/Right keys are used, the selection moves to the closest available breaker/switch from the currently highlighted object. To select the breaker/switch, press the enter key. Upon pressing the Enter key, the tab labels change to the programmable tab pushbutton labels and a flash message for the breaker selected appears (Flash Message: "BKR1 Selected"). Pressing Escape de-selects the breaker/switch and the tab pushbutton labels.

Annunciator

The graphical annunciator panel emulates a physical annunciator panel. Indicators on the graphical panel are backlit and have a description of the alarm condition that lights each indicator. The annunciator panel status window shows the alarms that are active.

To reset an active alarm, first highlight the active alarm using the navigation keys, then press the reset button to reset the highlighted alarm. If no indicator is selected, all alarms on the page are reset by pushing the reset button.

Figure 10-3: Physical and Graphical Annunciator Panels



Tab Pushbuttons

Navigation

There are two ways to navigate to the Tab Pushbutton control pages:

- Relay Home Screens
- **Path:** Status > Summary > Tab Pushbuttons (from relay)

Home Screens

By default, the Tab Pushbuttons summary page is programmed as one of the Home Screens. Press the home button repeatedly to cycle through the programmed Home Screens.

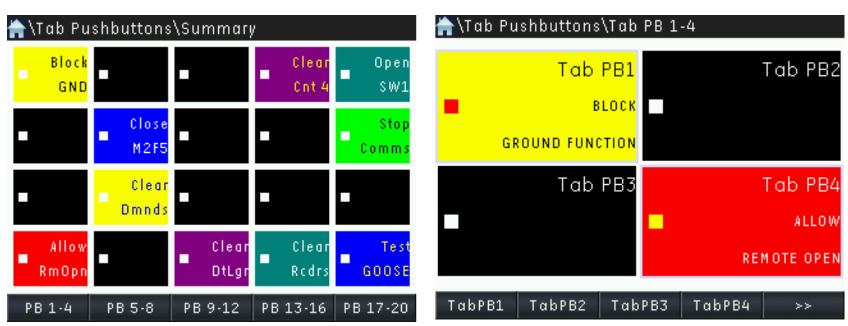
NOTICE

Tab pushbuttons can only be controlled physically through the front panel of the relay. Their operation is not available from the setup software.

Path: Status > Summary > Tab Pushbuttons

The initial view of the Tab Pushbutton controls is the Summary page, which shows the status of all 20 pushbuttons. To operate the pushbuttons, navigate to the individual pages where the tab pushbuttons can be used to activate them.

Figure 10-4: Tab pushbutton summary (left) and detailed view (right)



Only the tab pushbuttons that are not set to Disabled are shown in color; labels for the tab pushbuttons are shown for both active and disabled pushbuttons if labels have been configured. (Configure tab pushbuttons from Device > Front Panel > Tab PBs > Tab PB1(X).)

When the actual button is pressed, the button on the screen is highlighted in blue and the PB [X] PRESS operand becomes active. Although a disabled pushbutton can be pressed, no action is taken and its operands are not activated. Pressing ESCAPE returns the screen to Tab Pushbutton summary page. The Short Text for each Tab Pushbutton is used on the Summary Page.

Pressing >> shows the next set of tab pushbuttons. For example, when in the page with pushbuttons 1 to 4, pressing >> will navigate to the screen with pushbuttons 5 to 8. Press >> to cycle through all five pushbutton screens. To go from page 2 to page 1, press >> 4 times to cycle through and navigate to page 1 with pushbuttons 1 to 4. Alternatively, escape to the overall summary screen and navigate to any desired page of pushbuttons.

Breakers

The status of the breaker/breakers is displayed individually. If the selected trip output relay is Form A-type, the status of the breaker Trip and Close circuitry is also displayed here. The screen includes the total accumulated arcing current information for the breaker as well.

Path: Status > Breaker > Breaker X Status

STATE

Range: Not Configured, Opened, Closed, Disconnected, State Unknown

The Unknown state is displayed upon discrepancy of the 52a and 52b contacts for more than 30 milliseconds.

BKR TROLLEY STATE

Range: Not Configured, Opened, Closed, State Unknown

TRIP COIL

Range: Not Set, Fail, OK

The Trip Coil state is displayed when Form -A output relays are used, and Trip Coil monitoring is enabled.

CLOSE COIL

Range: Not Set, Fail, OK

The Close coil state is displayed when Form -A output relays are used, and Close Coil monitoring is enabled.

TOTAL ARCING CURRENT

Range: 0.00 to 42949672.95 kA2-cyc in steps of 0.01

The measure of arcing current from all three phases during breaker trips. Refer to the Breaker Arcing Current element description (under Setpoints > Monitoring > Breaker) for more details.

Information

Path: **Status > Information > Relay Info**

The Information pages display fixed device information. the pages are divided into three sections: Main CPU, Comms CPU, and Hardware Versions.

Main CPU

The Information related to the Main CPU is displayed here.

Path: **Status > Information > Relay Info > Main CPU**

- **Order Code:** The installed Order Code
- **Product Serial #:** The relay serial number
- **Hardware Revision:** The hardware revision of the relay
- **Firmware Version:** The firmware version of the Main CPU
- **Firmware Date:** The Main CPU firmware build date in the format mm/dd/yyyy
- **Firmware Time:** The Main CPU firmware build time
- **Boot 1/2 Version:** The boot 1/2 code version of the Main CPU
- **Boot 1/2 Date:** The Main CPU boot 1/2 code build date in the format mm/dd/yyyy
- **Boot 1/2 Time:** The Main CPU boot 1/2 code build time
- **MAC Address 1:** The MAC address for copper Ethernet port 1
- **Remote CANBUS RMIO:** The commissioned value of the CANBUS IO is displayed here. If the relay has never been commissioned then the value is None, i.e. default = None and Range = 6 alphanumeric characters.
- **NUM of RMIO RTDs:** The number of remote RTDs detected

Comms CPU

The Information related to the Comms CPU is displayed here.

Path: **Status > Information > Relay Info > Comms CPU**

- **Comms CPU fw Version:** The firmware version of the Comms CPU
- **Comms CPU Firmware Date:**
  The Comms CPU firmware build date in the format mm/dd/yyyy
- **Comms CPU Firmware Time:** The Comms CPU firmware build time
- **Boot Version:** The boot code version of the Comms CPU
- **Boot Date:** The Comms CPU boot code build date in the format mm/dd/yyyy
- **Boot Time:** The Comms CPU boot code build time
- **MAC Address 1:** The MAC address for Ethernet port 4
- **MAC Address 2:** The MAC address for Ethernet port 5

Hardware Versions

Path: **Status > Information > Relay Info > Hardware Versions**

The Information related to the relay hardware is displayed here.

- **FPGA Firmware Version:** The firmware version of the FPGA
- **IO F CPLD:** The version of the CPLD in IO slot F
- **IO G CPLD:** The version of the CPLD in IO slot G
- **AN J CPLD:** The version of the CPLD in analog slot J
- **AN K CPLD:** The version of the CPLD in analog slot K
- **Display CPLD:** The version of the CPLD of the display

Environment

The Information related to Environmental is displayed here.

NOTE

The Temperature Display setpoint can be changed from Celcius to Fahrenheit under **Setpoints > Device > Installation**.

Path: **Status > Information > Environment**

- **Instantaneous Temperature:** The most recent temperature measurement taken by the EAM.
- **Firmware Version:** The software version of the EAM module found in the relay.
- **Last Poll Date/ Time:** The date and time on which the last measurements were recorded in the format MM/DD/YY and HH/MM/SS.
- **Average Humidity:** The average of all the humidity measurements taken over time (last 1 hr) by the EAM.
- **Maximum Humidity:** The maximum humidity measurement taken by the EAM since it began recording data.
- **Minimum Humidity:** The minimum humidity measurement taken by the EAM since it began recording data.
- **Average Ambient Temp:** The average of all the instantaneous temperature measurements taken over time (last 1 hr) by the EAM.
- **Maximum Ambient Temp:** The maximum temperature taken by the EAM since it began recording data.
- **Minimum Ambient Temp:** The minimum temperature taken by the EAM since it began recording data.
- **Humidity (e.g. <30%):** The accumulated amount of time (hrs) that the humidity measured by the EAM stayed in the range specified.
- **Temp (e.g. <=-20°C):** The accumulated amount of time (hrs) that the temperature measured by the EAM stayed in the range specified.
- **Temp and Humidity (e.g. >40°C and <55%):** The accumulated amount of time (hrs) that the temperature and humidity measured by the EAM stayed in the ranges specified.
- **Surge Count:** The number of surge (>500 V/1.2/50 μS) events that have occurred since the EAM started recording data.

Settings Audit

The Information related to settings changes and settings file history is displayed here.

Path: Status > Information > Settings Audit

- **Last Setting Change:** The date and time of the last setting change.
- **File Modified:**
- **File Received:**
- **File Origin:**
- **File Name:**

Switches

Path: Status > Switches

SWITCH 1(X)

Range: Not Configured, Opened, Closed, Intermittent, Discrepancy
Default: Not Configured

Last Trip Data

There is no Enabling/Disabling of this feature. It is always 'ON'.

Path: Status > Last Trip Data

CAUSE

Range: Off, Any FlexLogic Operand
Default: No trip to Date

EVENT

Range: 0 to 4294967295 in steps of 1
Default: 0

DATE

Range: MM/DD/YYYY HH:MM
Default: 01/01/08 00:00:00

PARAMETER 1 to 64

Range: -2147483648 to 2147483647 in steps of 1
Default: 0

Arc Flash

Path: **Status > Arc Flash > Arc Flash 1**

The status value shows the state of the given Flex operand related to Arc Flash protection.

Light 1(4) PKP
Range: ON, OFF

HS Phase IOC PKP A/B/C
Range: ON, OFF

HS Ground IOC PKP
Range: ON, OFF

Arc Flash OP
Range: ON, OFF

Contact Inputs

Path: **Status > Contact Inputs**

The status of the Contact Inputs is shown here (see device menu via the menu path). The 'Off/On' display indicates the logic state of the Contact Input.

Output Relays

Path: **Status > Output Relays**

The status of all output relays is shown here, see above. In the Parameter column, the value indicates the label on the output terminal. The Value column indicates the present ON or OFF state of the output relay.

Virtual Inputs

Path: Status > Virtual Inputs 1(X)

The state of all virtual inputs is shown here, see next figure. The value for each Virtual Input is shown on the control panel graphically as a toggle switch in either the On (|) state or the Off (O) state.

Figure 10-5: Status of Virtual Inputs, HMI

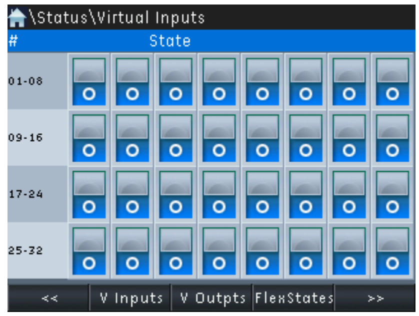


Figure 10-6: Status of Virtual Inputs, Enervista 8 Series Setup software

PARAMETER	VALUE
Virtual Input 1 ()	Off
Virtual Input 2 ()	Off
Virtual Input 3 ()	Off
Virtual Input 4 ()	Off
Virtual Input 5 ()	Off
Virtual Input 6 ()	Off
Virtual Input 7 ()	Off
Virtual Input 8 ()	Off
Virtual Input 9 ()	Off

Virtual Outputs

Path: Status > Virtual Outputs

The state of all virtual outputs is shown here, see next figure. The value for each Virtual Output is shown on the control panel graphically as a toggle switch in either the On (|) state or the Off (O) state.

Figure 10-7: Status of Virtual Outputs, HMI

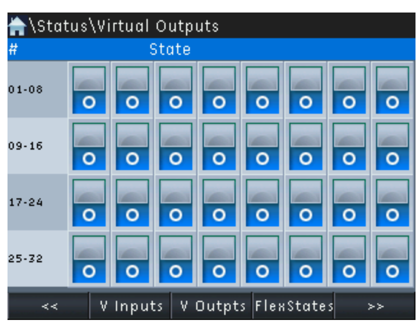


Figure 10-8: Status of Virtual Outputs, Enervista 8 Series Setup software

PARAMETER	VALUE
Virtual Output 1 ()	Off
Virtual Output 2 ()	Off
Virtual Output 3 ()	Off
Virtual Output 4 ()	Off
Virtual Output 5 ()	Off
Virtual Output 6 ()	Off
Virtual Output 7 ()	Off
Virtual Output 8 ()	Off

Flex State

Path: Status > Flex States

There are 256 Flex state bits available. The status value indicates the state of the given Flex state bit.

Communications

GOOSE Rx and Tx

The 845 supports 16 GOOSE transmissions and 64 GOOSE receptions each with 64 items per transmission or reception. Non-structured GOOSE is supported. Each item within the GOOSE message can be a digital or analog value. Messages are launched within one scan of a digital point status change or an analog exceeding its deadband.

The 845 server supports a subset of the server features described in part 7.2 of the IEC61850 standard.

GOOSE MESSAGING

As indicated above, the 845 supports 16 GOOSE transmissions and 64 GOOSE receptions with details shown in the table below:

Service	Launch Speed*	Support for Programmable time to live	# of Tx	# of Rx	Test Bit Support	Number of items in each transmission or reception	Number of remote inputs per relay
Configurable GOOSE	Within 2 ms (1 CPU scan)*	Time to live programmable from 1000 to 60000 ms	16	64	Y	64 Data Items per Data Set	32

* Launch speed is measured by comparing the time stamp in SOE of digital remote output status change to the time stamp of message seen on the network by a computer who's clock is synchronized by an IRIG-B card to the same IRIG-B source as the 845 relay.

REMOTE INPUTS

Path: Status > Communications > Remote Inputs

The present state of the 32 remote inputs are shown here. The state displayed is 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.

GGIO1 INDICATIONS

Path: Status > Communications > GGIO1 Indications

The present state of the 32 GGIO1 Indications are shown here. There are up to 32 GGIO indications that can be used to map any FlexLogic operand into the IED 61850 information model. Default value is Off.

GOOSE STATUS

Path: **Status > Communications > GOOSE Status**

GOOSE 1 to 64 Status

Range: OFF, ON

Default: OFF

This setting indicates GOOSE communications are being received. A GOOSE STATUS of ON indicates successful receipt of the last GOOSE packet. A GOOSE STATUS of OFF indicates the communications link has failed, with the speed this setting changes determined by the Update Time setting configured under GOOSE Transmission.

GOOSE HEADER

Path: **Status > Communications > GOOSE HDR Status**

GOOSE 1 to 64 H.Status

Range: OFF, ON

Default: OFF

This setting validates the GOOSE packet structure. A GOOSE HEADER STATUS of ON indicates that the structure of the last GOOSE packet was valid.

GOOSE ANALOG

Path: **Status > Communications > GOOSE Analog AV**

FLOAT 1 to 24

Range:

Default: 0.0

SINT32 1 to 8

Range:

Default: 0

IEC 61850 STATUS

Path: **Status > Communications > IEC 61850 Status**

COMMS NOT VALIDATED OK

Range: NO, YES

Default: NO

COMMS NOT VALIDATED DONE

Range: YES, NO

Default: YES

COMMS VALIDATED OK

Range: YES, NO

Default: YES

COMMS VALIDATED DONE

Range: YES, NO

Default: YES

MAIN NOT VALIDATED OK

Range: NO, YES

Default: NO

MAIN NOT VALIDATED DONE

Range: YES, NO
Default: YES

MAIN VALIDATED OK

Range: YES, NO
Default: YES

MAIN VALIDATED DONE

Range: YES, NO
Default: YES

NOT RUNNING.ERROR CID

Range: NO, YES
Default: NO

RUNNING.DEFAULT CID

Range: NO, YES
Default: NO

RUNNING.SAVING CID TO FLASH

Range: NO, YES
Default: NO

CID HANDLING DONE

Range: YES, NO
Default: YES

NUMBER OF CONNECTED CLIENTS

Default: 0

CLIENT 1(8) IP ADDRESS

Range: 0, 0XFFFFFFFF
Default: 0

ACTIVITY STATUS

The communication state for each enabled communication type is shown by its value. The main CPU and Comms software sets/resets the active bits for all enabled communication types. The communication state bits are not latched.

