GE
Grid Solutions

869

Motor Protection System

Motor Protection, Control and Management

Instruction manual

Product version: 2.4x
GE publication code: 1601-0450-AD (GEK-119649N)

CE

RoHS Compliant

WORLDWIDE 10 YEAR WARRANTY

REGISTERED ISO 9001 GE MULTILIN

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GE Multilin 869 Motor Protection System instruction manual for revision 2.4x.

Part number: 1601-0450-AD (May 2019)

NOTICE

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

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6.PROTECTION

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869 Motor Protection System

Chapter 1: Introduction

The Multilin 869 relay is a microprocessor-based unit intended for the management and primary protection of medium and large sized induction and synchronous motors. Base relay models provide thermal overload and overcurrent protection plus a number of current and voltage based backup functions.

Overview

The relay features:

- An enhanced thermal model with custom curves, current unbalance biasing, voltage dependent curves and running and stopped exponential cooling curves.An optional RTD module allowing for the thermal model RTD bias function.
- Motor start and supervision functions including thermal inhibit, maximum starting rate, time between starts, restart delay, acceleration time, and emergency restart.
- Basic functions including mechanical jam, current unbalance elements and VFD application support.
- Advanced features including stator differential, sensitive directional power and phase/neutral directional elements.
- Additional features for synchronous motor stator and rotor including out-of-step, loss of excitation, power factor (pull-out) with resynchronization control, complete start sequence control, auto-loading and unloading, reluctance-torque synchronization, dc exciter regulation (PF based), rotor over-temperature protection, speed-biased thermal protection, exciter voltage monitoring, and exciter current monitoring.

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 869 Motor Protection System

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 k Hz 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 digital 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 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 through 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

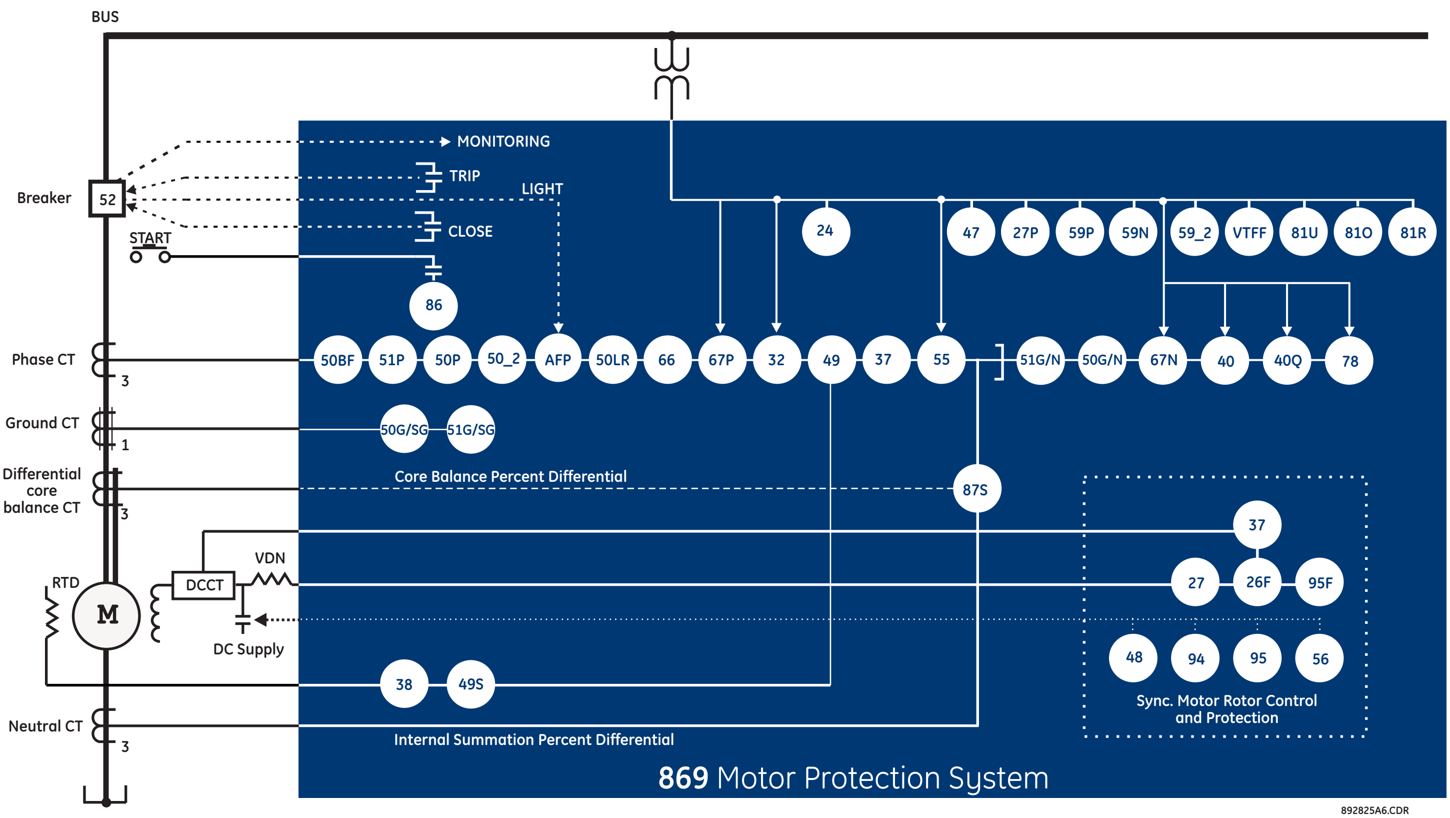

Table 1-1: ANSI Device Numbers and Functions

ANSI Device	Description	ANSI Device	Description
12/14	Over Speed Protection/ Under Speed Protection	51N	Neutral Time Overcurrent
24	Volts per Hertz	51P	Phase Time Overcurrent
26F	Sync. Motor Field Overtemperature	52	AC Circuit Breaker
27F	Sync. Motor Field Undervoltage	55	Power Factor
27P	Phase Undervoltage	56	Sync. Motor Start Sequence Control
32	Directional Power	59F	Sync. Motor Field Overvoltage
37	Undercurrent	59N	Neutral Overvoltage
37F	Sync. Motor Field Undercurrent	59P	Phase Overvoltage
37P	Underpower	59X	Auxiliary Overvoltage
38	Bearing RTD Temperature	59_2	Negative Sequence Overvoltage
40	Loss of Excitation	66	Maximum Starting Rate
41	Loss of Excitation	67N	Neutral Directional Element
40Q	DC Field Breaker/Contactor	67P	Phase Directional Element
46	Current Unbalance	76F	Sync. Motor Field Overcurrent
47	Phase Reversal	78	Out-of-Step Protection
48	Incomplete Sequence	81O	Overfrequency
49	Thermal Model	81U	Underfrequency
49S	Stator RTD Temperature	81R	Frequency Rate of Change
50BF	Breaker Failure	86	Start Inhibit
50G	Ground Instantaneous Overcurrent	87S	Stator Differential
50SG	Sensitive Ground Instantaneous Overcurrent	90F	Sync. Motor Power Factor Regulation

ANSI Device	Description	ANSI Device	Description
50SG/G	Ground Fault	95	Reluctance Torque Sync/Resync.
50LR	Mechanical Jam	96	Autoloading Relay
50N	Neutral Instantaneous Overcurrent	AFP	Arc Flash Protection
50P	Phase Instantaneous Overcurrent	VTFF	Voltage Transformer Fuse Failure
50_2	Negative Sequence Instantaneous Overcurrent		
51G	Ground Time Overcurrent		
51SG	Sensitive Ground Time Overcurrent		

Table 1-2: Other Device Functions

Acceleration Time	FlexLogic Equations	Reduced Voltage Starting
Analog Input	Flex States	RTD Temperature
Analog Output	IEC 61850 Communications	Setpoint Groups (6)
Breaker Arcing Current (I^2t)	Mechanical Jam	Short Circuit
Broken Rotor Bar	Metering: current, voltage, power, PF, energy, frequency, harmonics, THD	Stator Inter-Turn Fault
Switching Device Control	Modbus User Map	Time of Day Timer
Breaker Control	Motor Health Report	Trip Bus (6)
Breaker Health	Motor Learned Data	Transient Recorder (Oscillography)
Data Logger	Motor Start Records	Trip and Close Coil Monitoring
Demand	Motor Start Statistics	User-programmable LEDs
Digital Counters	Non-volatile Latches	User-programmable Pushbuttons
Event Recorder	OPC-UA Communications	Virtual Inputs (32)
Fault Report	Output Relays	Virtual Outputs (32)
Fast underfrequency	Overload Alarm	Voltage Disturbance
FlexElements	Power Quality	

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 869 relay. The 869 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 869 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 869 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 869 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 869 device:

- Device Authentication – in which case the authentication is performed on the 869 device itself, using the predefined roles as users (No RADIUS involvement).
  - 869 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 869
  - 869 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 869 device and server authentication are enabled, the 869 automatically directs authentication requests to the 869 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 869 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 869 device accounts to gain access to the 869 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 869 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 869.

869 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=869 for available order code combinations.

The information to specify an 869 relay is provided in the following Order Code figure:

Figure 1-3: 869 Order Codes

869 – E ** ** ** * * * * * * * * * * * * * * * N *		869 Motor Protection System
Application	E	Standard
Phase Currents - Slot J	P1	1A three-phase current inputs (J1)
	P5	5A three-phase current inputs (J1)
Phase Currents - Slot K	NN	No phase current inputs (Slot K)
	P1	1A three-phase current inputs (K1)
	P5	5A three-phase current inputs (K1)
	C5	5A three-phase current inputs (K1), SM Field Inputs (K2) with DcmA Field Current Input
	D5	5A three-phase current inputs (K1), SM Field Inputs (K2) with VDC Field Current Input
Ground Currents	G1	1A ground input (1 per phase current bank)
	G5	5A ground input (1 per phase current bank)
	S1	1A ground input (J1), 1A sensitive ground input (K1)
	B1	1A ground input (J1), 50:0.025A ground input (K1)
	B5	5A ground input (J1), 50:0.025A ground input (K1)
	0B	50:0.025A ground input (J1)
	5B	50:0.025A ground input (J1), 5A ground input (K1)
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 Relays, 3 Form C Relays, 7 Digital Inputs (Int/Ext Supply)
	K	5 Form A Relays, 1 Form C Relay, 10 Digital Inputs
	L	7 DcmA O/P, 4 DcmA I/P, 1 RTD
	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
	K	5 Form A Relays, 1 Form C Relay, 10 Digital 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: 12/14, 19, 37, 38, 46, 47, 49, 50P, 50N, 50G, 50SG, 50_2, 50LR (Mechanical Jam), 51P, 51N, 51G, 51SG, 66, 86, 37F*, 50F*
	M	Standard: Basic, 67P, 67N, 87S (2nd CT Bank required for 87S)
Voltage Monitoring and Protection	S	Standard: 27P, 27X, 47, 59P, 59N, 59X, 81O, 81U, VTFF, 26F*, 27F*, 49F*, 59F*
	P	Advanced: Standard, 32, 40, 40Q, 55, 59_2, 78, Fast U/F
Control	F	Standard: Breaker/Contactor Control, Virtual Inputs, FlexLogic, 50BF, Trip Bus, Field Breaker/ Contactor Control*, 56* (including Rel. Torque Sync and Autoloading, Inc. Seq.), PF Regulation*
	T	Advanced HMI: Standard, Tab Pushbuttons, Annunciator Panel, Configurable SLDs with Bay Control
Monitoring	B	Basic: Motor Health Report, Motor Start Report, Motor Learned Data, Data Logger, Breaker Coil Monitoring, Breaker Arcing, Harmonics, THD, Demand
	C	Standard: Basic, Breaker Health Report, Broken Rotor Bar**
	A	Advanced: Standard, Harmonic Detection, Stator Inter-turn Fault
	E	Extended: Advanced, ESA Functions
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, 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
Retrofit Kit Option	1	Wye 469-869 Retrofit Kit, terminal block wiring assembly for wye (for retrofit kit only)
	2	Delta 469-869 Retrofit Kit, terminal block wiring assembly for delta (for retrofit kit only)

1. Communications options 2A and 2E have been discontinued.
* Feature only available with Phase Currents - Slot K option C5/D5.
** Feature not available with Phase Currents - Slot K option C5/D5.

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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

Retrofit order codes must be configured using the GE Multilin Online Store (OLS) based on the existing relay order code and additional requirements.

Navigate to https://www.gegridsolutions.com/multilin/catalog/869.htm and click **Buy Retrofit Kit** for further information.

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"
- 8 Series Retrofit Kit, 469 to 869

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

ACCELERATION TIME (37P)

Acceleration Current: ....1.00 to 10.00 × FLA in steps of 0.01
Operating Mode: ....Definite Time, Adaptive
Timing Accuracy:..±100 ms or ±0.5% of total time (whichever is greater), applicable to definite time mode only

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

AUXILIARY OVERVOLTAGE (59X)

Operating Parameter:...Vx (Phasor)
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 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 × pickup at 60Hz
Curve Timing Accuracy: ....at >1.1 × 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)

CURRENT UNBALANCE (46)

Unbalance: .... Unbal = (I_2 / I_1) x A_{factor} x 100%
A_{factor} = (I_{avg} / FLA) if I_{avg} < FLA
A_{factor} = 1 if I_{avg} >= FLA
Trip/Alarm Pickup Level: .... 4.0 to 50.0% in steps of 0.1%
Trip Operating Curves: .... Definite Time: T=TDM sec
Inverse Time: T= (TDM/[Unbal]^2) sec
Trip Pickup Delay: .... 0.00 to 180.00 s in steps of 0.01 s when Trip Curve = Definite Time
Trip Time Dial Multiplier (TDM): .... 0.00 to 180.00 in steps of 0.01 when Trip Curve = Inverse Curve
Trip Maximum Time: .... 0.00 to 1000.00 s in steps of 0.01 s
Trip Minimum Time: .... 0.00 to 1000.00 s in steps of 0.01 s
Trip Reset Time: .... 0.00 to 1000.00 s in steps of 0.01 s
Alarm Time Delay: .... 0.00 to 180.00 s in steps of 0.01 s
Single Phasing Pickup Level: .... unbalance level > 40% or when I_{avg} >=25%FLA and current in any phase is less than the cutoff current
Single Phasing Time Delay: .... 2 seconds
Pickup Accuracy: .... ±2%
Operate Time: .... <2 cycles at 1.10 x pickup (NOTE 1)
Timing Accuracy: .... ±3% of delay setting time or ± 20 ms, whichever is greater
Element: .... Trip and Alarm
Single Phasing Element: .... Trip

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 x Rated Power in steps of 0.001
Pickup Level Accuracy: .... ± 1% or ± 0.001 x Rated Power, whichever is greater
Hysteresis: .... 2% or 0.001 x 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 x pickup at 60 Hz
< 65 ms at 1.1 x pickup at 50 Hz (NOTE 1)
Timer Accuracy: .... ± 3% of delay setting or ± ¼ cycle (whichever is greater) from pickup to operate

FAST UNDERFREQUENCY

Operating Parameter: .... Frequency and rate of change of frequency
UF Pickup Level: .... 20.00 to 65.00 Hz in steps of 0.01 Hz
df/dt Pickup Level: .... -10.00 to -0.10 Hz/s in steps of 0.01 Hz/s
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
Frequency Accuracy: .... 250 mHz/s or 3.5%, whichever is greater
Timer Accuracy: .... ± 3% of operate time or ± ¼ cycle (whichever is greater)

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

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

GROUND FAULT (50G)

Pickup Level : ....For 1A/5A Ground CT Type: 0.01 to 10.00 × CT in steps of 0.01 × CT;
For 50/0.025 Ground CT Type: 0.50 to 15.00 A in steps of 0.01A
For 1A Sensitive Ground CT Type:0.005 to 3.000 × CT in steps of 0.001 × CT
Dropout Level: ....97 to 98% of Pickup
Alarm Pickup Delay: ....0.00 to 180.00 s in steps of 0.01 s
Trip Pickup Start Delay: ....0.00 to 180.00 s in steps of 0.01 s
Trip Pickup Run Delay: ....0.00 to 180.00 s in steps of 0.01 s
Magnitude Accuracy: ....50:0.025A CT: ± 5% of reading or ± 0.2A (in primary) whichever is greater
1A/5A CT: 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: ....<16 ms @ 60Hz (I > 2.0 × PKP), with 0 ms time delay
<20 ms @ 50Hz (I > 2.0 × PKP), with 0 ms time delay
Timing Accuracy: ....±3% of delay setting at ±1 cycle (whichever is greater) from pickup to operate

LOSS OF EXCITATION (40)

Operating Condition: ....Positive-sequence impedance
Characteristic: ....2 independent negative mho circles (LOE circle 1, 2)
Circle 1(2) Diameter: ....0.1 to 300.0 Ω (in secondary) in steps of 0.1Ω
Circle 1(2) Offset: ....0.1 to 300.0 Ω (in secondary) in steps of 0.1Ω
Reach (Impedance) Accuracy: ....± 5%
Under Voltage (UV) Supervision Level: ....0.00 to 1.50 × VT in steps of 0.01 × VT
UV Pickup Accuracy: ....as per phase voltage inputs
Pickup Delay: ....0.00 to 600.00 s in steps of 0.01 s
Timer Accuracy: ....± 3% of delay setting or ± ½ cycle (whichever is greater)
Operate Time: ....< 3 cycles

MECHANICAL JAM

Operating Condition: ....Phase Overcurrent
Arming Condition: ....Motor not starting or stopped
Pickup Level or : ....1.00 to 10.00 × FLA in steps of 0.01
Dropout Level: ....97 to 98% of Pickup
Level Accuracy: ....For 0.1 to 2.0 × CT: ±0.5% of reading; at > 2.0 × CT rating: ±1.5% of reading
Pickup Delay: ....0.10 to 180.00 s in steps of 0.01
Dropout Delay: ....0.00 to 180.00 s in steps of 0.01
Timer Accuracy: ....±3% of delay setting time or ±20 ms, whichever is greater

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

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

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

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

OUT-OF-STEP (78)

Characteristic:	Single blinder with offset mho supervisory
Measured Impedance:	Positive-sequence
Current Supervision Pickup Level:	0.05 to 10.00 × CT in steps of 0.01 × CT
Fwd/Reverse Reach (sec.):	0.10 to 500.00 Ω in steps of 0.01 Ω
Left and Right Blinders (sec.):	0.10 to 500.00 Ω in steps of 0.01 Ω
Impedance Accuracy:	±5%
Blinder RCA:	40 to 90° in steps of 1°
Angle Accuracy:	± 2°
Timer Accuracy:	±3% of operate time or ±¼ cycle (whichever is greater)

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.

OVERLOAD ALARM

Operating Parameter:	Average phase current (RMS)
Pickup Level:	0.50 to 3.00 × FLA in steps of 0.01 × FLA
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 rating ±1.5% of reading
Pickup Delay:	0.00 to 180.00 s in steps of 0.01 s
Dropout Delay:	0.00 to 180.00 s in steps of 0.01 s
Timer Accuracy:	±3% of delay setting or ± ½ cycle (whichever is greater) from pickup to operate

PERCENT DIFFERENTIAL (87S)

Methods:	Internal summation and Core balance
Pickup Level:	0.05 to 1.00 × CT in steps of 0.01
Slope 1 and 2:	1 to 100% in steps of 1
Break 1:	0.50 to 2.00 × CT in steps of 0.01
Break 2:	2.00 to 30.00 × CT in steps of 0.01
Operate Time:	<16 ms at >3 × Pickup at 60 Hz; <20 ms at >3 × Pickup at 50 Hz

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

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.

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

PHASE REVERSAL

Phase Reversal Condition:	V_2/V_1=100% when phase to phase voltages are greater than 50% of VT
Configuration:	ABC or ACB phase rotation
Pickup/Dropout Time Delay:	0.00 to 180.00 s in steps of 0.01 s
Timer Accuracy:	±3% of delay setting or ±1% cycle (whichever is greater) from pickup to operate

PHASE UNDERVOLTAGE (27P)

Voltage:	Fundamental Phasor Magnitude
Minimum Voltage:	0.00 to 1.50 × VT in steps of 0.01 × VT
Pickup Level:	0.00 to 1.50 × VT in steps of 0.01 × 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 × pickup at 60 Hz < 25 ms at 0.90 × pickup at 50 Hz
Curve Timing Accuracy:	at < 0.90 × 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 × 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
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 × pickup at 60Hz < 30 ms at 1.1 × pickup at 50Hz
Timer Accuracy:	± 3% of delay setting or ± ¼ cycle (whichever is greater) from pickup to operate

REACTIVE POWER (40Q)

Operating Condition:	Three-phase reactive power
Positive/Negative var Trip/Alarm Pickup Level:	1 to 25000 kvar in steps of 1 kvar
Pickup Level Accuracy:	±1.0% of reading
Positive/Negative var Trip/Alarm Pickup Delay:	0.00 to 600.00 s in steps of 0.01 s
Timer Accuracy:	±3.0% of delay time or ±10 ms, whichever is greater
Hysteresis:	2 to 3%
Operate Time:	< 45 ms at 60 Hz < 50 ms at 50 Hz
Elements:	Trip and Alarm

RTD PROTECTION

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

SENSITIVE GROUND INSTANTANEOUS OVERCURRENT (50SG)

Operating Parameter:	Isg (Fundamental Phasor Magnitude)
Pickup Level:	0.005 to 3.000 × CT in steps of 0.001 × CT 0.50 to 15.00 A in steps of 0.01 A (For 50:0.025)
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 > 2.0 × CT rating For 50:0.025: ±0.1 A for 0.5 A to 4 A; ±0.2 A for > 4 A
Operate Time:	< 12 ms at 3 × Pickup at 60 Hz
Timer Accuracy:	±3% of operate time or ± ¼ cycle (whichever is greater)

SENSITIVE GROUND TIME OVERCURRENT (51SG)

Operating Parameter: .... Isg (RMS or Fundamental)
Pickup Level: .... 0.005 to 3.000 xCT in steps of 0.001 xCT
0.50 to 15.00 A in steps of 0.01 A (For 50:0.025)
Dropout Level: .... 97 to 98% of Pickup
Level Accuracy: .... For 0.1 to 2.0 xCT: ±0.5% of reading or ±0.4%of rated (whichever is greater)
For > 2.0 xCT: ±1.5% of reading > 2.0 xCT rating
For 50:0.025: ±0.1A for 0.5A to 4A; ±0.2A for >4A
Dropout Level: .... 97 to 98% of Pickup
Curve Shape: .... IEEE Extremely/Very/Moderately Inverse
ANSI Extremely/Very/Normally/Moderately Inverse
IEC A/B/C and Short Inverse
IAC Extreme/Very/Inverse/Short Inverse
I2t, I4t, FlexCurves A/B/C/D, Definite Time
Curve Multiplier: .... 0.05 to 600.00 in steps of 0.01
Reset Time: .... Instantaneous, Timed
Curve Timing Accuracy: .... Currents > 1.03 to 20 x pickup: ± 3% of operate time or ± ½ cycle (whichever is greater) from pickup to operate

SHORT CIRCUIT

Inputs: .... RMS Phase Currents
Pickup Level: .... 1.00 to 30.00 x CT in steps of 0.01 x CT
Dropout Level: .... 97 to 98% of Pickup
Pickup Delay: .... 0.00 to 180.00 s in steps of 0.01 s
Level Accuracy: .... For 1.0 to 2.0 x CT: ±0.5% of reading or ±0.4% of rated, whichever is greater For > 2.0 x CT: ±1.5% of reading
Operate Time: .... <16 ms @ 60Hz (I > 2.0 x PKP), with 0 ms time delay
<20 ms @ 50Hz (I > 2.0 x PKP), with 0 ms time delay
Timer Accuracy: .... ±3% of delay setting or ±1/2 cycle (whichever is greater) from pickup to operate
Elements: .... Trip or Alarm

THERMAL MODEL (49)

Thermal Overload Curves: .... Motor curve, FlexCurves A/B/C/D/OL, Standard Motor curve with voltage dependent function, FlexCurves A/B/C/D/OL with voltage dependent function, IEC curve
Motor Curve Time Multiplier: .... 0.00 to 25.00 in steps of 0.01
FlexCurve Time Multiplier: .... 0.00 to 600.00 in steps of 0.01
IEC Curve Time Constant 1(2): .... 0 to 1000 in steps of 1
Thermal Overload Pickup: .... Overload factor x FLA
Overload Factor (OL): .... 1.00 to 1.50 in steps of 0.01
Motor Full Load Current (FLA): .... 1 to 5000 A in steps of 1

Standard Overload Curve, Cutoff Effect: ....

$$t_{trip} = \frac{\text{TDM} \times 2.2116623}{0.02530337 \times \left(\frac{I_{motor}}{\text{FLA}} - 1\right)^2 + 0.05054758 \times \left(\frac{I_{motor}}{\text{FLA}} - 1\right)}$$

Standard Overload Curve, Shift Effect: $t_{trip} = \dfrac{TDM \times 2.2116623}{0.02530337 \times \left(\dfrac{I_{motor}}{OL \times FLA} - 1\right)^2 + 0.05054758 \times \left(\dfrac{I_{motor}}{OL \times FLA} - 1\right)}$

Motor Rated Voltage: .... 1 to 50000 V in steps of 1
Thermal Model Biasing: .... Current Unbalance, RTDs
Thermal Model Update Rate: .... 1 power cycle
Stopped/Running Cool Time Constants: .... 1 to 1000 min. in steps of 1
Stopped/Running Cool Time Constant Decay: .... Exponential
Hot/Cold Safe Stall Ratio: .... 0.01 to 1.00 in steps of 0.01
Current Accuracy: .... Per phase current inputs
Current Source: .... True RMS
Timer Accuracy: .... ±100 ms or ±2%, whichever is greater
Timer Accuracy for Voltage Dependent Overload: .... ±100 ms or ±4%, whichever is greater

UNDERCURRENT (37)

Operating Parameter: .... Per-phase current Ia, Ib, Ic (Phasor)
Trip/Alarm Pickup Level: .... 0.10 to 0.95 × FLA in steps of 0.01 × FLA
Dropout Level: .... 102 to 103% of Pickup
Trip/Alarm Time Delay: .... 0.00 to 180.00 s in steps of 0.01 s
Pickup Accuracy: .... For 0.1 to 2.0 × CT: ±0.5% of reading or ±0.4% of rated, whichever is greater
Operate Time: .... <45 ms at 60 Hz,<50 ms at 50 Hz
Timer Accuracy: .... ±3% of delay setting or ± 2 power cycles (whichever is greater) from pickup to operate
Stages: .... Trip and Alarm

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.

UNDERPOWER

Operating Condition: .... Three-phase real power
Number of Elements: .... 1, alarm and trip stages
Trip/Alarm Pickup Level: .... 1 to 25000 kW in steps of 1
Pickup Level Accuracy: .... ±1.0% of reading
Hysteresis: 3%
Trip/Alarm Pickup Delay: .... 0 to 180.00 s in steps of 0.01
Timer Accuracy: .... ±3% of delay time or ±10 ms, whichever is greater, pick up to operate
Operate Time: .... <45 ms at 60 Hz; <50 ms at 50 Hz (NOTE 1)

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 x pickup
Number of Elements: 1

(NOTE 1) When the setpoint "Motor Load Filter Interval" is programmed as non-zero, it might increase the trip/alarm times by 16.7 ms (or 20 ms at 50 Hz) for each additional cycle in the filter interval for the following protection elements: Acceleration Time, Current Unbalance, Mechanical Jam, Overload Alarm, Thermal Model, Undercurent, Power Factor, and Underpower.

Sync. Motor Rotor Protection

SC SPEED-DEPENDENT THERMAL PROTECTION

Time-Speed Thermal Curves: .... SPM 1.05, SPM 1.46, SPM 2.05, SPM 3.00, FlexCurve ST
SC Thermal Capacity Used Update Rate: 2 power cycles
Speed Accuracy: .... tbd
Timer Accuracy: .... ±100 ms or ±2%, whichever is greater
Timer Accuracy for Voltage Dependent Overload: .... ±100 ms or ±4%, whichever is greater

SM FIELD UNDERCURRENT

Operating Parameter: .... Field Current Input
Trip/Alarm Pickup Level: .... 0.05 to 1.00 x MFA in steps of 0.01 x MFA (where MFA is Max FLD Amps Primary)
Dropout Level: .... 102 to 103% of pickup
Trip/Alarm Time Delay: .... 0.00 to 180.00 s in steps of 0.01 s
Pickup Accuracy: .... < ±1% of full scale reading
Operate Time: .... < 2 cycles
Timing Accuracy: .... ±0.5% of delay setting or ± 3/4 power cycles (whichever is greater)
No. of Elements per Setting Group: 2

SM FIELD OVERCURRENT

Operating Parameter: .... Field Current Input
Trip/Alarm Pickup Level: .... 0.05 to 1.00 x MFA in steps of 0.01 x MFA (where MFA is Max FLD Amps Primary)
Dropout Level: .... 97 to 98% of pickup
Trip/Alarm Time Delay: .... 0.00 to 180.00 s in steps of 0.01 s
Pickup Accuracy: .... < ±1% of full scale reading
Operate Time: .... < 2 cycles
Timing Accuracy: .... ±0.5% of delay setting or ± 3/4 power cycles (whichever is greater)
No. of Elements per Setting Group: 2

SM FIELD UNDERVOLTAGE

Operating Parameter:	SM Field VDC (Field DC Voltage)
Trip/Alarm Pickup Level:	0.0 to 350.0 V in steps of 0.1 V
Dropout Level:	102 to 103% of pickup
Trip/Alarm Time Delay:	0.00 to 180.00 s in steps of 0.01 s
Pickup Accuracy:	< ±1% of full scale reading
Operate Time:	< 2cycles
Timing Accuracy:	±0.5% of delay setting or ± 3/4 power cycles (whichever is greater)
No. of Elements per Setting Group:	2

SM FIELD OVERVOLTAGE

Operating Parameter:	SM Field VDC (Field DC Voltage)
Trip/Alarm Pickup Level:	1.0 to 350.0 V in steps of 0.1 V
Dropout Level:	97 to 98% of pickup
Trip/Alarm Time Delay:	0.00 to 180.00 s in steps of 0.01 s
Pickup Accuracy:	< ±1% of full scale reading
Operate Time:	< 2 cycles
Timing Accuracy:	±0.5% of delay setting or ± 3/4 power cycles (whichever is greater)
No. of Elements per Setting Group:	2

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

MAXIMUM HOT/COLD STARTING RATE

Monitored Time Interval: 1 to 300 minutes in steps of 1
Maximum Number of Hot Starts: 1 to 16 starts in steps of 1
Maximum Number of Cold Starts: 1 to 16 starts in steps of 1
Timer Accuracy: ±2s or ±1% of total time (whichever is greater)

MAXIMUM STARTING RATE

Monitored Time Interval: 1 to 300 minutes in steps of 1
Maximum Number of Starts: 1 to 16 starts in steps of 1
Timer Accuracy: ±2s or ±1% of total time (whichever is greater)

RESTART DELAY

Restart Delay: 0 to 65000 seconds in steps of 1
Timer Accuracy: ±2s or ±1% of total time (whichever is greater)

REDUCED VOLTAGE START

Mode: Current Only, Current and Timer, Current or Timer
Start Current Level: 0.25 to 3.00 of FLA, in steps of 0.01
Start Timer: 1.0 to 600.0 s in steps of 0.1

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

TIME BETWEEN STARTS

Time Between Starts: 0 to 300 minutes in steps of 1
Timer Accuracy: ±2s or ±1% of total time (whichever is greater)

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

Sync. Motor DC Field Control

POWER FACTOR REGULATION

PF Regulator Target: -0.90 to 1.00 power factor in steps of 0.01
which means
Lagging range -0.90,-0.91,...,-0.99,1.00
Leading range 0.00,0.01, ...,0.99,1.00
PF Regulator Feedback: Angle between current and voltage signals
Control Output (Configurable): Voltage output ranges: 0/+10 V, +/-10 V
Current output ranges: 0/+20 mA, 4-20 mA
Minimum operating Voltage: 0.00 to 1.25 × VT in steps of 0.01 × VT
Minimum operating Current: 0.00 to 10.00 × CT in steps of 0.01 × CT
Output Control Voltage Accuracy: Voltage mode: <±0.5% of Full Scale Reading
Output Control Current Accuracy: Current mode: <±0.5% of Full Scale Reading
Change in Output per 1-degree angle: 0.06 V for voltage output range +/-10 V
0.11 V for voltage output range 0/+10 V
0.11 mA for current output range 0/ +20 mA
0.09 mA for min/max output limit settings 4-20 mA
PF Regulator Response Time: < 1 cycle

START SEQUENCE CONTROL

Operating Parameter:......................................Brush-type: slip frequency-based or start time-based
Brushless: start time-based
Modes of Operation (brush-type only):.....Time-based or slip frequency-based
Synchronous Slip (brush-type only):..........1.0% to 10.0% in steps of 0.1 %
FAR Delay: ....0.00 to 180.00 s in steps of 0.01 s
Slip Frequency Accuracy: ....± 0.03% of Nominal Frequency (60Hz or 50Hz)
Stages::...Close and configurable

INCOMPLETE SEQUENCE FUNCTION

Operating Parameter:......................................Incomplete Sequence Delay Timer
Timing Accuracy:..±0.5% of delay setting or ± 1/4 power cycles (whichever is greater) from pickup to operate
Stages:...Trip, Alarm, and Configurable

Monitoring

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 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 × Pickup at 60 Hz
< 12 ms typical at 2 × Pickup at 50 Hz

BREAKER HEALTH

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

BROKEN ROTOR BAR

Operating Parameter:......................................Fundamental Phasor Magnitude
Pickup Level:...-60db to -12db in steps of -1dB
Dropout Level: ....97 to 98% of Pickup

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

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%

ESA (ELECTRICAL SIGNATURE ANALYSIS)

ESA (Bearing & Mechanical (Foundation looseness, Eccentricity and Mis-alignment)) Fault
Computing Parameter: .... Ia
Indicating Parameter:..................................... Peak Magnitude (dB), Energy (dB), Change in dB
Operating Parameter: .... Change in Peak and Energy magnitude (dB) or Peak and Energy magnitude (dB)
Pickup level 1 & 2:.. Change in Peak and Energy magnitude > 'X' dB w.r.t base line dB (configurable in setup SW) or Peak and Energy magnitude > 'X' dB w.r.t base line dB (configurable in setup SW)
Pickup delay 1 & 2: .... 5 to 60 min (multiples of 5 min) (Configurable in setup software)

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

TIME OF DAY TIMER

Number of Elements: 2
Setting Resolution: .... 1 minute
Accuracy: .... ± 1 s

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

POWER FACTOR (55)

Lead/Lag Trip/Alarm Pickup Level:............. 0.05 to 0.99 in steps of 0.01, lead and lag
Lead/Lag Trip/Alarm Time Delay:............... 0.000 to 600.00 s in steps of 0.01 s
Modes of Control: .... Resync Mode or Ride-Thru Mode
Start Block Delay: .... 0.000 to 600.00 s in steps of 0.01 s
Minimum Operating Voltage:....................... 0.00 to 1.25 × VT in steps of 0.01 × VT
Minimum Operating Current:....................... 0.00 to 10.00 × CT in steps of 0.01 × CT
Level Accuracy: .... ± 0.02
Timer Accuracy:.. ± 3% of delay setting or ± 1¼ cycle (whichever is greater) from pickup to operate
Stages: .... Trip and Alarm
No. of Elements:... 2

SPEED PROTECTION

Configuration: Assign to any contact input
Operating Range: 50 to 120% of Rated RPM
Minimum Pulse Width: >8% of a revolution
Level Accuracy: ±1% of rated speed
Timer Accuracy: ±3% of delay setting or ±2 power cycles (whichever is greater) from pickup to operate
Element: Trip and Alarm

STATOR TURN FAULT

Operating Parameter: I_2, V_1, V_2
Pickup Level Stage1/Stage2: 0.001 to 10.000 in steps of 0.001
Level Accuracy: For 1.0 to 2.0 x CT: ±0.5% of reading or ±0.4% of rated, whichever is greater For > 2.0 x CT: ±1.5% of reading
Dropout Level: 97 to 98% of Pickup
Pickup Delay Stage1/Stage2: 0.01 to 600.00 s in steps of 0.01 s
Operate Time: <16 ms at 3 x pickup at 60 Hz
Timer Accuracy: ±3% of operate time or ± 1/4 cycle (whichever is greater)

SYNC. MOTOR FIELD OVERTEMPERATURE

Operating Parameter: FLD Resistance
Pickup Level: 0.10 to 500.00 ohms in steps of 0.01 ohms
Dropout Level: 97 to 98% of Pickup
Time Delay: 0.01 to 600.00 s in steps of 0.01 s
Pickup Accuracy: <±1% of Full Scale Reading
Operate Time: <2.5 cycles
Timing Accuracy: ±3% of operate time or ± 3/2 cycle (whichever is greater)
Minimum Field Voltage: 0.00 to 50.00 VDC in steps of 0.01 VDC
Minimum Field Current: 0.02 to 0.30 x MFA in steps of 0.01 where MFA is Max FLD Amps Primary
No. of Elements: 2

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

VOLTAGE DISTURBANCE

Number of Elements: 3
Operating Parameter: Va, Vb, Vc, or Vab, Vbc,Vca (RMS)
Number of Events in Records: 30

VOLTAGE SWELL

Pickup Level: 0.02 to 3.00 x VT in steps of 0.01 x VT
Dropout Level: 97 to 98% of pickup
Pickup Delay: 0.000 to 6000.000 s in steps of 0.001s (Definite Time)
Operate Time: < 25 ms at 1.1 x pickup at 60Hz< 30 ms at 1.1 x pickup at 50Hz
Timing Accuracy: ±0.5% of delay setting or ± 1/4 power cycles (whichever is greater) from pickup to operate

VOLTAGE SAG

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
Pickup Delay: 0.000 to 6000.000 s in steps of 0.001s (Definite Time)
Operate Time: < 20 ms at 0.90 x pickup at 60 Hz< 25 ms at 0.90 x pickup at 50 Hz

Recording

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)

MOTOR START STATISTICS

Number of records:.. 5
Content:.. Start Date/Time, Start Acceleration Time, Start Effective Current, Start Peak Current
Number of records:.. Non-volatile memory

MOTOR START RECORDS

Length:.. 6 records, each containing a total of 60 seconds of motor starting data
Trigger:.. Motor starting status
Trigger Position:.. 1 second pre-trigger duration
Sample Rate:.. 1 sample/100 ms

MOTOR LEARNED DATA

Number of records:.. 250
Content:.. Learned/last acceleration time, learned/last starting current, learned/last start TCU, learned average load, learned average real power, learned average reactive power, learned average power factor, average run time (days/hours/ minutes), maximum speed, analog input minimum/ maximum values, RTD maximum temperature, Learned/Last Start SM SC TCU
Data Storage:.. .LDR File, CSV Format
Learned acceleration time accuracy:....... 3%
Learned starting current accuracy:........... 1%
Learned average motor load accuracy:.. 1%
Learned average power accuracy:............ 1%

TRANSIENT RECORDER

Default AC Channels: .... 8 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

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
-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: 5 (A, B, C, D, OL)
Reset points FlexCurves A, B, C, D: 40 (0.00 to 0.98 × pickup)
Operate points FlexCurves A, B, C, D: 80 (1.03 to 20.0 × pickup)
Operate points FlexCurve OL: 10 to 30
Time delay FlexCurves A, B, C, D: 0 to 200,000,000 ms in steps of 1 ms
Time delay FlexCurve OL: 0.500 to 200,000.000 s in steps of 0.01 s
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

MOTOR METERING VALUES

Parameters: Motor Load, Thermal Model Biased Load, Filtered Motor Load, Filtered RMS Phase A, B, C Currents, Filtered Phasor Magnitude Phase A, B, C Currents
RMS 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
Magnitude Accuracy: ± 0.5% of reading or ± 0.2% of rated (whichever is greater) from 0.1 to 2.0 × CT

SYNC. MOTOR METERED VALUES

AC Field Voltage (brush-type motors only)

Parameter: SM Field VAC
Range: 0.00 to 1000.00 VAC prior to VDN (primary voltage)
Accuracy: <± 1% of full scale reading

DC Exciter Voltage

Parameter: SM Field VDC
Range: 0.00 to 350.00 VDC prior to VDN (primary voltage)
Accuracy: <± 1% of full scale reading

DC Field Current IF

Parameter: SM Field Amps
Range: 0.00 to 3000.00 (primary)
Accuracy: <± 1% of full scale reading

AC Field Voltage Frequency

Parameter: K2-FLD VAC Frequency

Range: 0.5–72 Hz (Field VAC >30 V primary)1–72 Hz (Field VAC >15 V primary)2-72 Hz (Field VAC >10 V primary)

Accuracy: +/- 3mHz (30V<Field VAC primary)+/- 15mHz (15V<Field VAC<30V primary)+/- 30mHz (10V<Field VAC<15V primary)

Rotor Slip

Source: AC Field Voltage VF ~

Range: 0.0 to 120.0% of nominal frequency (60Hz or 50Hz)

Accuracy at 2 to 85 V (secondary): ± 0.03% of nominal frequency (60Hz or 50Hz)

SM PF Regulator Output

Range: Voltage output ranges: 0/+10V, +/-10V,
Current output ranges: 0/+20mA, 4-20mA

Magnitude Accuracy: Voltage mode: <±0.5% of full scale reading
Current mode: <±0.5% of full scale reading

SM PF Error

Range: -1.00 to 1.00

Accuracy: ± 0.02 for 50 Hz and 60 Hz; ± 0.05 for 25 Hz

SM Field Resistance

Range: 0.00 to 500.00

Accuracy: <± 1% of full scale reading

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 × CT
± 1.0% of reading > 2.0 × CT
Angle Accuracy: .... 2° (3° for 25 Hz)

For 50:0.025 CT between 0.5A to 15A:

CBCT Angle Accuracy:............ ± 25°

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 × CT: ± 0.020 Hz (input frequency 15 to 70 Hz);
I > 0.4 × CT: ± 0.01 Hz (input frequency 15 to 70 Hz)

CURRENT AND VOLTAGE HARMONICS

Parameters:............ Magnitude of each harmonic and THD
Range:............ 2nd to 25th 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%

NOTICE

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
Conversion Range:	Standard CT: 0.02 to 46 × CT rating RMS symmetrical CBCT (50:0.025): 0 to 15 A
Short Term CT Withstand:	1 second at 100 × rated current 2 seconds at 40 × rated current continuous 3 × rated current
CBCT (50:0.025) Withstand:	continuous 150 mA

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

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.

Sync. Motor Inputs and Outputs

CAUTION

APPLICATION NOTE: VDN (Voltage Divider Network Module).The VDN module must be installed in an electrical enclosure which is not accessible under normal working conditions.

The VDN outer mounting frame must not be bonded to any grounded enclosure. Means of isolation (i.e Nylon screws /washers/spacers) shall be used during installation to avoid any direct bonding to earth ground.

AC FIELD VOLTAGE INPUT

Input Primary (at VDN input terminals): ... 0 to 1000 VAC (1414 Vpk, 2828 Vp-p)
Input Voltage Divider (VDN) Ratio: 11.6:1
Operating Range (at VDN input): .... 0 to 1000 VAC (measured)
Operating Range (at Relay Terminals): ..... 0 to 87 VAC (measured)
Rated Cont. Voltage (at VDN input): 1000VAC
Rated Cont. Voltage (at Relay Terminals): 100VAC
Voltage Accuracy (at VDN input): .... <±3V
Cut-off level: .... 1V (primary)
Burden (Input Impedance or VA): .... 11.3K at relay terminals; 131.3K at VDN and Relay
Terminal counts: .... 2 (Terminals K9 and K10, Bank: SM BNK1-K2)
Frequency Range: .... 0.5–72 Hz (Field VAC >30 V primary)1–72 Hz (Field VAC >15 V primary)2-72 Hz (Field VAC >10 V primary)
Sampling Frequency (samples per cycle): .... 64 samples per power cycle
128 samples per power cycle (available for transient recorder)

DC EXCITER VOLTAGE INPUT

Input Primary (at VDN input): .... 0 to 350 VDC
Input Voltage Divider (VDN) Ratio: 1.18:1
Operating Range (at VDN input): .... 0 to 350 VDC
Rated Continuous Voltage (at VDN input): .... 350 V
Rated Continuous Voltage (at relay terminals): .... 300 V
Maximum Voltage Withstand (at relay terminals): .... 300 V
Accuracy: .... <±1% Full scale Reading
Burden (Input Impedance or VA): .... 3.4 Mohm differential at VDN with Relay
Terminal counts: .... 2 (Terminals K11 and K12, Bank: SM BNK1-K2)
Sampling Frequency (samples per cycle): .... 64 samples per power cycle
128 samples per power cycle (available for transient recorder)

DC FIELD CURRENT IF INPUT

Input Range (Configurable): .... 0 to 20mA, 4 to 20 mA OR 0-10 VDC
Input impedance: .... 246.5 R (Current mode);
>10 K (Voltage mode)
Accuracy: .... Current/Voltage mode; ±1% of Full-Scale Reading at 25°C
Common Mode Voltage: .... +/-10V
Withstand current: 50mA
Use shielded cable: .... GND-ed on both ends
Terminal counts: .... 2 (Terminals K13 and K14, Bank: SM BNK1-K2)
Sampling Frequency (samples per cycle): .... 64 samples per power cycle
128 samples per power cycle (available for transient recorder)

VDC OUTPUT, VPF

Output Range (Configurable): .... 0/+10 V, ±10 V, 0-20 mA, 4-20 mA
Max. load resistance: .... 600 R for Current OUT;
1 K for Voltage OUT
Accuracy: .... ±0.5% of Full scale (Typical 10 mV, maximum 50 mV) for Voltage OUT;
±0.5% of Full scale for Current OUT
Isolation: .... 500 VDC
Refresh Rate: .... 2 ms
Terminal counts: .... 2 (Terminals K15 and K16, Bank: SM BNK1-K2)

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.

CAUTION VDN (Voltage Divider Network module) APPLICATION NOTE: The VDN module must be installed in an electrical enclosure which is not accessible under normal working conditions.

The VDN outer mounting frame must not be bonded to any grounded enclosure. Means of isolation (i.e nylon screws /washers/spacers) shall be used during installation to avoid any direct bonding to earth ground.

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 869 settings to a file on your PC. After the firmware has been upgraded, it is necessary to load this file back into the 869.
- 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 869 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).
- 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

GE
Grid Solutions

869 Motor Protection System

Chapter 2: Installation

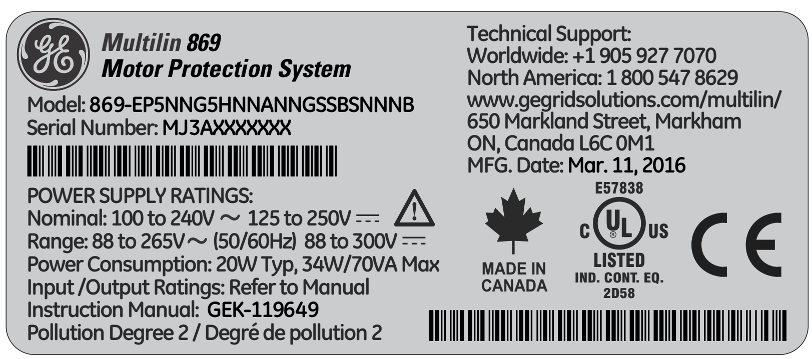
Mechanical Installation

This section describes the mechanical installation of the 869 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 869. This label indicates the product model, serial number, and date of manufacture.

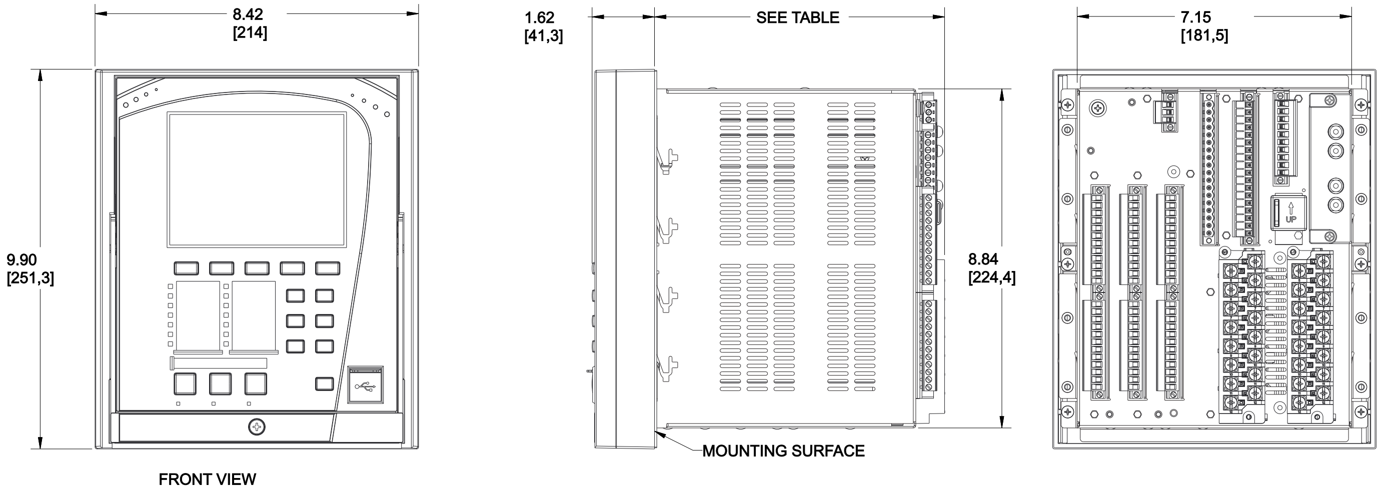
Figure 2-1: Product Label



Dimensions

The dimensions (in inches [millimeters]) of the 869 are shown below. Additional dimensions for mounting, and panel cutouts, are shown in the following sections.

Figure 2-2: 869 Dimensions



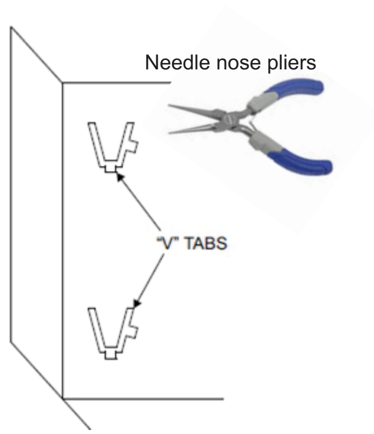
CONNECTOR PLUG TYPE	SCREW CONNECTION LOCATION	MAX DEPTH
RIGHT-ANGLE	SIDE	7.55[191.8]
STRAIGHT	FRONT	7.71[195.8]

Mounting

The 869 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

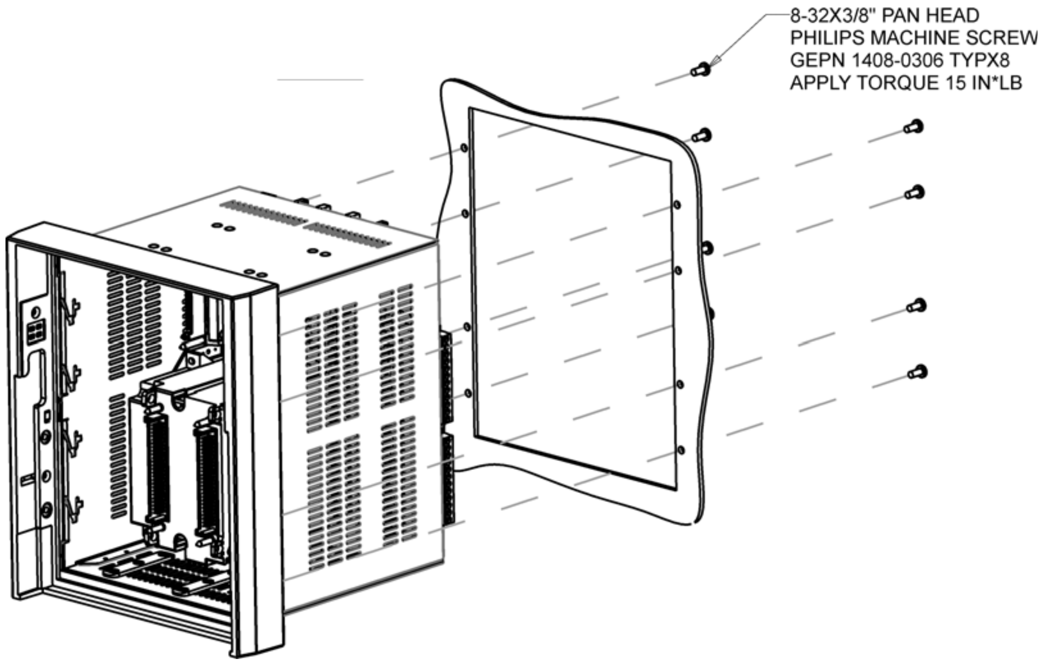
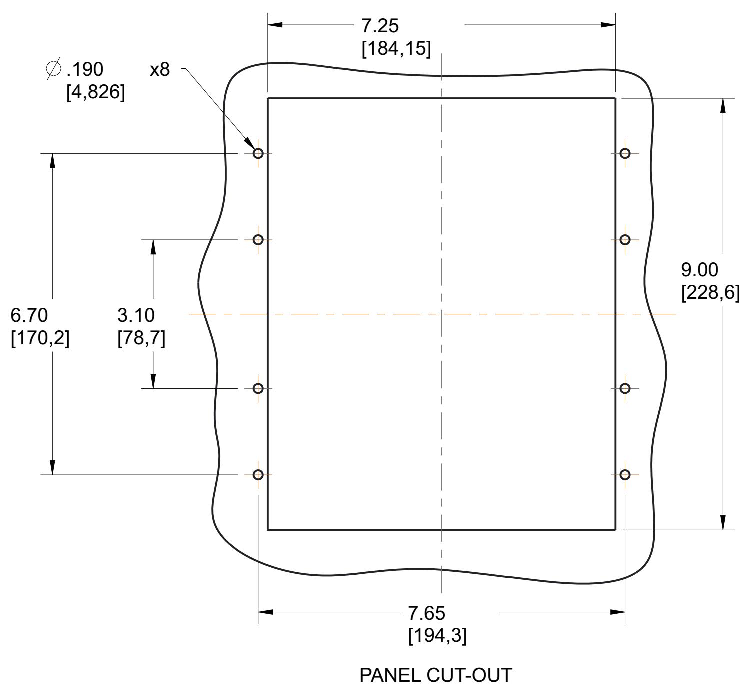


Figure 2-5: Panel cutout dimensions



Depth Reducing Collar

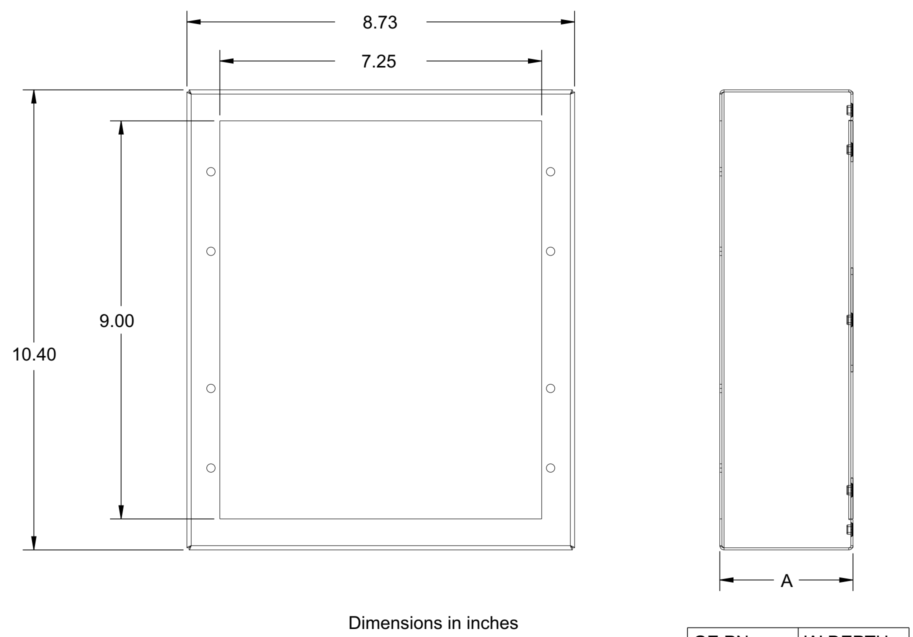
Two different sizes of optional depth reducing collar are available for mounting relays in narrow-depth service panels, or wherever space is an issue.

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"

Figure 2-7: Depth reducing collar panel cutout

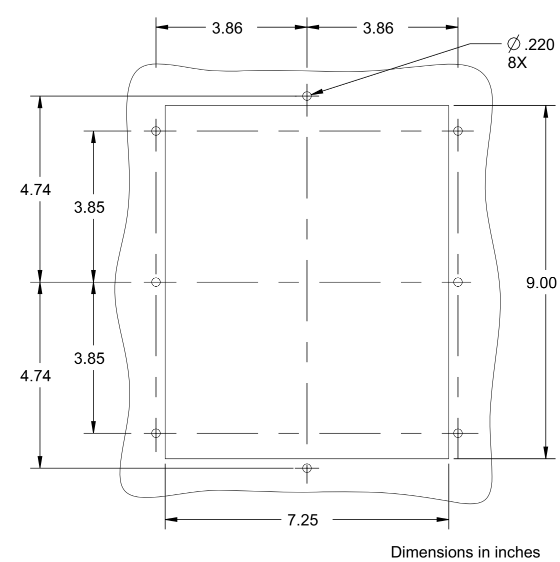
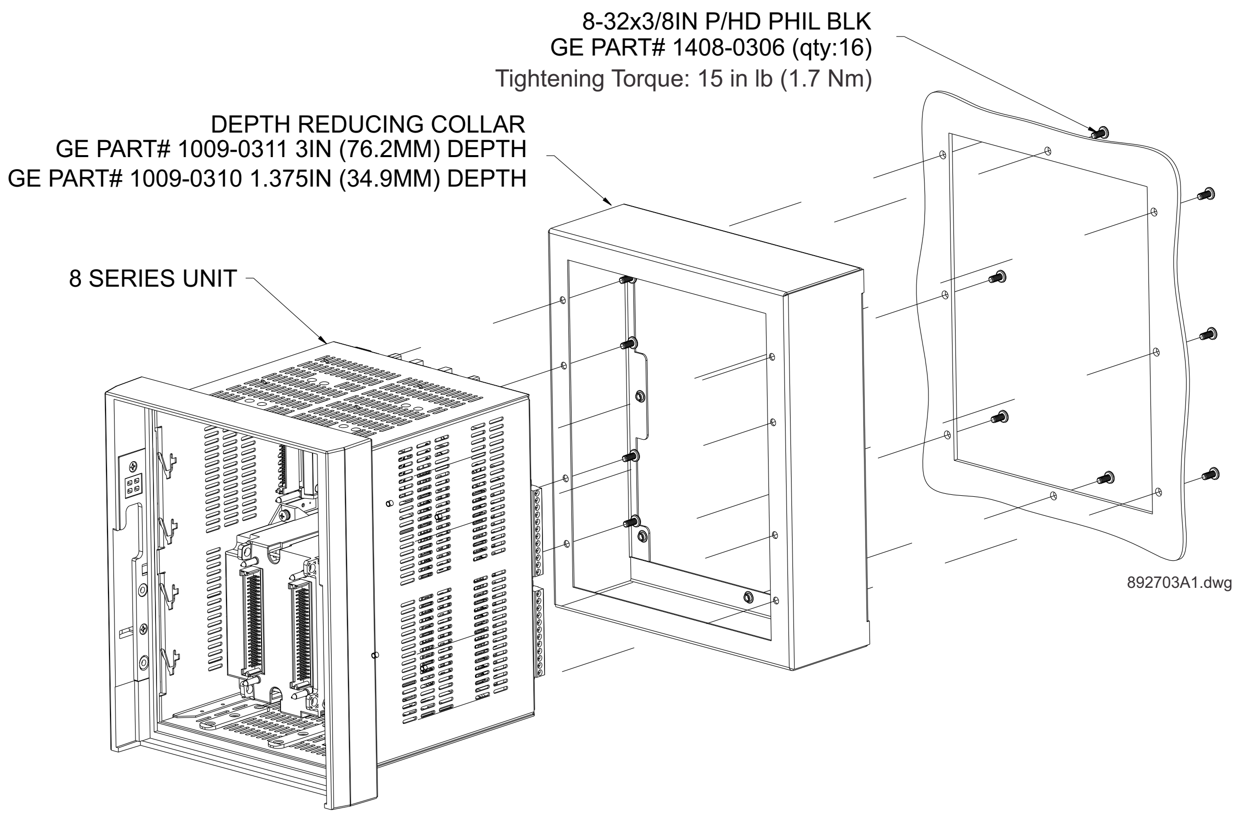


Figure 2-8: Depth reducing collar installation



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

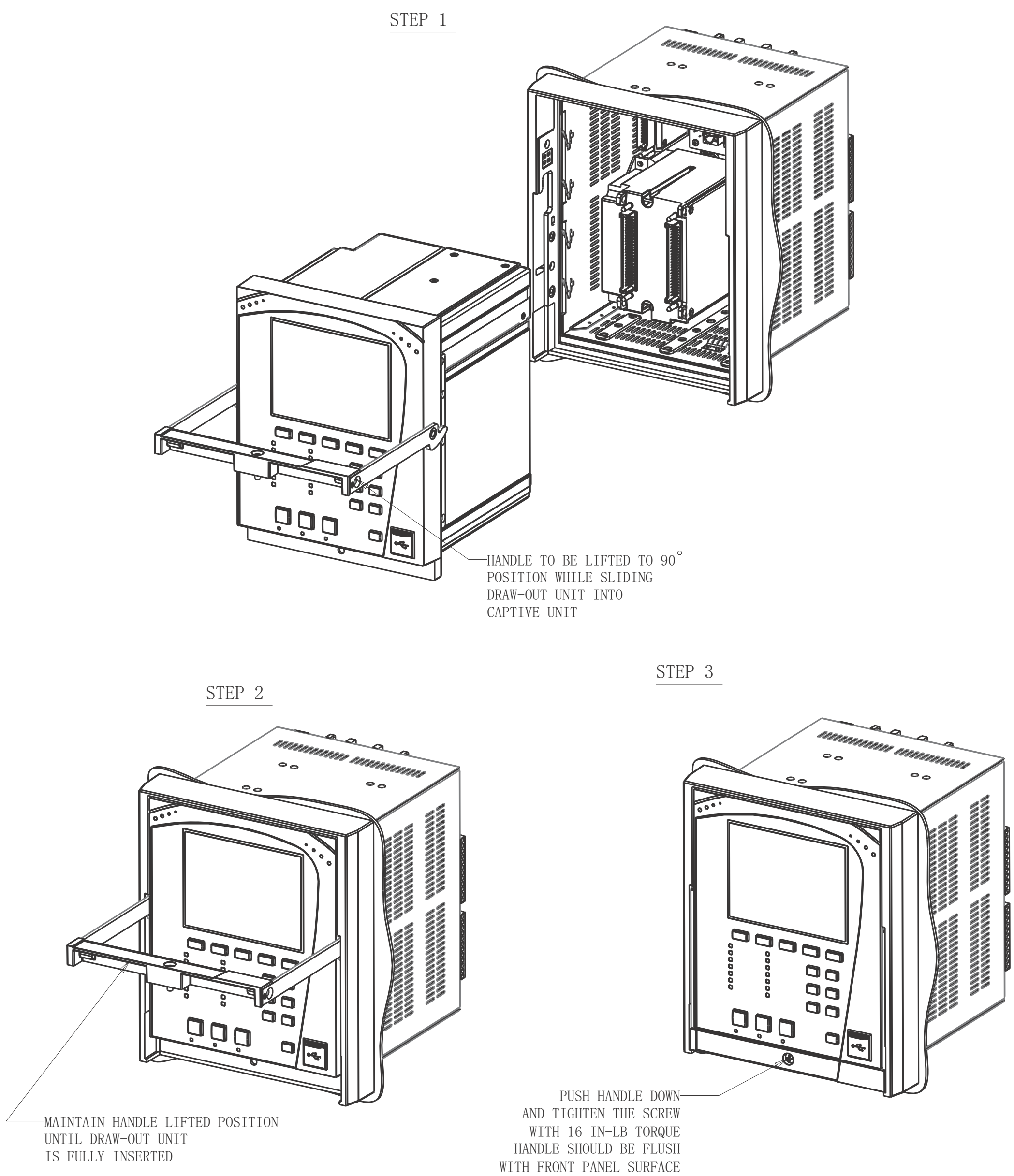
Unit withdrawal and insertion may only be performed when control power has been removed from the unit.

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

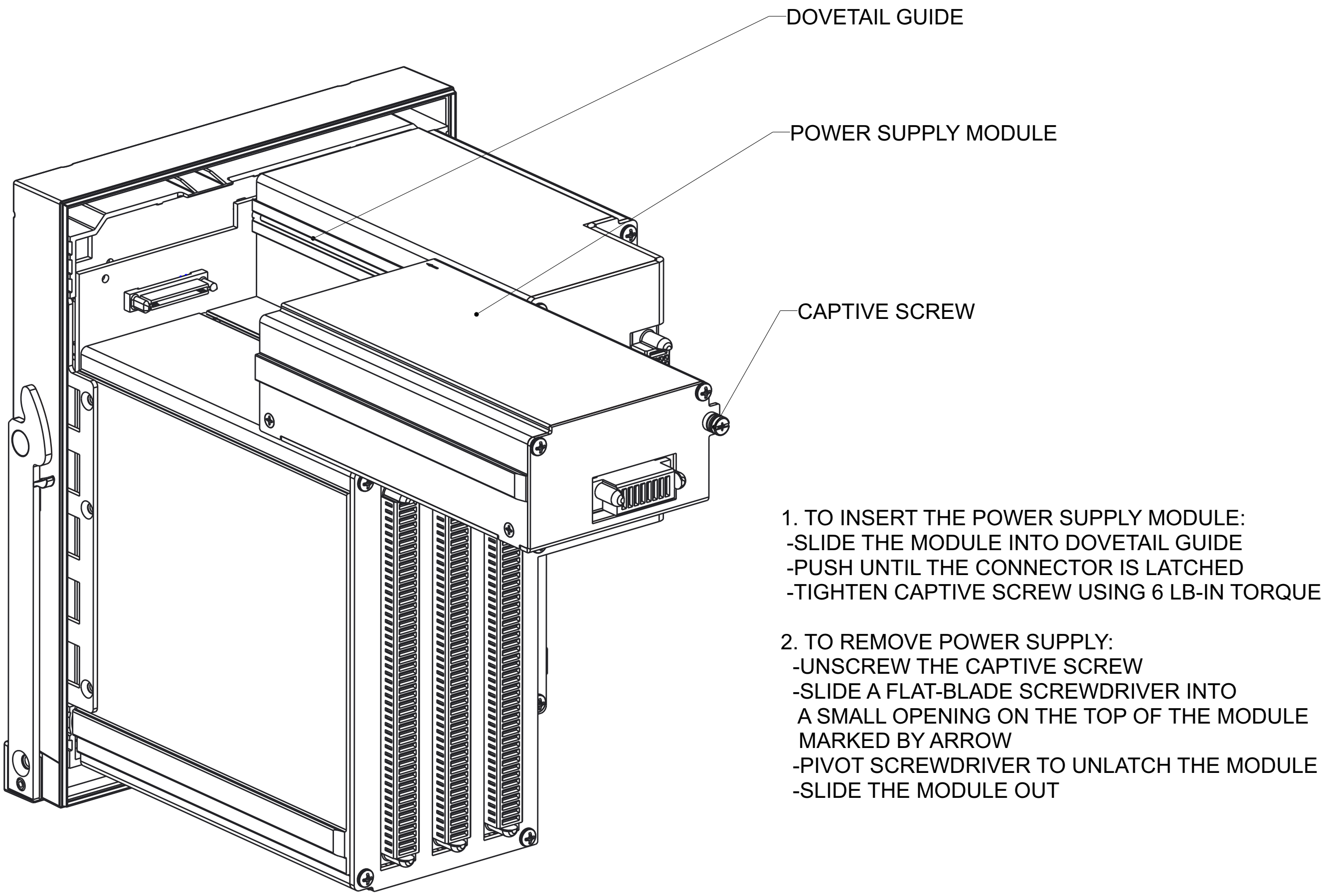
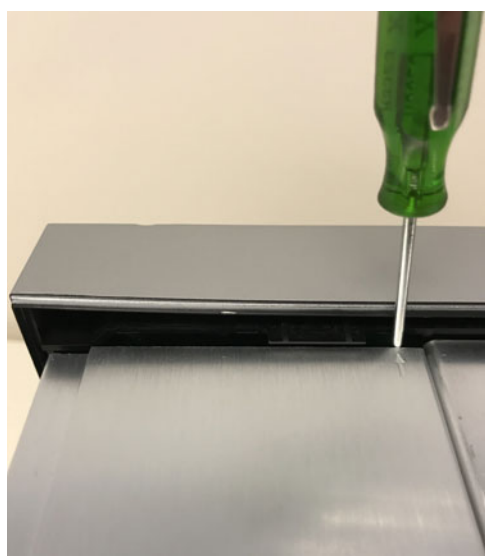


Figure 2-11: Unlatch Module (location is marked by arrow)



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.