Path: **Status > Communications > Activity Status**

SERIAL MODBUS

Range: NONE, ACTIVE
Default: NONE

SERIAL DNP

Range: NONE, ACTIVE
Default: NONE

SERIAL IEC103

Range: NONE, ACTIVE
Default: NONE

ETHERNET MODBUS

Range: NONE, ACTIVE
Default: NONE

ETHERNET DNP

Range: NONE, ACTIVE
Default: NONE

ETHERNET IEC104
Range: NONE, ACTIVE
Default: NONE

ETHERNET IEC61850
Range: NONE, ACTIVE
Default: NONE

ETHERNET GOOSE
Range: NONE, ACTIVE
Default: NONE

ETHERNET DEVICENET
Range: NONE, ACTIVE
Default: NONE

ETHERNET PROFIBUS
Range: NONE, ACTIVE
Default: NONE

CONNECTIONS

Path: **Status > Communications > Connections**

MMS TCP - Maximum
Range: 0 to 99 in steps of 1
Default: 0

MMS TCP - Remaining
Range: 0 to 99 in steps of 1
Default: 0

Modbus TCP - Maximum
Range: 0 to 99 in steps of 1
Default: 0

Modbus TCP - Remaining
Range: 0 to 99 in steps of 1
Default: 0

DNP TCP - Maximum
Range: 0 to 99 in steps of 1
Default: 0

DNP TCP - Remaining
Range: 0 to 99 in steps of 1
Default: 0

IEC - 104 - Maximum
Range: 0 to 99 in steps of 1
Default: 0

IEC - 104 - Remaining
Range: 0 to 99 in steps of 1
Default: 0

OPC - UA - Maximum
Range: 0 to 99 in steps of 1
Default: 0

OPC - UA - Remaining

Range: 0 to 99 in steps of 1
Default: 0

SFTP - Maximum

Range: 0 to 99 in steps of 1
Default: 0

SFTP - Remaining

Range: 0 to 99 in steps of 1
Default: 0

Device Status

The general status of system components is displayed here.

Path: **Status > Device Status**

RUNNING, SAVING CID to FLASH

Range: YES, NO
Default: NO

CID HANDLING DONE

Range: YES, NO
Default: YES

SELF-TEST FAULT

Range: YES, NO
Default: NO

MAINTENANCE

Range: YES, NO
Default: NO

IN SERVICE

Range: YES, NO
Default: YES

PICKUP STATE

Range: YES, NO
Default: YES

BREAKER X CONNECTED

Range: YES, NO
Default: YES

BREAKER X CLOSED

Range: YES, NO
Default: NO

BREAKER X TRIPPED

Range: YES, NO
Default: NO

ALARM

Range: YES, NO
Default: NO

TRIP

Range: YES, NO
Default: NO

ACTIVE GROUP

Range: SP Group 1-6 Active
Default: SP Group 1 Active

Clock Status

Path: **Status > Clock**

SYSTEM CLOCK

Range: MMM DD YY HH:MM:SS

The current date and time of the system clock is displayed here.

RTC SYNC SOURCE

Range: None, Port 4 PTP Clock, Port 5 PTP Clock, IRIG-B, SNTP Server 1, SNTP Server 2

The **RTC Sync Source** actual value is the time synchronizing source the relay is using at present.

PTP Status

The present values of the PTP protocol are displayed here.

Path: **Status > PTP**

Grandmaster ID is the grandmaster Identity code being received from the present PTP grandmaster, if any. When the relay is not using any PTP grandmaster, this actual value is zero. The grandmaster Identity code is specified by PTP to be globally unique, so one can always know which clock is grandmaster in a system with multiple grandmaster-capable clocks.

RTC Accuracy is the estimated maximum time difference at present in the Real Time Clock (RTC), considering the quality information imbedded in the received time signal, how long the relay has had to lock to the time source, and in the case of time signal interruptions, the length of the interruption. The value 999,999,999 indicates that the magnitude of the estimated difference is one second or more, or that the difference cannot be estimated.

Port 4 (5) PTP State is the present state of the port's PTP clock. The PTP clock state is:

- DISABLED
  If the port's function setting is Disabled
- NO SIGNAL
  If enabled but no signal from an active master has been found and selected
- CALIBRATING
  If an active master has been selected but lock is not at present established
- SYNCH'D (NO PDELAY)
  If the port is synchronized, but the peer delay mechanism is non-operational
- SYNCHRONIZED
  If the port is synchronized

HMI Display

The HMI Display menu option opens a virtual HMI DIsplay window within the EnerVista 8 Series Setup software. The virtual HMI display provides front panel access to the relay with clickable buttons and realtime display of the front panel, including navigation and viewing relay settings, screens, and LEDs.

Path: **Status > HMI Display**

NOTE

The HMI Display functionality is not available with the Advanced Cybersecurity option.

845 Transformer Protection System

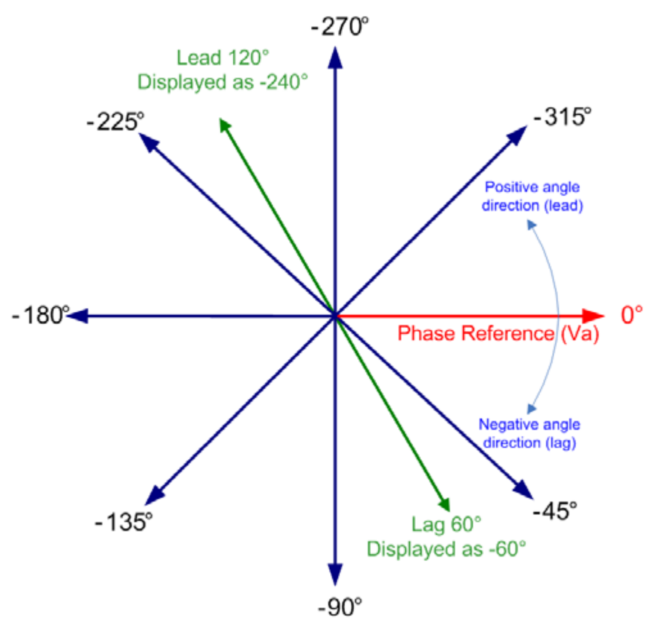
Chapter 11: Metering

All phasors calculated by 8 Series relays and used for protection, control and metering functions are rotating phasors, that maintain the correct phase angle relationships with each other at all times.

For display and oscillography purposes, all phasor angles in a given relay are referred to an AC input channel pre-selected as the phase A voltage. If there is no voltage input, the phase A current is used for angle reference. The phase angle of the reference signal always display zero degrees and all other phase angles are relative to this signal. If the preselected reference signal is not measurable at a given time, the phase angles are not referenced.

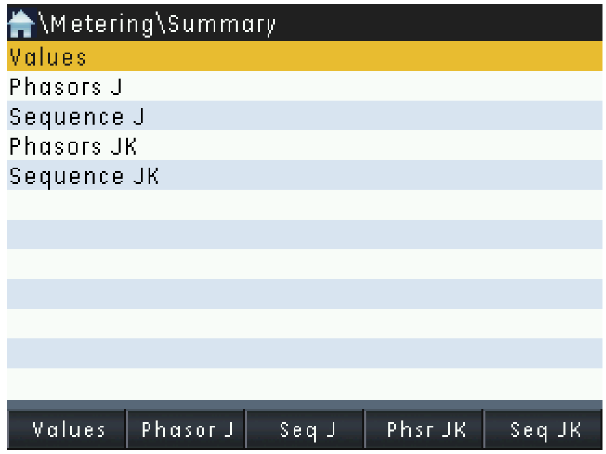
The phase angles in 8 Series relays are always presented as negative values in the lagging direction as illustrated in the following.

Figure 11-1: Phase Angle Measurement 8 Series Convention

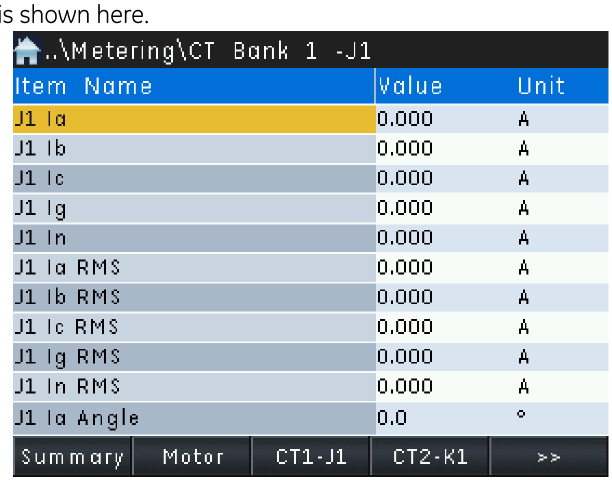


The relay measures all RMS (root mean square) currents and voltages, frequency, and all auxiliary analog inputs. Other values like neutral current, phasor symmetrical components, power factor, power (real, reactive, apparent), are derived. A majority of these quantities are recalculated every protection pass and perform protection and monitoring functions. Displayed metered quantities are updated approximately three (3) times a second for readability. All phasors and symmetrical components are referenced to the A-N voltage phasor for wye-connected VTs; to the A-B voltage phasor for delta-connected VTs; or to the phase A current phasor when no voltage signals are present.

Figure 11-2: An example of the Metering\Summary submenu

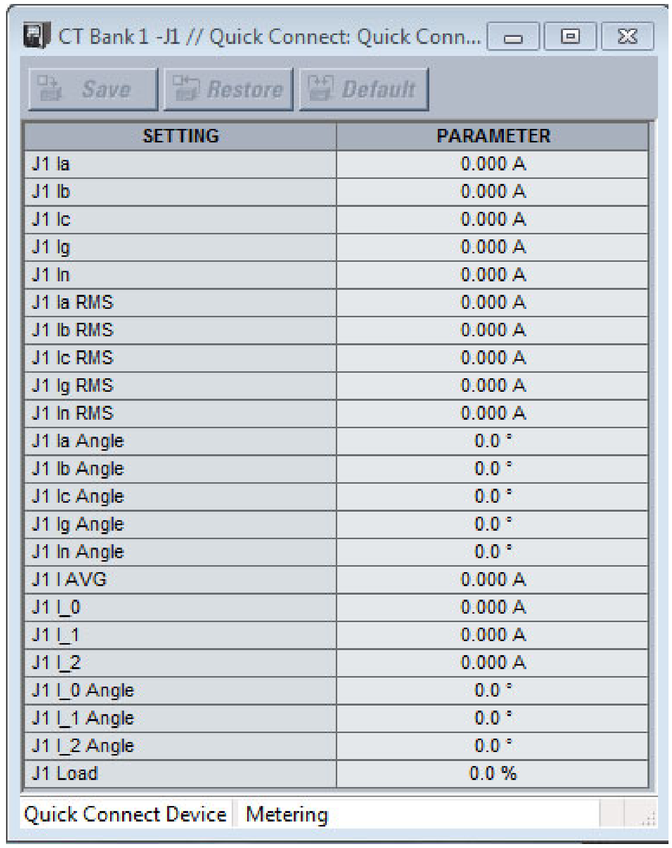


All the measured values can be viewed on the front panel display or monitored by remote devices through the communication system. An example of the HMI display showing actual currents is shown here.



The measured values can also be displayed in the PC (EnerVista 8 Series) program. The same example of actual currents displayed in the EnerVista 8 Series program is shown as follows.

Figure 11-3: Current Metering Screen (EnerVista 8 Series)



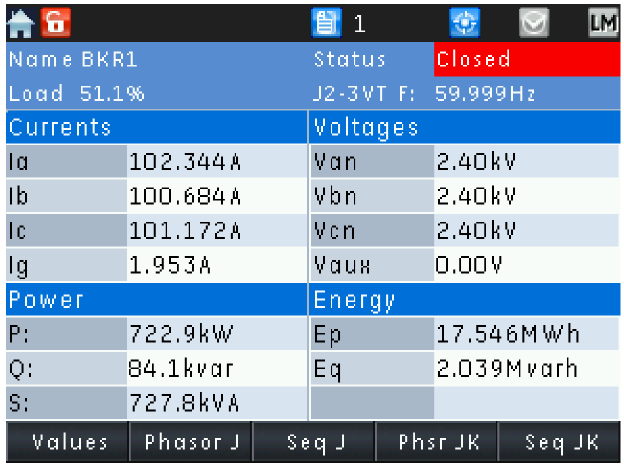
SETTING	PARAMETER
J1 Ia	0.000 A
J1 Ib	0.000 A
J1 Ic	0.000 A
J1 Ig	0.000 A
J1 In	0.000 A
J1 Ia RMS	0.000 A
J1 Ib RMS	0.000 A
J1 Ic RMS	0.000 A
J1 Ig RMS	0.000 A
J1 In RMS	0.000 A
J1 Ia Angle	0.0 °
J1 Ib Angle	0.0 °
J1 Ic Angle	0.0 °
J1 Ig Angle	0.0 °
J1 In Angle	0.0 °
J1 I AVG	0.000 A
J1 I_0	0.000 A
J1 I_1	0.000 A
J1 I_2	0.000 A
J1 I_0 Angle	0.0 °
J1 I_1 Angle	0.0 °
J1 I_2 Angle	0.0 °
J1 Load	0.0 %

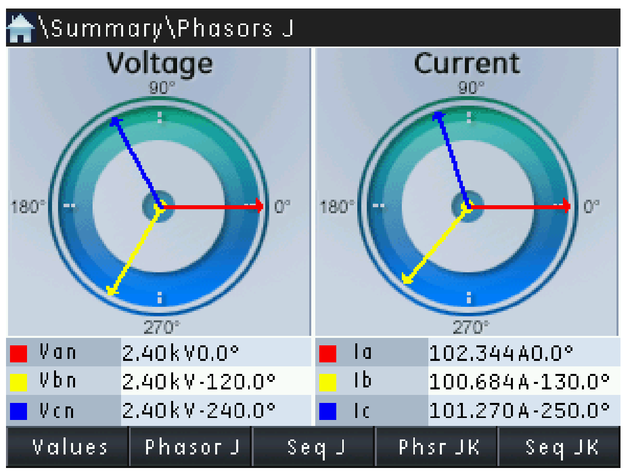
The complete list of actual values available in the Metering menu is covered in the following sections.

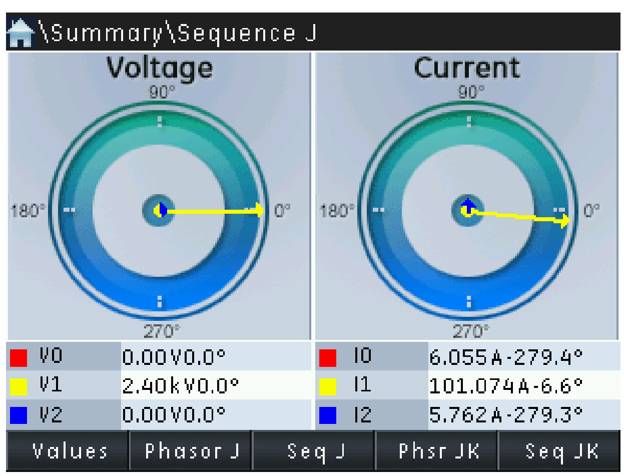
Summary

Path: Metering > Summary

The Metering Summary menu consists of display screens, including a graphical presentation of key phasor quantities.