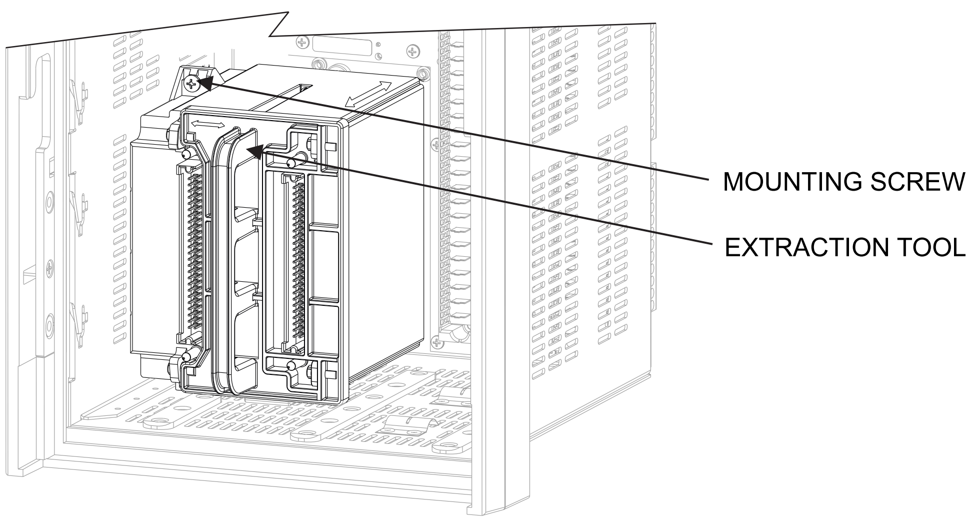
⚠WARNING

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

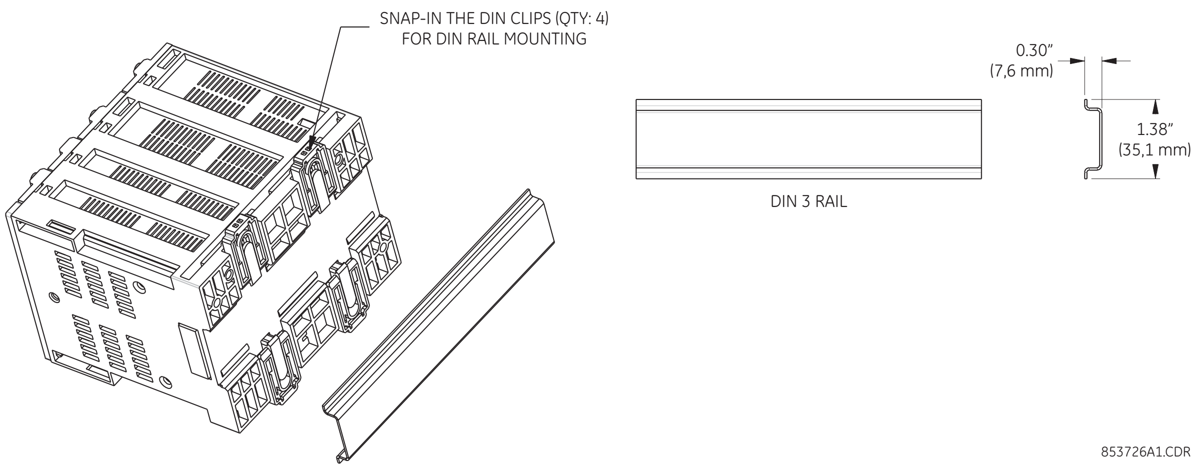


Figure 2-14: RMIO - Base Unit screw mounting

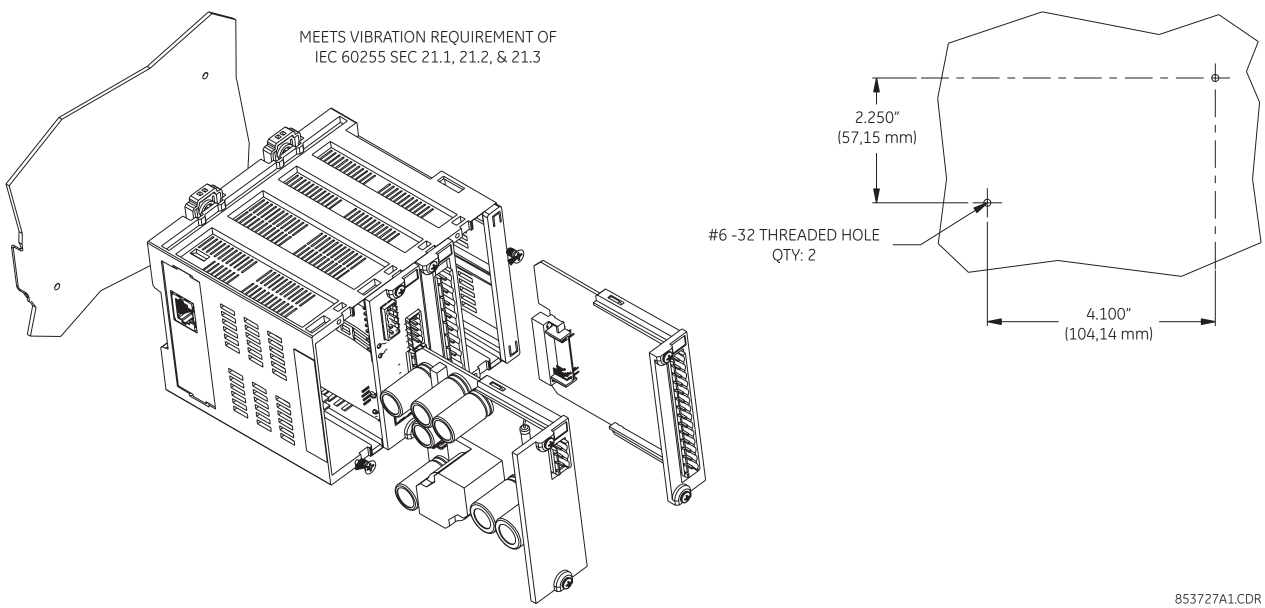
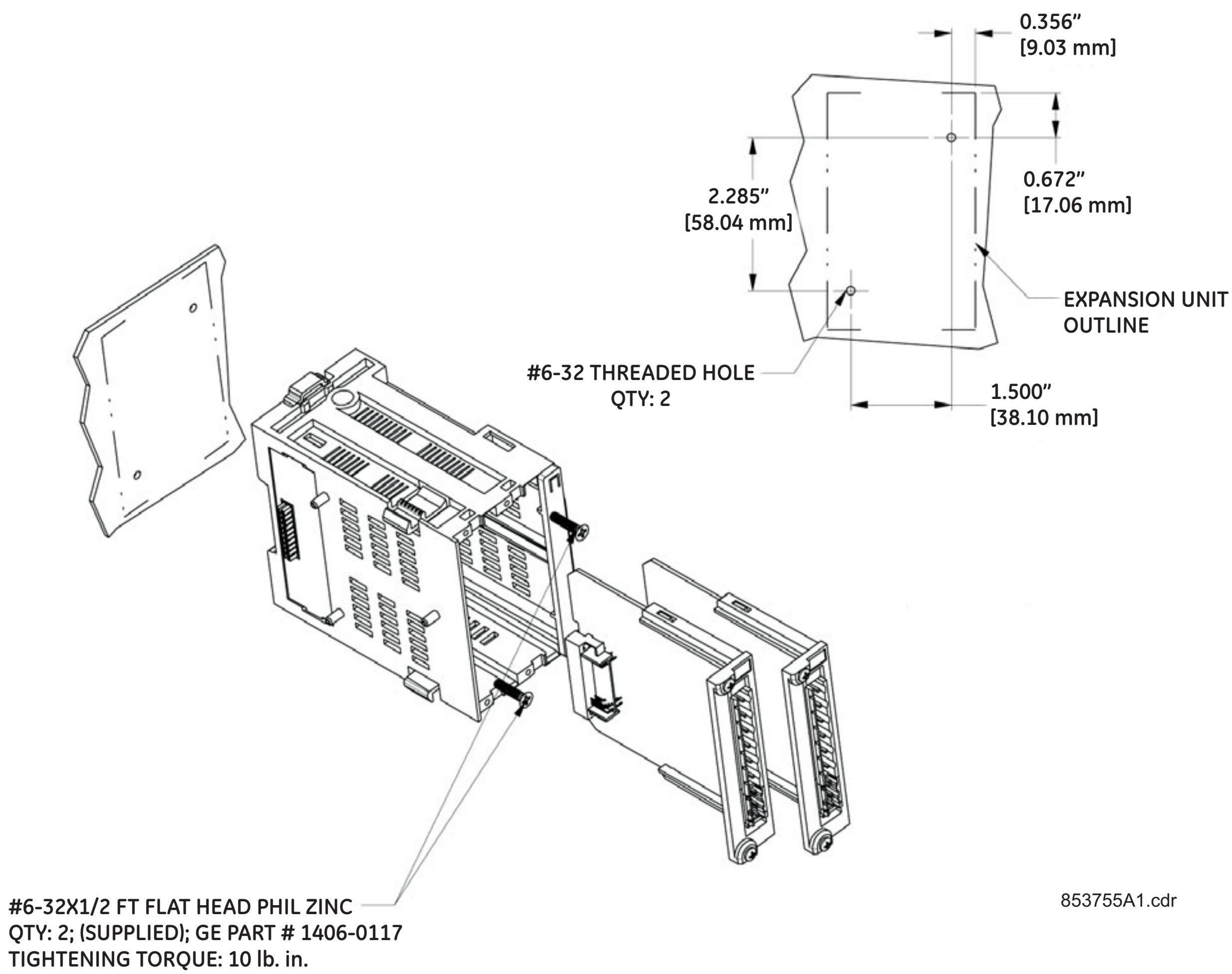


Figure 2-15: RMIO - Expansion Unit screw mounting

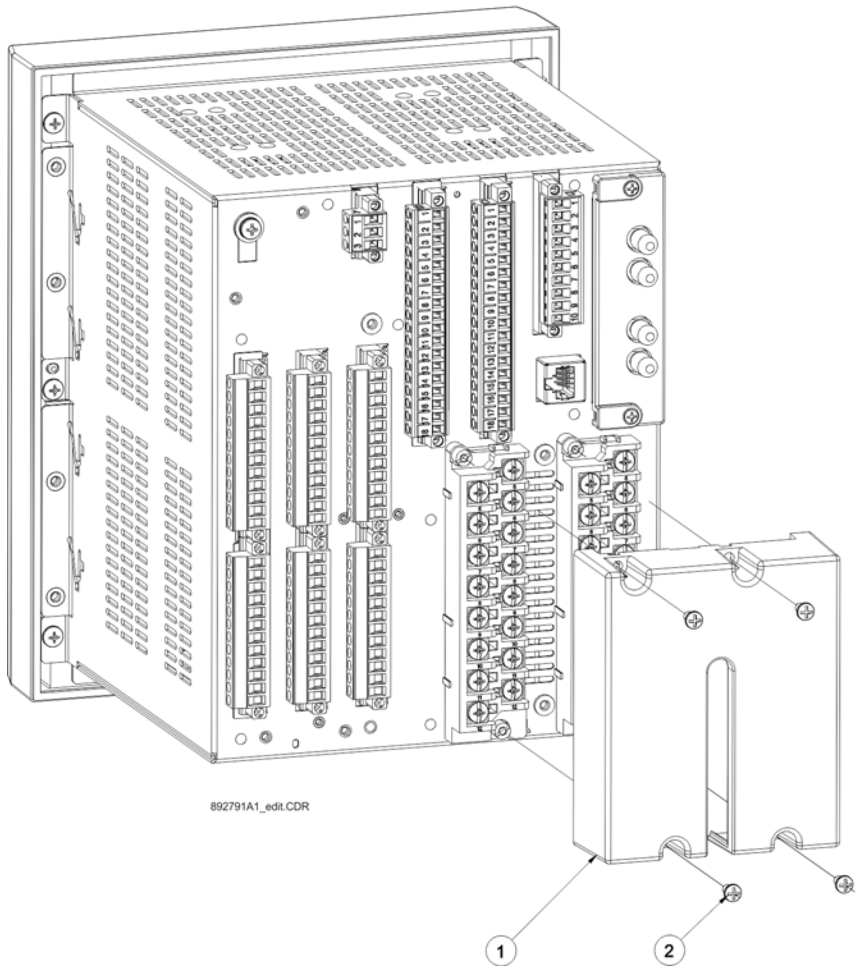


IP20 Back Cover

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

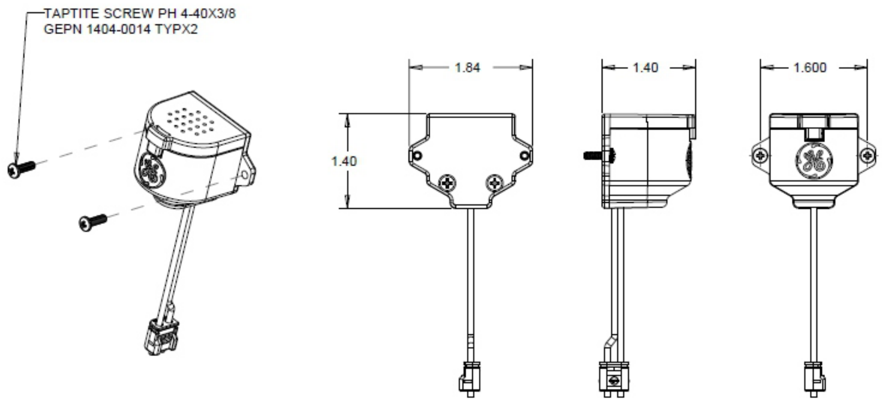
Arc Flash sensor fiber is pressure sensitive and must be handled carefully to avoid damage. Read the following guidelines fully before proceeding.

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

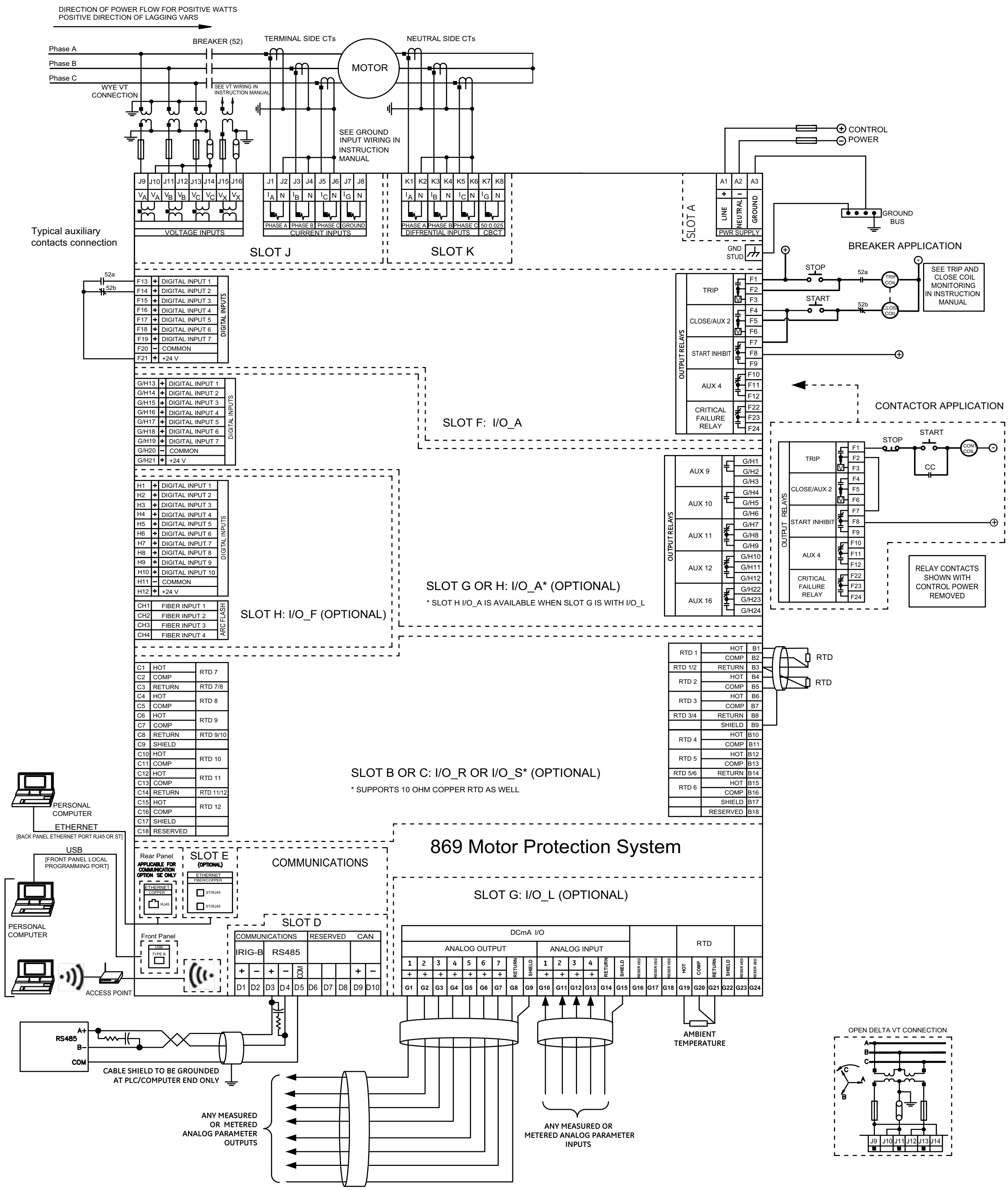
Both the AF sensor connections (CH 1 through CH 4) and the sensor cables are shipped with dust caps in place to avoid dust contamination. The small rubber dust caps must be removed before operation.

Electrical Installation

Typical Wiring Diagram

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

Figure 2-18: Typical Wiring (892769A3)



NOTICE

The TRIP output relay mode depends on the Breaker/Contactor selection. If the selection is "Breaker" the relay is in a non-failsafe mode, if the selection is "Contactor" the relay is in a failsafe mode.

These defaults are applied in EnerVista when you are creating a set point file. If settings are done using the relay's HMI, the user must ensure that the "Operation" set point for the breaker or contactor is as noted above.

Figure 2-19: Typical wiring diagram (contactor application with open transition wye-delta starter)

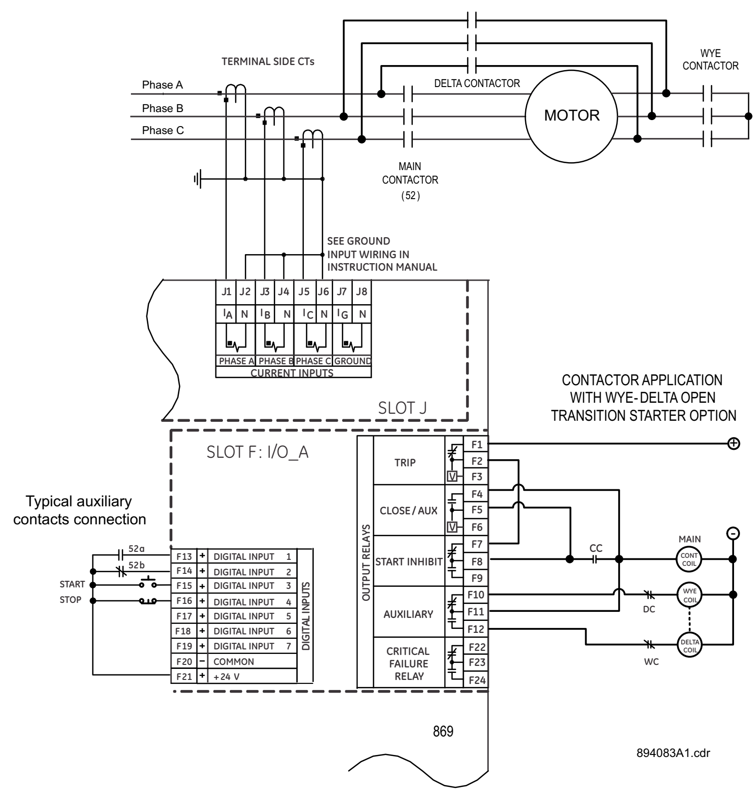


Figure 2-20: Speed2 Motor wiring diagram

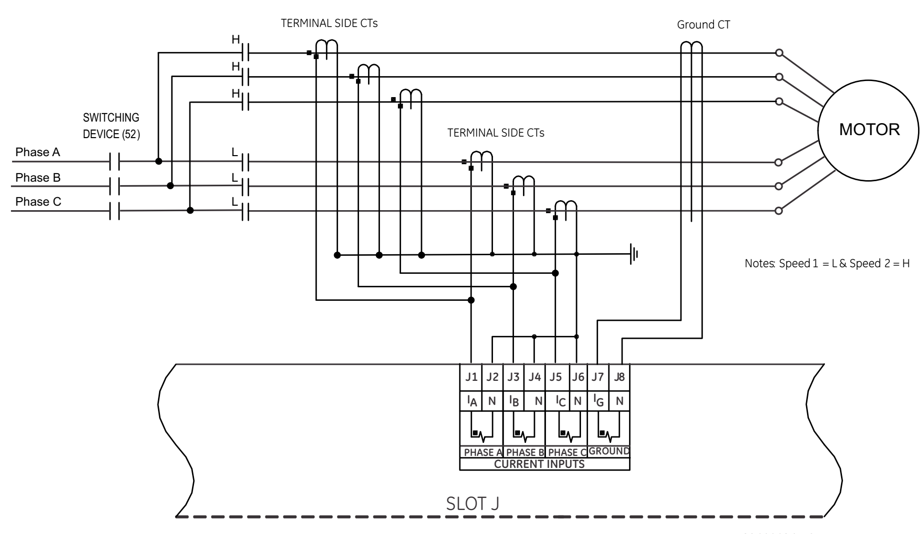


Figure 2-21: Typical wiring Brush-type Motor (892792A1)

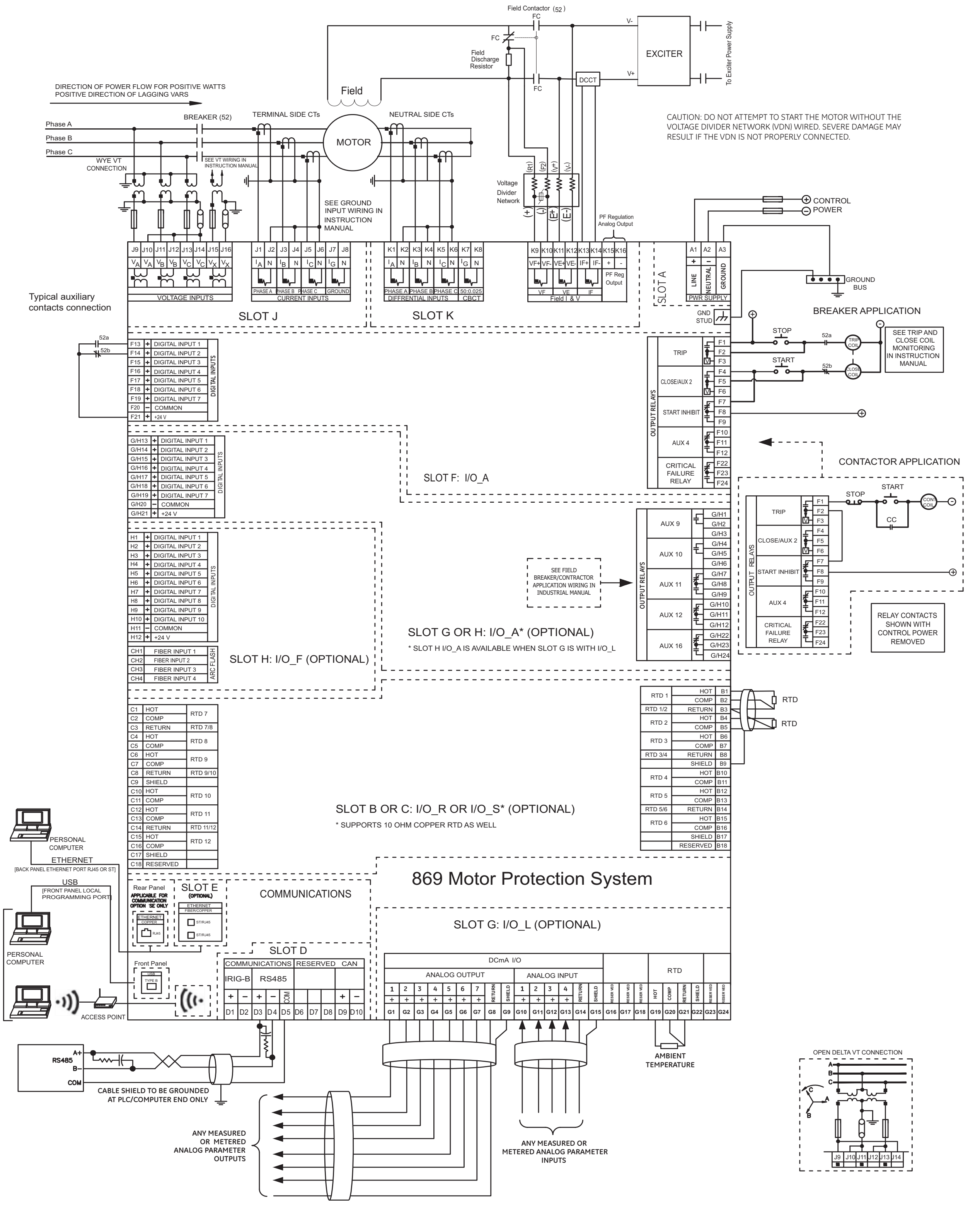


Figure 2-22: Typical wiring Brushless Motor (892793A1)

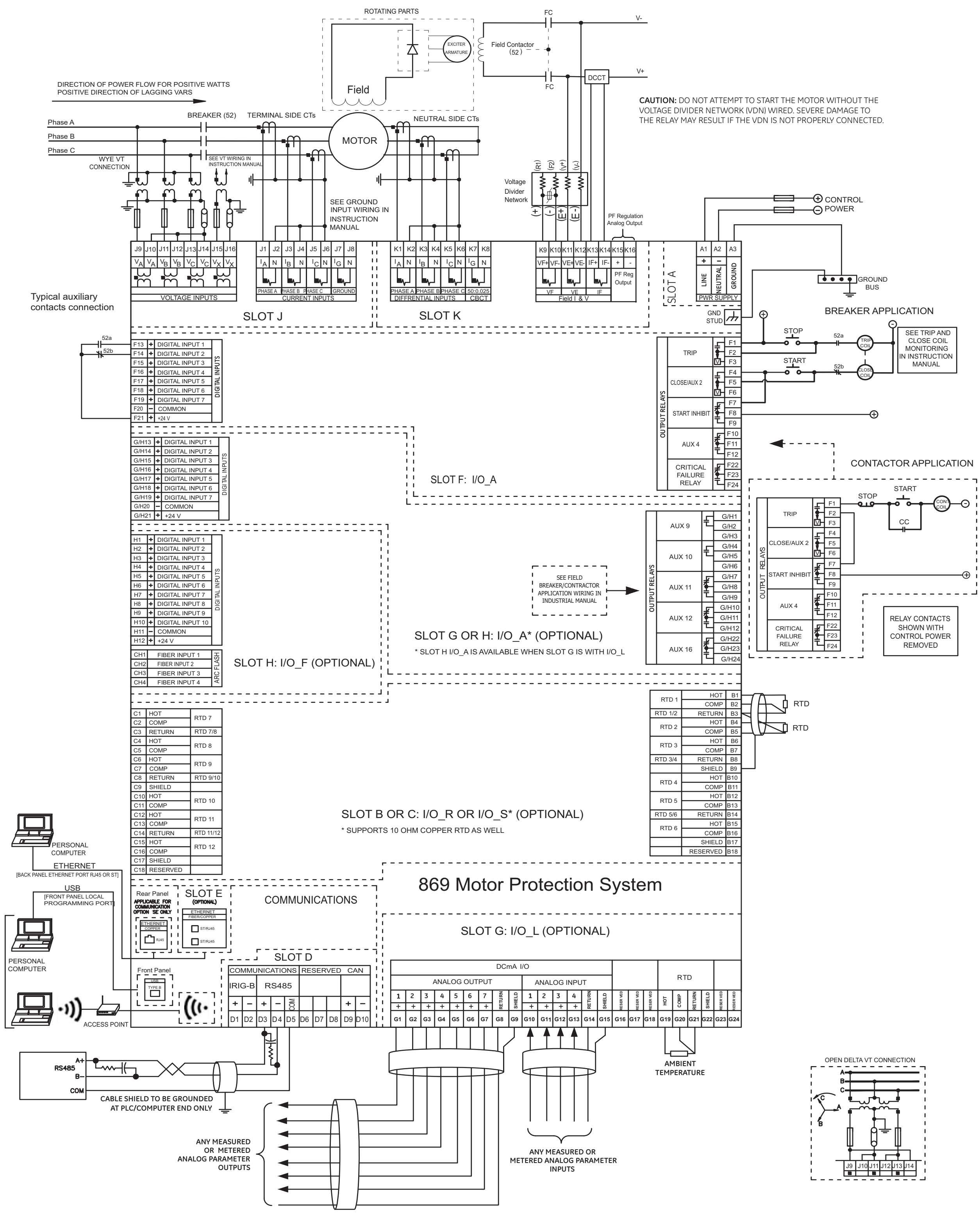
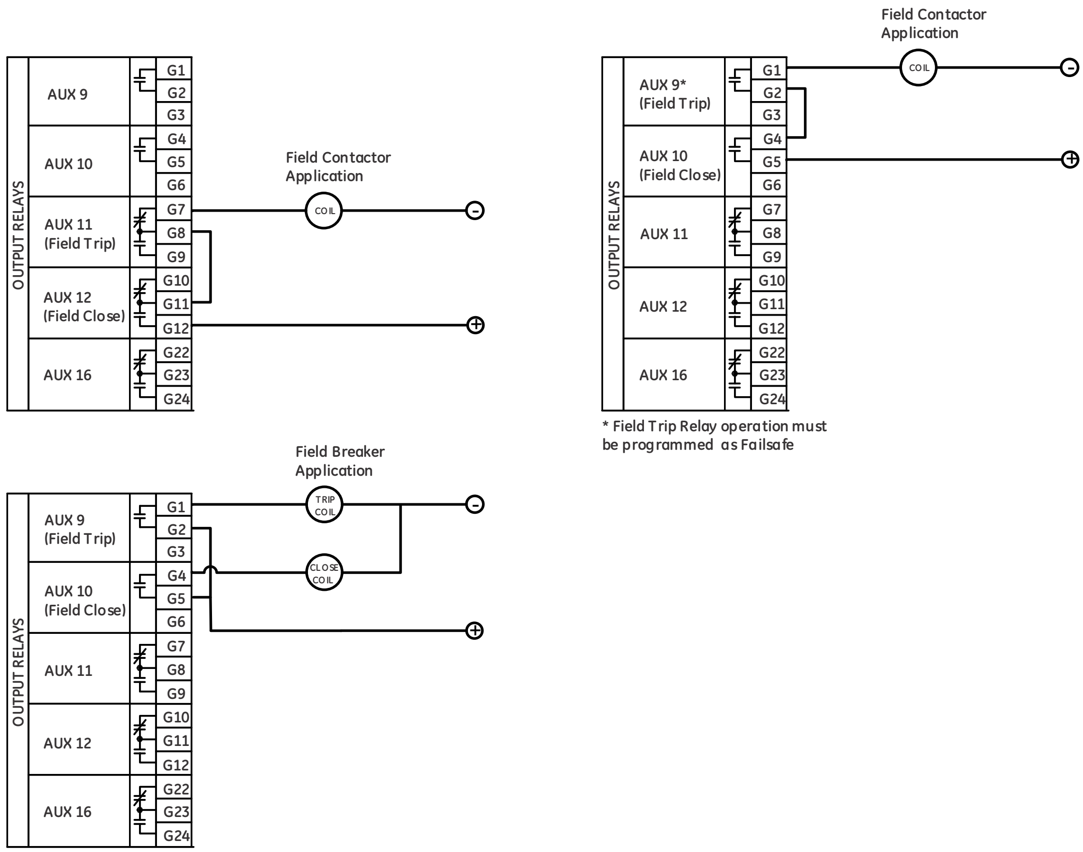


Figure 2-23: Typical wiring diagrams of synchronous motor field switching devices (contactor and breaker)



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 2-24: Orient the Lugs Correctly

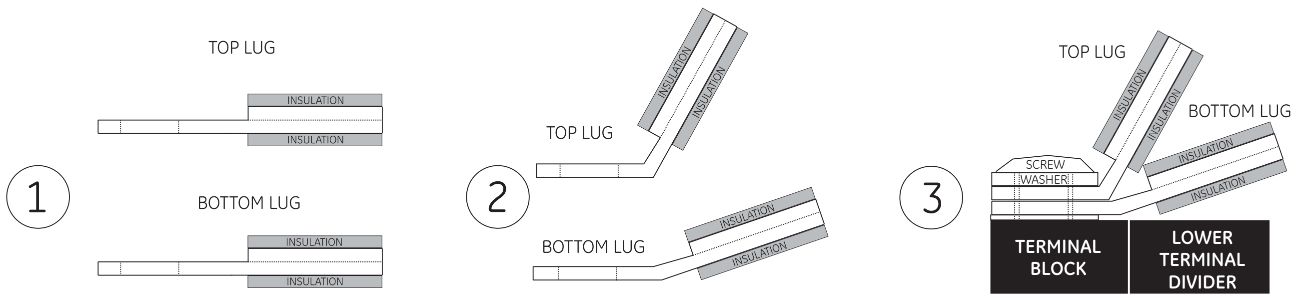


Figure 2-25: Correct Installation Method

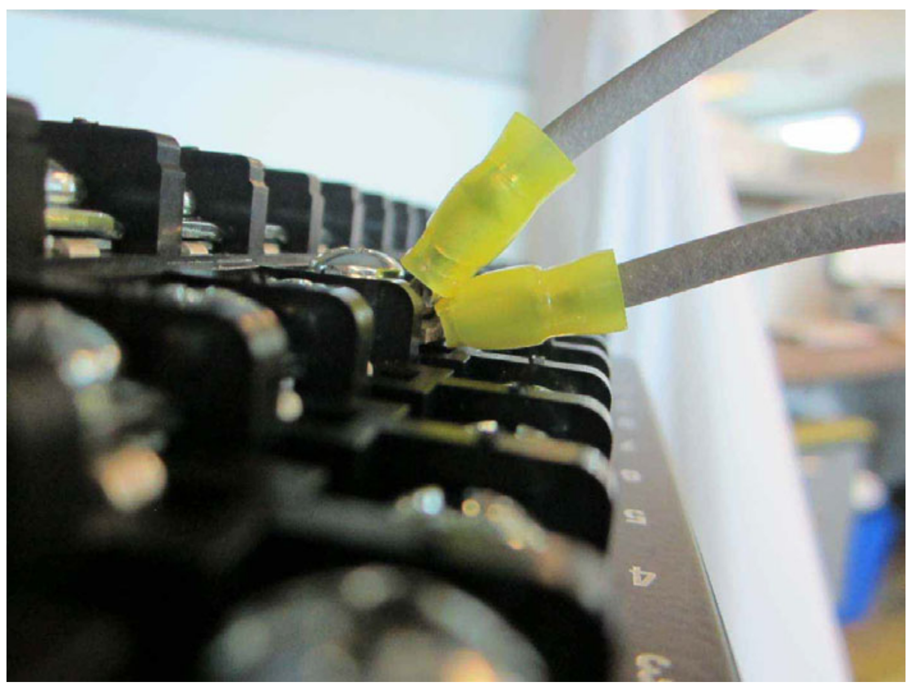
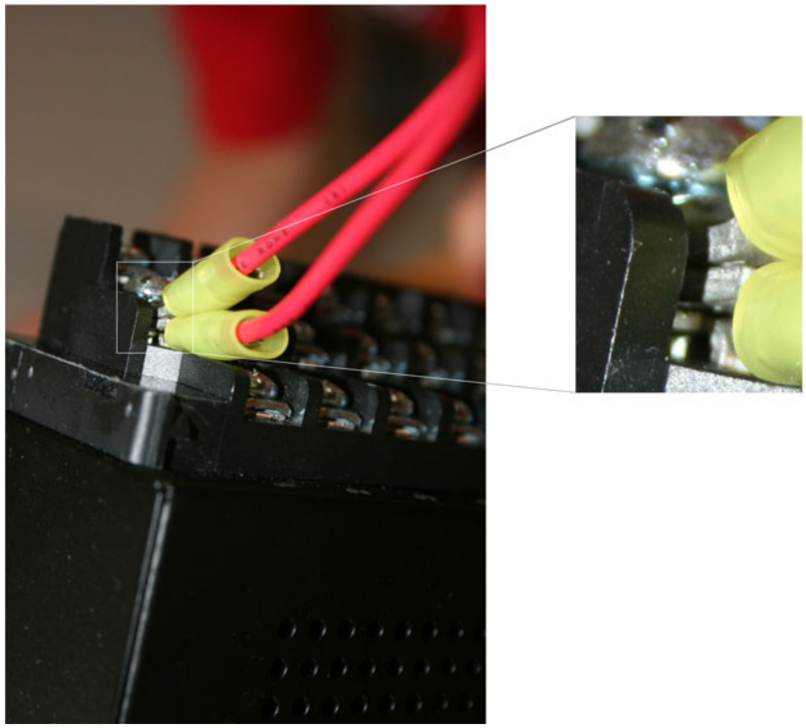


Figure 2-26: INCORRECT INSTALLATION METHOD (lower lug reversed)



A broad range of applications are available for the 869 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 869 Platform.