Transformer

INTRODUCTION

The percent (biased) differential protection is the main protection for power transformers with regards to detecting all types of transformer internal fault. This protection is based on Kirchoff's law, where the sum of all currents flowing in and out of the protected equipment equals zero. However, when applying this law to the overall differential protection, one must keep in mind that the direct summation of the measured currents per-phase, does not automatically result into zero differential current. This is because:

1. The transformer voltage ratio defines different winding nominal currents
2. The winding CTs are not rated to the exact match of the winding nominal currents
3. Physically, the transformer windings are connected in Delta, Wye or Zig-Zag configuration, and they introduce a phase shift.

For the correct performance of the overall percent differential protection, it is necessary to correct the magnitude and phase relationships of the CT secondary currents for each winding, in order to obtain near zero differential currents under normal transformer operating conditions. Traditionally, the phase shift between the currents from the transformer windings has been corrected by connecting the CTs from the Wye winding in Delta connection, and the CTs from the Delta winding in Wye connection. In the past, the magnitude correction has been accomplished using interposing CTs, or tapped relay windings. This however is not required any more when installing the 845 relay.

The 845 relay simplifies the process by performing the magnitude and phase shift compensations automatically (internally). Upon entering settings for the protected transformer and winding CT ratings, the relay automatically calculates and applies the correct magnitude scaling to the winding currents as well as applying the correct phase shift in order to prepare the currents for summation. To perform the correct currents compensation, all winding CTs need to be connected in Wye (polarity markings pointing away from the transformer). When the Tap Changer detection feature is enabled on the relay, the algorithm automatically compensates the currents for the differential computation based on the new voltage ratio corresponding to the detected tap.

Percent Differential Current

Path: **Metering > Transformer > Percent Differential**

Ia Differential (Ia Diff)

Range: 0.000 to 1000.000 x CT in steps of 0.001

Ib Differential (Ib Diff)

Range: 0.000 to 1000.000 x CT in steps of 0.001

Ic Differential (Ic Diff)

Range: 0.000 to 1000.000 x CT in steps of 0.001

Ia Restraint (Ia Restr)

Range: 0.000 to 1000.000 x CT in steps of 0.001

Ib Restraint (Ib Restr)

Range: 0.000 to 1000.000 x CT in steps of 0.001

Ic Restraint (Ic Restr)

Range: 0.000 to 1000.000 x CT in steps of 0.001

Ia Differential 2nd Harmonic (Ia Diff 2nd Harm)

Range: 0.0 to 100.0% in steps of 0.1

Ib Differential 2nd Harmonic (Ib Diff 2nd Harm)
Range: 0.0 to 100.0% in steps of 0.1

Ic Differential 2nd Harmonic (Ic Diff 2nd Harm)
Range: 0.0 to 100.0% in steps of 0.1

Ia Differential 5th Harmonic (Ia Diff 5th Harm)
Range: 0.0 to 100.0% in steps of 0.1

Ib Differential 5th Harmonic (Ib Diff 5th Harm)
Range: 0.0 to 100.0% in steps of 0.1

Ic Differential 5th Harmonic (Ic Diff 5th Harm)
Range: 0.0 to 100.0% in steps of 0.1

NOTICE

The values for differential and restraint currents are displayed in per times CT. The CT primary, from the CT Bank assigned as Signal Input for Winding 1, is the reference CT (base CT) used for estimating the differential and restraint currents. The winding reference is explained in the Transformer Setup section.

The phasors of differential and restraint currents are displayed in primary amperes.

The phasors of differential and restraint currents are displayed in primary amperes.

Windings

The harmonic derating factor for each of the windings shows the effect of non-sinusoidal load currents on the power transformer's rated full load current. The actual values messages display the harmonic derating factor for windings 1 through 3.

The 845 displays winding load parameters as follows:

Path: Metering > Transformer > Windings

Winding 1 load (W1 Load (% of rated))
Range: 0.0 to 100.0 %

Winding 1 average phase current (W1 Average Ph Current)
Range: 0.000 to 120000.000 A

Winding 1 harmonic derating factor (W1 Harm Derate Factor
Range: 0.00 to 1.00

Winding 2 load (W2 Load (% of rated))
Range: 0.0 to 100.0 %

Winding 2 average phase current (W2 Average Ph Current)
Range: 0.000 to 120000.000 A

Winding 2 harmonic derating factor (W2 Harm Derate Factor)
Range: 0.00 to 1.00

Winding 3 load (W3 Load (% of rated))
Range: 0.0 to 100.0 %

Winding 3 average phase current (W3 Average Ph Current)
Range: 0.000 to 120000.000 A

Winding 3 harmonic derating factor (W3 Harm Derate Factor)
Range: 0.00 to 1.00

For a two winding transformer the winding load and winding average phase current are calculated as:

$W(1/2)\ Load\ (\%\ of\ rated) = \sqrt{3} \times I_{avg}(1/2) \times V_{rated}(1/2) \times 100\% / S_{rated}$

Where:

$I_{avg} = (I_a + I_b + I_c)/3$ is the actual average phase current (W(1/2) Average Ph Current) for the corresponding winding.

I_a , I_b , I_c are magnitudes of the corresponding actual phase currents of the winding.

V_{rated} is the rated phase to phase nameplate voltage for the corresponding winding.

S_{rated} is the rated nameplate apparent power for the transformer.

For three winding transformer the winding load and winding average phase current are calculated as:

W(1/2/3) Load (% of rated) = $\sqrt{3} \times I_{avg}(1/2/3) \times V_{rated}(1/2/3) \times 100\% / S_{Wrated}(1/2/3)$

Where:

$I_{avg} = (I_a + I_b + I_c)/3$ is the actual average phase current (W(1/2/3) Average Ph Current) for the corresponding winding.

I_a , I_b , I_c are magnitudes of the corresponding actual phase currents of the winding.

V_{rated} is the rated phase to phase nameplate voltage for the corresponding winding.

S_{rated} is the rated nameplate apparent power for the transformer.

Thermal Elements

Path: **Metering > Transformer > Thermal Elements**

The calculation of all "Thermal Elements" actual values starts at the time the relay is first powered up. Therefore, the Daily Rate Loss of Life starts accumulating in the next 24 hour period. All records can be cleared either from the relay's keypad, or from the EnerVista 8 Series Setup PC program using the Clear Loss of Life command from the menu **Records/ Clear Records**.

Tap Changer

Path: **Metering > Transformer > Tap Changer**

Tap Position

Range: -19 to 39 in steps of 1, Invalid, Not Set

Ohms In 1

Range: 0 to 5100 ohms in steps of 1

Winding Voltage

Range: 0.00 to 1200000.00 kV in steps of 0.01

Delta V Above Min Tap V

Range: 0.00 to 1200000.00 kV in steps of 0.01

"Invalid" Tap Detection

An "Invalid" tap position is displayed under one of the following conditions:

- The measured analog input value is one tap step lower than the analog value corresponding to minimum tap.
- The measured analog input value is one tap step higher than the analog value corresponding to maximum tap.
- The detected BCD combination corresponds to a tap which is either below the minimum, or above the maximum tap programmed in Tap Changer setup menu.
- Sudden change from valid BCD combination corresponding to a valid tap position to another valid BCD combination corresponding to a non-sequential tap position.

Currents

NOTE: The number of Currents supported is order code dependent.

NOTE: The CT bank names shown are set in the CT Bank Name setpoints under **Setpoints > System > Current Sensing > CT Bank X**.

Path: **Metering > CT Bank 1-J1 (CT Bank 2-K1) (CT Bank 3-K2)**

Phase A/B/C (Ia/Ib/Ic) 0.000 A
Range: 0.000 to 12000.000 A

Ground (Ig)
Range: 0.000 to 12000.000 A

Neutral (In)
Range: 0.000 to 12000.000 A

Phase A/B/C (Ia/Ib/Ic RMS)
Range: 0.000 to 12000.000 A

Ground (Ig RMS)
Range: 0.000 to 12000.000 A

Neutral (In RMS)
Range: 0.000 to 12000.000 A

Phase A/B/C Angle (Ia/Ib/Ic Angle)
Range: 0.0 to 359.9°

Ground Angle (Ig Angle)
Range: 0.0 to 359.9°

Neutral Angle (In Angle)
Range: 0.0 to 359.9°

Average (I AVG)
Range: 0.000 to 12000.000 A

Zero Sequence (I_0)
Range: 0.000 to 12000.000 A

Positive Sequence (I_1)
Range: 0.000 to 12000.000 A

Negative Sequence (I_2)
Range: 0.000 to 12000.000 A

Zero Sequence (I_0 Angle)
Range: 0.0 to 359.9°

Positive Sequence Angle (I_1 Angle)
Range: 0.0 to 359.9°

Negative Sequence Angle (I_2 Angle)
Range: 0.0 to 359.9°

Ground Differential (Igd)
Range: 0.000 to 12000.000 A

Ground Differential Angle (Igd Angle)
Range: 0.0 to 359.9°

Load (I%)

Range: 0.0 to 100.0 %

NOTE

Percent of load-to-trip is calculated from the phase with the highest current reading. This metered value is the ratio between the highest phase current injected for the current bank, and the lowest pickup setting among all Phase Timed and Instantaneous overcurrent elements. If all these elements are disabled, the value displayed is "0".

For example, if the lowest pickup is 0.5 xCT, and the highest injected phase current is 1 xCT, the displayed value for load-to-trip is 200%.

Voltages

NOTE

The number of Voltages supported is order code dependant.

NOTE

The VT bank names shown are set in the CT Bank Name setpoints under **Setpoints > System > Current Sensing > CT Bank X**.

Path: **Metering > VT Bank > Ph VT Bnk1-J2**

Phase A (Van)

Range: 0.00 to 600000.00 V

Phase B (Vbn)

Range: 0.00 to 600000.00 V

Phase C (Vcn)

Range: 0.00 to 600000.00 V

Phase to Phase AB (Vab)

Range: 0.00 to 600000.00 V

Phase to Phase BC (Vbc)

Range: 0.00 to 600000.00 V

Phase to Phase CA (Vca)

Range: 0.00 to 600000.00 V

Neutral (Vn)

Range: 0.00 to 600000.00 V

Phase A (Van RMS)

Range: 0.00 to 600000.00 V

Phase B (Vbn RMS)

Range: 0.00 to 600000.00 V

Phase C (Vcn RMS)

Range: 0.00 to 600000.00 V

Phase to Phase AB (Vab RMS)

Range: 0.00 to 600000.00 V

Phase to Phase BC (Vbc RMS)

Range: 0.00 to 600000.00 V

Phase to Phase CA (Vca RMS)

Range: 0.00 to 600000.00 V

Neutral (Vn RMS)
Range: 0.00 to 600000.00 V

Phase A Angle (Van Angle)
Range: 0.0 to 359.9°

Phase B Angle (Vbn Angle)
Range: 0.0 to 359.9°

Phase C Angle (Vcn Angle)
Range: 0.0 to 359.9°

Phase to Phase AB Angle (Vab Angle)
Range: 0.0 to 359.9°

Phase to Phase BC Angle (Vbc Angle)
Range: 0.0 to 359.9°

Phase to Phase CA Angle (Vca Angle)
Range: 0.0 to 359.9°

Neutral Angle (Vn Angle)
Range: 0.0 to 359.9°

Average Phase to Phase (V AVG L-L)
Range: 0.00 to 600000.00 V

Average Phase (V AVG L-N)
Range: 0.00 to 600000.00 V

Zero Sequence (V0)
Range: 0.00 to 600000.00 V

Positive Sequence (V1)
Range: 0.00 to 600000.00 V

Negative Sequence (V2)
Range: 0.00 to 600000.00 V

Zero Sequence Angle (V0 Angle)
Range: 0.0 to 359.9°

Positive Sequence Angle (V1 Angle)
Range: 0.0 to 359.9°

Negative Sequence Angle (V2 Angle)
Range: 0.0 to 359.9°

Path: **Metering > Aux VT Bank > Ax VT Bnk1-J2**

Auxilary Voltage (Vaux)
Range: 0.00 to 600000.00 V

Auxilary Voltage RMS (Vaux RMS)
Range: 0.00 to 600000.00 V

Auxilary Voltage Angle (Vaux Angle)
Range: 0.0 to 359.9°

Frequency

Path: Metering > Frequency 1 - J

Frequency (Current Input J1-CT)
Range: 2.000 to 90.000 Hz

Frequency Rate of Change (Current Input J1-CT)
Range: -20.00 to 20.00 Hz/s

Frequency (Phase Voltage Input J2-3VT)
Range: 2.000 to 90.000 Hz

Frequency Rate of Change (Phase Voltage Input J2-3VT)
Range: -20.00 to 20.00 Hz/s

Frequency (Auxiliary Voltage Input J2-Vx)
Range: 2.000 to 90.000 Hz

Frequency Rate of Change (Auxiliary Voltage Input J2-Vx)
Range: -20.00 to 20.00 Hz/s

Volts Per Hertz

Path: Metering > Volts per Hertz

VOLTS PER HERTZ 1 (2)
Range: 0.00 to 4.00 V/Hz in steps of 0.01
Default: 0.00 V/Hz

Harmonic Magnitude

Path: Metering > Harmonic I Magnitude

J1 Phase A 2nd Harm Mag
Range: 0.000 to 4294967.295 in steps of 0.001

J1 Phase B 2nd Harm Mag
Range: 0.000 to 4294967.295 in steps of 0.001

J1 Phase C 2nd Harm Mag
Range: 0.000 to 4294967.295 in steps of 0.001

J1 Phase A 5th Harm Mag
Range: 0.000 to 4294967.295 in steps of 0.001

J1 Phase B 5th Harm Mag
Range: 0.000 to 4294967.295 in steps of 0.001

J1 Phase C 5th Harm Mag
Range: 0.000 to 4294967.295 in steps of 0.001

K1 Phase A 2nd Harm Mag
Range: 0.000 to 4294967.295 in steps of 0.001

K1 Phase B 2nd Harm Mag
Range: 0.000 to 4294967.295 in steps of 0.001

K1 Phase C 2nd Harm Mag
Range: 0.000 to 4294967.295 in steps of 0.001

K1 Phase A 5th Harm Mag
Range: 0.000 to 4294967.295 in steps of 0.001

K1 Phase B 5th Harm Mag
Range: 0.000 to 4294967.295 in steps of 0.001

K1 Phase C 5th Harm Mag
Range: 0.000 to 4294967.295 in steps of 0.001

K2 Phase A 2nd Harm Mag
Range: 0.000 to 4294967.295 in steps of 0.001

K2 Phase B 2nd Harm Mag
Range: 0.000 to 4294967.295 in steps of 0.001

K2 Phase C 2nd Harm Mag
Range: 0.000 to 4294967.295 in steps of 0.001

K2 Phase A 5th Harm Mag
Range: 0.000 to 4294967.295 in steps of 0.001

K2 Phase B 5th Harm Mag
Range: 0.000 to 4294967.295 in steps of 0.001

K2 Phase C 5th Harm Mag
Range: 0.000 to 4294967.295 in steps of 0.001

Harmonics 1(Harmonics 4)

NOTE

The number of Harmonics supported is order code dependent.

All values relate to phase currents measured on the input cards (J1, etc.).