Figure 2-27: Rear Terminal Layout of the 8 Series Platform

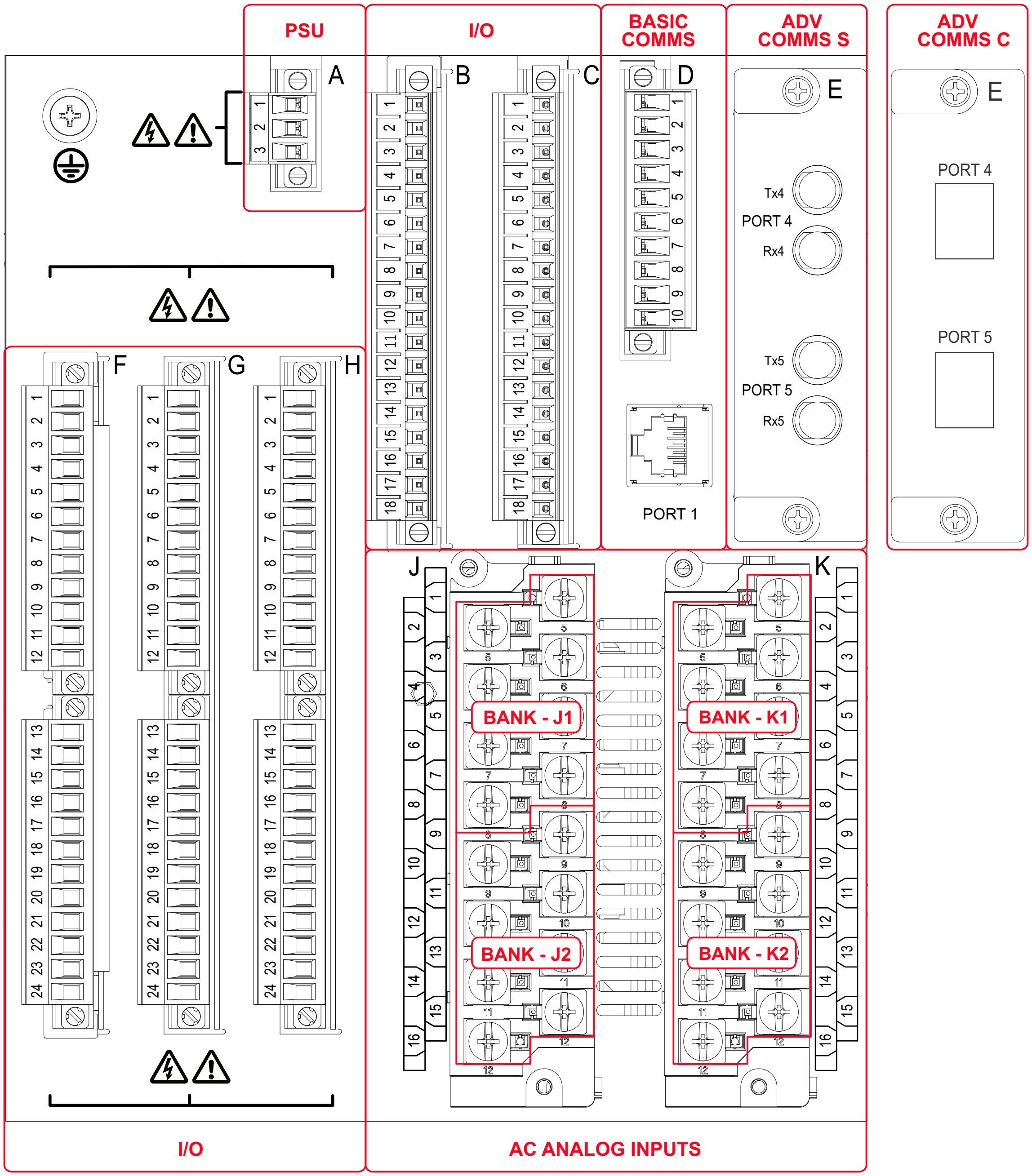


Table 2-1: Power Supply

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 2-28: 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	THRESHOLD SETTING GROUP 1	DIGITAL INPUTS
F/G/H21	+	DC +24V	THRESHOLD SETTING GROUP 1	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	THRESHOLD SETTING GROUP 1	DIGITAL INPUTS
F/G/H21	+	DC +24V	THRESHOLD SETTING GROUP 1	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

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

894213A1.CDR

Figure 2-29: Optional I/O card terminal mappings cont.

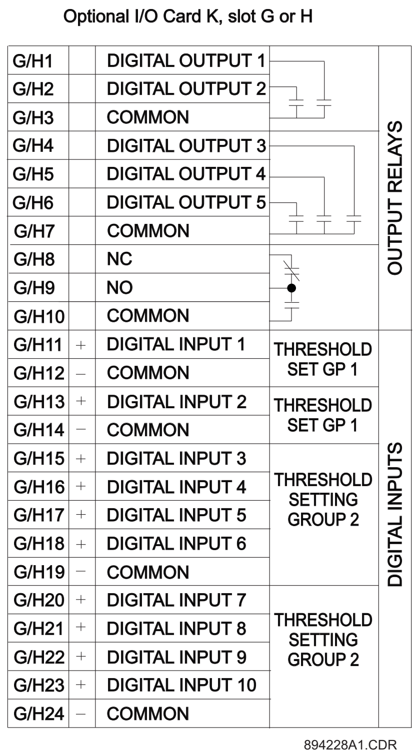


Table 2-4: AC Analog

AC Inputs - 1 X 3-Phase 1/5A CT, 4 VT (Slot J)		AC Inputs - 1 X 3-Phase 1/5A CT, 1x50:0.025A (Slot K - OPTIONAL)		AC Inputs - 1 X 3-Phase CT, SM Field Inputs with DCmA or DCV Field Current Input (Slot K - OPTIONAL)	
Terminal	**Description**	**Terminal**	**Description**	**Terminal**	**Description**
1	CT1 PhA	1	CT2 PhA	1	CT2 PhA
2	CT1 PhA RETURN	2	CT2 PhA RETURN	2	CT2 PhA RETURN
3	CT1 PhB	3	CT2 PhB	3	CT2 PhB
4	CT1 PhB RETURN	4	CT2 PhB RETURN	4	CT2 PhB RETURN
5	CT1 PhC	5	CT2 PhC	5	CT2 PhC
6	CT1 PhC RETURN	6	CT2 PhC RETURN	6	CT2 PhC RETURN
7	CT1 N/G*	7	CBCT_IN (or 50:0.025_IN)	7	CT2 N/G
8	CT1 N/G RETURN*	8	CBCT_RETURN (or 50:0.025_RETURN)	8	CT2 N/G RETURN
9	VT1A IN	9	RESERVED	9	AC Field Voltage Input VF +
10	VT1A RETURN	10	RESERVED	10	AC Field Voltage Input VF -
11	VT1B IN	11	RESERVED	11	DC Exciter Voltage Input VE +
12	VT1B RETURN	12	RESERVED	12	DC Exciter Voltage Input VE -
13	VT1C IN	13	RESERVED	13	DC Field Current Input IF +
14	VT1C RETURN	14	RESERVED	14	DC Field Current Input IF -
15	VT1N IN	15	RESERVED	15	DC PF Regulator Voltage Output PFVout +
16	VT1N RETURN	16	RESERVED	16	DC PF Regulator Voltage Output PFVout -

AC Inputs - 1 X 3-Phase 1/5A CT, 4 VT (Slot J)		AC Inputs - 1 X 3-Phase 1/5A CT, 1x50:0.025A (Slot K - OPTIONAL)		AC Inputs - 1 X 3-Phase CT, SM Field Inputs with DCmA or DCV Field Current Input (Slot K - OPTIONAL)	
Terminal	**Description**	**Terminal**	**Description**	**Terminal**	**Description**
* If Ground Current option is 0B or 5B:					
7	CBCT_IN (or 50:0.025_IN)				
8	CBCT_RETURN (or 50:0.025_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 2-30: Right-angle plugs with side screw connections

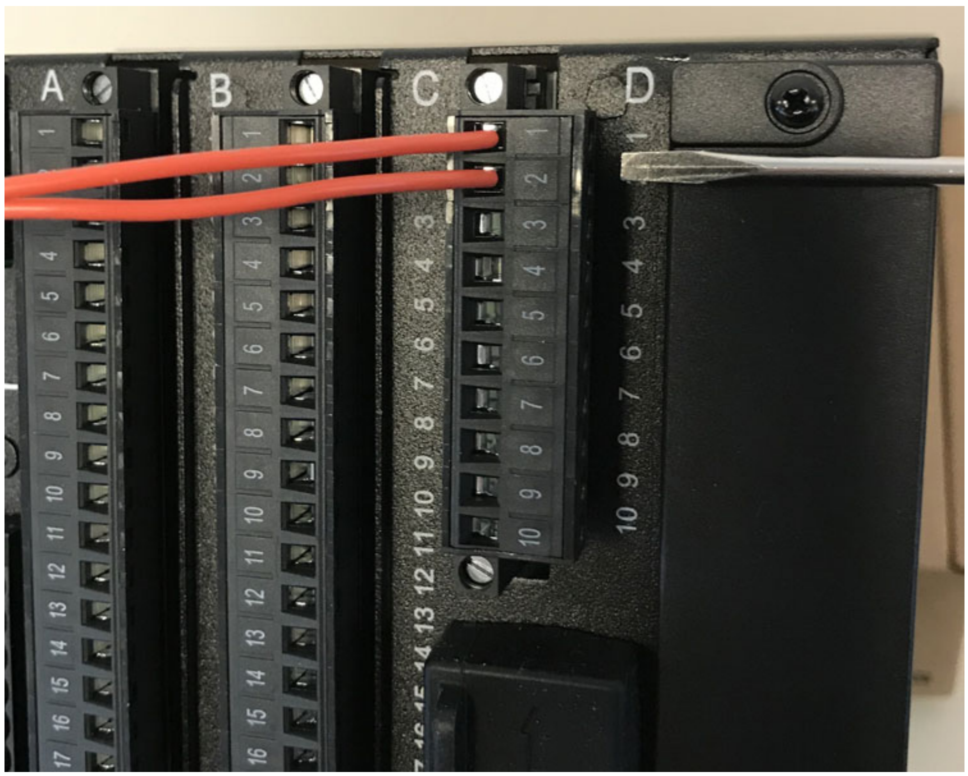
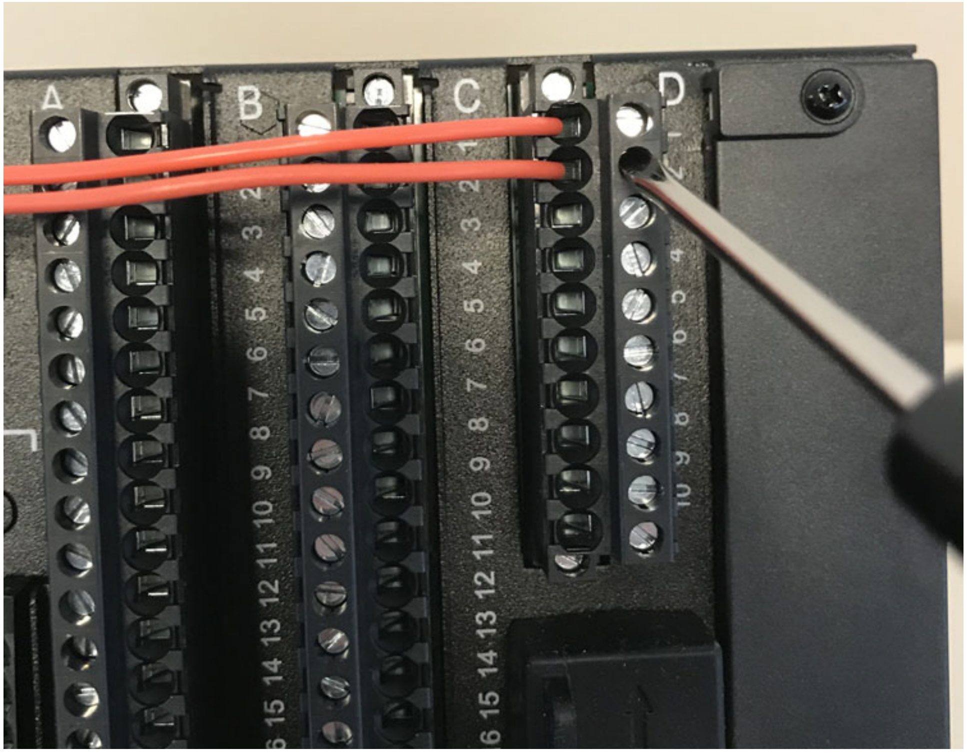


Figure 2-31: Straight plugs with front screw connections



Wire Size

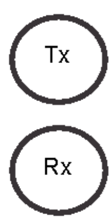
Use the following guideline for wiring to terminal strips A, B, C, D, F, G, H:

- 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 2-32: 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 2-33: RMIO unit showing 2 IO_G modules

Figure 2-34: RMIO terminal identification with 4 IO_G modules

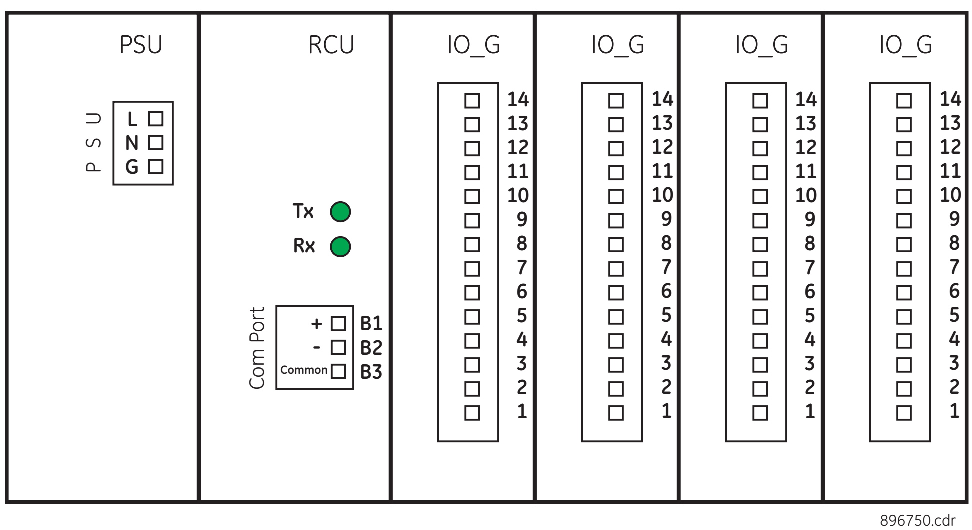
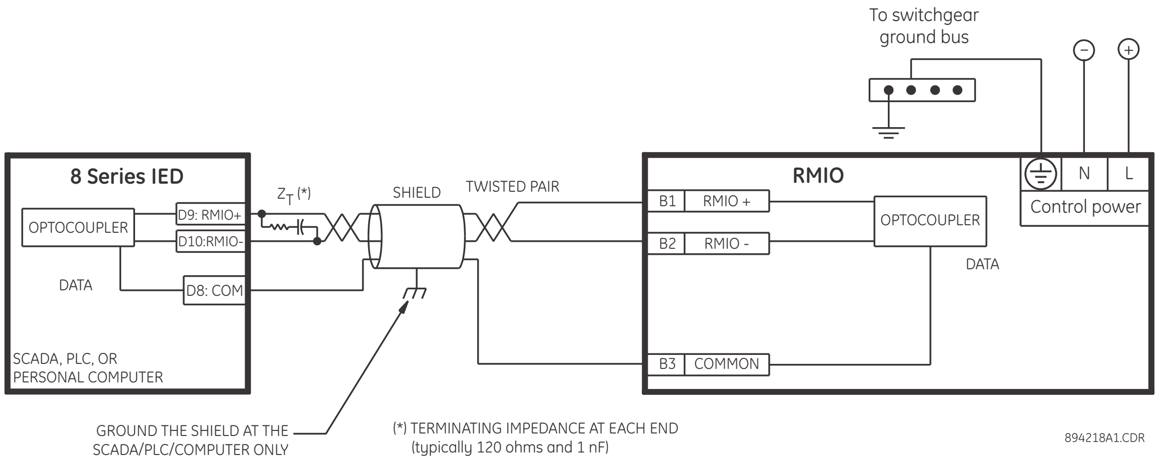


Figure 2-35: RMIO wiring diagram



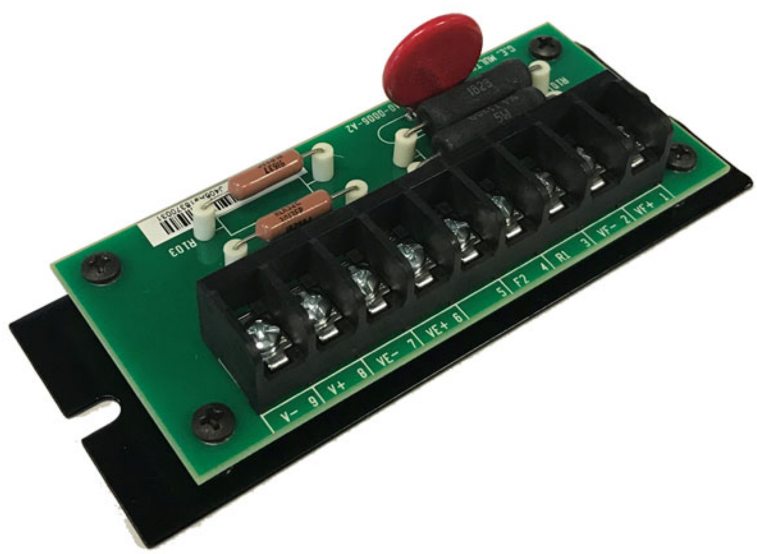
NOTE

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

Voltage Divider Network (VDN) Installation

The VDN is provided as a standard accessory for synchronous motor applications (order code options C5 and D5 only).

Figure 2-36: Voltage network divider (VDN) board

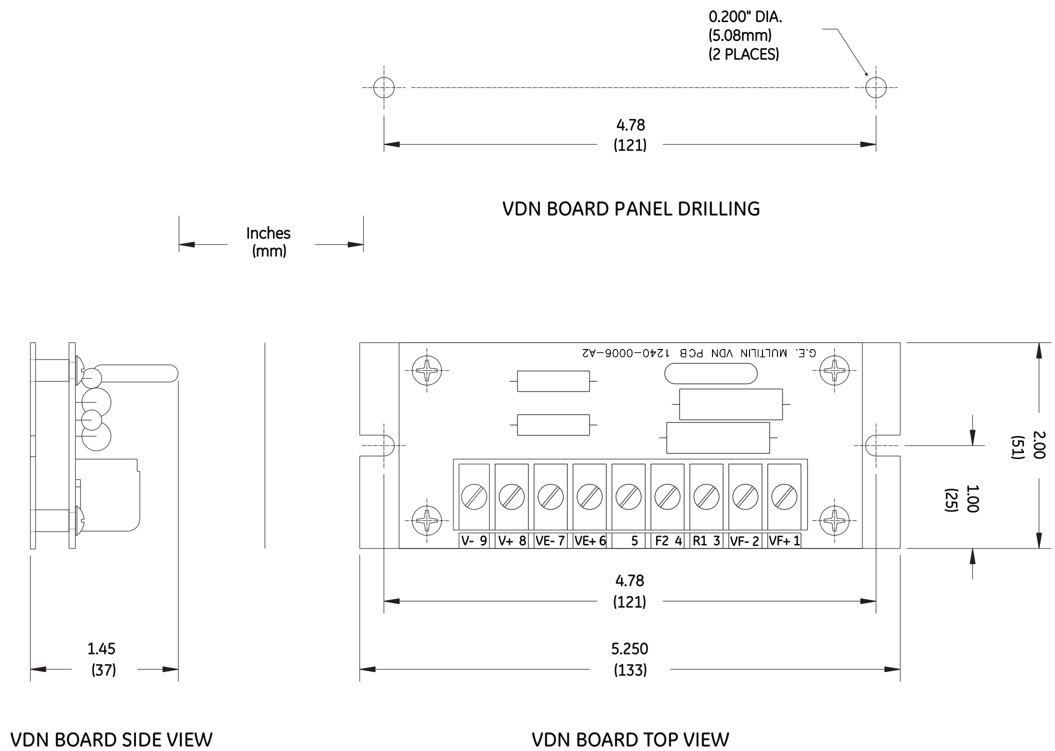


For synchronous motor applications, the field voltage inputs (VF+ and VF-) and the exciter voltage inputs (VE+ and VE-) are connected to the relay via the supplied voltage divider network (VDN).

⚠CAUTION

Do not attempt to start the motor without the voltage divider network (VDN) wired. Severe damage to the relay may result if the VDN is not properly connected.

Figure 2-37: Voltage network divider (VDN) board dimensions and terminal labels



CAUTION

VDN (Voltage Divider Network module) APPLICATION NOTE:

The VDN module must be installed in an electrical enclosure which is not accessible under normal working conditions.

The VDN outer mounting frame must not be bonded to any grounded enclosure. Means of isolation (i.e Nylon screws /washers/spacers) shall be used during installation to avoid any direct bonding to earth ground.

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 lagging vars. The phase sequence is user programmable for either ABC or ACB rotation.

The 869 relay has 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 feeder ground fault current. 869 relay CT inputs are grouped into terminal block assembly, mounted on the rear of the chassis. 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 and Sensitive Ground CT Inputs

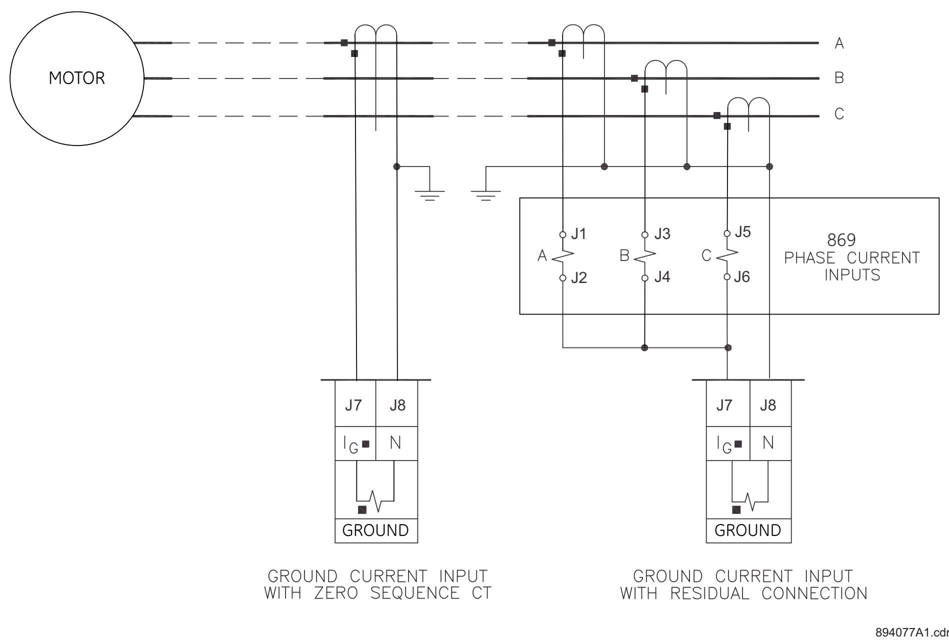
There are two dedicated ground inputs referred to throughout this manual as the Ground Current (1A/5A secondary) and the Sensitive Ground (50:0.025) inputs.

Before planning to make any ground connections, be aware that the relay automatically calculates the neutral (residual) current from the sum of the three phase current phasors, which is used by the Neutral IOC and TOC which are both suitable for the ground fault detection.

The following figures show two possible ground connections using the ground current input (Terminals J7 and J8) and sensitive ground connections using the sensitive ground current input (Terminals K7 and K8).

The ground input (Terminals J7 and J8) is used in conjunction with a zero sequence CT (core balance) as a source, or in the neutral of wye-connected source CTs. When using the residual connection, set the Ground CT Primary setpoint to a value equal to the Phase CT Primary setpoint. Note that only 1A and 5A secondary CTs may be used for the residual connection.

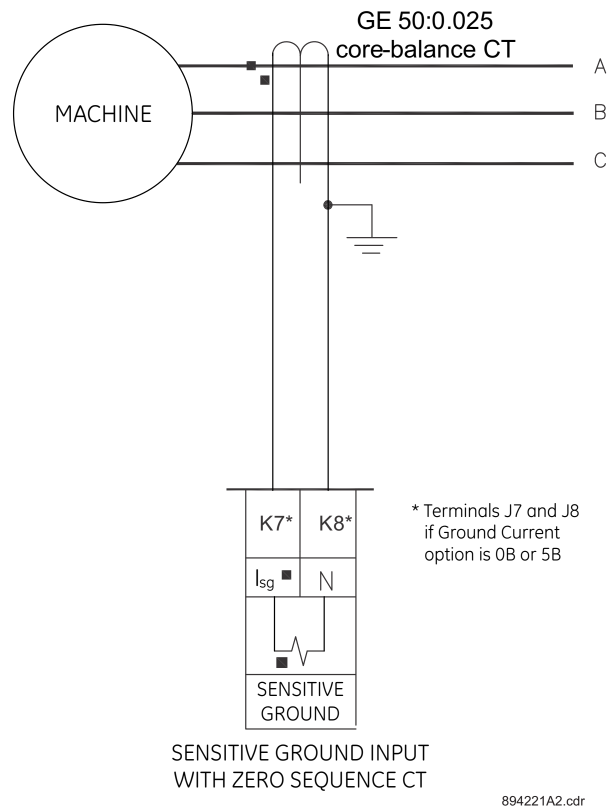
Figure 2-38: Ground Current Input Connections



Alternatively, the 50:0.025 ground CT input has been designed for sensitive ground current detection on high resistance grounded systems where the GE Digital Energy 50:0.025 core-balance CT is to be used.

For example, in mining applications where earth leakage current must be measured for personnel safety, primary ground current as low as 0.5 A primary may be detected with the GE Digital Energy 50:0.025 CT. Only one ground CT input tap must be used on a given unit. Note that when this CT input is selected for the Ground Fault function, fixed ratio of 50:0.025 A is used by the relay.

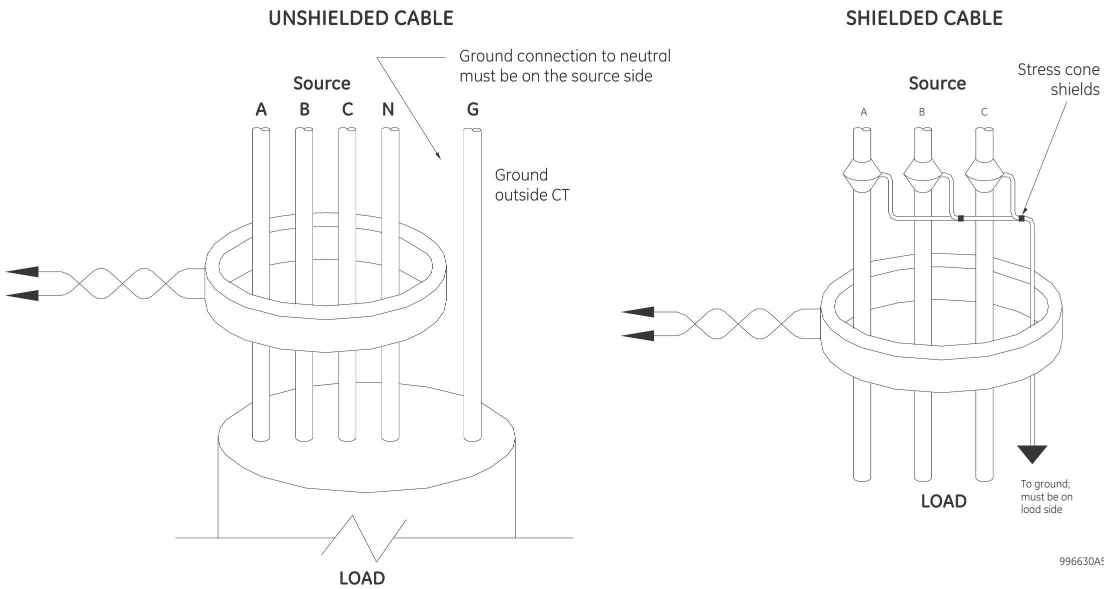
Figure 2-39: Sensitive Ground Current Input Connections



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 2-40: Zero Sequence (Core Balance) CT Installation



Differential CT Inputs

Wiring diagrams for differential input options are depicted in the following figures.

Figure 2-41: Internal Summation Percent Differential Wiring

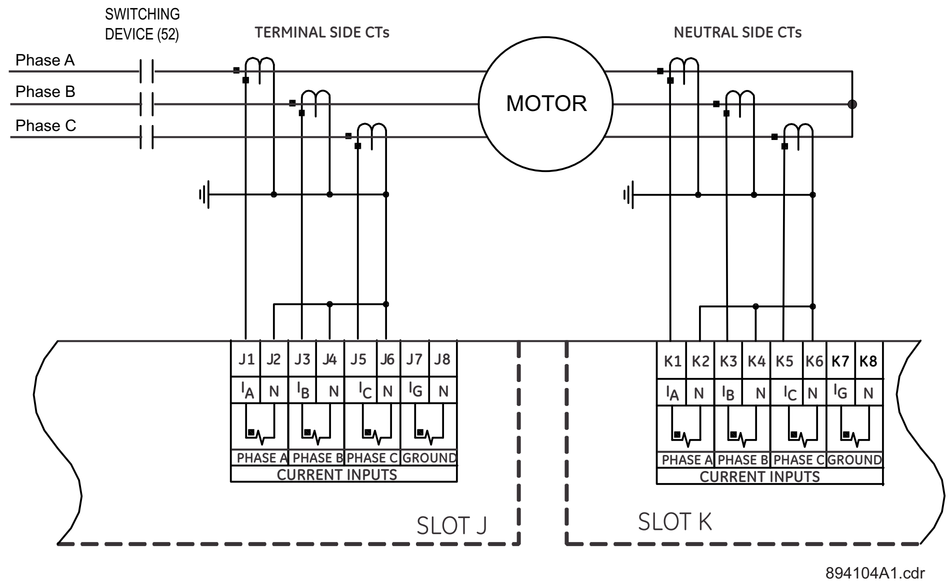


Figure 2-42: External Summation Percent Differential Wiring

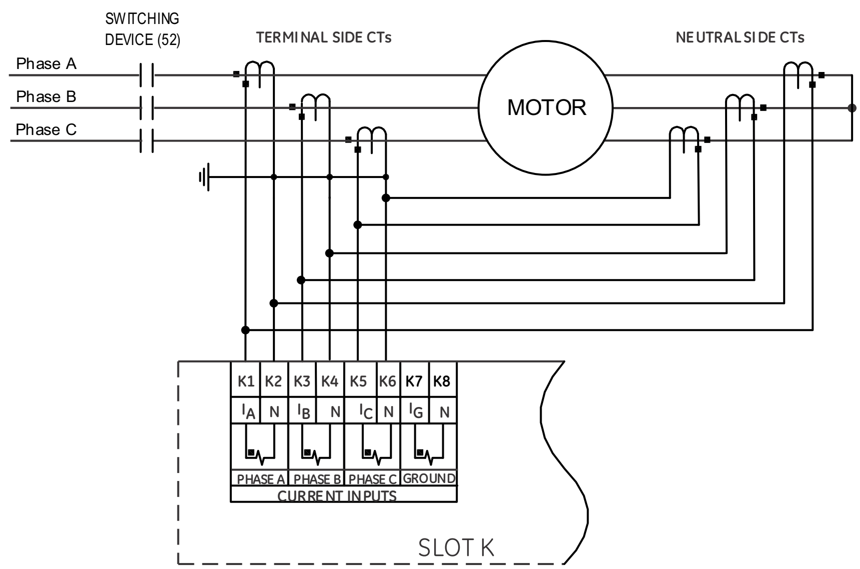
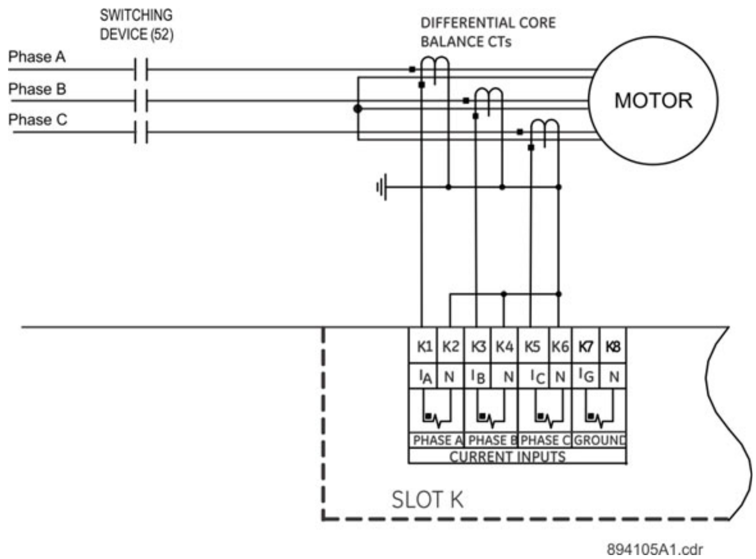


Figure 2-43: Core Balance Percent Differential Wiring

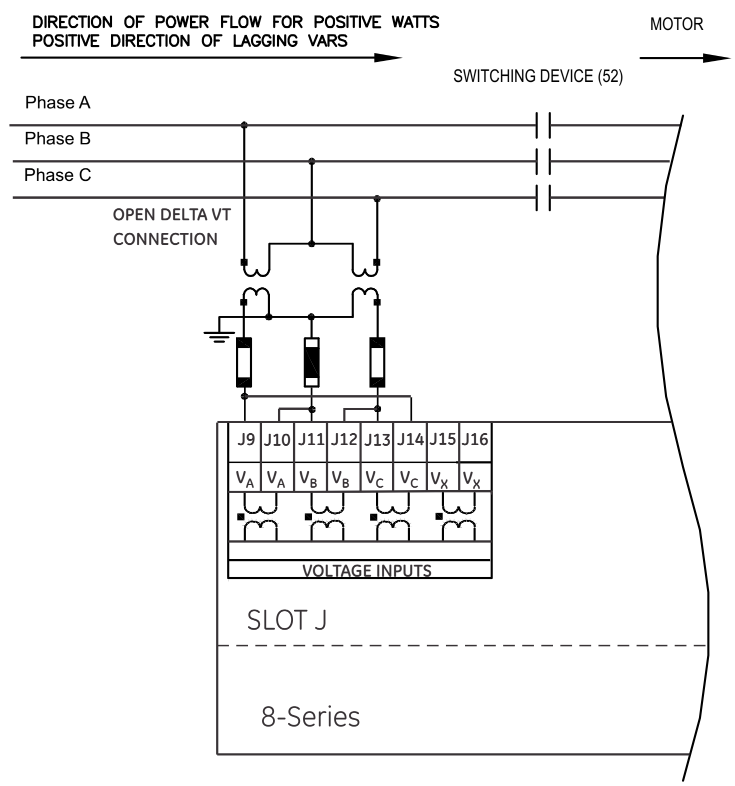


Voltage Inputs

The 869 relays have four channels for AC voltage inputs, each with an isolating transformer. 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 869 supports wye and delta (or open delta) VT connections. The typical open delta VT wiring diagram is shown in the following figure: Open Delta VT Connections. The typical wye VT wiring diagram is shown in the figure: Typical Wiring diagram.

Figure 2-44: Open Delta VT Connections



Control Power

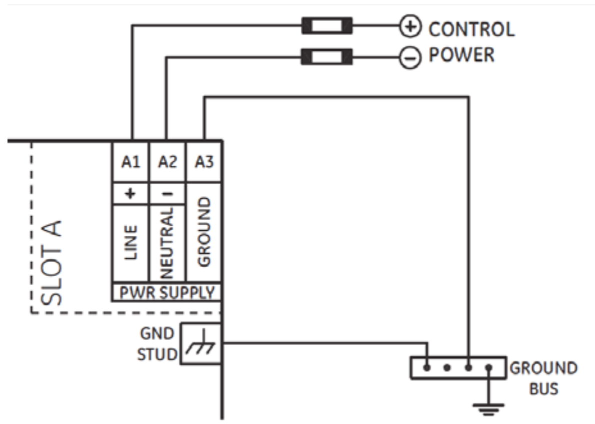
Control power is supplied to the relay such that it matches the relay's installed power supply range.

⚠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 2-45: Control Power Connection



Contact Inputs

Depending on the order code, the 869 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.

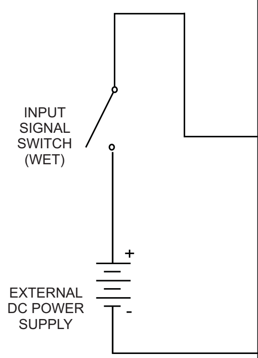
Wet or Dry input signal types can be connected to contact input terminals as shown in the figure: Wet and Dry Contact Input Wiring Examples.

Dry inputs use an internal +24V that is supplied by the 869. The voltage threshold must be set to 17V for the inputs to be recognized using the internal +24V.

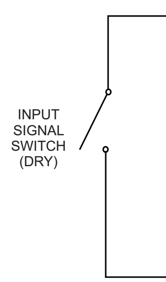
NOTICE

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

Figure 2-46: 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 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
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

Slots F,G,H with I/O options A, A, A			
Terminal #	**SLOT F**	**SLOT G**	**SLOT H**
12	RELAY_4	RELAY_12	RELAY_20
13	Digital In_1	Digital In_8	Digital In_15
14	Digital In_2	Digital In_9	Digital In_16
15	Digital In_3	Digital In_10	Digital In_17
16	Digital In_4	Digital In_11	Digital In_18
17	Digital In_5	Digital In_12	Digital In_19
18	Digital In_6	Digital In_13	Digital In_20
19	Digital In_7	Digital In_14	Digital In_21
20	Common	Common	Common
21	+24V	+24V	+24V
22	RELAY_8	RELAY_16	RELAY_24
23	RELAY_8	RELAY_16	RELAY_24
24	RELAY_8	RELAY_16	RELAY_24

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

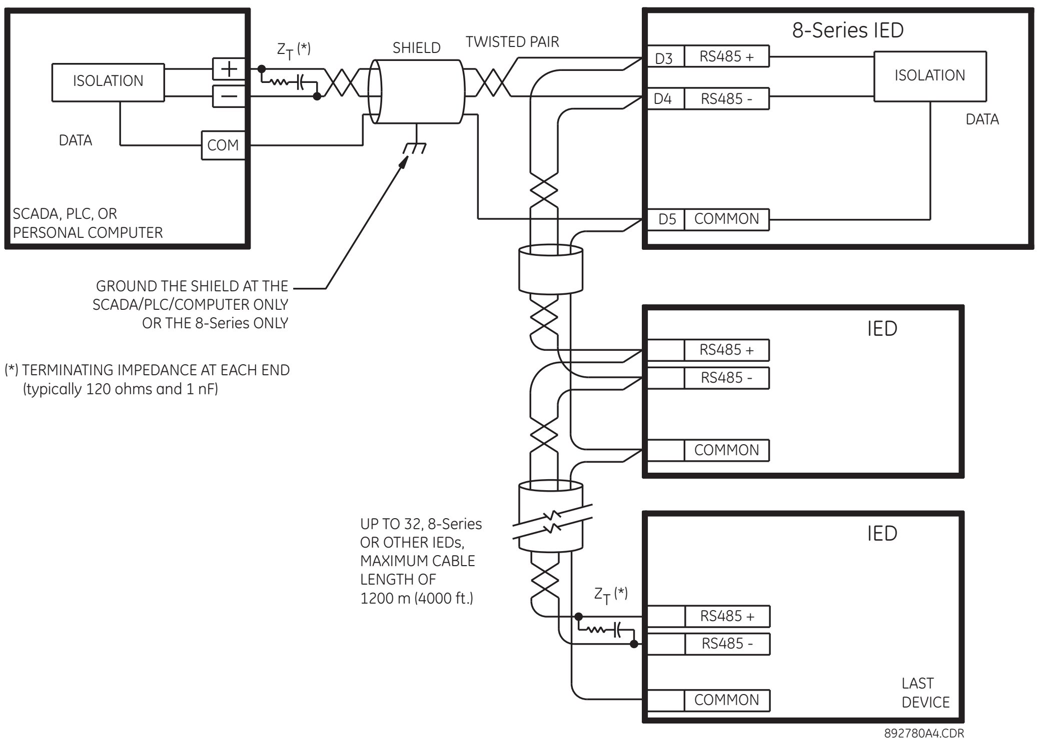
Slots F, G, H with I/O options A, N, F		
Terminal #	**SLOT F**	**SLOT H**
1	RELAY_1	Digital In_8
2	RELAY_1	Digital In_9
3	RELAY_1	Digital In_10
4	RELAY_2	Digital In_11
5	RELAY_2	Digital In_12
6	RELAY_2	Digital In_13
7	RELAY_3	Digital In_14
8	RELAY_3	Digital In_15
9	RELAY_3	Digital In_16
10	RELAY_4	Digital In_17
11	RELAY_4	Common
12	RELAY_4	+24V
13	Digital In_1	ARC FLASH Sensor 1 Sensor 2 Sensor 3 Sensor 4
14	Digital In_2	
15	Digital In_3	
16	Digital In_4	
17	Digital In_5	
18	Digital In_6	
19	Digital In_7	
20	Common	
21	+24V	
22	RELAY_8	
23	RELAY_8	
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 2-47: RS485 wiring diagram



⚠CAUTION

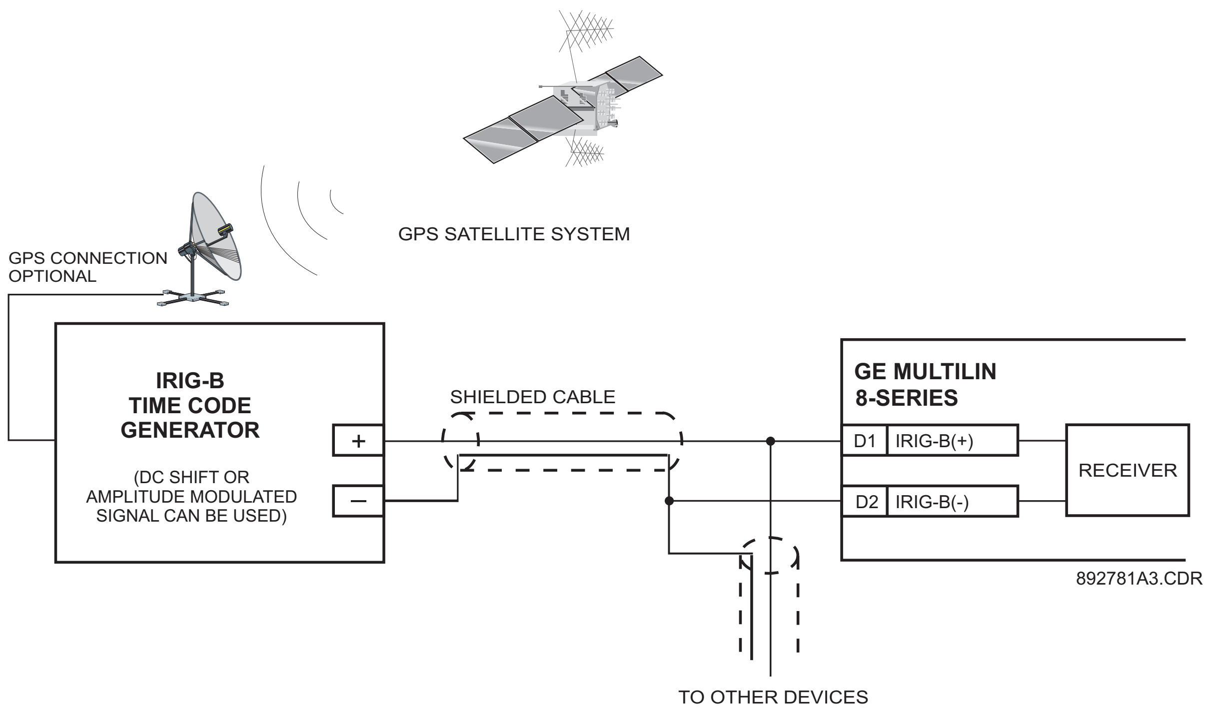
To ensure that all devices in a daisy-chain are at the same potential, it is imperative that the common terminals of each RS485 port are tied together and grounded only once, at the master or at the 869. Failure to do so may result in intermittent or failed communications.

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 869 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 869 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 2-48: IRIG-B connection



GE
Grid Solutions

869 Motor Protection System

Chapter 3: Interfaces

There are two methods of interfacing with the 869.

- 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 869 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.

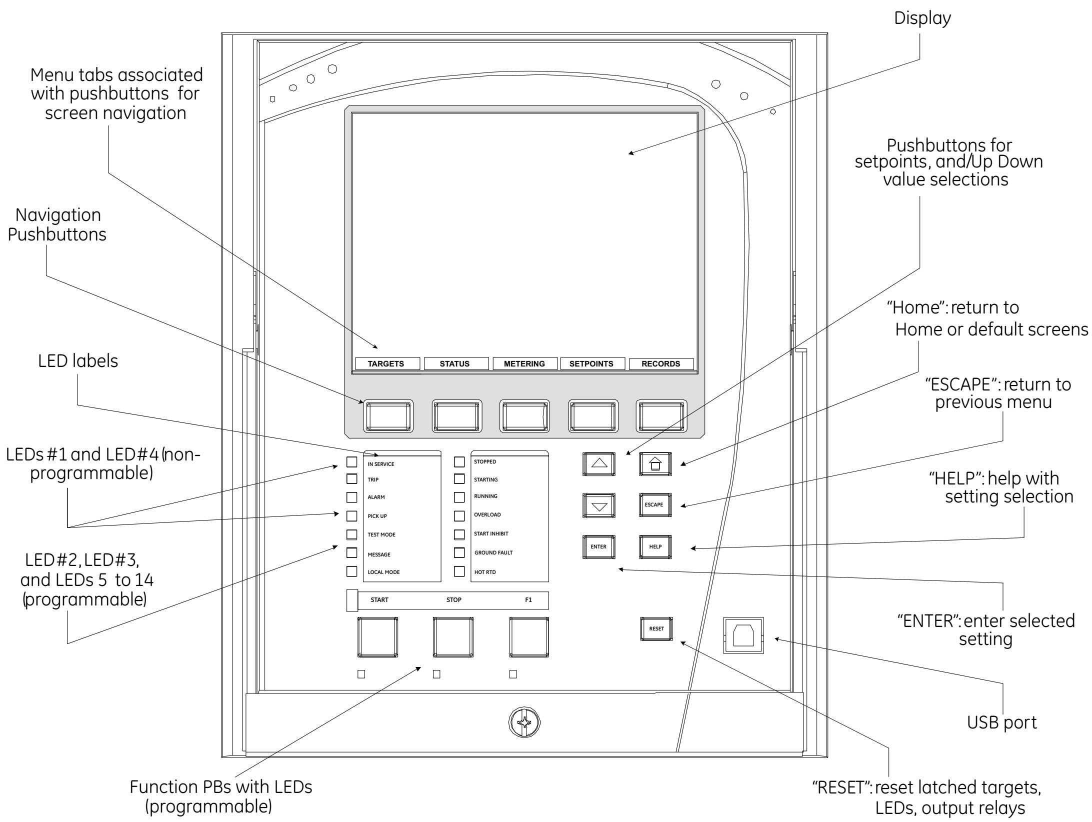
Note: If the relay is in the commissioning phase, to bypass authentication use the setpoint access feature to gain administrative access to the front panel in the same way as with basic security (see the “Basic Security” section).

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

Front Control Panel Interface

The 869 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: 869 Front Control Panel



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

Graphical Display Pages

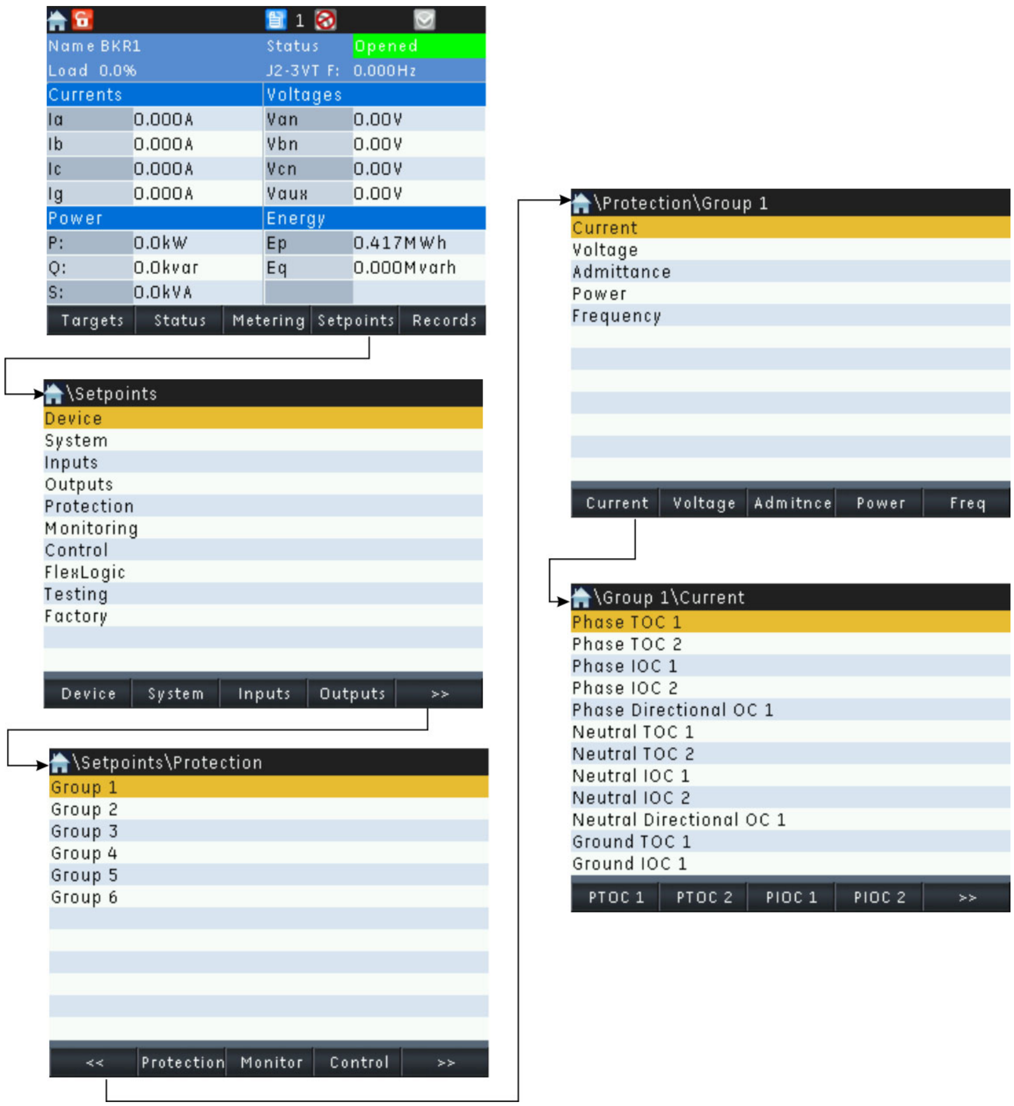
The front panel liquid crystal display (LCD) allows visibility under various lighting conditions. When the keypad and display are not being used and there are no active Targets, the Home screen with system information is displayed after a user-defined period of inactivity. Pressing the Escape key during the display of the default message, returns the display to the previous display screen. Any Trip, Alarm, or Pickup operation causing a new active Target is displayed immediately, automatically overriding the Home screen.

Figure 3-2: 869 Display Page Hierarchy

Working with Graphical Display Pages

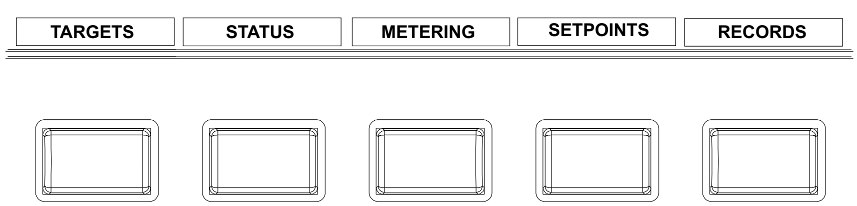
The 869 display contains five main menu items labeled Targets, Status, Metering, Setpoints, and Records located at the bottom of the screen. Choosing each main menu item displays the corresponding sub-menu.

Figure 3-3: Typical paging operation from the main menu



There are two ways to navigate throughout the 869 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.

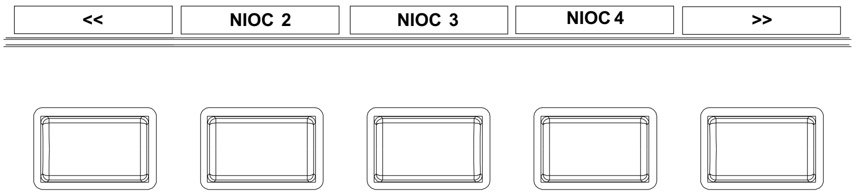
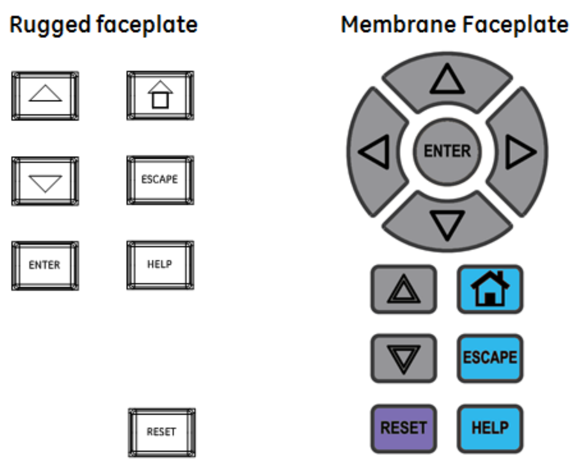
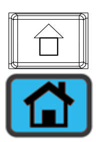


Figure 3-5: Keypad Pushbuttons

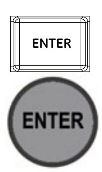


Each Keypad pushbutton serves the following function:

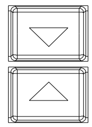


The **Home** pushbutton is used to display the home screen, and all screens defined under the Front Panel/Screens menu as *default* screens.

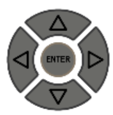
The **Help** pushbutton is used to provide the Modbus address corresponding to the present location when in the Actual Values menu.



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.

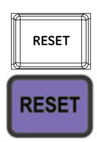


The **Up,** and **Down** pushbuttons are used to select/highlight an item from a menu, as well as select a value from the list of values for a chosen item.



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 869 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 869 and Breaker/Contactor & Motor status color

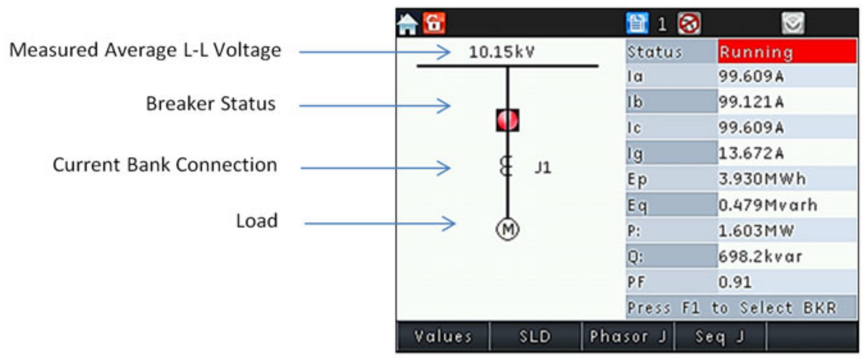
The 869 has a single line diagram (SLD) that represents the power system. The single line diagram provided is pre-configured to show:

- Breaker status
- AC input connection
- System 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/contactor status icon changes state according to the breaker/contactor status input and the color of the icon changes in accordance with the color scheme setting (**Setpoints > Device > Front Panel > Display Properties > Color Scheme**). Regardless of the switching device selection (**System > Motor > Setup > Switching Device**), the breaker/contactor colors follows the color scheme setting By default, the "Green (Open)" setting is selected.

The Breaker/Contactor and motor status color is based on the following logic.

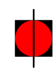
Figure 3-7: Breaker/Contactor and Motor status color

	SLD Breaker/Contactor Symbol Color				Motor Status				
Color Scheme	Open Color	Close Color	Not Configured	Unknown	Stopped	Starting	Running	Overload	Tripped
Red (Open)			?	?	Red	Green	Green	Red	Orange
Green (Open)			?	?	Green	Red	Red	Green	Orange

In addition, the following motor status appears when the relay includes synchronous motor application order codes.

	Motor Status		
Color Scheme	SM Stabilizing	SM Running	SM Resync
Red (Open)	Green	Green	Green
Green (Open)	Red	Red	Red

When switching device detection (Breaker or Contactor) Connected/Disconnected (Racked-In/Racked-Out) is configured, the symbols change with respect to the Connected/Disconnected state of the switching device. 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	Switching Device State	Symbol
Not Configured*	Connected*	
Configured	Connected	
Configured	Disconnected	

*869 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:

Asynchronous Motor Applications*	
Parameter	**Input for the value**
Ia	Metering\CT Bank 1 -J1\J1 Ia
Ib	Metering\CT Bank 1 -J1\J1 Ib
Ic	Metering\CT Bank 1 -J1\J1 Ic
Ig	Metering\CT Bank 1 -J1\J1 Ig
Ep	Metering\Energy 1\Pwr1 Pos WattHours
Eq	Metering\Energy 1\Pwr1 Pos VarHours
P	Metering\Power 1\Pwr1 Real
Q	Metering\Power 1\Pwr1 Reactive
PF	Metering\Power 1\Pwr1 PF

Synchronous Motor Applications**	
Parameter	**Input for the value**
Motor Load	Metering\Motor\Motor Load\Motor Load
TCU	Status\Motor\Motor Thermal Capacity Used
Current Unbal	Metering\Motor\Motor Load\Motor Current Unbalance
Voltage(L-L)	Metering\Ph VT Bnk1-J2\J2 V AVG L-L
Field DC Amps	Metering\SM Bnk1-K2\SM Field Amps
Field VDC	Metering\SM Bnk1-K2\SM Field VDC
P	Metering\Power 1\Pwr1 Real
Q	Metering\Power 1\Pwr1 Reactive
PF	Metering\Power 1\Pwr1 PF

* Requires Order Code selection 'NN/S1/S5' for Phase Currents - Slot K Bank 1/2
** Requires Order Code selection 'C5/D5' for Phase Currents - Slot K Bank 1/2

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 869 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 3-8: LED numbering

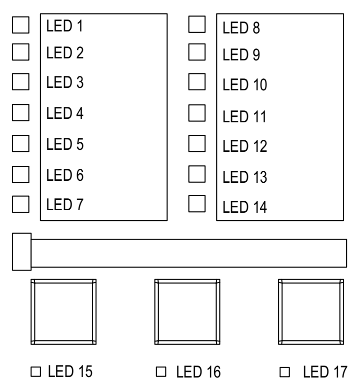
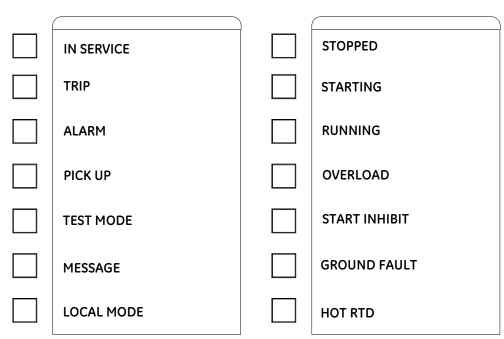


Figure 3-9: Typical LED Indicator Panel



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 869, 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

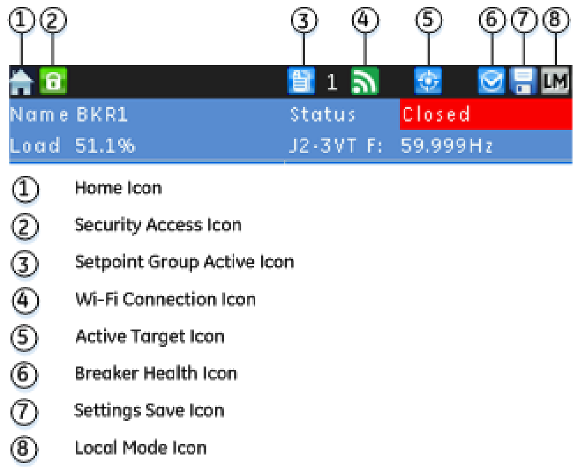


Table 3-1: Security Icon

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

Targets are messages displayed on the screen when any change of state of protection, control, monitoring, or digital signal takes place. For the user's convenience, the targets for major motor protection elements are set to Latched by default. The user can disable targets for any particular element by selecting and entering the setting "Disabled" within the element's menu.

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

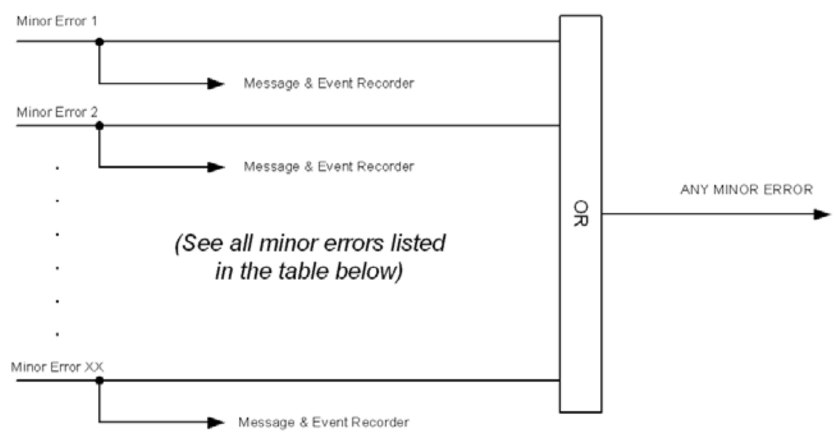


Figure 3-12: Major Errors

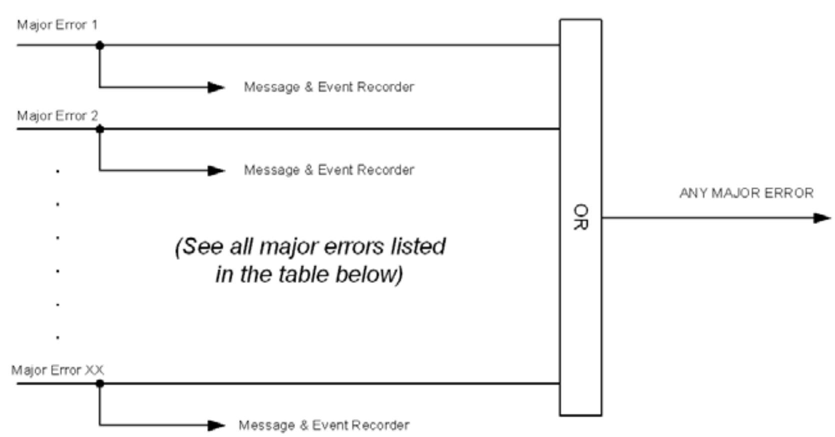


Table 3-8: Minor Self-test Errors

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.

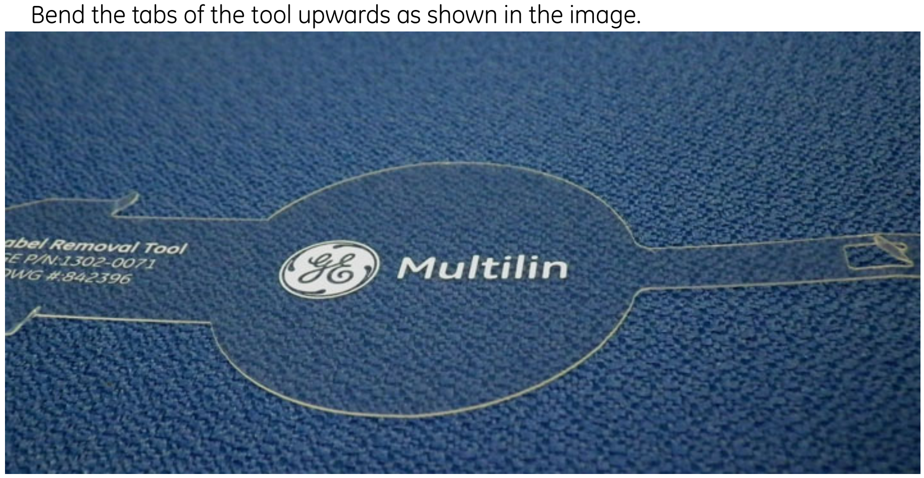
NOTE

Templates for printing custom LED labels are available online at:

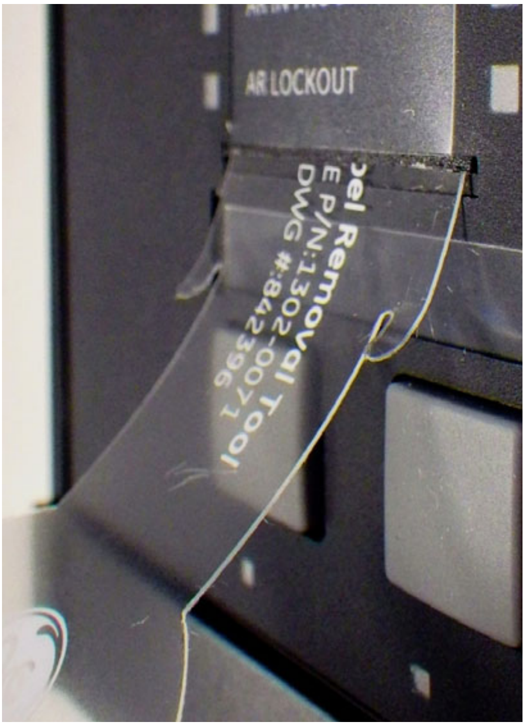
http://www.gegridsolutions.com/app/ViewFiles.aspx?prod=869&type=9.