Path: Metering > Harmonics 1 - J1

Phase A/B/C Total Harmonic Distortion (Phase A/B/C THD)
Range: 0.0 to 100.0 %

Phase A/B/C Second Harmonic (Phase A/B/C 2)
Range: 0.0 to 100.0 %

Phase A/B/C Third Harmonic (Phase A/B/C 3)
Range: 0.0 to 100.0 %

-

-

-

Phase A/B/C Twenty Fifth Harmonic (Phase A/B/C 25)
Range: 0.0 to 100.0 %

Harmonic Detection

The second, third, fourth, and fifth harmonics per phase are shown here. The harmonics values are presented in percent relative to the fundamental magnitude.

Note that similar harmonic ratios and THD values are also displayed under the general metering menus, “Harmonics 1 - J1”, etc., where all values are calculated every three cycles. The THD values used in the Harmonic Detection element are the same for the general metering, so they are not shown here again. The harmonic ratios in the Harmonic Detection element are calculated and updated every protection pass.

Path: **Metering > Harmonic Detection**

Synchrocheck

Path: **Metering > Synchrocheck**

If a Synchrocheck function setting is "Disabled," the corresponding metering display is not displayed.

Bus Voltage Magnitude (Bus Volts Magnitude)

Range: 0.00 to 600000.00 V

Bus Voltage Angle (Bus Volts Angle)

Range: 0.0 to 359.9°

Bus Voltage Frequency (Bus Volts Frequency)

Range: 2.000 to 90.000 Hz

Line Voltage Magnitude (Line Volts Magnitude)

Range: 0.00 to 600000.00 V

Line Voltage Angle (Line Volts Angle)

Range: 0.0 to 359.9°

Line Voltage Frequency (Line Volts Frequency)

Range: 2.000 to 90.000 Hz

Voltage Difference (Volts Difference)

Range: 0.00 to 600000.00 V

Voltage Angle Difference (Angle Difference)

Range: 0.0 to 359.9°

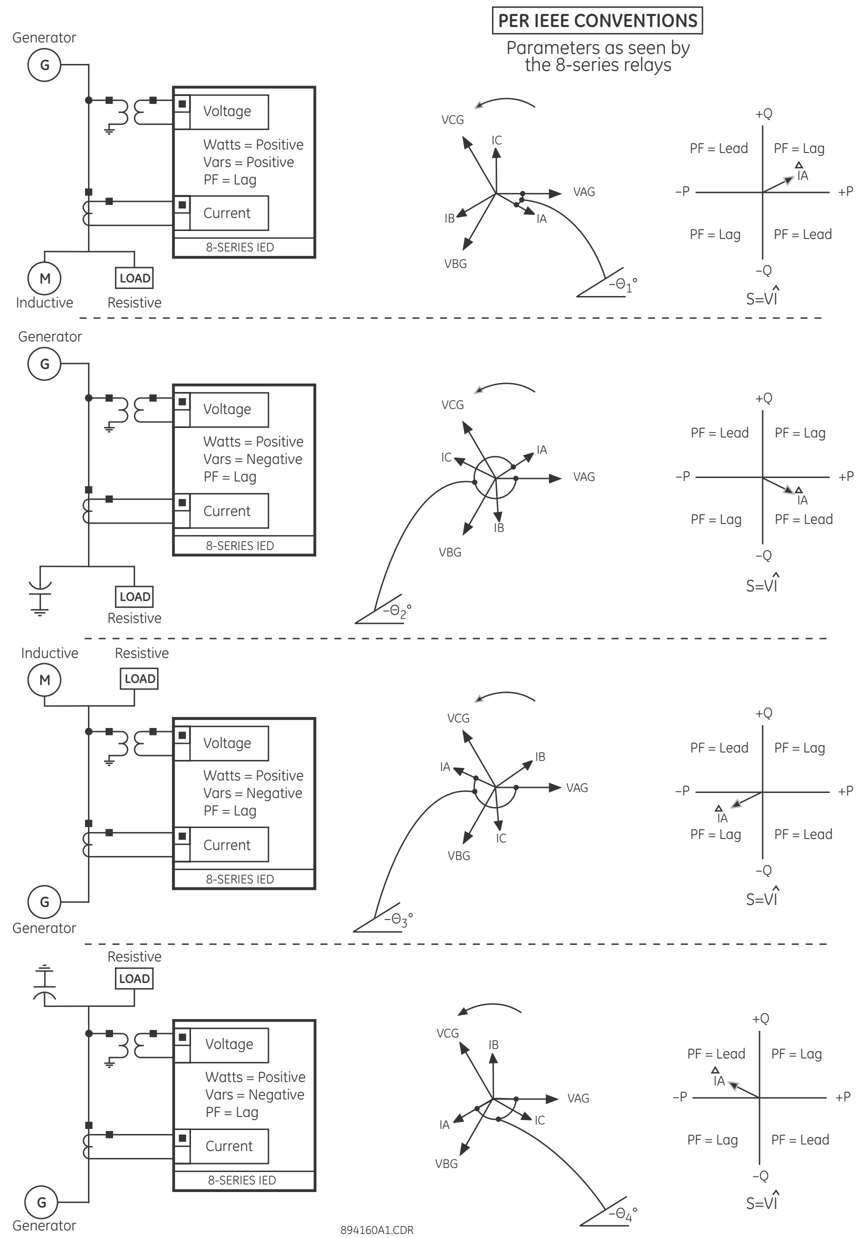
Voltage Frequency Difference (Frequency Difference)

Range: 2.000 to 90.000 Hz

Power

The following figure illustrates the convention used for measuring power and energy in the 8 Series devices.

Figure 11-4: Flow direction of signed values for watts and VARs



Path: Metering > Power 1(X)

Real Total (Real)

Range: - 214748364.8 kW to 214748364.7 kW

Reactive Total (Reactive)

Range: - 214748364.8 kvar to 214748364.7 kvar

Apparent Total (Apparent)
Range: 0 kVA to 214748364.7 kVA

Phase A Real (Ph A Real)
Range: - 214748364.8 kW to 214748364.7 kW

Phase B Real (Ph B Real)
Range: - 214748364.8 kW to 214748364.7 kW

Phase C Real (Ph C Real)
Range: - 214748364.8 kW to 214748364.7 kW

Phase A Reactive (Ph A Reactive)
Range: - 214748364.8 kvar to 214748364.7 kvar

Phase B Reactive (Ph B Reactive)
Range: - 214748364.8 kvar to 214748364.7 kvar

Phase C Reactive (Ph C Reactive)
Range: - 214748364.8 kvar to 214748364.7 kvar

Phase A Apparent (Ph A Apparent)
Range: 0 kVA to 214748364.7 kVA

Phase B Apparent (Ph B Apparent)
Range: 0 kVA to 214748364.7 kVA

Phase C Apparent (Ph C Apparent)
Range: 0 kVA to 214748364.7 kVA

Power Factor Total (PF)
Range: 0.01 Lag to 1.00 to 0.01 Lead

Phase A Power Factor (Ph A PF)
Range: 0.01 Lag to 1.00 to 0.01 Lead

Phase B Power Factor (Ph B PF)
Range: 0.01 Lag to 1.00 to 0.01 Lead

Phase C Power Factor (Ph C PF)
Range: 0.01 Lag to 1.00 to 0.01 Lead

Energy

Energy (X)

Path: Metering > Energy > Energy 1(X)

Reset Energy D/T
Range: MM/DD/YY HH:MM:SS

Positive Watt Hours (Pos WattHours)
Range: 0.000 MWh to 4294967.295 MWh

Negative Watt Hours (Neg WattHours)
Range: 0.000 MWh to 4294967.295 MWh

Positive Var Hours (Pos VarHours)
Range: 0.000 Mvarh to 4294967.295 Mvarh

Negative Var Hours (Neg VarHours)
Range: 0.000 Mvarh to 4294967.295 Mvarh

Energy Log

Path: Metering > Energy 1 > Energy Log

Pwr1 Last Event Pos WattHours
Range: 0.000 to 4294967.295 MWh in steps of 0.001 MWh
Default: 0.000 MWh

This is the logged value of Pos WattHours energy accumulated during the last event or shift interval. The shift interval refers to the time between the last two reset commands, where the reset command refers to the rising edge of the FlexLogic operand set under setpoint Reset Event Energy (**Path:** Power Systems > Power Sensing). An application example is the monitoring of the total energy accumulated at the end of an event or a shift interval. An event/shift interval can be defined by the breaker status operand (open or closed).

Pwr1 Last Event Neg WattHours
Range: 0.000 to 4294967.295 MWh in steps of 0.001 MWh
Default: 0.000 MWh

This value shows the logged value of Neg WattHours energy accumulated during the last event or shift interval.

Pwr1 Last Event Pos VarHours
Range: 0.000 to 4294967.295 Mvarh in steps of 0.001 Mvarh
Default: 0.000 Mvarh

This value shows the logged value of Pos VarHours energy accumulated during the last event or shift interval.

Pwr1 Last Event Neg VarHours
Range: 0.000 to 4294967.295 Mvarh in steps of 0.001 Mvarh
Default: 0.000 Mvarh

This value shows the logged value of Neg VarHours energy accumulated during the last event or shift interval.

Pwr1 Today Pos WattHours

Range: 0.000 to 4294967.295 MWh in steps of 0.001 MWh

Default: 0.000 MWh

This value shows the current value of Pos WattHours energy accumulated since the start of the day, that is time 00:00 (midnight). At the end of the day this value resets to zero and the total accumulated energy value is logged as Yesterday Pos WattHours.

Pwr1 Today Neg WattHours

Range: 0.000 to 4294967.295 MWh in steps of 0.001 MWh

Default: 0.000 MWh

This value shows the current value of Neg WattHours energy accumulated since the start of the day.

Pwr1 Today Pos VarHours

Range: 0.000 to 4294967.295 Mvarh in steps of 0.001 Mvarh

Default: 0.000 Mvarh

This value shows the current value of Pos VarHours energy accumulated since the start of the day.

Pwr1 Today Neg VarHours

Range: 0.000 to 4294967.295 MWh in steps of 0.001 MWh

Default: 0.000 MWh

This value shows the current value of Neg VarHours energy accumulated since the start of the day.

Pwr1 Yesterday Pos WattHours

Range: 0.000 to 4294967.295 MWh in steps of 0.001 MWh

Default: 0.000 MWh

This value shows the current value of Pos WattHours energy accumulated during the previous day. This value is logged at the end of the day, midnight, or 23:59 hrs.

Pwr1 Yesterday Neg WattHours

Range: 0.000 to 4294967.295 MWh in steps of 0.001 MWh

Default: 0.000 MWh

This value shows the current value of Neg WattHours energy accumulated during the previous day.

Pwr1 Yesterday Pos VarHours

Range: 0.000 to 4294967.295 Mvarh in steps of 0.001 Mvarh

Default: 0.000 Mvarh

This value shows the current value of Pos VarHours energy accumulated during the previous day.

Pwr1 Yesterday Neg VarHours

Range: 0.000 to 4294967.295 MWh in steps of 0.001 MWh

Default: 0.000 MWh

This value shows the current value of Neg VarHours energy accumulated during the previous day.

NOTE

All Energy Log values can be reset to zero using the command Energy Log Data under **Records > Clear Records** or by the Flexlogic operand programmed by the setpoint Energy Log Data under **Device > Clear Records**. The Reset Energy Log D/T in either case is recorded and displayed.

Power Factor

The power factor value input to the power factor element(s) is displayed here. Note that the value may not be equal to the power factor value displayed under Metering > Power 1 since the supervision conditions are applied in the element.

Path: Metering > Power Factor

POWER FACTOR 1(X)

Range: -0.99 to 1.00 in steps of 0.01
Default: 0.00

Current Demand

NOTE

The number of Current Demand supported is Order Code dependent.

The relay measures Current Demand on each phase, and three phase Demand for real, reactive, and apparent power. These parameters can be monitored to reduce supplier Demand penalties or for statistical metering purposes. Demand calculations are based on the measurement type selected under **Monitoring > Functions > Demand**. For each quantity, the relay displays the Demand over the most recent Demand time interval, the maximum Demand since the last maximum Demand reset, and the time and date stamp of this maximum Demand value. Maximum Demand quantities can be reset to zero at **Records > Clear Records > Max Current Demand**.

Path: Metering > Current Demand 1(X)

Cur1 Reset Demand D/T MM/DD/YY 00:00:00

Cur1 Ph A/B/C Demand

Range: 0.000 to 12000.000 A

Cur1 Max Ph A/B/C Demand

Range: 0.000 to 12000.000 A

Cur1 D/T Ph A/B/C Demand MM/DD/YY HH:MM:SS

Current Demand K1

Path: Metering > Current Demand K1

Reset (K1 Reset Demand Date/Time) MM/DD/YY 00:00:00

Phase A Demand (K1 Ph A Demand)

Range: 0.000 to 12000.000 A

Phase B Demand (K1 Ph B Demand)

Range: 0.000 to 12000.000 A

Phase C Demand (K1 Ph C Demand)

Range: 0.000 to 12000.000 A

Maximum Phase A Demand (K1 Max Ph A Demand)
Range: 0.000 to 12000.000 A

Maximum Phase B Demand (K1 Max Ph B Demand)
Range: 0.000 to 12000.000 A

Maximum Phase C Demand (K1 Max Ph C Demand)
Range: 0.000 to 12000.000 A

Date/Time Phase A Demand (K1 Date/Time Ph A Demand) MM/DD/YY HH:MM:SS

Date/Time Phase B Demand (K1 Date/Time Ph B Demand) MM/DD/YY HH:MM:SS

Date/Time Phase C Demand (K1 Date/Time Ph C Demand) MM/DD/YY HH:MM:SS

Current Demand K2

Path: Metering > Current Demand K2

Reset (K2 Reset Demand Date/Time) MM/DD/YY 00:00:00

Phase A Demand (K2 Ph A Demand)
Range: 0.000 to 12000.000 A

Phase B Demand (K2 Ph B Demand)
Range: 0.000 to 12000.000 A

Phase C Demand (K2 Ph C Demand)
Range: 0.000 to 12000.000 A

Maximum Phase A Demand (K2 Max Ph A Demand)
Range: 0.000 to 12000.000 A

Maximum Phase B Demand (K2 Max Ph B Demand)
Range: 0.000 to 12000.000 A

Maximum Phase C Demand (K2 Max Ph C Demand)
Range: 0.000 to 12000.000 A

Date/Time Phase A Demand (K2 Date/Time Ph A Demand) MM/DD/YY HH:MM:SS

Date/Time Phase B Demand (K2 Date/Time Ph B Demand) MM/DD/YY HH:MM:SS

Date/Time Phase C Demand (K2 Date/Time Ph C Demand) MM/DD/YY HH:MM:SS

Directional Power

Path: Metering > Directional Power

The effective operating quantities of the sensitive directional power elements are displayed here. The display may be useful to calibrate the feature by compensating the angular errors of the CTs and VTs with the use of the RCA and CALIBRATION settings.

Directional Power 1

Range: -214748364.8 kW to 214748364.7 kW

Default: 0.0 kW

...

Directional Power X

Range: -214748364.8 kW to 214748364.7 kW

Default: 0.0 kW

Arc Flash

Path: Metering > Arc Flash > Arc Flash 1

HS Phase Current A/B/C

Range: 0.00 to 120000.00 A in steps of 0.01

HS Ground Current

Range: 0.00 to 120000.00 A in steps of 0.01

Sensor 1(X) Light Level

Range: 0.00 to 300000.0 Lu in steps of 0.1

Sensor 1(X) Max Light Level

Range: 0.00 to 300000.0 Lu in steps of 0.1

RTDs

Path: Metering > RTDs

NOTE

The Temperature can be displayed in Celsius or Fahrenheit. The selection is made in **Setpoints > Device > Installation > Temperature Display**.