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

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



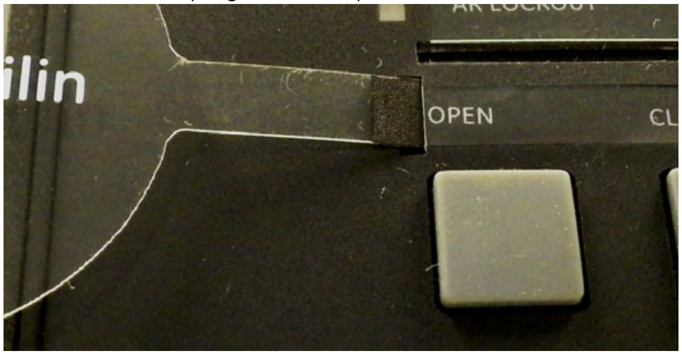
2. Slide the label removal tool under the LED label as shown in the next image. Make sure the bent tabs are pointing away from the relay. Move the tool inside until the tabs enter the pocket.



3. Remove the tool with the LED label.

The following describes how to remove the user-programmable pushbutton label from the 869 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 869 firmware

The EnerVista 8 Series Setup software allows immediate access to all 869 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 869 connected to the computer. In this case, settings may be saved to a file for future use. If a 869 is connected to a PC and communications are enabled, the 869 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.

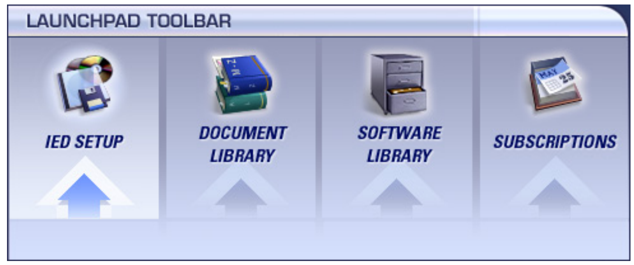
- Dual-core processor
- Microsoft Windows™ 7 or 8.1; 32-bit or 64-bit is installed and running properly.
- At least 1 GB of free hard disk space is available.
- At least 2 GB of RAM is installed.
- 1280 x 800 display screen

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/.

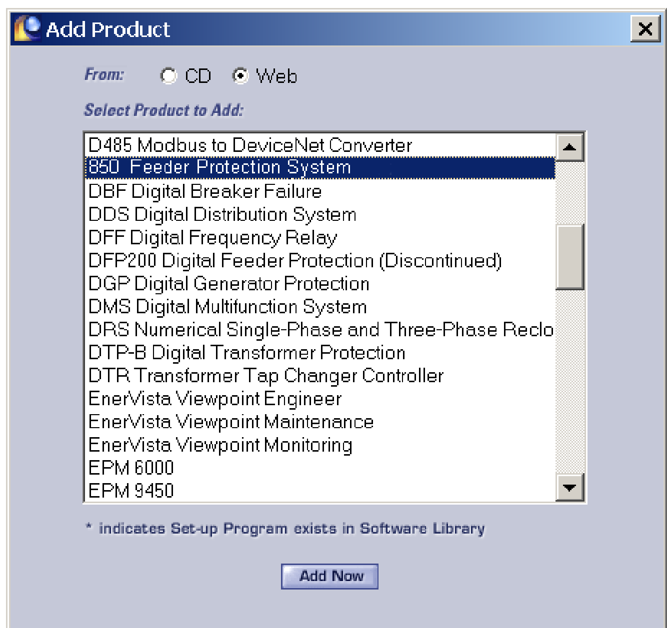
Installing the EnerVista 8 Series Setup Software

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.

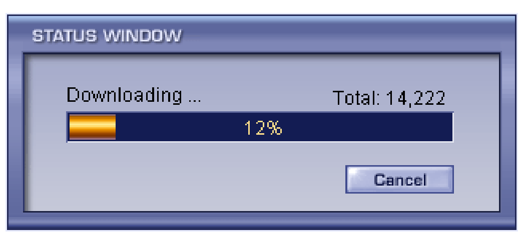
1. Insert the GE EnerVista CD into your CD-ROM drive.
2. Click the **Install Now** button and follow the installation instructions to install the no-charge EnerVista software on the local PC.
3. When installation is complete, start the EnerVista Launchpad application.
4. Click the **IED Setup** section of the LaunchPad toolbar.



5. In the EnerVista Launchpad window, click the **Add Product** button and select the 869 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 869.



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.

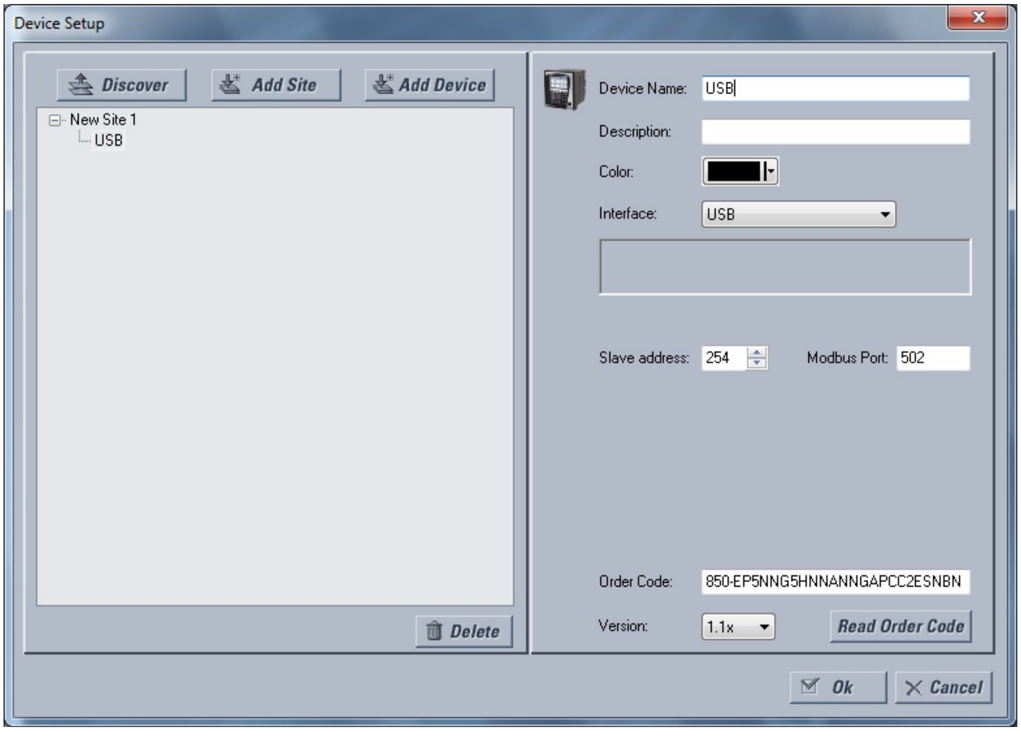


7. Select the complete path, including the new directory name, where the EnerVista 8 Series Setup software is being installed.
8. Click on **Next** to begin the installation. The files are installed in the directory indicated, the USB driver is loaded into the computer, and the installation program automatically creates icons and adds the EnerVista 8 Series Setup software to the Windows start menu.
9. The 869 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 869 Relay using the USB port:

10. Plug the USB cable into the USB port on the 869 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

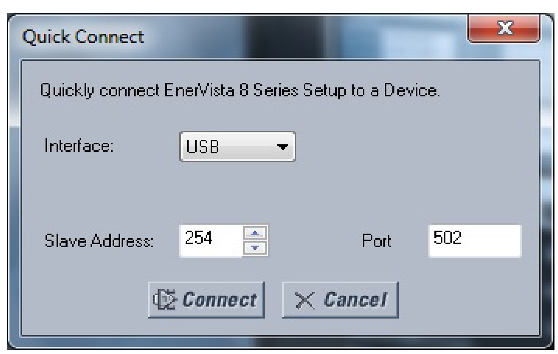
The latest EnerVista software and firmware can be downloaded from:
https://www.gegridsolutions.com/

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

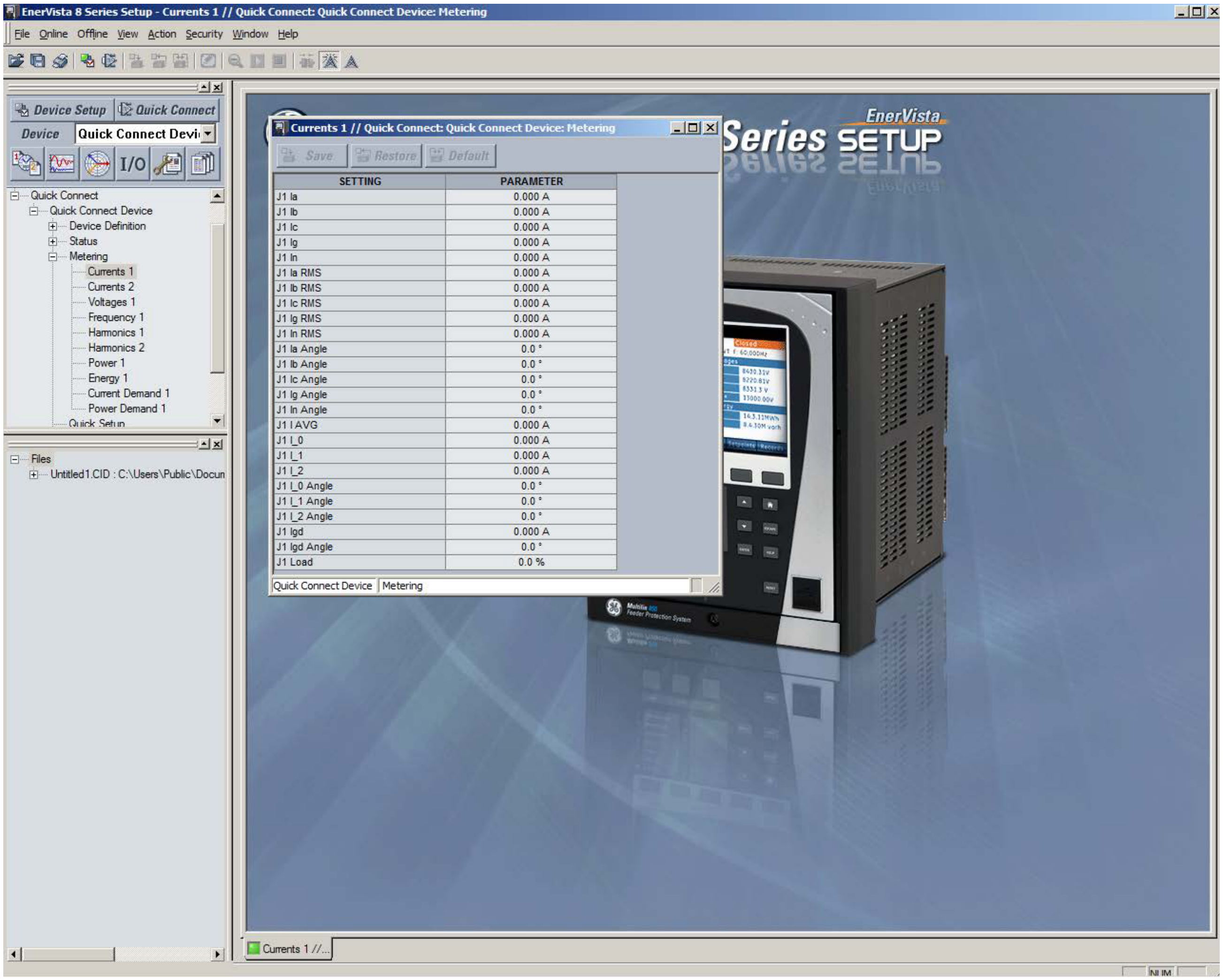
Using the Quick Connect Feature

The **Quick Connect** button can be used to establish a fast connection through the front panel USB port of a 869 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 869 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 869 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.

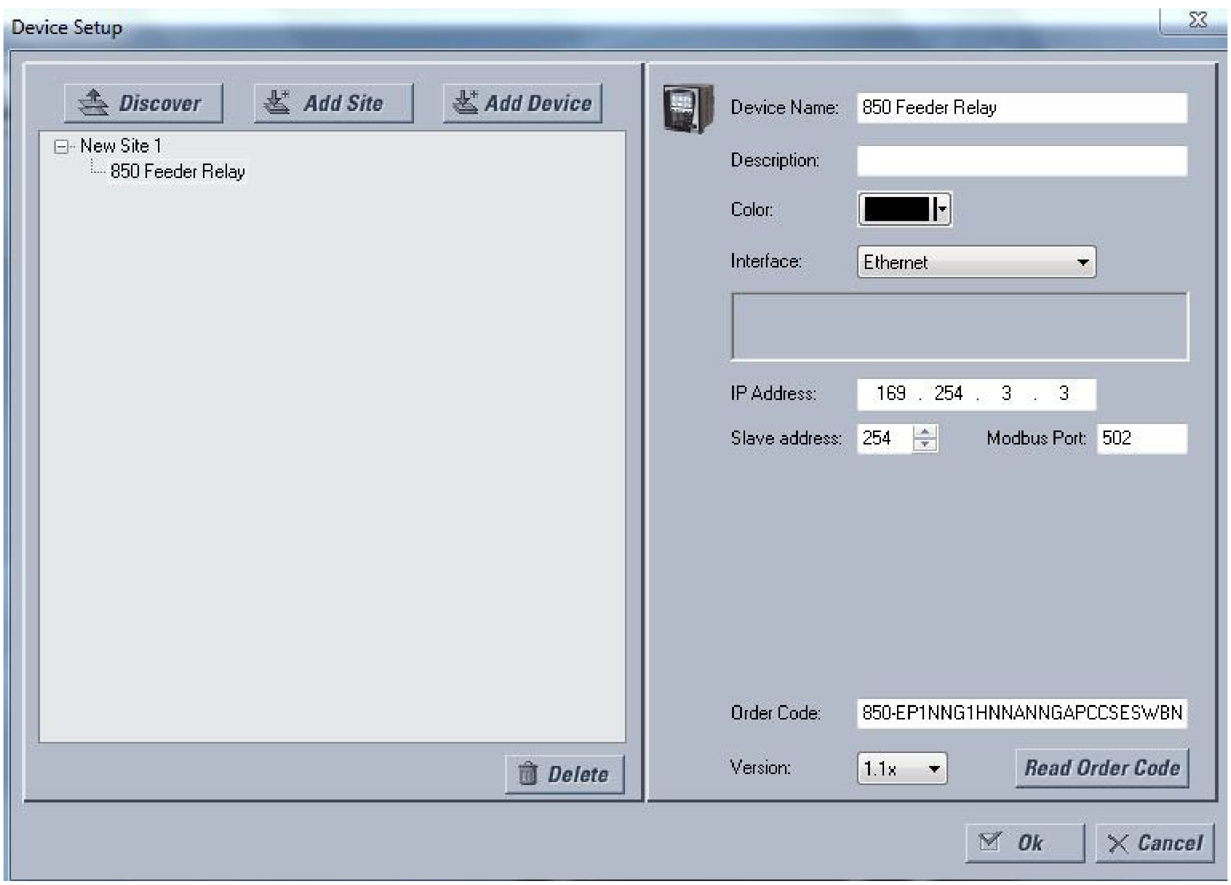
Configuring Ethernet Communications

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

NOTICE

869 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 869 relay (from the **Setpoints > Device > Communications** menu).
9. Click the **Read Order Code** button to connect to the 869 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 869 Site Device has now been configured for Ethernet communications. Proceed to the following section to begin communications.

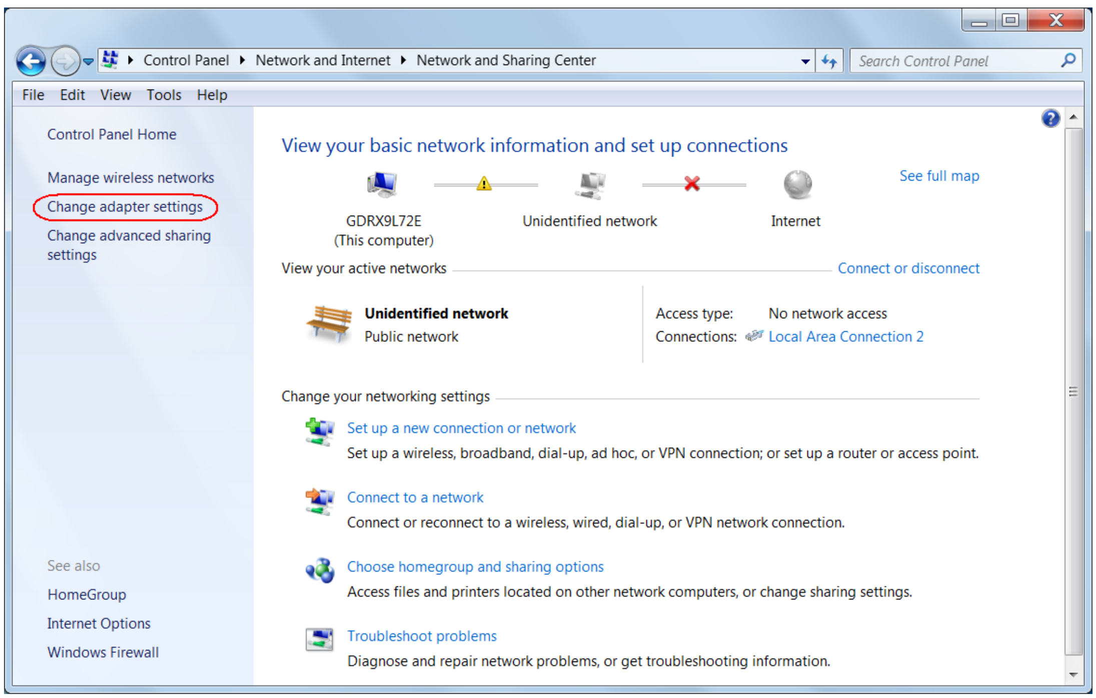
Configuring USB Address

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.

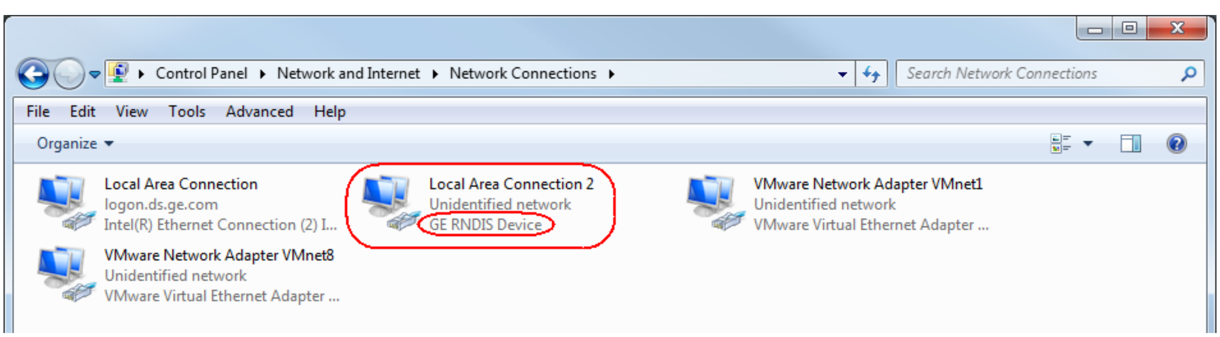
1. Open the Windows Control Panel and select **Network and Internet > Network Sharing**.

NOTE

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

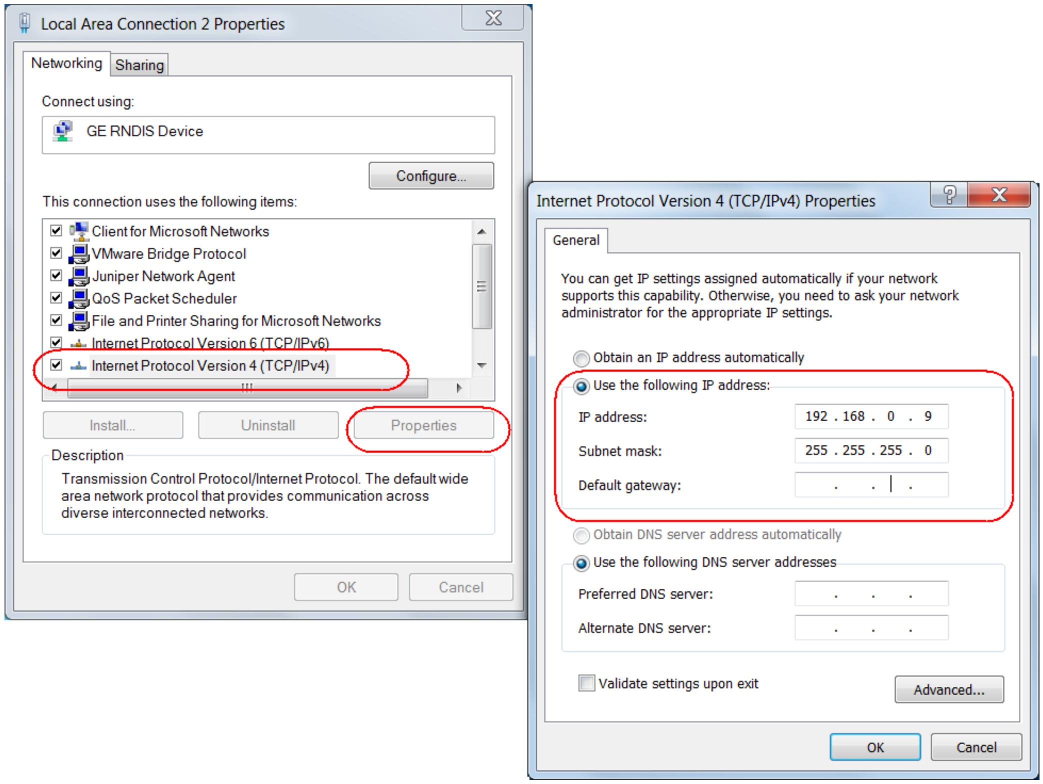


2. Click **Change adapter settings**.

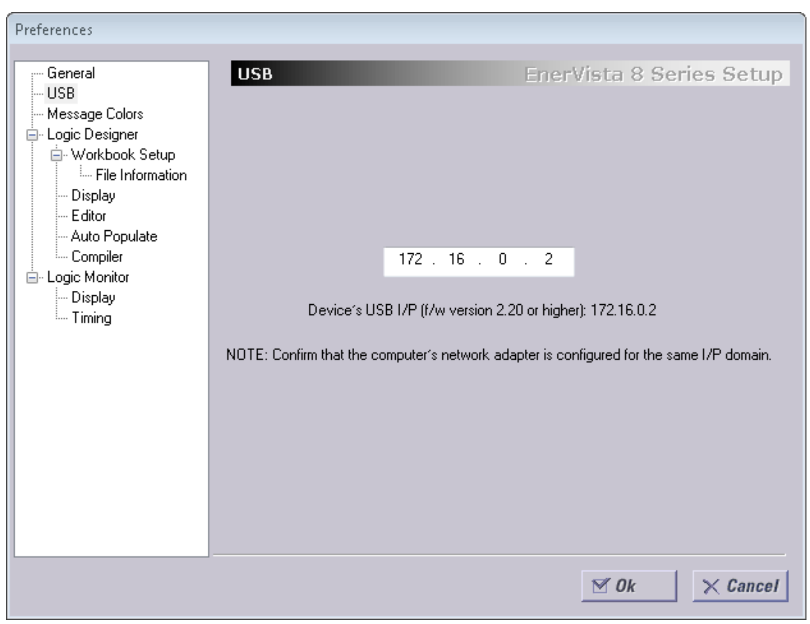


3. Find the **GE RNDIS Device** (or **GE RNDIS Device #2**) and right-click the network it is on to open the **Properties** window.

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.

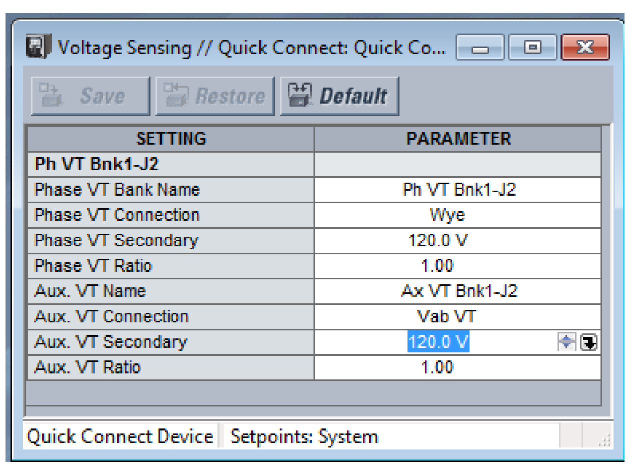
Engaging a Device

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.

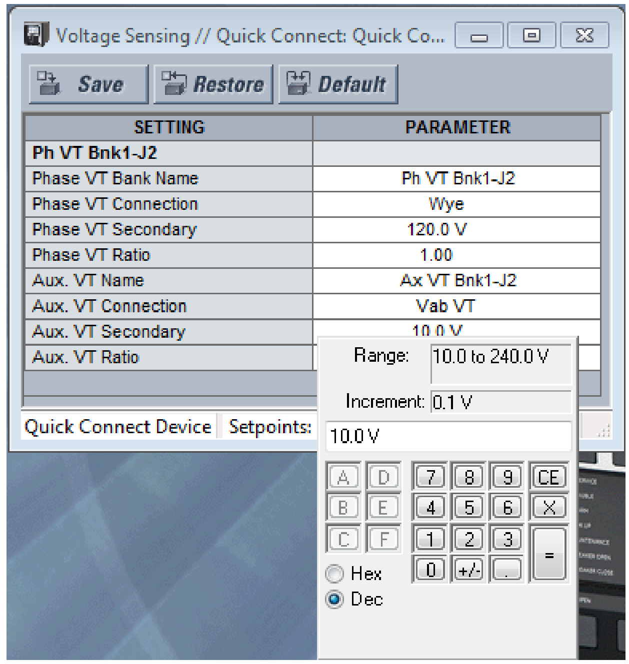
Entering Setpoints

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

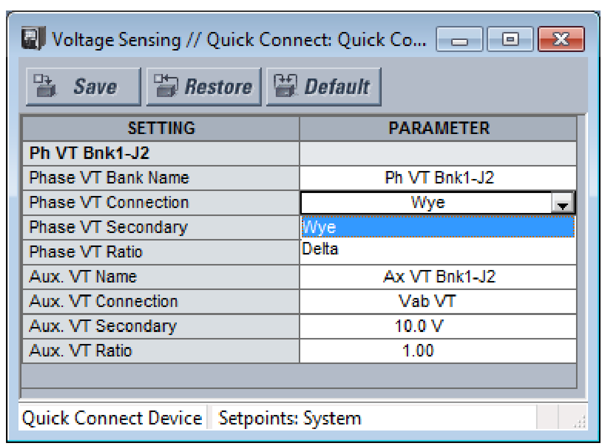
1. Establish communications with the relay.
2. Select the **Setpoint > System > Voltage Sensing** menu item.
3. Select the Aux. VT Secondary setpoint by clicking anywhere in the parameter box. This displays three arrows: two to increment/decrement the value and another to launch the numerical keypad.



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 869. 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 869 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.

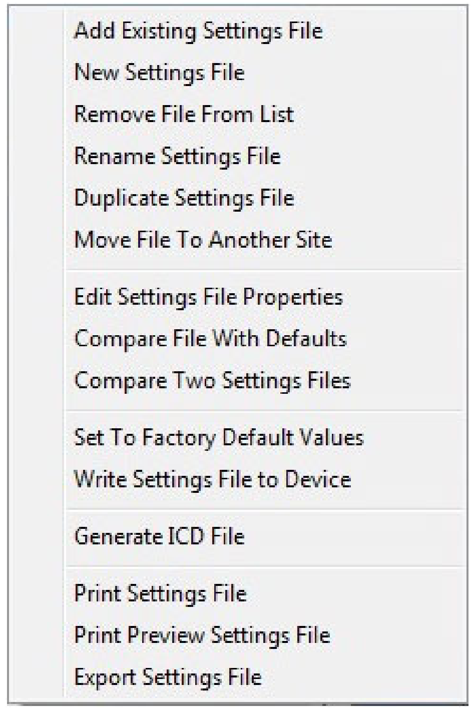
The setpoint files in the EnerVista 8 Series Setup window are accessed in the Files Window. Use the following procedure to download and save setpoint files to a local PC.

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:

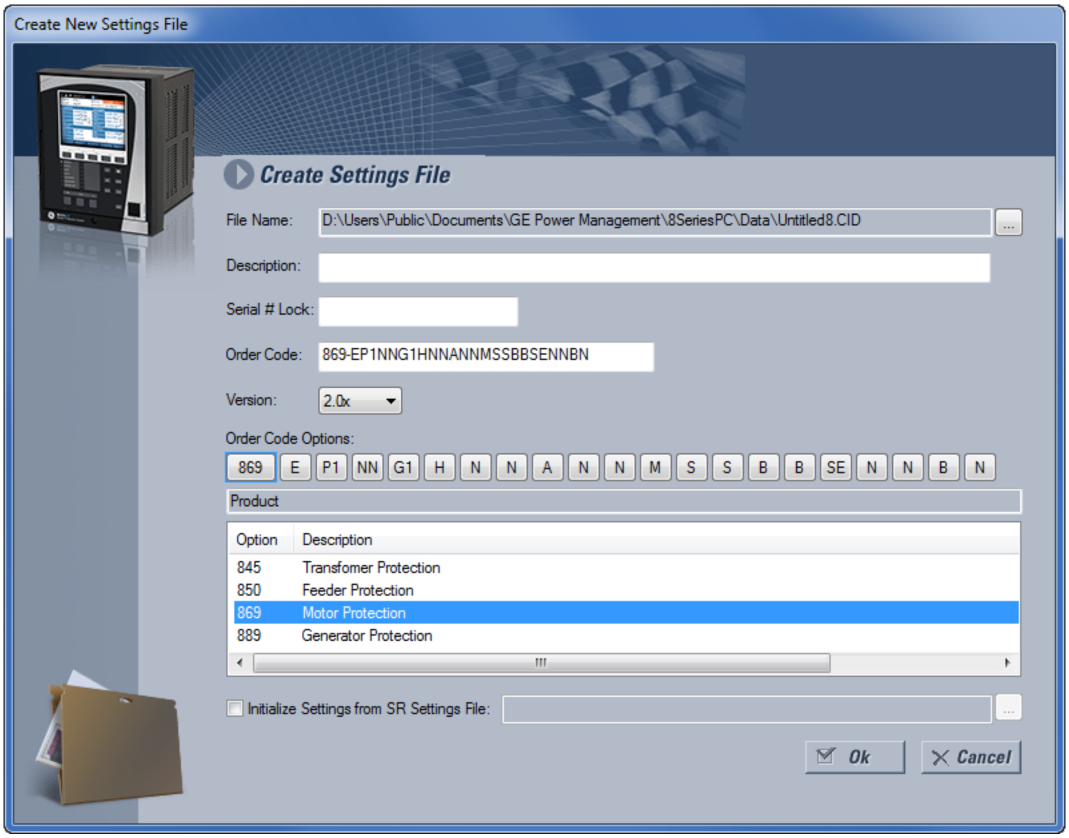


2. The Open dialog box is displayed, prompting to select a previously saved setpoint file. As for any other MS Windows® application, browse for the file to be added then click **Open**. The new file and complete path will be added to the file list.

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 869 setpoint files should have the extension '.cid' (for example, '869 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 869 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.