RTD 1(13)

Range: -40 to 250°C (-40 to 482°F)

Temperatures < -40°C are displayed as “Shorted” and temperatures > 250°C are displayed as “Open RTD”.

RRTDs

Path: Metering > RRTDs

NOTE

The Temperature can be displayed in Celsius or Fahrenheit. The selection is made in **Setpoints > Device > Installation > Temperature Display**.

RRTD 1(12) 40°C

Range: -40 to 250°C (temperatures < -40°C or temperatures >250°C are displayed as "Trouble RRTD")

RTD Maximums

Path: Metering > RTD Maximums

NOTE

The Temperature can be displayed in Celsius or Fahrenheit. The selection is made in **Setpoints > Device > Installation > Temperature Display**.

Reset RTD Date/Time

Range: DD/MM/YY hh/mm/ss

NOTE

Maximum RTD values can be cleared (reset) by setting the value of Setpoints > Records > Clear Records > RTD Maximums to "ON". Executing this command loads -40°C (or -40°F) as the initial Maximum RTD value.

RTD 1(13) Max

Range: -40 to 250°C (-40 to 482°F)

Temperatures < -40°C are displayed as "Shorted" and temperatures > 250°C are displayed as "Open RTD".

RTD 1(13) Max Date/Time

Range: DD/MM/YY hh/mm/ss

RRTD Maximums

Path: Metering > RRTD Maximums

NOTE

The Temperature can be displayed in Celsius or Fahrenheit. The selection is made in **Setpoints > Device > Installation > Temperature Display**.

Reset RRTD Date/Time

Range: DD/MM/YY hh/mm/ss

NOTE

Maximum RRTD values can be cleared (reset) by setting the value of **Setpoints > Records > Clear Records > RRTD Maximums** to “ON”. Executing this command loads -40°C (or -40°F) as the initial Maximum RRTD value.

RRTD 1(12) Max

Range: -40 to 250°C (-40 to 482°F)

Temperatures < -40°C are displayed as “Shorted” and temperatures > 250°C are displayed as “Open RRTD”.

RRTD 1(12) Max Date/Time

Range: DD/MM/YY hh/mm/ss

Analog Inputs

Path: Metering > Analog Inputs

Analog Ip 1 (4)

Range: -500000 to 500000 units in steps of 1

FlexElements

Path: Metering > FlexElements

The operating signals for the FlexElements are displayed in pu values using the definitions of the base units in the *Definitions of the Base Unit for the FLEXELEMENT* table. This table is in the Setpoints>FlexLogic>FlexElements section.

FlexElement Operating Signals:

FlexEl 1 Op Signal
FlexEl 2 Op Signal
FlexEl 3 Op Signal
FlexEl 4 Op Signal
FlexEl 5 Op Signal
FlexEl 6 Op Signal
FlexEl 7 Op Signal
FlexEl 8 Op Signal

845 Transformer Protection System

Chapter 12: Records

Events

The 845 has an event recorder which runs continuously. All event records are stored in flash memory such that information is permanently retained. The events are displayed from newest to oldest event. Each event has a header message containing a summary of the event that occurred, and is assigned an event number equal to the number of events that have occurred since the recorder was cleared. The event number is incremented for each new event.

The Event Recorder captures contextual data associated with the last 1024 events listed in chronological order from most recent to oldest. Events for a particular element are captured, if the setpoint "Events" from its menu is selected to **Enabled**. By default, the Events setpoint from all elements is set to Enabled.

Path: **Records > Event Records**

The events are cleared by pressing the pushbutton corresponding to the tab CLEAR, or when issuing clear event records command from the general clear records menu.

Event Viewer

The Event Viewer within the EnerVista 8 Series Setup software provides a consolidated view of up to 1024 events from a single 8 Series device or up to as many as ten connected 8 Series devices or event files (10 x 1024 events in total).

To open the Event Viewer for a connected device, follow these steps in the EnerVista 8 Series Setup software:

1. Establish communications with the relay.
2. Select the **Setpoints > Records > Events** menu item.

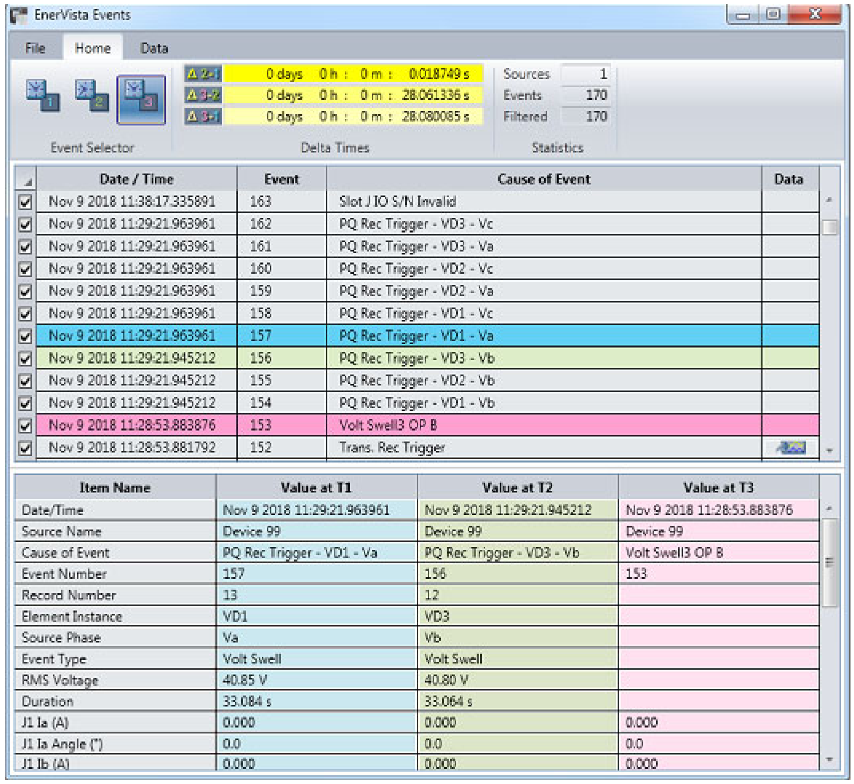
   A small Events window opens displaying the following:

   – Date/Time of Last Clear

   – Events Since Last Clear

   – Date/Time of Last Retrieval

In addition, the Event Viewer launches for a detailed view of up to 1024 of the most recent events.



The Event Viewer window runs as a separate application, and can be moved outside of the main EnerVista 8 Series Setup window and resized as needed.

If the EnerVista 8 Series Setup software is closed, the Event Viewer remains open but offline (no further events are received from running devices, however event data is still available).

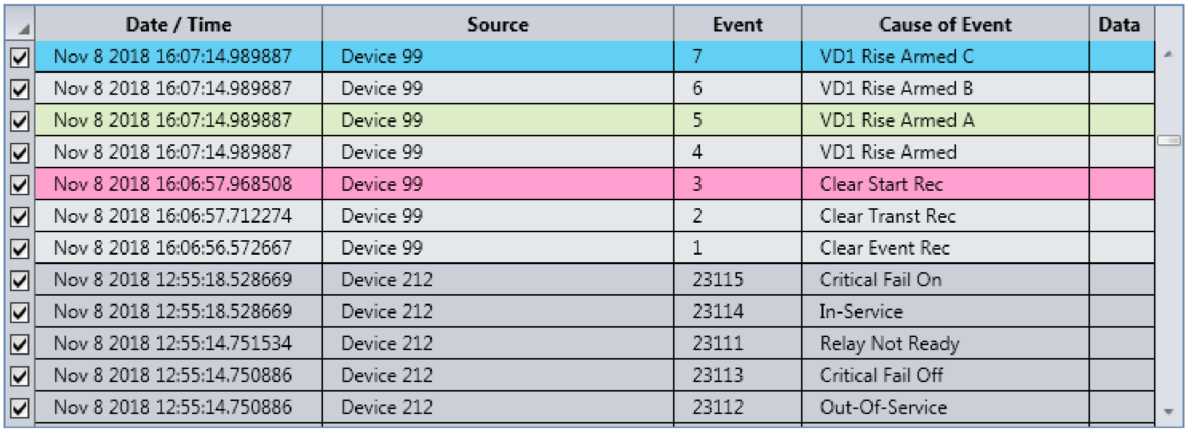
The Event List includes all events in descending chronological order. For multiple sources, a Source column showing the device name or file name is shown between the Date/Time and the Event columns.

To add an additional connected 8 Series relay to the open Event Viewer, follow these steps in the EnerVista 8 Series Setup software:

1. Establish communications with the relay.
2. Select the **Setpoints > Records > Events** menu item.

   The Event Viewer adds up to 1024 of the most recent events to the open window, labelled with the new device name in the Source column.

The Event column is only shown when **Show Event Numbers** is selected on the **Data** tab.



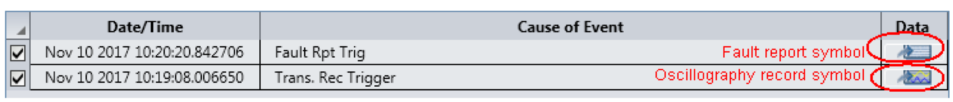
Date / Time	Source	Event	Cause of Event	Data
Nov 8 2018 16:07:14.989887	Device 99	7	VD1 Rise Armed C	
Nov 8 2018 16:07:14.989887	Device 99	6	VD1 Rise Armed B	
Nov 8 2018 16:07:14.989887	Device 99	5	VD1 Rise Armed A	
Nov 8 2018 16:07:14.989887	Device 99	4	VD1 Rise Armed	
Nov 8 2018 16:06:57.968508	Device 99	3	Clear Start Rec	
Nov 8 2018 16:06:57.712274	Device 99	2	Clear Transt Rec	
Nov 8 2018 16:06:56.572667	Device 99	1	Clear Event Rec	
Nov 8 2018 12:55:18.528669	Device 212	23115	Critical Fail On	
Nov 8 2018 12:55:18.528669	Device 212	23114	In-Service	
Nov 8 2018 12:55:14.751534	Device 212	23111	Relay Not Ready	
Nov 8 2018 12:55:14.750886	Device 212	23113	Critical Fail Off	
Nov 8 2018 12:55:14.750886	Device 212	23112	Out-Of-Service	

On the left side of the Event List a checkbox column with a toggle button at the top allows selection of specific events. Only the selected events are saved or copied by the **Save to File** and **Copy to Clipboard** options in the **File** tab.

Use the following keys to navigate quickly through the Event List:

- 'End' scrolls to the bottom of the Event List
- 'Home' scrolls to the top of the Event List
- 'Page Down' scrolls one page down in the Event List
- 'Page Up' scrolls one page up in the Event List

When the Event Viewer and the EnerVista 8 Series Setup software are both open, new events from connected devices are added to the Event Viewer as they occur and oscillography and fault report records are gradually retrieved from the device, in order of oldest to newest (assuming oscillography records and fault report records are saved in a common location).



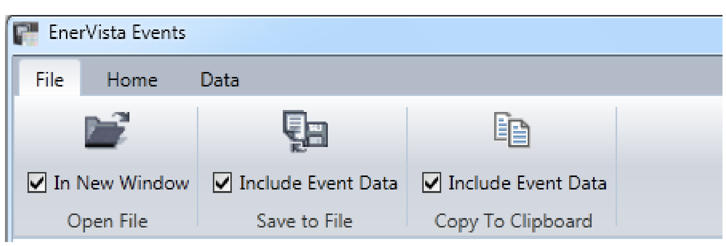
Date/Time	Cause of Event	Data
Nov 10 2017 10:20:20.842706	Fault Rpt Trig	
Nov 10 2017 10:19:08.006650	Trans. Rec Trigger	

Oscillography record events (such as 'Trans. Rec Trigger' shown above) have a symbol in the Data column that includes a link to launch the oscillography record in the EnerVista 8 Series Setup software.

Fault report events (such as 'Fault Rpt Trig' shown above) can be opened in the same manner by clicking the fault report symbol in the Data column.

FILE TAB

Use the **File** tab to open event files in the Event Viewer, save events to a file, or copy events to the clipboard.



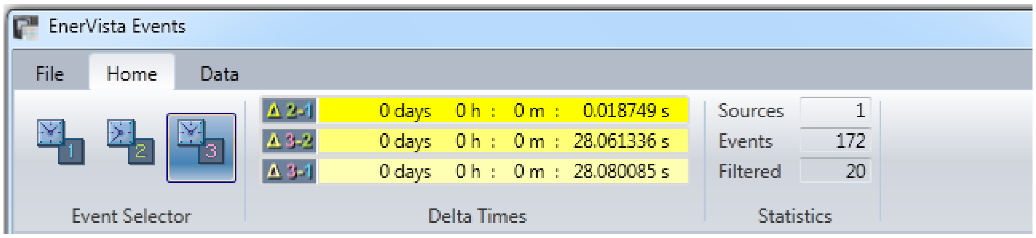
- **Open File**: opens a window to browse to an events file (of type .eev, .txt. or .evt) and opens it in the existing Event Viewer window, or in a new Event Viewer window.
  - Check **In New Window** to open the file in a new Event Viewer window.
- **Save to File**: saves the selected events to a file. Hidden (filtered) events are not saved.

  - Select the events to save using the checkboxes on the left of the events list.
  - Check **Include Event Data** to save full details of each event instead of just a summary.
- **Copy to Clipboard**: copies the selected events to the clipboard. Hidden (filtered) events are not copied.
  - Select the events to copy using the checkboxes on the left of the events list.
  - Check **Include Event Data** to copy full details of each event instead of just a summary.

HOME TAB

Use the **Home** tab to select the events shown in the detailed view, measure time between events, and view the current Event Viewer statistics.

By default, the Event Viewer opens displaying the **Home** tab with the last three events selected. Details of these three events are displayed in the lower pane of the Event Viewer window.



To select up to three events from the list displayed in the Event Viewer, follow these steps:

1. From the **Home** tab, choose which event to set by clicking button 1, 2, or 3 above the **Event Selector** label.
2. Click an event from the list of displayed events.

   The event changes color to match the selected button (blue for 1, green for 2, or red for 3) and the event details display in the lower pane, highlighted in the same color.

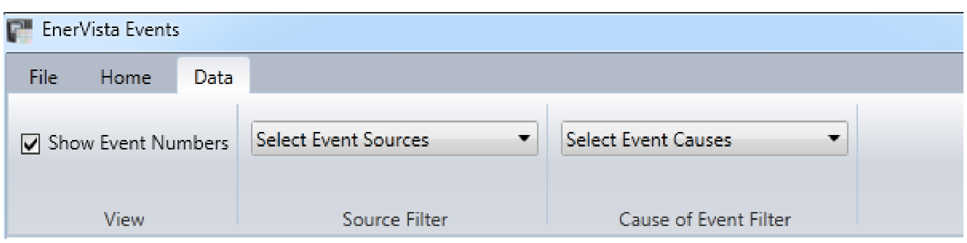
The absolute times between the three selected events are displayed above the **Delta Times** label.

The **Statistics** area in the **Home** tab includes the following information:

- **Sources:** the number of event sources (devices and files) currently available.
- **Events**: the number of events being managed by the Event Viewer.
- **Filtered**: the number of events shown after any active filters are applied. (Filters are applied in the **Data** tab).

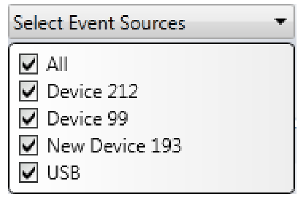
DATA TAB

Use the **Data** tab to filter the events shown in the Event Viewer.