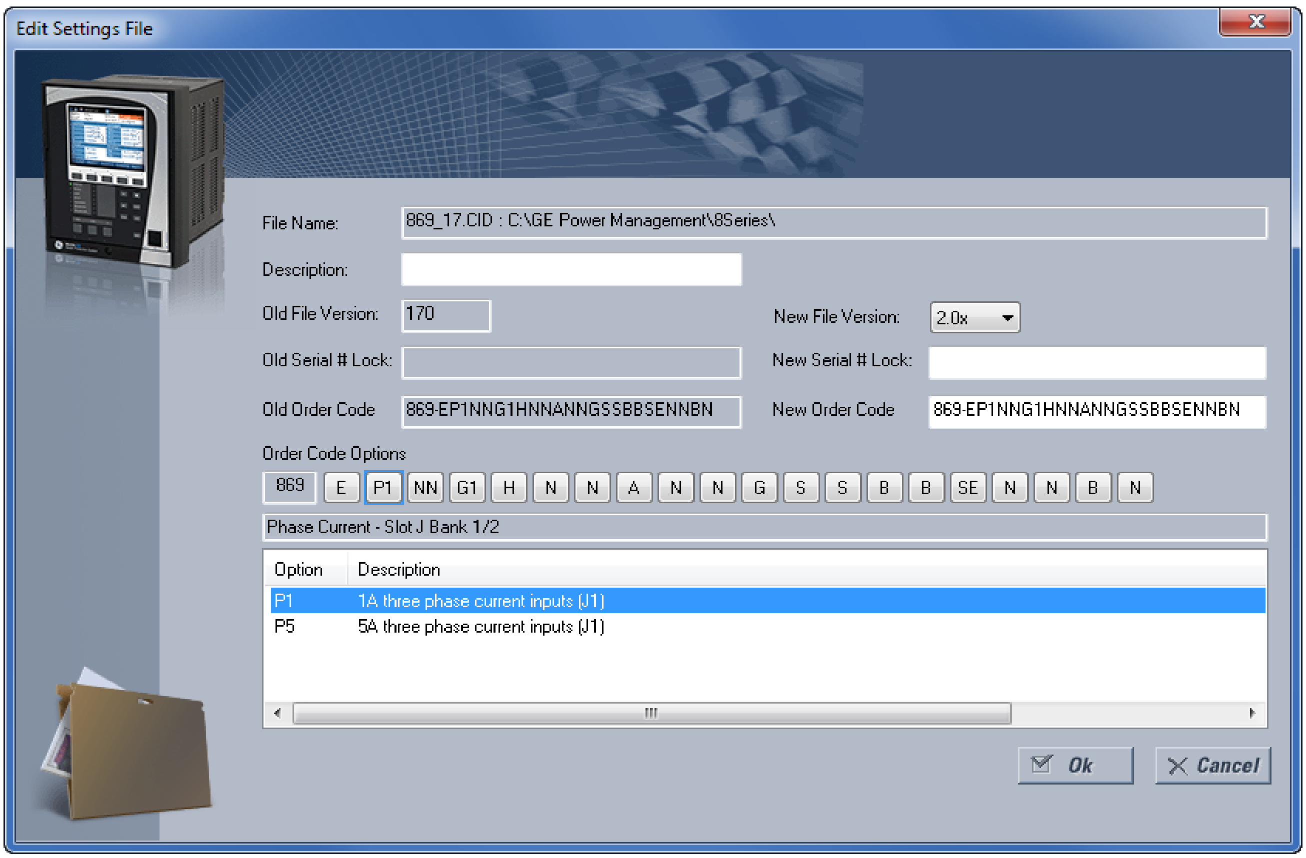
NOTE

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 869 firmware has been upgraded. This is illustrated in the following procedure:

1. Establish communications with the 869 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”.

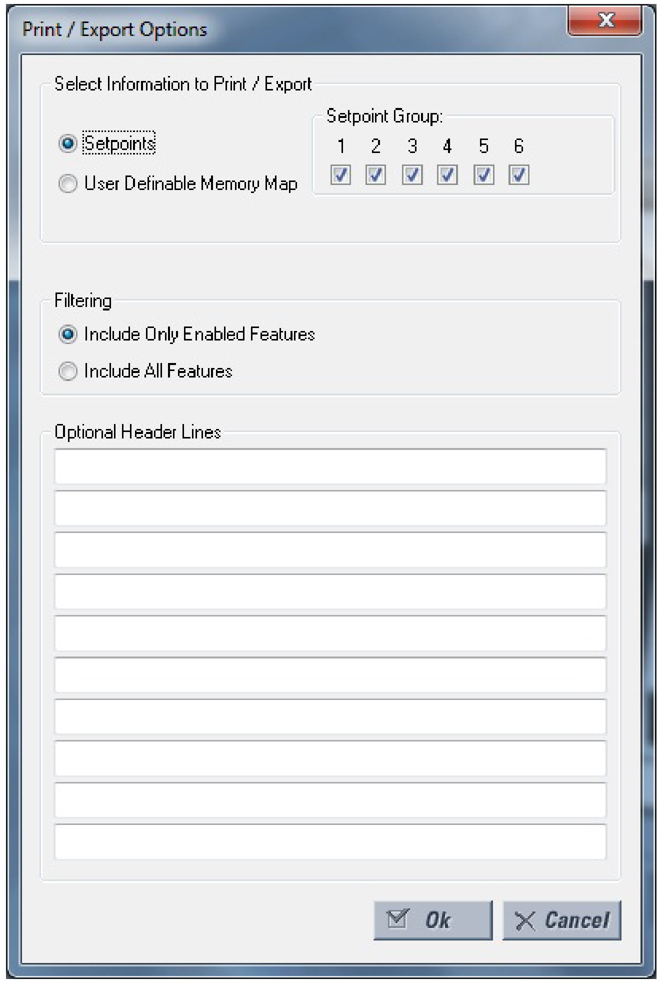


7. Enter any special comments about the setpoint file in the "Description" field.
8. Select the desired firmware version from the "New File Version" field.
9. When complete, click **OK** to convert the setpoint file to the desired revision. See *Loading Setpoints from a File* below, for instructions on loading this setpoint file into the 869.

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 869 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.

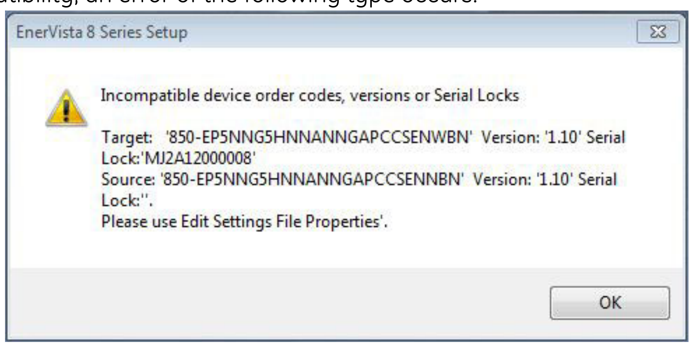
Loading Setpoints from a File

⚠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 869 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 869 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: 869 Quick Setup (Online) tree position

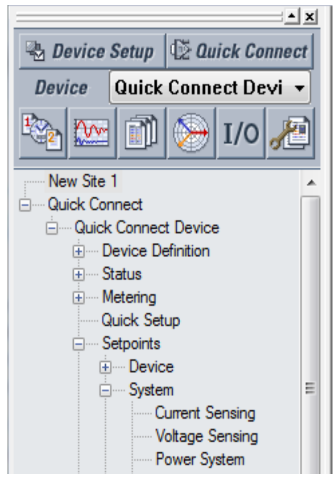
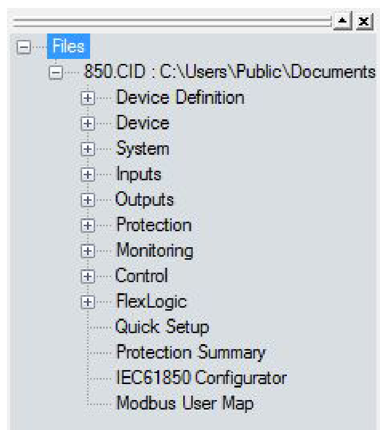
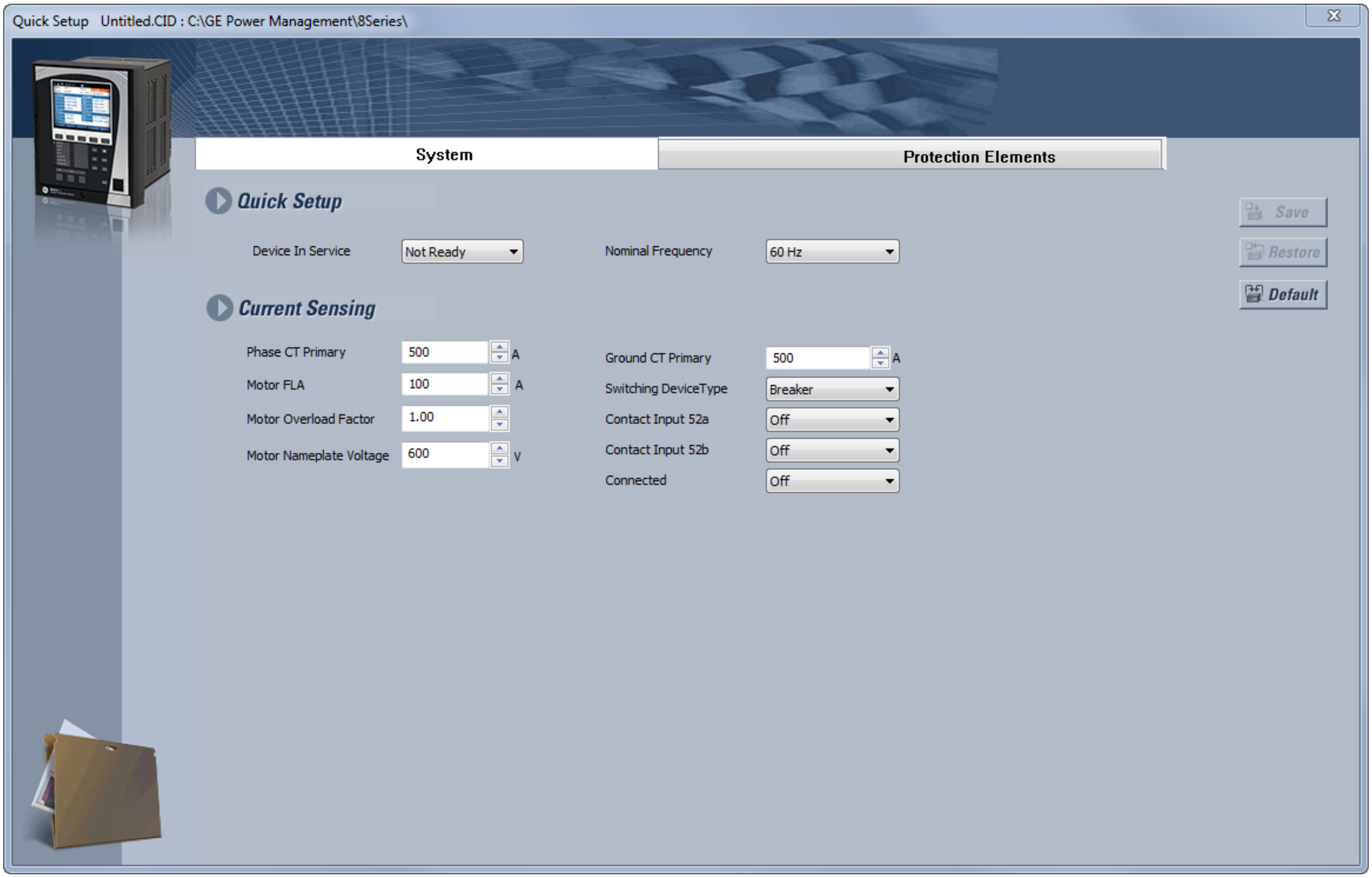


Figure 3-14: 869 Quick Setup (Offline) tree position



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:

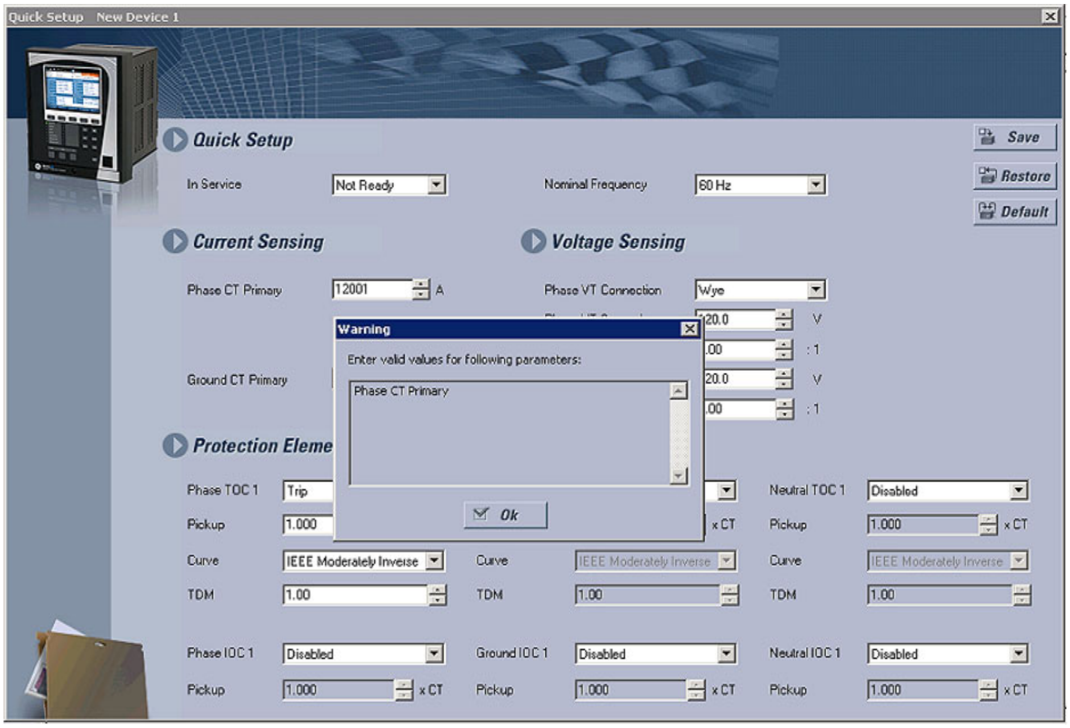
Figure 3-15: Quick Setup window



- 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 869 firmware, follow the procedures listed in this section. Upon successful completion of this procedure, the 869 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 869 relay.

NOTICE

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

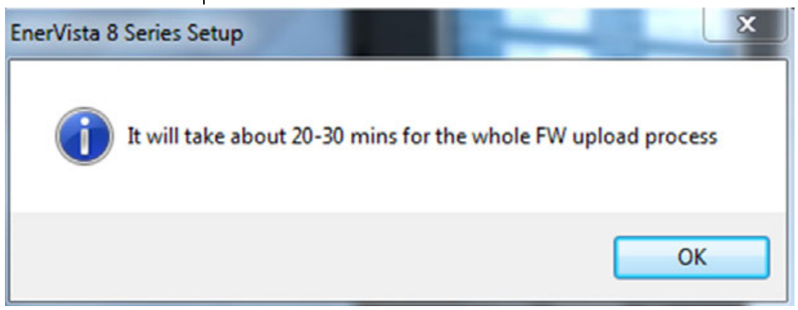
NOTICE

Before upgrading firmware, it is very important to save the current 869 settings to a file on your PC. After the firmware has been upgraded, it will be necessary to load this file back into the 869. Refer to *Downloading and Saving Setpoints Files* for details on saving relay setpoints to a file.

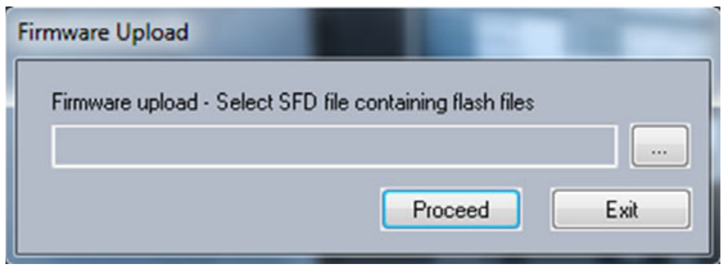
Loading New Relay Firmware

Loading new firmware into the 869 flash memory is accomplished as follows:

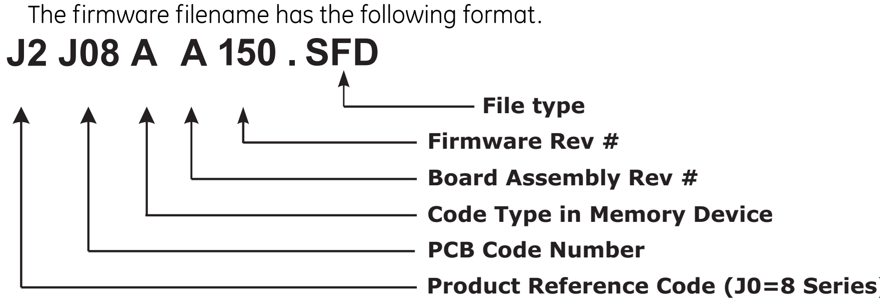
1. Connect the relay to the local PC and save the setpoints to a file as shown in *Downloading and Saving Setpoints Files*.
2. Select the **Maintenance > Update Firmware** menu item. The following screen appears. Select OK to proceed.



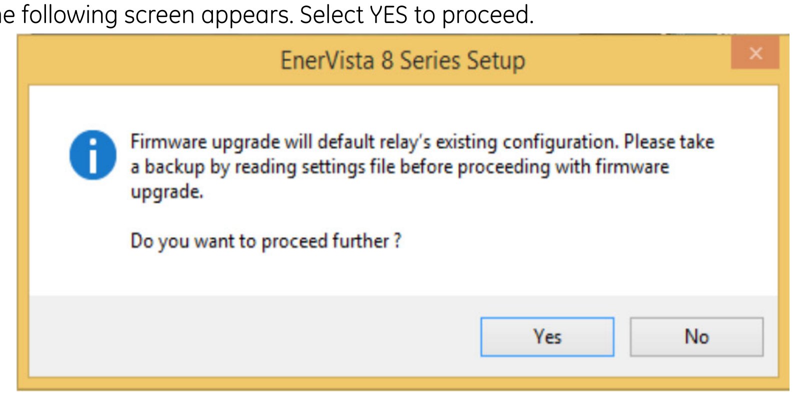
3. The EnerVista 8 Series Setup software requests the new firmware file. Locate the folder that contains the firmware file to load into the 869.



The firmware filename has the following format.

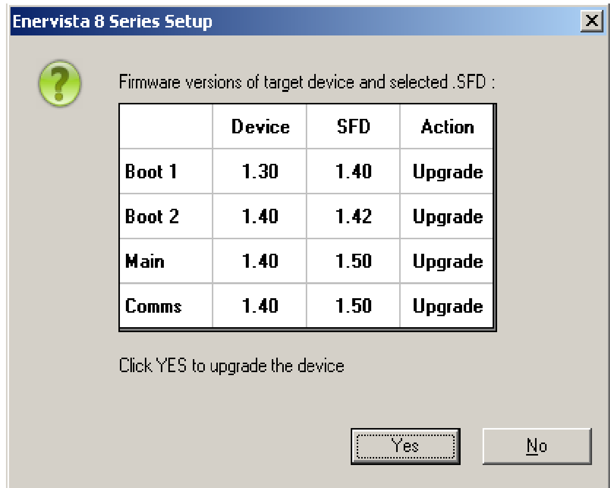


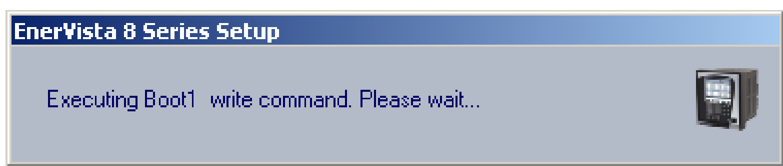
The following screen appears. Select YES to proceed.

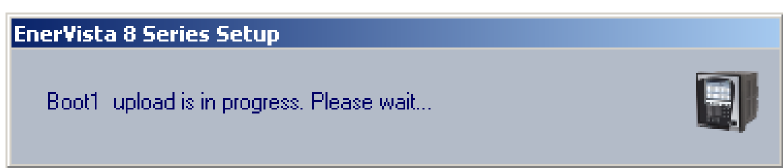


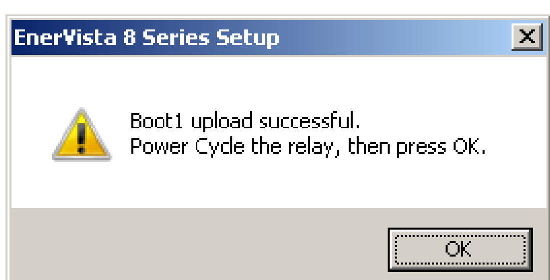
4. EnerVista 8 Series Setup software now prepares the 869 to receive the new firmware file. The 869 front panel momentarily displays "Upload Mode", indicating that it is in upload mode.

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







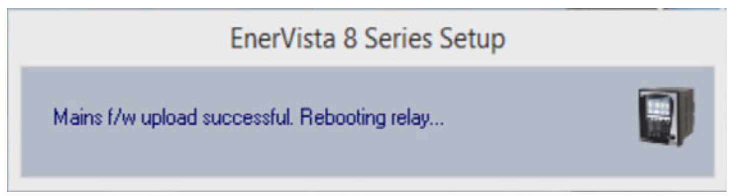


6. After the Boot 2 upload is completed, the EnerVista 8 Series Setup software requests that the user reboot the relay. After the Boot 1 upload is completed, the EnerVista 8 Series Setup software again requests that the user to reboot the relay.

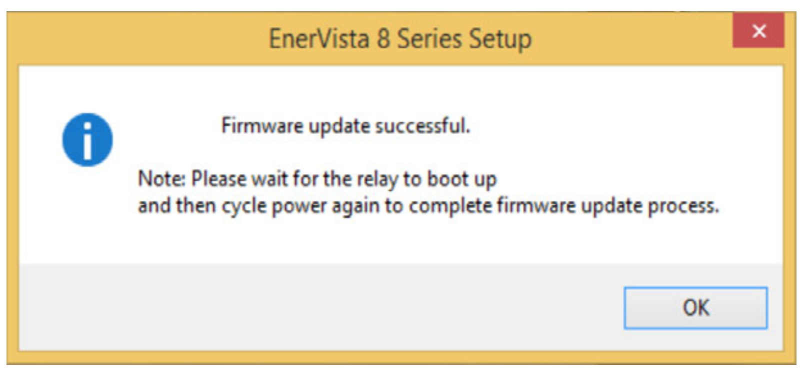
⚠CAUTION

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 869 has finished loading. Wait for the relay to boot, and then **Cycle power to the relay to complete firmware update.**



After successfully updating the 869 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.

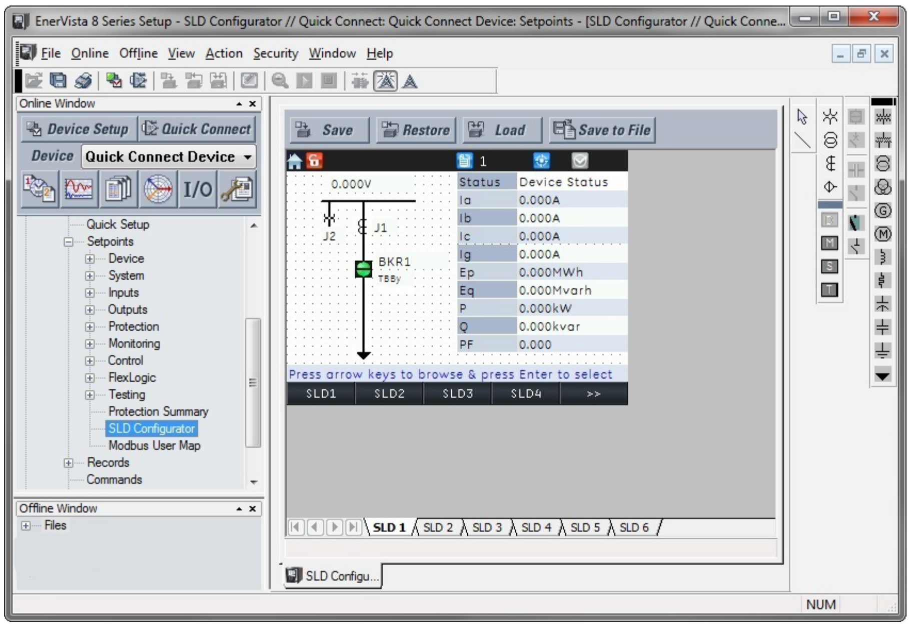
Advanced EnerVista 8 Series Setup Software Features

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.

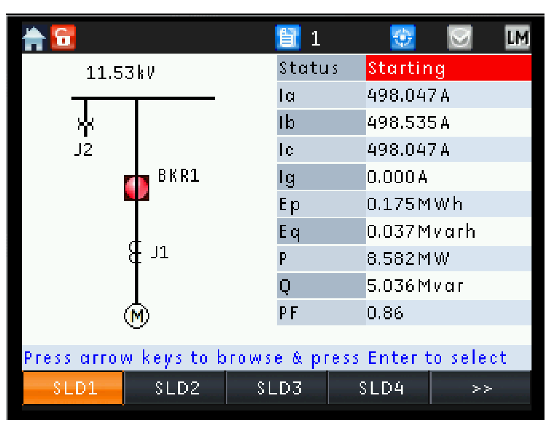
Single line diagrams (SLD) are viewed from the relay front panel and individual SLD pages can be selected for the default home screen pages. The 8 Series provides six (6) SLD pages. Each page can have a combination of active and passive objects. Status, metering, and control objects are active while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

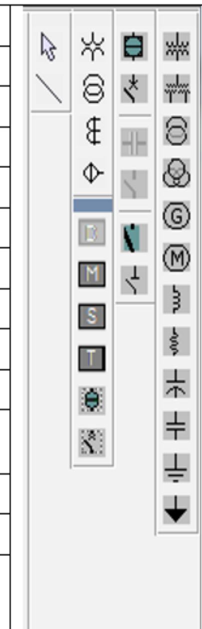
Figure 3-17: Template SLD



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 3-18: SLD Configurator Component Library

Column1	Column2	Column3	Column4
Select	VT (GE) [12]	Breaker (GE) [1]	Transformer 2W (GE) [2]
Line [50]	VT (IEC) [12]	Breaker (IEC) [1]	Transformer 3W (GE) [2]
Separator	CT (GE) [12]	Separator	Transformer 2W (IEC) [2]
	CT (IEC) [12]	Contactor (GE) [1]	Transformer 3W (IEC) [2]
	Separator	Contactor (IEC) [1]	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.

In 869 , a contactor can be used instead of a breaker by selecting it as the switching device from the motor setup settings. While designing the single line diagram through the SLD Configurator, the breaker and contactors will be available depending on the switching device selection in motor setup.

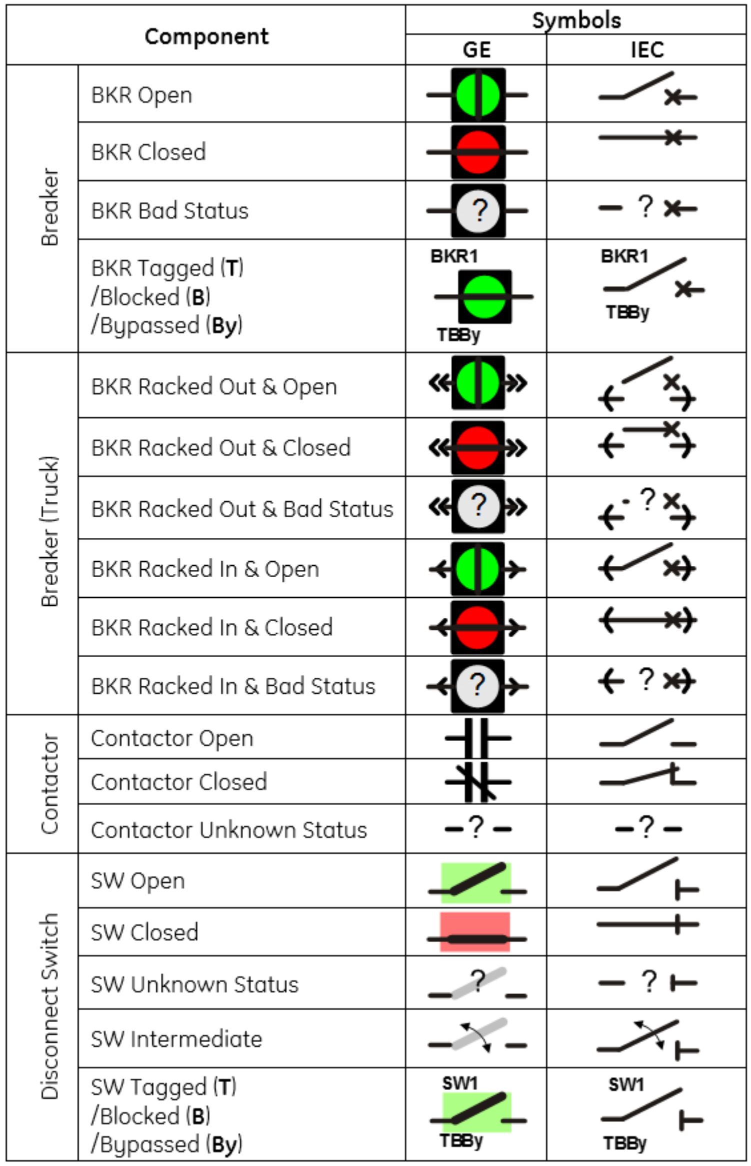
NOTE

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.

NOTE

The displayed breaker or contactor name comes from their respective system setup settings. This setpoint has a 13-character limit. The name should be kept to a minimum so that it appears properly on the SLD.

Figure 3-19: Control Object Symbols



NOTE

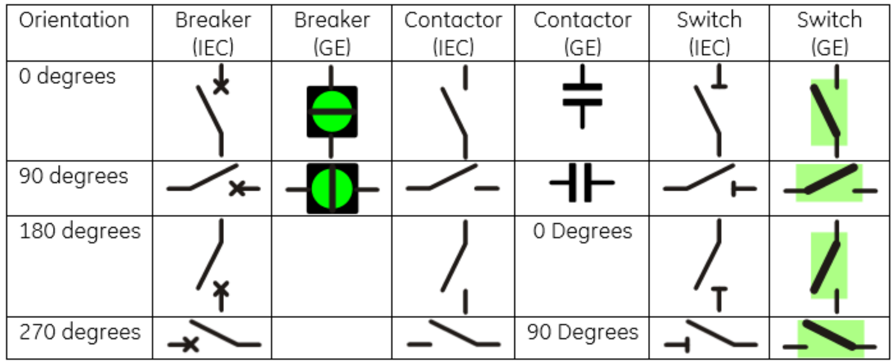
GE symbols are color-coded ANSI symbols.

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.

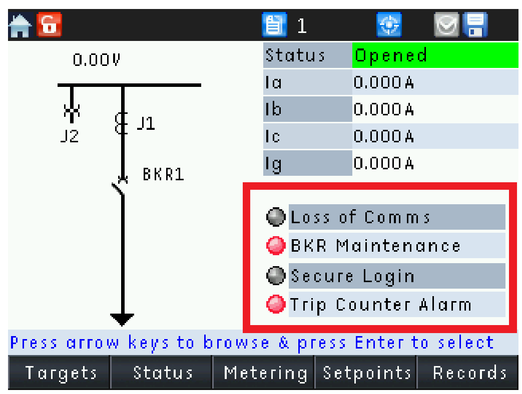
Figure 3-20: Orientation for Breakers and Switches



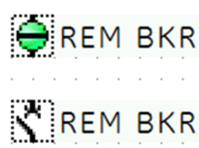
Status Objects

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 3-21: Reclose Blocked signal



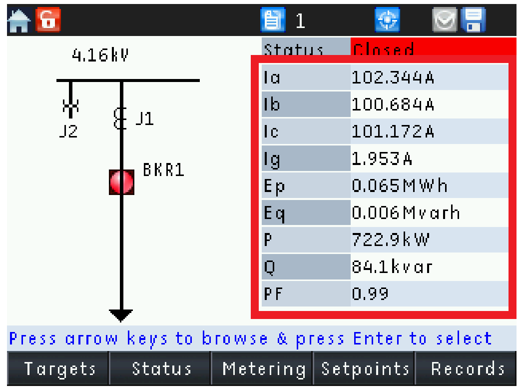
In addition, Remote Breaker status objects are added for GE and IEC style. Remote breaker status allows monitoring of three distant breakers. These objects are not controllable and hence cannot be used for selection and operation.



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 3-22: 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 motor is running/stopped/overload/tripped.

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.

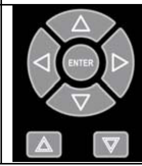
Navigation

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

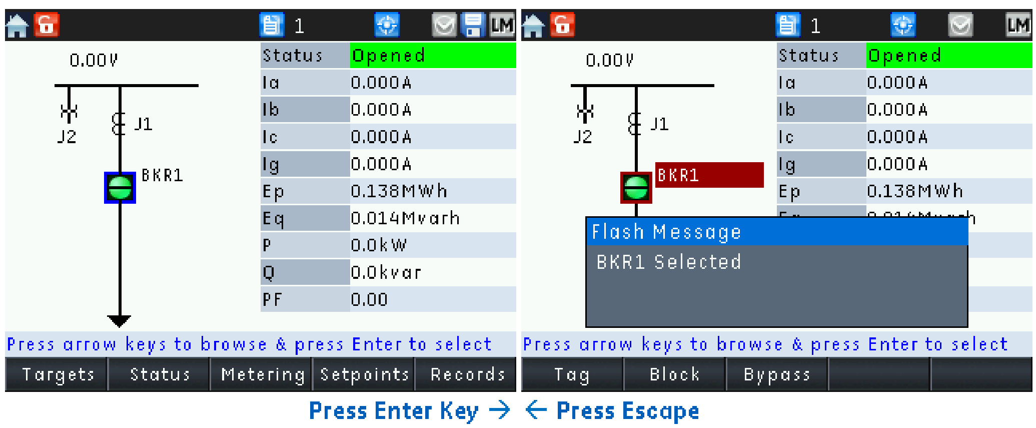
While in the SLD screen, only one page is active at any point of time. If SLD1 is active, only breakers and switches on SLD1 can be operated and controlled. By default, when entering the SLD menu, the screen displays SLD1. SLD2 through SLD6 can be accessed through the navigation pushbuttons as shown 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, contactor and switches).

Figure 3-23: 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/contactor starting/stopping operations from the front panel now follow select-before-operate mechanism. The breaker/contactor must be first selected by browsing and pressing Enter key for selection. Once selected, the motor can be started or stopped with the front panel's Start and Stop 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**). Starting and Stopping operations can be carried out by pressing the Start and Stop 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

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.

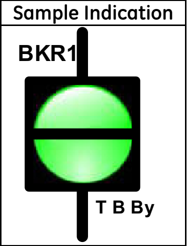
NOTE

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 3-24: 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.	

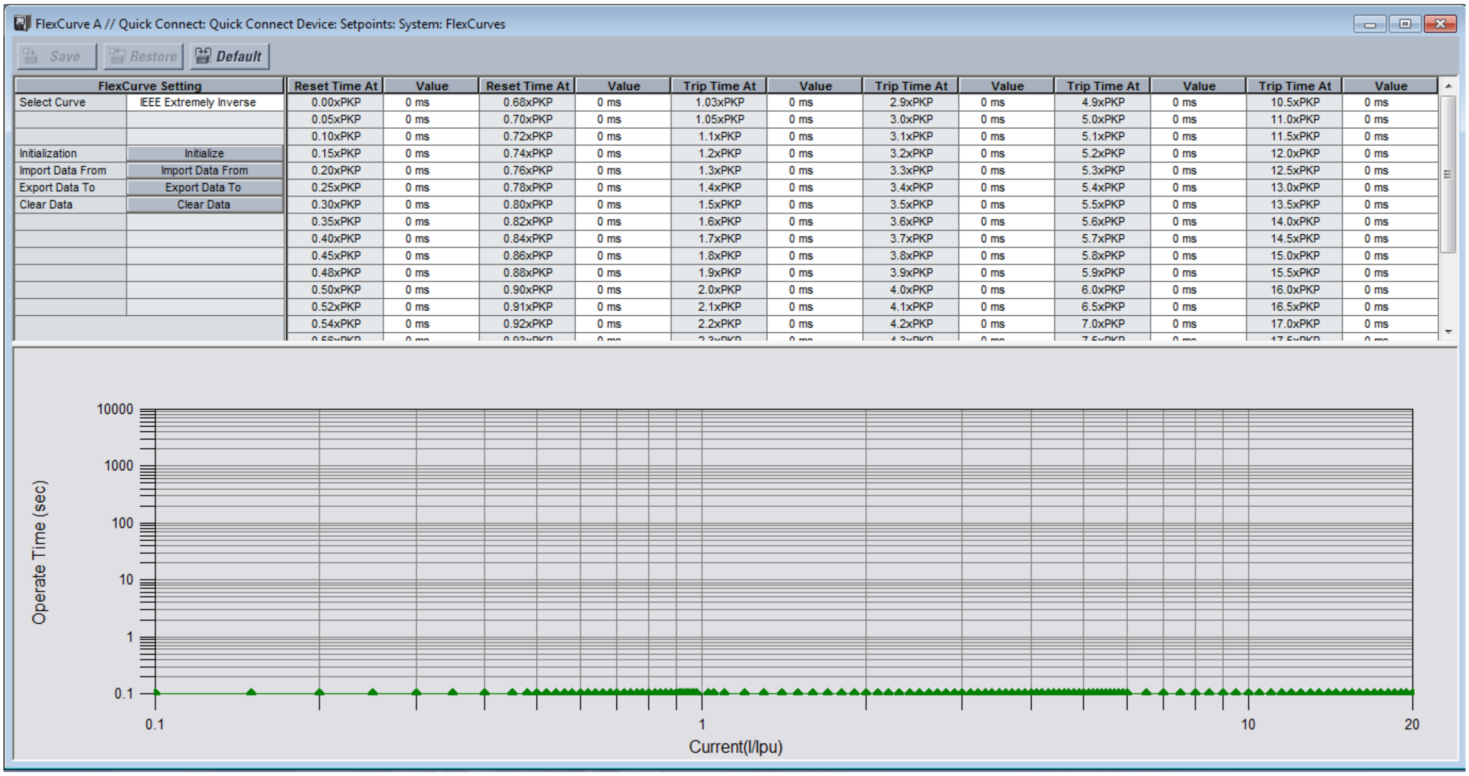
NOTE

For bypassing select-before-operate to start and stop motor, the Start Motor PB and Stop Motor PB settings can be utilized under breaker/contactor control.