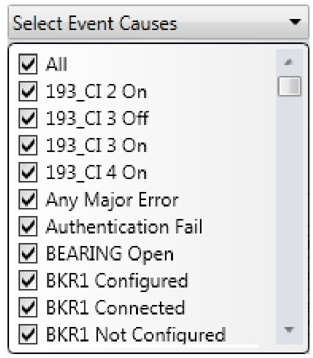
- **Show Event Numbers**: toggles on and off the event number column in the list of events. The event number can be useful for reconciling events between the Eevnt Viewer and local HMI of an 845 device.
- **Select Event Sources**: provides a drop-down list of all available event sources (devices and files). Uncheck a device or file to hide the associated events from the main list.

By default events from all sources are shown.



- **Cause of Event Filter**: provides an alphabetized list of all event names, allowing different event types to be shown or hidden.

  By default all events are shown.



Transient Records

Path: Records > Transients > Transient Records

Using the EnerVista 8 Series Setup select a record and then click the “Launch Viewer” button to view the waveform.

Fault Reports

The latest fault reports can be displayed.

Path: Records > Fault Reports

NUMBER OF REPORTS

This value shows the number of reports since the last clear.

LAST TRIP DATE/TIME

Range: MM/DD/YY/ HH:MM:SS

This value is the date and time on which the last report was generated.

LAST CLEAR DATE/TIME

Range: MM/DD/YY/ HH:MM:SS

This value is the date and time on which the record was cleared.

FAULT REPORT X TIME

Range: MM/DD/YY/ HH:MM:SS

This value is the date and time on which the specified fault report was generated.

Data Logger

The 845 Data Logger record can be retrieved and seen from this window. It displays the oldest and newest timestamps, and the total number of samples captured for all channels programmed in **Setpoints > Device > Data Logger** menu.

Path: **Records > Data Logger**

Breakers Records

Breaker Arcing Current

Path: **Records > Breakers Records > Breaker 1**

ARCING CURRENT PHASE A

Range: 00.00 TO 42949672.95 kA2-cyc in steps of 0.01

ARCING CURRENT PHASE B

Range: 00.00 TO 42949672.95 kA2-cyc in steps of 0.01

ARCING CURRENT PHASE C

Range: 00.00 TO 42949672.95 Ka2-cyc in steps of 0.01

TOTAL ARCING CURRENT

Range: 00.00 TO 42949672.95 Ka2-cyc in steps of 0.01

Breaker Health

The menu displays the breaker monitoring values. The latest value, average of last five values and average of values since last reset are recorded, calculated and displayed.

When the DETECTION mode is selected, the values displayed here can be used as the reference for user settings. The values are saved into non-volatile memory to avoid the loss of data during the power down period.

Path: **Records > Breakers Records > Breaker Health**

TOTAL BREAKER TRIPS

Range: 0 to 10000 in steps of 1

TRIPS SINCE LAST RESET

Range: 0 to 10000 in steps of 1

ALARM COUNTER

Range: 0 to 100 in steps of 1

LAST TRIP TIME

Range: 0 TO 4294967295 ms in steps 1

AVG. OF 5 TRIP TIME

Range: 0 TO 4294967295 ms in steps 1

AVG. OF TRIP TIME

Range: 0 TO 4294967295 ms in steps 1

LAST CLOSE TIME

Range: 0 TO 4294967295 ms in steps 1

AVG. OF 5 CLOSE TIME
Range: 0 TO 4294967295 ms in steps 1

AVG. OF CLOSE TIME
Range: 0 TO 4294967295 ms in steps 1

LAST PH A/B/C ARC TIME
Range: 00.00 TO 42949672.95 Ka2-cyc in steps of 0.01

AVG. OF 5 PH A/B/C ARC TIME
Range: 0 TO 4294967295 ms in steps 1

AVG. OF PH A/B/C ARC TIME
Range: 0 TO 4294967295 ms in steps 1

LAST SPRING CHARGE TIME
Range: 0.000 to 6000.000 s in steps of 0.001

AVG. OF 5 CHARGE TIME
Range: 0.000 to 6000.000 s in steps of 0.001

AVG. OF CHARGE TIME
Range: 0.000 to 6000.000 s in steps of 0.001

LAST PH A/B/C ARC ENERGY
Range: 00.00 TO 42949672.95 Ka2-cyc in steps of 0.01

AVG. OF 5 PH A/B/C ARCENER
Range: 00.00 TO 42949672.95 Ka2-cyc in steps of 0.01

AVG. OF PH A/B/C ARC ENERGY
Range: 00.00 TO 42949672.95 Ka2-cyc in steps of 0.01

Digital Counters

The present status of the sixteen Digital Counters is shown here. The status of each Counter, with the user-defined Counter name, includes the accumulated and frozen counts (the count units label also appears). Also included, is the date and time stamp for the frozen count. The Counter microseconds frozen value refers to the microsecond portion of the time stamp.

Path: **Records > Digital Counter 1 (16)**

COUNTER X ACCUMULATED
Range: -2147483648 to 2147483647 in steps of 1

COUNTER X FROZEN
Range: -2147483648 to 2147483647 in steps of 1

DATE/TIME FROZEN
Default: 01/01/70 00:00:00
Range: Date/Time Format (MM/DD/YY HH:MM:SS)

COUNTER X us FROZEN
Range: 0 to 999999 µs in steps of 1

Remote Modbus Device

Up to 64 FlexAnalog operands and 32 FlexLogic operands are supported in the configurable Remote Modbus Device. Profiles are configured under **Device > Communications > Remote Modbus Device > Device 1**, with details provided in Chapter 5. Up to 10 format codes enumerations (by default GMD_FC1 to GMD_FC10) can be defined separately for each Modbus Device Profile. For the default BSG3 device profile, 27 analogs and 27 digital operands are pre-configured in the default CID settings file.

All parameters are polled consecutively. Each FlexLogic value can be read from a different Modbus address and bit mask which is then mapped into any of the available 64 bit locations.

Path: **Records > Remote Modbus Device > Device 1 > Status**

DEVICE STATUS

Range: Offline, Online

Default: Offline

Device Status is set to 'High' when the last communication attempt has failed. The operand is set to 'Low' following a successful communication attempt.

LAST SUCCESSFUL POLL

Range: MM/DD/YYYY HH:MM:SS

Default: 01/01/2000 00:00

This is a timestamp value for the last successful read. The Last Successful Poll is updated if the update of all pooled data is successful.

Path: **Records > Remote Modbus Device > Device 1 > Digital States**

FLEXLOGIC OPERANDS 1-32

Range: Defined by Remote Modbus Device Profile

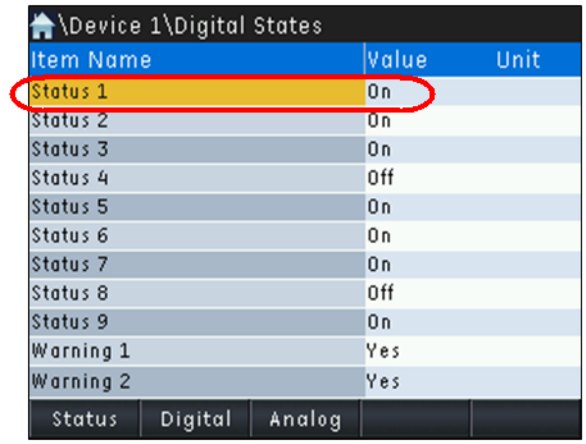
Default: Off

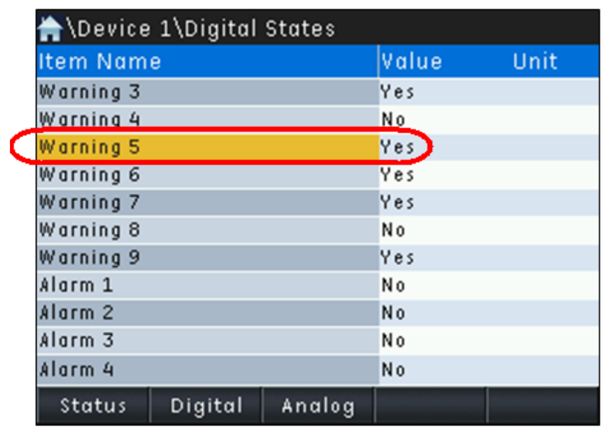
Up to 32 FlexLogic operands can be shown here.

The displayed text (see 'Item Name' field in EnerVista 8 Series Setup software) is the FlexLogic name defined in the Remote Modbus Device Editor 'Label' field for each Digital Point in the current profile. See **Device > Communications > Remote Modbus Device > Device 1**.

The value displayed is based on the Enumeration field defined in the Remote Modbus Device Editor for each specific digital point.

Figure 12-1: Example of Digital States for the default BSG3 RMD profile





Path: Records > Remote Modbus Device > Device 1 > Analog Values

RMD-FLEXANALOG 1-64

Range: -2147483648 to 2147483647 in steps of 1

Default: 0

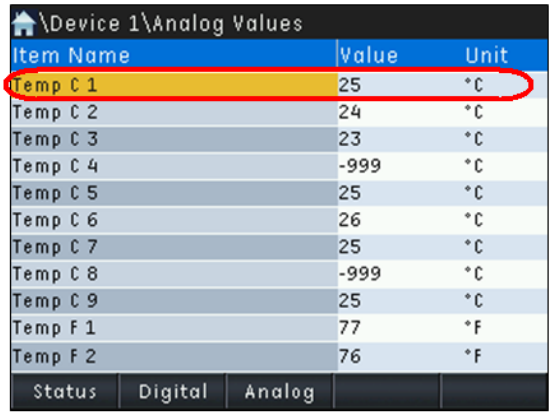
Up to 64 FlexAnalog operands can be shown here.

The value displayed is based on the Enumeration field defined in the Remote Modbus Device Editor for each specific digital point.

The displayed text (see 'Item Name' field in EnerVista 8 Series Setup software) is the FlexAnalog name defined in the Remote Modbus Device Editor 'Label' fieldfor each Analog Point in the current profile. See Device > Communications > Remote Modbus Device > Device 1.

The value displayed is based on the Data Type, Multiplier, Decimals, and Units fields defined in the Remote Modbus Device Setpoint for each specific analog point.

Figure 12-2: Example for Analog Values of the default BSG3 RMD profile



Clear Records

The Clear Records command is accessible from the front panel and from the EnerVista 8 Series Setup software.

Path: Records > Clear Records

Records can be cleared by assigning “On” to the appropriate setting.

NOTICE

The Clear Records command is also available from Device > Clear Records, where the allowable settings also include FlexLogic operands.

845 Transformer Protection System

Chapter 13: Maintenance

The following maintenance options are available through the EnerVista 8 Series Setup software.

Path: **Maintenance > Modbus Analyzer**

The Modbus Analyzer is used to access data via the Modbus User map for testing, troubleshooting and maintaining connected devices. See the 8 Series Protective Relay Communications Guide for modbus memory map details.

Path: **Maintenance > Update Firmware**

Selecting Update Firmware loads new firmware into the flash memory. See Loading New Relay Firmware in Chapter 3, Interfaces > Software Interface > Upgrading Relay Firmware.

Path: **Maintenance > Environmental Awareness Health Report**

Over the life of the 845 product remedial action can be required. The 845 has a module which can record environmental data.

Environmental Health Report

Prolonged exposure to harsh environments and transient conditions that exceed those stated in Section 1 - Specifications reduce the life of electronic products. The 845 has an Environmental Awareness Module (EAM) to record environmental data over the life of the product. The patented module measures temperature, humidity, surge pulses and accumulates the events every hour in pre-determined threshold buckets over a period of 15 years. Retrieve this data in the form of a histogram using EnerVista Setup Software to ensure any change in the operating condition of the installed fleet is identified quickly so remedial action can be taken.

Figure 13-1: Environmental Report

ENVIRONMENTAL HEALTH REPORT

PRODUCT INFORMATION

Device Summary	
Device Name	Quick Connect Device
Device Type	845 Transformer Protection System
Order Code	845-EP1H1G1HNNAANGMSBC2ESWBN
Firmware Version	1.40
Serial Number	MJ1T13000155

Generated At:	May 14, 2015 03:15 PM

DEVICE ENVIRONMENT STATISTICS

Summary	
Time In Service	22 Days 8 Hrs 53 Mins 6 Secs
Time Since Last Power cycle	0 Days 1 Hrs 46 Mins 26 Secs
Minimum Ambient Temperature	25.71°C
Maximum Ambient Temperature	42.61°C
Average Ambient Temperature	37.82°C

Summary	
Minimum Humidity	13.14%
Maximum Humidity	30.45%
Average Humidity	13.14%

General Maintenance

The 845 requires minimal maintenance. As a microprocessor-based relay, its characteristics do not change over time. The expected service life of a 845 is 20 years when the environment and electrical conditions are within stated specifications.

While the 845 performs continual self-tests, it is recommended that maintenance be scheduled with other system maintenance. This maintenance can involve in-service, out-of-service, or unscheduled maintenance.

In-service Maintenance

1. Visual verification of the analog values integrity, such as voltage and current (in comparison to other devices on the corresponding system).
2. Visual verification of active alarms, relay display messages, and LED indications.
3. Visual inspection for any damage, corrosion, dust, or loose wires.
4. Event recorder file download with further events analysis.

Out-of-service Maintenance

1. Check wiring connections for firmness.
2. Analog values (currents, voltages, RTDs, analog inputs) injection test and metering accuracy verification. Calibrated test equipment is required.
3. Protection elements setting verification (analog values injection or visual verification of setting file entries against relay settings schedule).
4. Contact inputs and outputs verification. This test can be conducted by direct change of state forcing or as part of the system functional testing.
5. Visual inspection for any damage, corrosion, or dust.
6. Event recorder file download with further events analysis.

Unscheduled Maintenance (System Interruption)

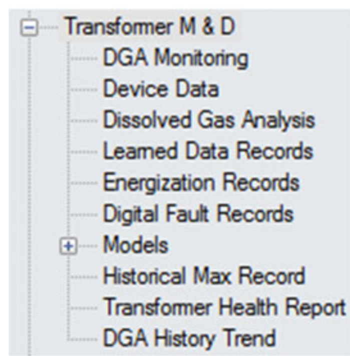
- View the event recorder and oscillography for correct operation of inputs, outputs, and elements.

GE
Grid Solutions

845 Transformer Protection System

Chapter 14: Transformer M&D

The 845 Transformer Protection Relay and M&D (monitoring and diagnostics) devices are connected and operated in client-server mode of operation. The contents from the M&D device are organized as per the menu tree shown below under “Transformer M&D menu”.



NOTE

Detailed information on the Transformer M&D menu tree contents (i.e., DGA Monitoring, DGA Models etc.) is available in the M&D User Guide.

DGA Monitoring

The 845 relay provides configuration parameters to establish communication with DGA devices on Modbus TCP/IP protocol. Four DGA devices are supported – Transfix, DGA 500, Minitrans, and HM2. The 845 relay supports MODBUS TCP client protocol which acts as the master or client to M&D devices.

The following configuration parameters are used for establishing the communication between the 845 relay and DGA device.

IP ADDRESS

Range: standard IPv4 address

Default: 0.0.0.0

This setting specifies the IP address of the M&D DGA device that communicates with the 845 relay.

SLAVE ADDRESS

Range: 0 to 254

Default: 0

This setting is the slave ID field (unit ID) within the Modbus protocol. It is the ID of the M&D device, and each M&D device in general has a unique ID.

PORT

Range: 0 to 10000

Default: 502

This setting is the standard port setting of the Modbus protocol. Port setting 502 is the setting most often used for all Modbus based communications.

DEVICE TYPE

Range: None, Transfix, DGA 500, Minitrans, HM2

Default: None

This setting defines the type of M&D DGA device being used with the 845 relay on the Modbus protocol. Supported device types include Transfix, DGA 500, Minitrans and HM2.

Device Data

The Device Data menu item provides the device ID and serial number of the DGA device connected to the 845 relay.

Device Data // HTC : HTC 1 Relay: Transformer M & D

Save Restore Default

SETPOINT	PARAMETER
Device_ID	TX1-UPS004726
Serial Number	TX1-UPS004726

Dissolved Gas Analysis

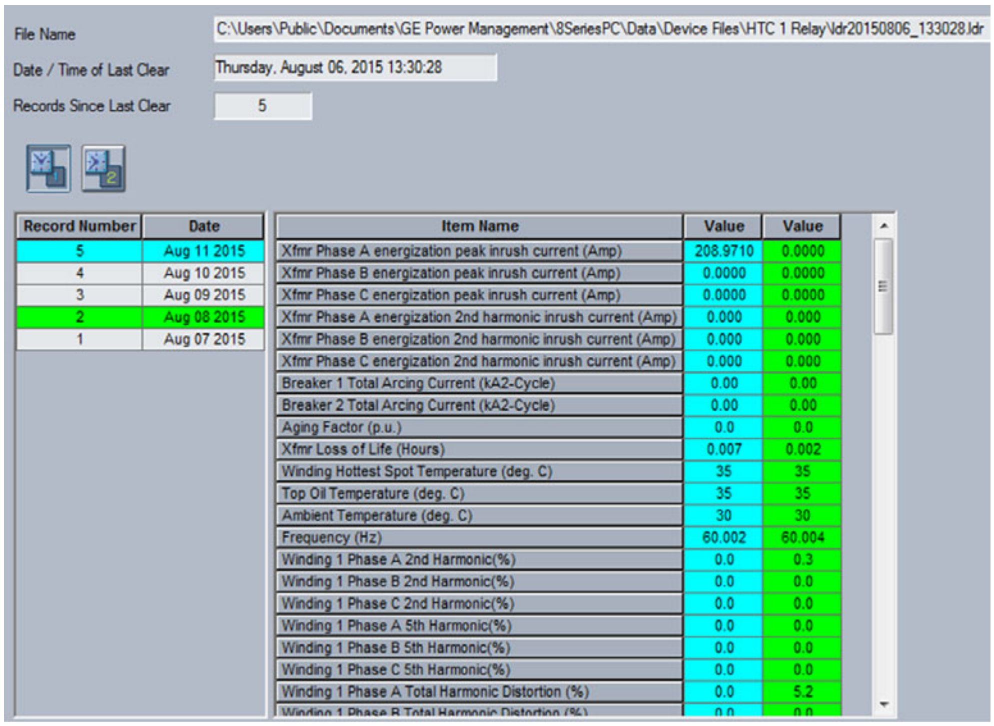
The 845 relay reads gas ppm values at regular intervals of time based on the DGA device type and displays the latest gas ppm values along with a measurement date/timestamp.

For HM2 DGA device types, data is read at 15 minute intervals. For Transfix, DGA 500 and Minitrans device types, data is read based on the scheduler configuration in the device. In addition to gas ppm data, basic diagnostic information on DGA device hardware and components is also provided.

GAS VARIABLE NAME	LATEST VALUE	ALARM LIMIT
Hydrogen (H2)	27.400 ppm	50.000 ppm
Carbon Dioxide (CO2)	424.044 ppm	500.000 ppm
Carbon Monoxide (CO)	5.327 ppm	150.000 ppm
Ethylene (C2H4)	5.151 ppm	20.000 ppm
Ethane (C2H6)	9.828 ppm	40.000 ppm
Methane (CH4)	8.433 ppm	30.000 ppm
Acetylene (C2H2)	4.639 ppm	25.000 ppm
Moisture (H2O)	23.166 ppm	1000.000 ppm
Oxygen (O2)	4233.275 ppm	1500.000 ppm
TDCG	60.781 ppm	500.000 ppm
Nitrogen (N2)	0.000 ppm	0.000 ppm
Ambient Temperature	26 °C	
Measurement Date/Timestamp	08/11/15 10:30:00	

Learned Data Records

The Learned Data recorder measures and records up to 365 data record sets from actual transformer operation. This data can be used to evaluate the changes/trends over time in transformer models. The records can only be retrieved using the EnerVista 8 Series Setup software. Learned Data records are calculated each day at mid-night 12:00:00 AM with a total of 365 records supported based on the FIFO concept.



Energization Records

The Transformer Energization record is generated by the 845 relay for every successful transformer energization event. The energization record can only be retrieved using EnerVista 8 Series Setup software. Six of the latest energization records are supported by the 845 relay based on the FIFO concept.

Each energization record contains:

- Transient record data with 10 cycles of user configured energization winding source voltage, and current waveform data of each phase sampled at 64 samples/cycle
- Computed energization parameters through data captured in the metering module from the initial 10 cycles of captured raw data during an energization event and downsampling this data to 64 samples/cycle.
- The latest available calculated, measured or monitored values for the selected winding source after successful energization.

Energization Record	
Record Number	1
Date	Aug 10 2015
Timestamp	10:31:51.354495
Phase A Peak Inrush Current (Amp)	208.9710
Phase B Peak Inrush Current (Amp)	0.0000
Phase C Peak Inrush Current (Amp)	0.0000
Phase A 2nd harmonic inrush current (Amp)	0.000
Phase B 2nd harmonic inrush current (Amp)	0.000
Phase C 2nd harmonic inrush current (Amp)	0.000
Phase A 2nd harmonic inrush current (%)	0.0
Phase B 2nd harmonic inrush current (%)	0.1
Phase C 2nd harmonic inrush current (%)	0.1
Phase A 5th harmonic inrush current (Amp)	0.000
Phase B 5th harmonic inrush current (Amp)	0.000
Phase C 5th harmonic inrush current (Amp)	0.000
Phase A 5th harmonic inrush current (%)	0.0
Phase B 5th harmonic inrush current (%)	0.1
Phase C 5th harmonic inrush current (%)	0.1
Frequency (Hz)	0.000
Phase A RMS Current (Amp)	149.414
Phase B RMS Current (Amp)	0.000
Phase C RMS Current (Amp)	0.000
Energization Winding Source	J1
Energization Winding Average Current (Amp)	49.805
Ground Current (Amp)	0.000
Phase A Total Harmonic Distortion(%)	0.0
Phase B Total Harmonic Distortion(%)	0.0
Phase C Total Harmonic Distortion(%)	0.0
Xfmr Status	Energized

Digital Fault Records

The Transformer Digital fault record is generated by the 845 relay for every successful transformer trip event that occurs. The recorder can only be retrieved using EnerVista 8 Series Setup software. Six of the latest Digital fault records are supported by the 845 relay based on the FIFO concept.

Each Digital fault record contains:

- Oscillography and pre/post configured electrical phasor data generated during a trip condition
- Pre and post fault gas ppm data
- Electrical and thermal data captured during fault
- DGA models computed with pre/post fault gas ppm data, and
- A PDF report capturing integrated fault data

Select DFR	6
Launch DFR Oscillography	
Launch DFR Models	
Export DFR to PDF	

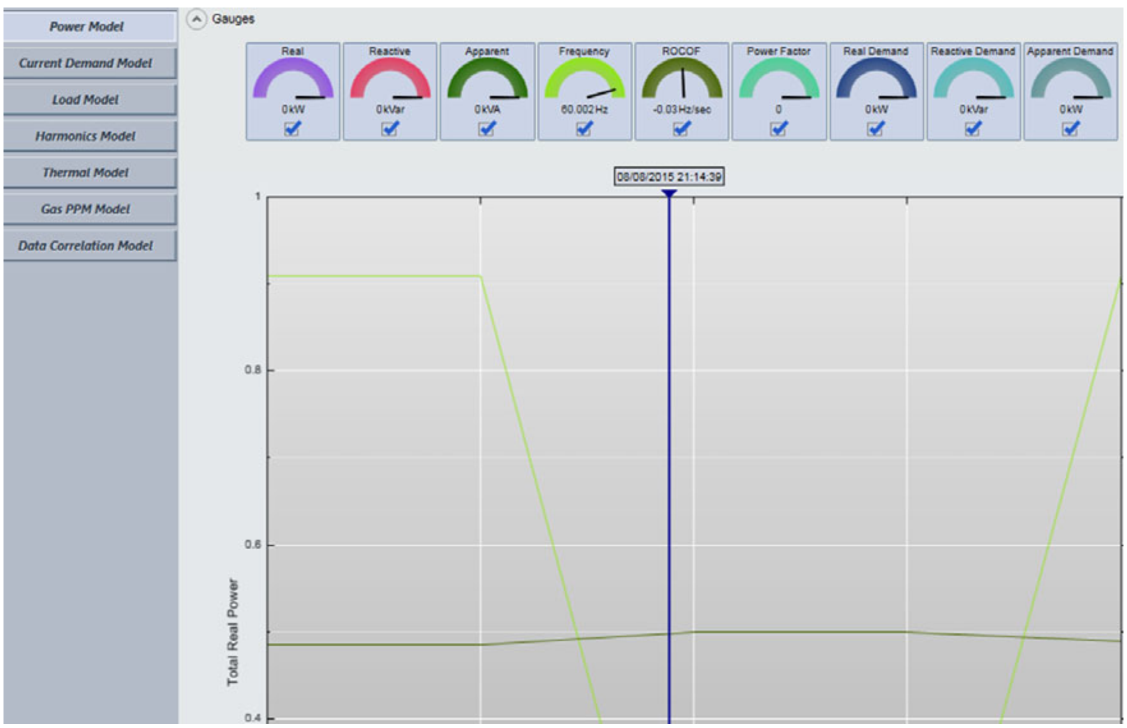
Models

Models consist of transformer operational data represented in a constructive manner using electrical, thermal and DGA data. This section contains transformer models and DGA models.

Transformer Models

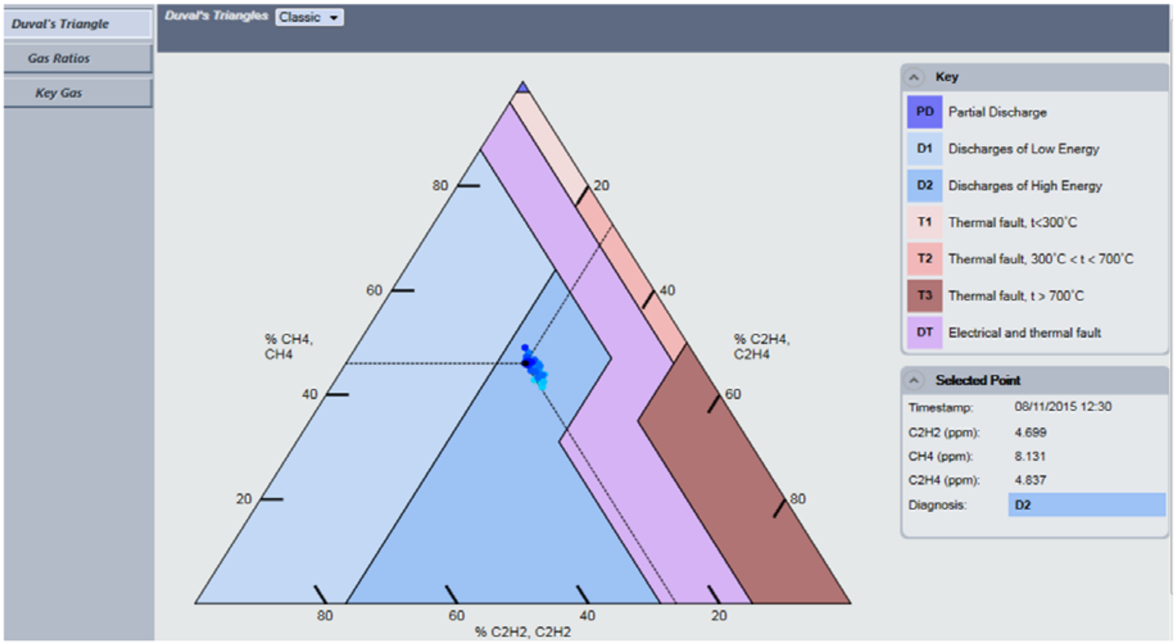
Transformer models represent transformer operational electrical, thermal and DGA data based on learned data in the form of a trend chart. Each trend chart consists of computed or monitored parameter trends, classified based on relevancy as a group of 10 parameters.

The Data correlation model in this section is a customized trend chart where the user can select the required parameter trends to display.



DGA Models

DGA models consist of the standard Duval Triangle and Gas Ratios model which is computed based on the latest 50 DGA data samples. The Key Gas model is computed based on the latest DGA data.



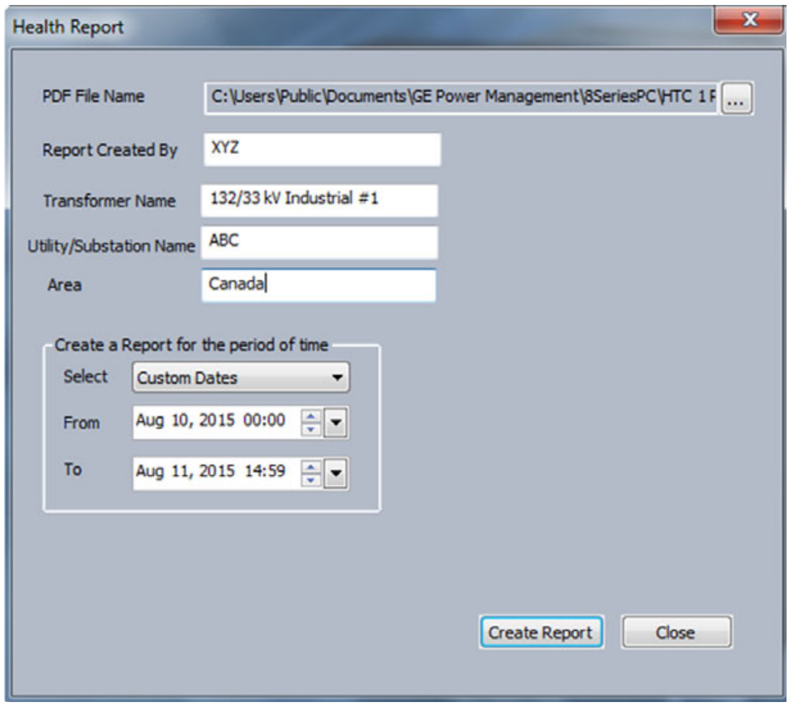
Historical Maximum Record

The Historical maximum record consists of lifetime operational maximum values along with a time stamp of the parameter.

Historical Max Record			
Date Time	**Parameter**	**Value**	**Phase**
Aug 10 2015 11:47:39	Xfmr Energization Peak inrush current (Amp)	908.1450	C
Aug 10 2015 12:47:50	Xfmr Energization 2nd harmonic inrush current (Amp)	3278.806	C
Aug 11 2015 12:21:15	Winding 1 2nd Harmonic(%)	31.0	B
Aug 10 2015 11:24:56	Winding 1 5th Harmonic(%)	60.3	B
Aug 11 2015 12:21:15	Winding 1 Total Harmonic Distortion (%)	84.5	B
Aug 11 2015 13:57:40	Winding 1 Harmonic Derating Factor	1.00	N/A
Aug 11 2015 12:40:1	Winding 1 Average Phase Current (Amp)	498.047	N/A
Aug 11 2015 12:40:1	Winding 1 Transformer overload (%)	115.0	N/A
Aug 11 2015 12:40:1	Breaker 1 Total Arcing Current (kA2-Cycle)	14358495.06	N/A
Aug 11 2015 14:1:24	Winding 2 2nd Harmonic(%)	20.2	C
Aug 11 2015 13:52:44	Winding 2 5th Harmonic(%)	30.0	C
Aug 11 2015 14:1:24	Winding 2 Total Harmonic Distortion (%)	36.0	C

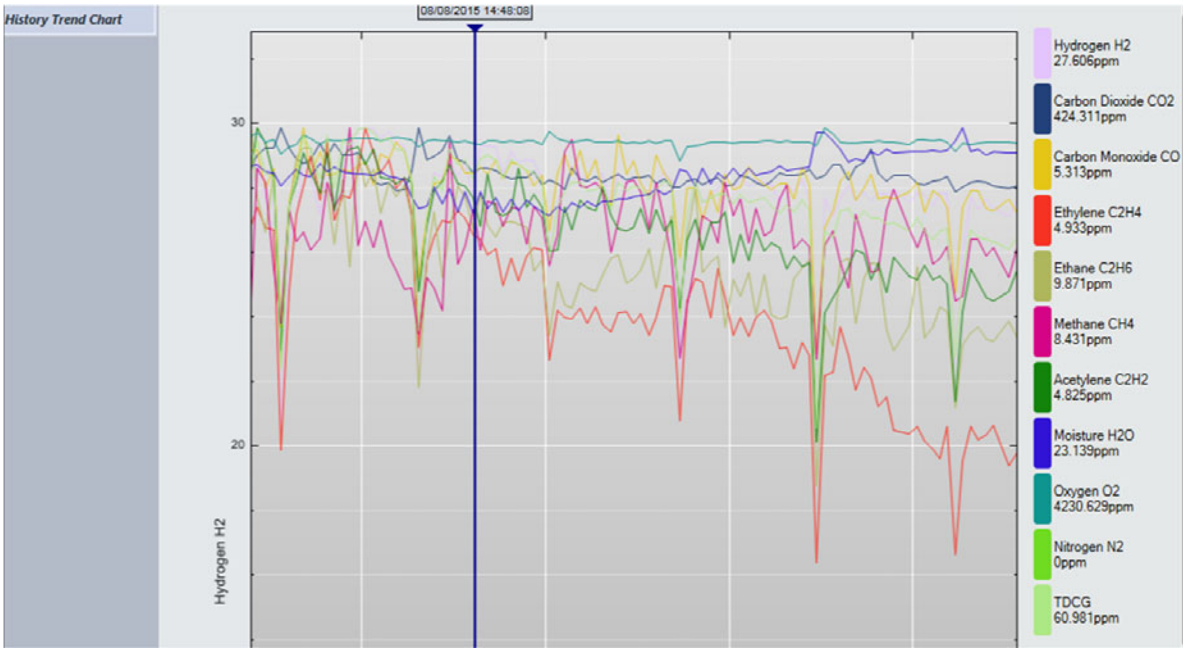
Transformer Health Report

The Transformer health report gives an executive summary on transformer operational data within a user-selectable date/times range in the form of a PDF report. The health report PDF consists of report data, online DGA status, nameplate data, energization summary, protection events summary, key learned data parameter trends, historical maximum data, DGA data and DGA models based on the 845 order code.



DGA Historical Trend

DGA historical trend provides a trend chart of DGA parameters with the latest 100 gas ppm values displayed as a varying trend based on the DGA device type.



845 Transformer Protection System

Appendix A

Appendix A includes the warranty and revision history.

Warranty

For products shipped as of 1 October 2013, GE Digital Energy warrants most of its GE manufactured products for 10 years. For warranty details including any limitations and disclaimers, see the GE Digital Energy Terms and Conditions at https://www.gegridsolutions.com/multilin/warranty.htm

For products shipped before 1 October 2013, the standard 24-month warranty applies.

Revision history

Table A-1: Revision History

MANUAL P/N	RELEASE DATE
1601-0651-A1	24 May 2015
1601-0651-A2	August 2015
1601-0651-A3	February 2016
1601-0651-A4	December 2016
1601-0651-A5	July 2017
1601-0651-A6	February 2018
1601-0651-A7	March 2018
1601-0651-A8	July 2018
1601-0651-A9	December 2018
1601-0651-AA	May 2019

Major Updates

Table A-2: Major Updates for 845-AA

Chapter	CHANGES
general	minor corrections throughout.
cover	Manual revision number from A9 to AA
1	Order codes updated (minor). Security Overview note added re. Enervista Viewpoint Monitor. Metering specifications updated.
2	Dimensions (figure 2-2) updated with two different terminal strip types. Typical wiring diagrams updated to 892841A3, 892823A3, 892789A3 (figures 2-18, 2-19, 2-20). Terminal Strip Type section added. Output relay tables updated. Magnetic Module installation section updated.
5	Annunciator description updated.
6	Percent Differential description updated.
9	Annunciator operands added. Power Factor operands updated FlexElements description updated. Base Units table updated.
12	Event Viewer section added.

Table A-3: Major Updates for 845-A9

Chapter	CHANGES
general	minor corrections throughout.
cover	Manual revision number from A8 to A9
1	Order Codes updated. Specifications, Monitoring, Demand, Measured Values, Added Minimum, real, and reactive power. Specifications, Inputs, Updated IRIG-B. Specifications, Inputs, Updated Clock Backup Retention. Specifications, Recording, Updated Data Logger Rate.
2	Wire Size updated.
3	Configuring USB Address added.
5	Power Sensing setpoint RESET EVENT ENERGY added. Data Logger setpoint RATE updated.
7	Updated Demand setpoints and logic diagrams.
9	Added FlexLogic operands for IEC 61850 mappings.
11	Added Energy Log.

Table A-4: Major Updates for 845-A8

Chapter	CHANGES
cover	Manual revision number from A7 to A8

Table A-4: Major Updates for 845-A8

Chapter	CHANGES
1	Order Codes updated. Specifications, Protection, Underfrequency and Overfrequency Level Accuracy updated Specifications, Metering, Real Power, Reactive Power, and Apparent Power Parameters clarified. Specifications, Communications, IEC 61850 Ed2 and IEE 1588 (PTP Version 2) versions added.
3	Loading New Relay Firmware steps updated. Working with Setpoints and Setpoint Files list of actions resulting in a Device Not Ready status added. Transient Recorder Comtrade version c37.111-1999 added.
5	Power Sensing section updated. Output Relay introduction and figure updated. IEC 61850 introduction updated. IEC 61850 Configurator Details note added about saving configuration file resulting in device offline temporarily. Breaker state detection logic diagram updated. Transformer Status Detection logic diagram and settings descriptions updated.
7	Trip and Close Circuit Monitoring section updated. Harmonic Detection logic diagram updated.
8	Synchrocheck logic diagram and settings updated.
9	FlexElements RTD base unit corrected.

Table A-5: Major Updates for 845-A7

Chapter	CHANGES
cover	Manual revision number from A6 to A7
1	Specifications, Metering, Voltage Accuracy for open delta connections updated
3	Added note about online label templates.
5	Security setpoint descriptions added. Output Relay 1 TRIP logic diagram updated.
8	Setpoint group example updated.

Table A-6: Major Updates for 845-A6

Chapter	CHANGES
cover	Manual revision number from A5 to A6 and product version revision from 2.0x to 2.2x
general	New: RMIO/RRTDs, I/O cards.
1	Note and link to online store for available order codes updated. Order Codes updated, RMIO order codes added. Operator role clarified. Specifications: Fast Underfrequency, RTDs, Contact Inputs, Ethernet updated.
2	IP20 back cover installation steps and figure added. RMIO installation steps and figure added. Terminal mappings updated, including new I/O cards. Rear terminal layout: added optional Cu ports. Output Relays section updated.

Table A-6: Major Updates for 845-A6

Chapter	CHANGES
3	Added Help button description. Single Line Diagram (SLD) breaker status descriptions updated. Offline settings file note added re. invalid order codes are permitted. Added note re. Setpoint Group drag-and-drop functionality. Added note re. fw upgrade only supported for versions 1.3 and up.
4, 5, 6, 7, 8, 9	Previous Chapter 4 split into 6 chapters (4 through 9). Remaining chapters renumbered.
5	Added Device > Clear Records section. Updated Transient Recorder section. Data Logger FUNCTION description updated. Display Properties: German added to Language settings.
6	Added SIGNAL INPUT, VT INPUT, and CT INPUT setpoints to protection elements as applicable. Updated Underfrequency logic diagram.
7	Added SIGNAL INPUT, VT INPUT, and CT INPUT setpoints to monitoring elements as applicable. RTD Temperature section updated with new RRTDs.
8	Added SIGNAL INPUT, VT INPUT, and CT INPUT setpoints to control elements as applicable. Added Breaker Control note. Added note to Synchrocheck.
9	Updated Test section.
10	Added Settings Audit section.
n/a	Minor corrections throughout.

Table A-7: Major Updates for 845-A5

Chapter	CHANGES
cover	Manual revision number from A4 to A5 and product version revision from 1.7x to 2.0x
1	Added Accessories list to Order Code section
1	Added note to Order Code section: Refer to the online store for available order code combinations.
2	Added depth-reducing collar installation instructions and dimensions
3	Revised Single Line Diagram section, see Interfaces > Front Panel Interface > Graphical Display Pages
3	Added new SLD Configurator section see Interfaces> Software Interface > Advanced EnerVista 8 Series Setup Software Features
4	Added new Tab Pushbuttons section to Setpoints > Device > Front Panel > Tab Pushbuttons
4	Added new Annunciator with Panel section to Setpoints > Device > Front Panel > Annunciator
4	Added new Switches section (for disconnect switch setup) to Setpoints > System > Switches
4	Revised Breaker logic diagram to 892740A2.cdr to update settings for contact input 52a, 52b and remove the breaker disconnected dependencies
4	Revised Undercurrent logic diagram to 894205A1.cdr to add setting for signal input

Table A-7: Major Updates for 845-A5

Chapter	CHANGES
4	Added new SOTF section to Setpoints > Protection
4	Revised Negative Sequence Directional OC logic diagram to 894204A1.cdr to add setting for signal input
4	Revised Broken Conductor logic diagram to 894043A2.cdr to add setting for signal input
4	Revised Load Encroachment logic diagram to 894044A2.cdr to add settings for CT input and VT inputs
4	Revised Thermal Overload logic diagram to 894045A3.cdr to add setting for signal input
4	Added new Timed Undervoltage section to Setpoints > Protection > Voltage Elements
4	Added new UV Reactive Power section to Setpoints > Protection > Voltage Elements
4	Revised Neutral Overvoltage logic diagram to 894050A2.cdr to add setting for signal input
4	Revised Negative Sequence OV logic diagram to 894051A2.cdr to add setting for signal input
4	Added new Admittance section to Setpoints > Protection
4	Revised Power Factor logic diagram to 894059A3.cdr to add setting for signal input
4	Revised Pulsed Outputs logic diagram to 894064A2.cdr to add setting for signal input
4	Added new Local Control Mode section, see Setpoints > Control
4	Added new Breaker Control section, see Setpoints > Control
4	Added new Switch Control (for disconnect switch control) section to Setpoints > Control > Switch Control
4	Added new Pole Discordance section to Setpoints > Control
4	Added new CT Supervision section to Setpoints > Control
4	Added new Ethernet Loopback test section to Setpoints > Testing

Table A-8: Major Updates for 845-A4

PAGE NUMBER (A3)	PAGE NUMBER (A4)	CHANGES
cover	cover	Manual revision number from A3 to A4 and product version revision from 1.6x to 1.7x
1-21	1-21	Changed Time Delay to 200,000,000 ms for Introduction>Specifications>User-Programmable Elements>FlexCurves
2-9	2-9	Replaced typical wiring diagram for 2-winding transformer with VTs on HV side (894117A3.cdr) with 892841A1.pdf.
2-10	2-11	Replaced typical wiring diagram for 2-winding transformer with VTs on LV side (894011A3.cdr) with 892822A1.pdf.
2-11	2-12	Replaced typical wiring diagram for 2-winding transformer without VTs (894012A3.cdr) with 892823A1.pdf.

Table A-8: Major Updates for 845-A4

PAGE NUMBER (A3)	PAGE NUMBER (A4)	CHANGES
2-12	2-13	Replaced typical wiring diagram for 3-winding transformer (894013A3.cdr) with 892789A1.pdf.
4-, 5-, 6-. 7-	4-, 5-, 6-, 7-	Removed the HMIs associated with the path description in each chapter
4-28	4-29	Replaced single communications card option with two communications card options for "S" and "C" in Setpoints > Device > Communications > Ethernet Ports
-	4-61	Updated Setpoints>Device>Installation to add Voltage Cutoff and Current Cutoff settings
-	4-283	Added new RTD Trouble section to Setpoints>Monitoring
4-337	4-314	Updated the FlexLogic Operands table

Table A-9: Major Updates for 845-A3

PAGE NUMBER (A2)	PAGE NUMBER (A3)	CHANGES
cover	cover	Manual revision number from A2 to A3 and product version revision from 1.5x to 1.6x
cover	cover	Replaced GE Digital Energy with GE Grid Solutions throughout
1-18	1-19	Added Harmonic detection specification to Specifications>Monitoring
		Revised the Line VT Connections diagram to 892776A3.cdr
-	4-10	Added new Custom Configuration section to Setpoints>Device
4-39	4-37	Changed DNP 3 to DNP Protocol
-	4-69	Added Event data section to Setpoints>Device
-	4-300	Added Harmonic detection section to Setpoints>Monitoring
4-336	4-337	Revised the FlexLogic table to add Flexlogic operands for Harmonic detection
4-355	4-304	Moved RTD Temperature section from Setpoints>RTD Temperature to Setpoints>Monitoring>RTD Temperature
4-347		Added Testing>Simulation section after FlexLogic section
-	5-2	Updated Status chapter to include Last trip data section
-	6-11	Added Harmonic magnitude section to Metering chapter
6-11	6-12	Replaced Harmonics 1 with Harmonics 1 (Harmonics 4)
6-12, 6-13, 6-14	-	Removed Harmonics 2, 3, and 4
-	6-13	Updated Metering chapter to include Harmonic detection section
-	6-16	Added Power factor section
-	6-21	Added FlexElements section

Table A-10: Major Updates for 845-A2

PAGE NUMBER (A1)	PAGE NUMBER (A2)	CHANGES
		Manual revision number from A1 to A2 and product version revision from 1.4x to 1.5x
1-8	1-8	Updated 845 order codes, see slots B, C, G and H
1-10	1-10	Added Arc Flash specifications to Specifications>Protection
1-22, 1-23	1-22, 1-23	Added Analog Inputs and Analog Outputs to Specifications>Inputs and Specifications>Outputs respectively
2-8, 2-9, 2-10. 2-11	2-9, 2-10, 2-11, 2-12	Revised all Typical Wiring diagrams to add Arc Flash, Analog Inputs and LVIO; replaced existing RTD details
4-	4-126, 4-137	Added Analog Inputs and Analog Outputs details to Setpoints>Inputs and Setpoints>Outputs
4-	4-304	Added Arc Flash protection details to Setpoints>Control
4-320	4-336	Revised the FlexLogic table to add the new Flexlogic operands
4-337	4-353	Updated RTD Temperature details, i.e. table
5-	5-2	Updated Status chapter to include Arc Flash status description
6-	6-18, 6-19	Updated Metering chapter to include Arc Flash and Analog Inputs
-	8-1	Added new chapter for Transformer M&D information

Table A-11: Major Updates for 845-A1

PAGE NUMBER	CHANGES
	Manual revision number A1 (first release)