For detailed tagging, blocking and bypassing operations, refer to the section Local Control Mode (breakers, contactor 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 869 for viewing FlexCurves. Select **Initialize** to copy the trip times from the selected curve to the FlexCurve.

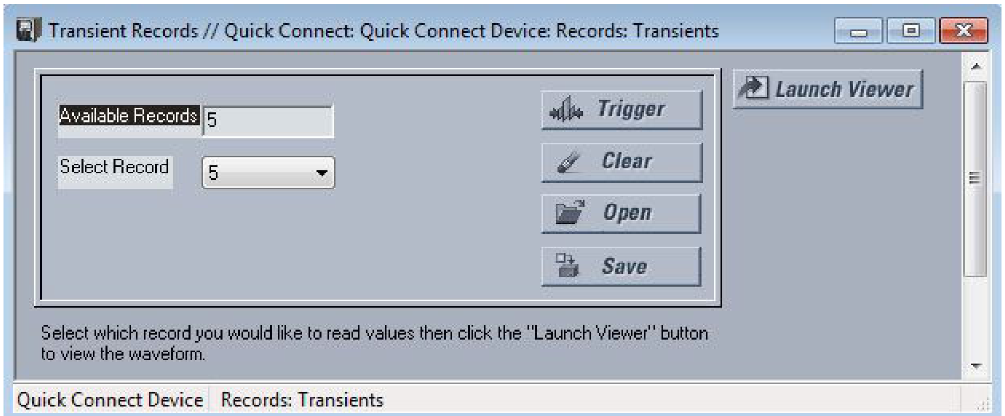
Transient Recorder (Waveform Capture)

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.



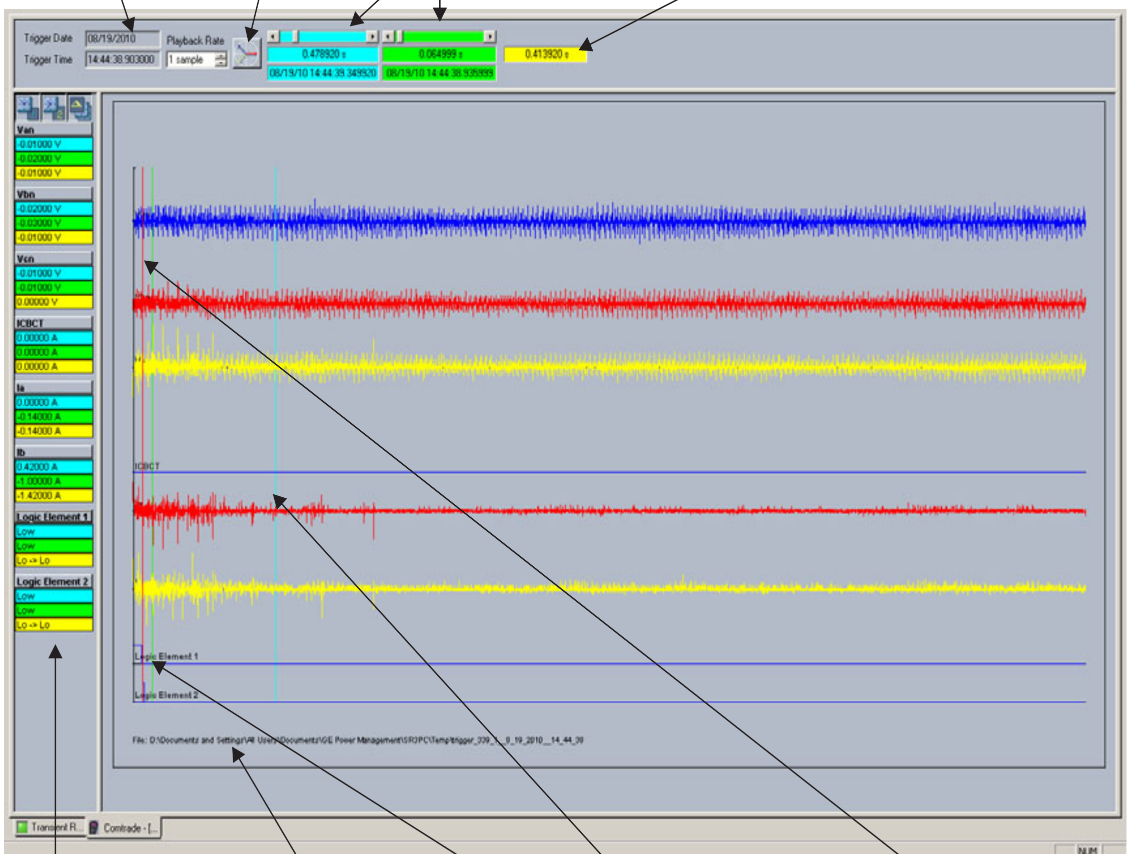
- Click on **Trigger Waveform** to trigger a waveform capture.
- To view the captured waveforms, click on the **Launch Viewer** button. A detailed Waveform Capture window appears as shown below.
- Click on the **Save** button to save the selected waveform to the local PC. A new window appears, requesting 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.

TRIGGER TIME & DATE
Displays the time and date of the Trigger.

VECTOR DISPLAY SELECT
Click here to open a new graph to display vectors.

CURSOR LINE POSITION
Indicates the cursor line position in time with respect to the beginning of the buffer.

DELTA
Indicates time difference between the two cursor lines.



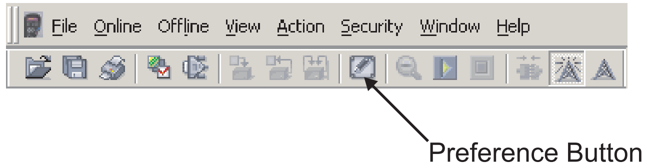
Display graph values at the corresponding cursor line. Cursor lines are identified by their colors.

FILE NAME
Indicates the file name and complete path (if saved).

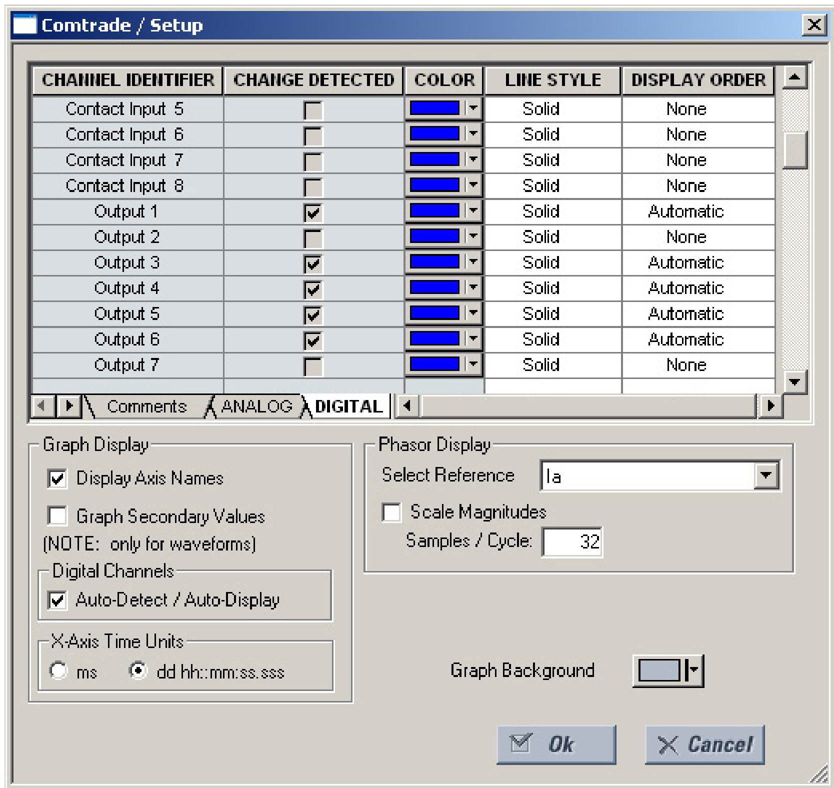
CURSOR LINES
To move lines, locate the mouse pointer over the cursor line, then click and drag the cursor to the new position.

TRIGGER LINE
Indicates the point in time for the trigger.

- 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.



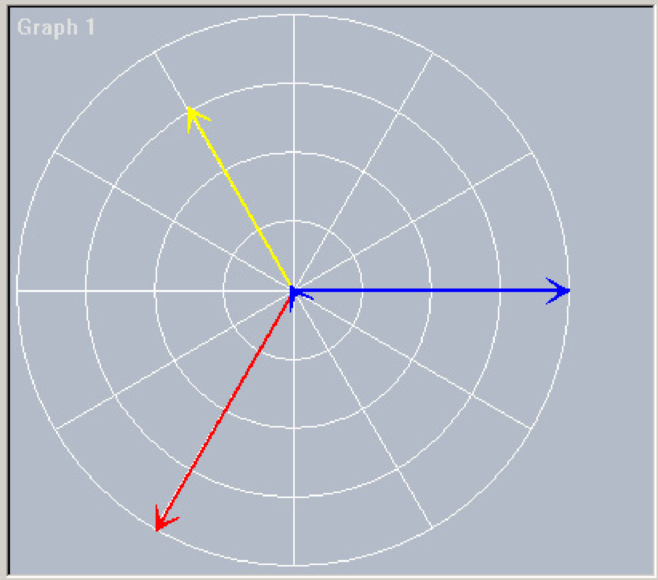
The following window appears:



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:

CHANNEL IDENTIFIER	COLOR	GRAPH	MAGNITUDE / ANGLE
Ia		Graph 1	502.01 A 0.00 deg
Ib		Graph 1	502.05 A -119.85 deg
Ic		Graph 1	385.60 A -240.01 deg
Ig		Graph 1	11.64 A -239.41 deg



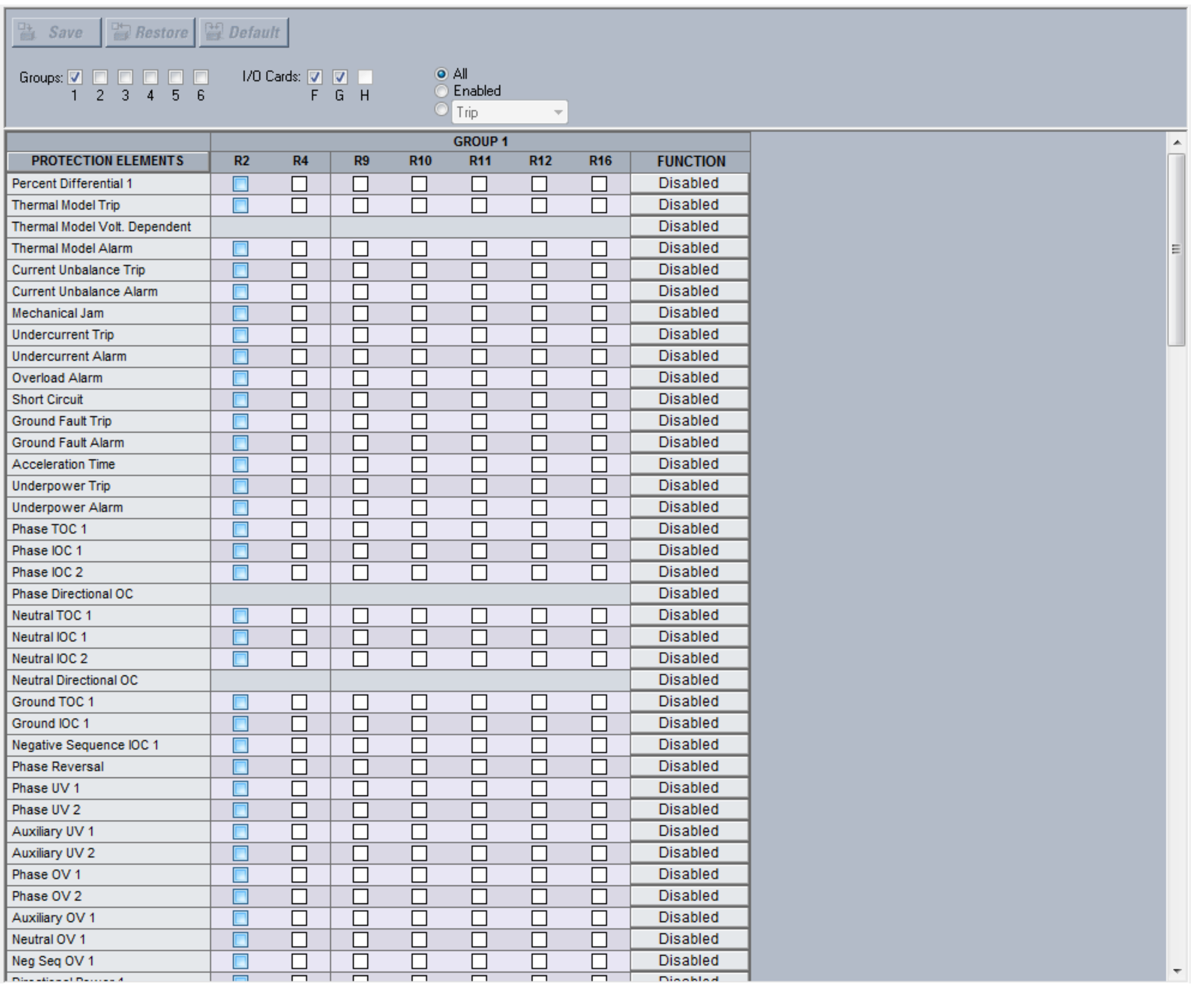
Protection Summary

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) 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 469 offline settings files to 8 Series files for 869 devices.

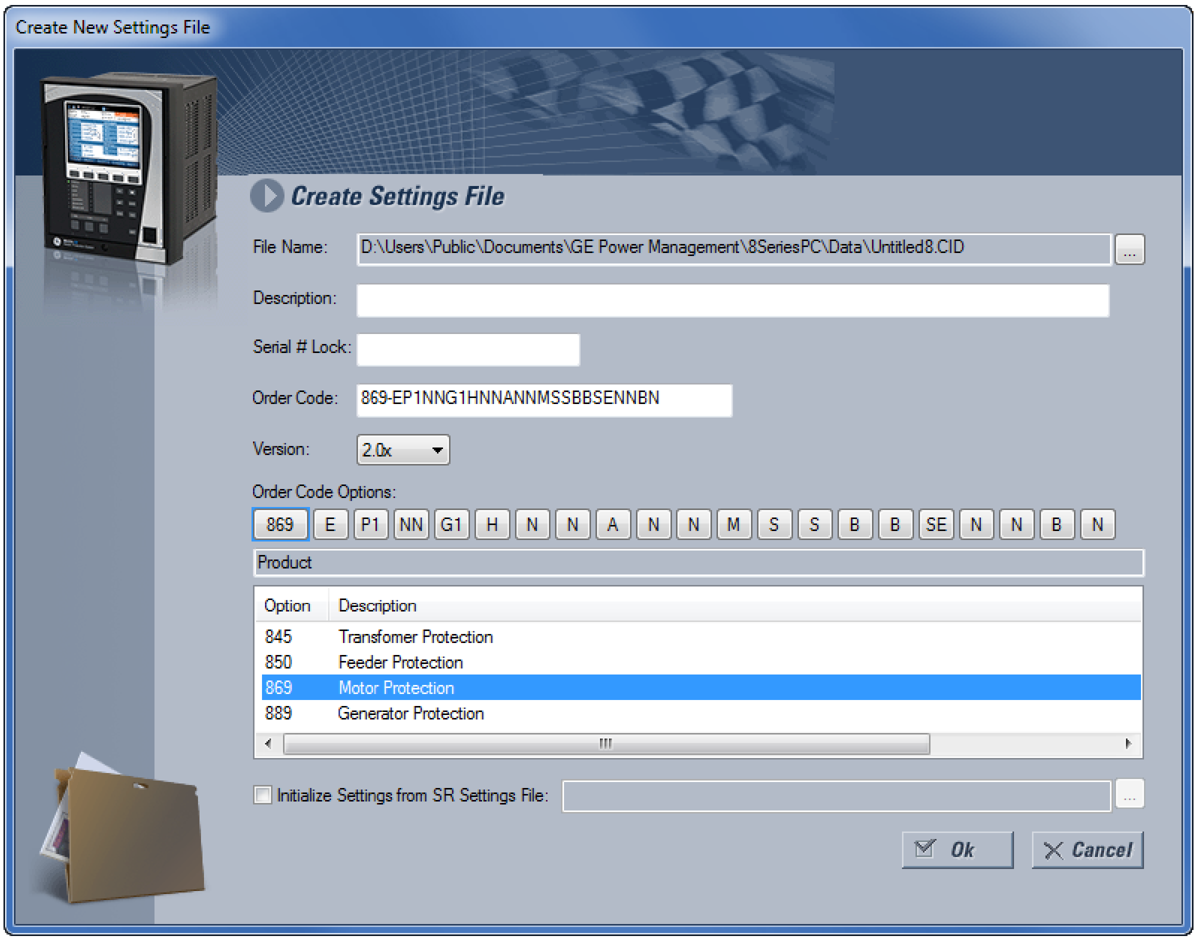
The EnerVista 8 Series Setup software reduces the manual effort required when moving from an older product to the 869. The settings file conversion feature takes an existing 369/469 settings file and generates a new settings file compatible with the 8 Series order code specified. After the import is complete, the results are displayed in an interactive results window.

Convert SR 469 Files

EnerVista 8 Series Setup version 1.2x and above supports conversion of SR 469 files above version 5.0 only to 869 settings files. For files below version 5.0x, first convert these files to version 5.0 or higher using the latest EnerVista 469 Setup software before doing the 869 conversion.

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 Settings 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.
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.

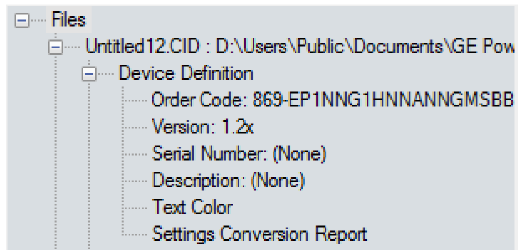
Convert 369 Files

EnerVista 8 Series Setup version 1.3x and above supports conversion of all 369 files as long as they are from a 32-bit PC. If the file is 16-bit it must be converted to a 32-bit file using the 369 EnerVista Setup before doing the 869 conversion.

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 3-25: 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 3-26: 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.

NOTE

Custom curves from 469 cannot be converted to 869 although they appear in the conversion report. Although settings show successful conversion, the settings must still be verified before putting the relay in 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.

869 Motor Protection System

Chapter 4: About Setpoints

The 869 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.

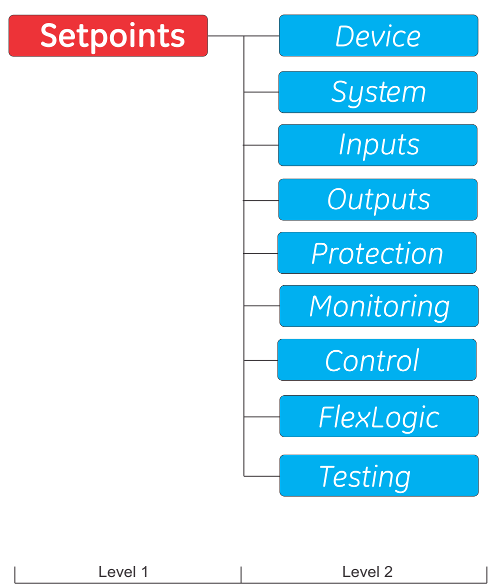
NOTE

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



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 869 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
- FLA: motor current at full load (Full Load Amperes)

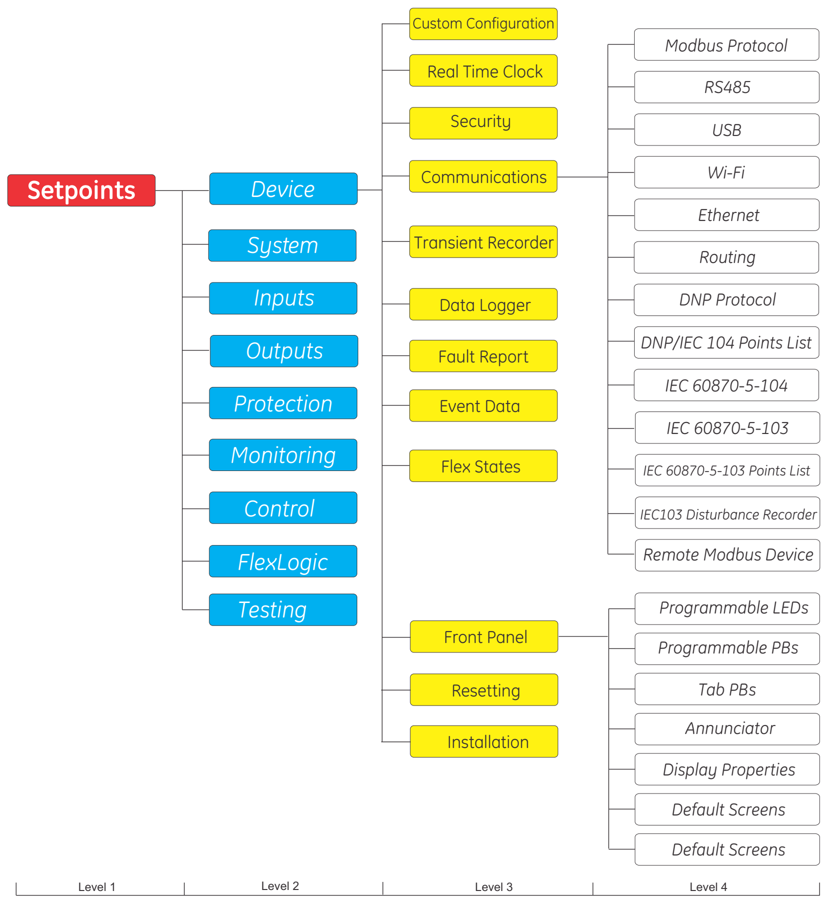
869 Motor Protection System

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.

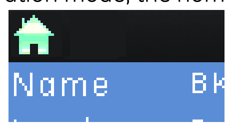
Simplified configuration mode does not remove any functionality or setting from the device. It only controls the view or display of the settings. All the settings made in Regular configuration mode are still applied during simplified mode (they are either hidden or read-only). Therefore, simplified configuration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

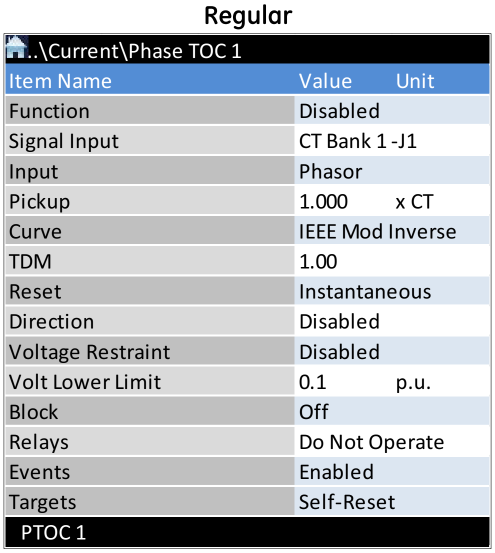
The Phase TOC 1 function in Regular mode has 14 setpoints made available to edit (read-write). In the case of Simplified mode this function has only 6 out of the 14 setpoints made available to edit (read-write), 5 setpoints are hidden, and 3 setpoints are read/view-only.

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

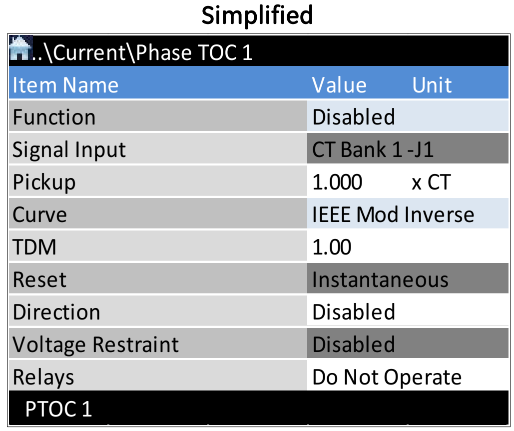


..\Current\Phase TOC 1

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

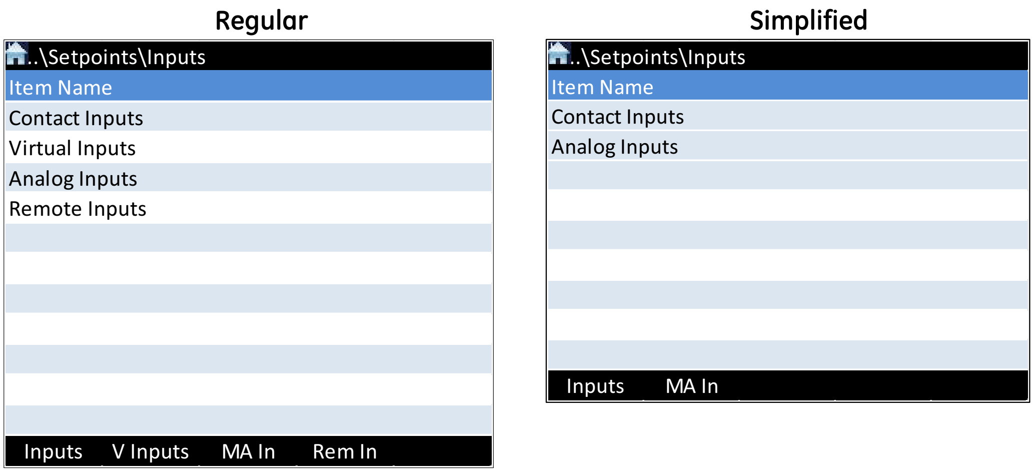
Item Name	Value	Unit
Function	Disabled	
Signal Input	CT Bank 1 -J1	
Pickup	1.000	x CT
Curve	IEEE Mod Inverse	
TDM	1.00	
Reset	Instantaneous	
Direction	Disabled	
Voltage Restraint	Disabled	
Relays	Do Not Operate	

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



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 869 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 869 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 869, by default the 869 clock syncs to PTP over IRIG-B. If PTP is not available the 869 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.

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.

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.

SNTP Protocol

869 Motor Management 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

869 Motor Management 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 869 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
|----------- Clear	Yes	Yes	No
Status	R	R	R
Metering	R	R	R
Setpoints			
|-------------- Device			
| |-------------- Real Time Clock	RW	RW	R
| |-------------- Security	RW	R	R
| |-------------- Communications	RW	R	R
Records			
|------------ Clear	Yes	Yes	No
Maintenance			
|----------- Modbus Analyzer	NA	NA	NA
|----------- Update Firmware	Yes	No	No
|----------- Retrieve File	Yes	Yes	Yes events, oscillography, diagnostic

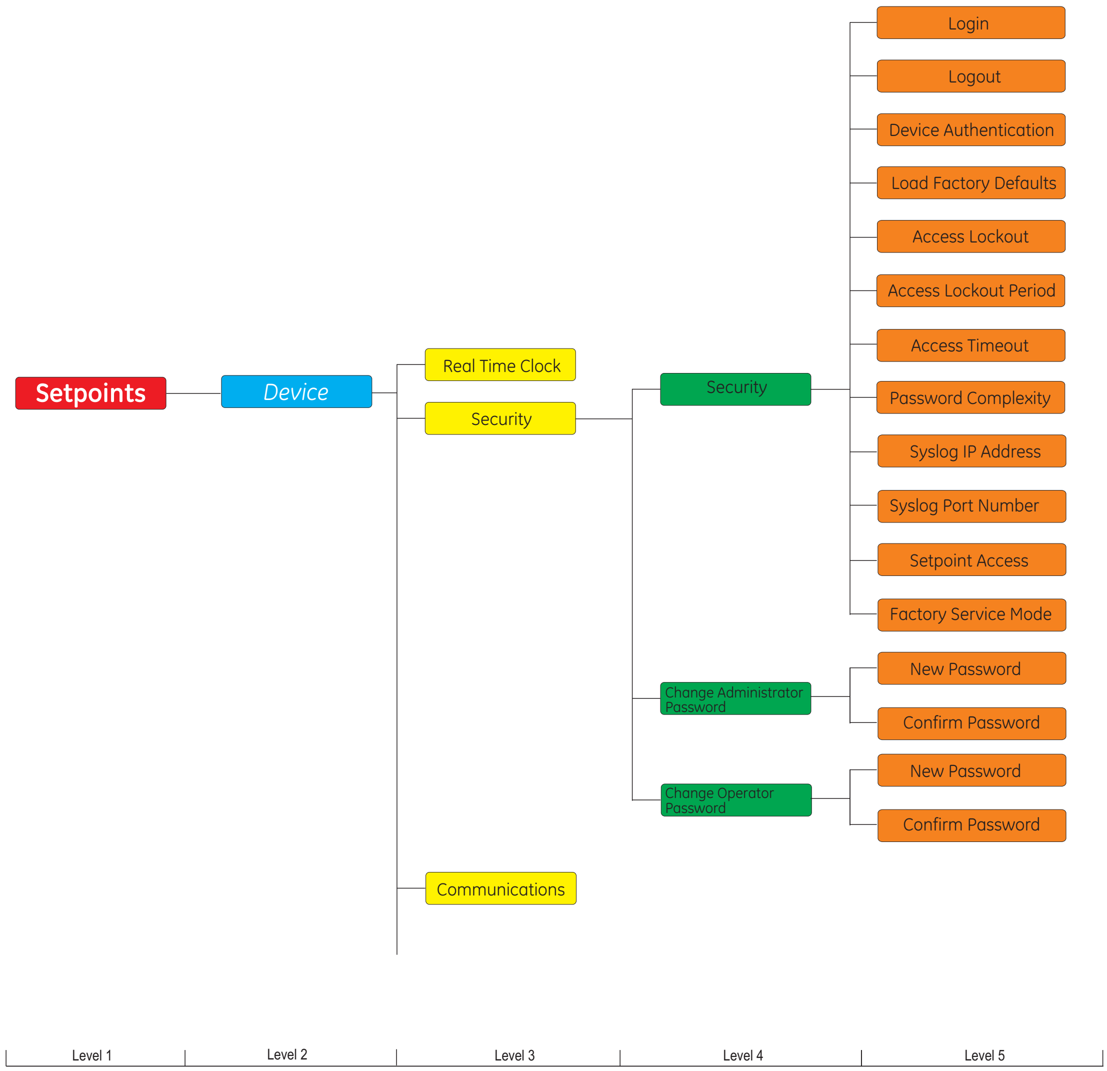
NOTICE

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 869)	All files	Yes	Yes	Yes
Write (Upload to 869)	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 869. 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 869.

The 869 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 869 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 869 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 869 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 869:

- 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 869 over Ethernet, the 869 slave address, TCP port number and the 869 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 869 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 869 without the communications card,
- five for an 869 with the communications card.

COMPATIBILITY

Range: Disabled, SR469

Default: Disabled

The Compatibility mode changes the Modbus actual value registers to emulate a 469 relay. The emulation supports typical actual value data for common data items. See the *8 Series Protective Relay Communications guide* for the list.

NOTE

When the device is programmed as a 469 relay, 869 actual values cannot be retrieved from Modbus.

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 869.
02	ILLEGAL DATA ADDRESS	The address referenced in the data field transmitted by the master is not an allowable address for the 869.
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

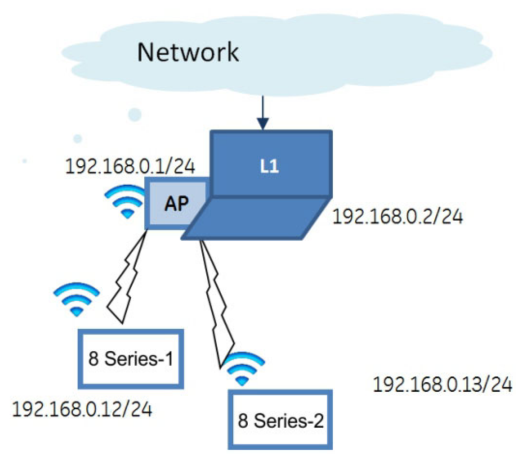
1. The PC WiFi Network Settings are as follows:
   Passphrase: provided with the 8 Series relay
2. The Access Point Settings are given below:

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 869 to accommodate the features of the 869 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 (869) 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

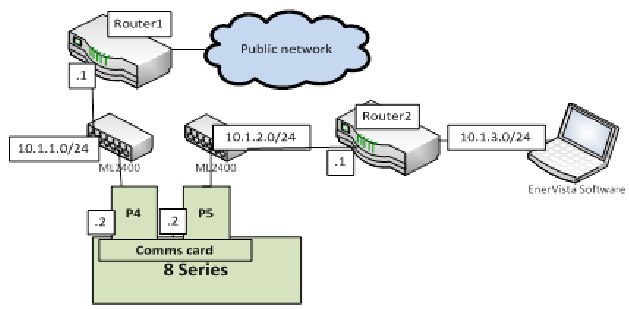
Description: A route with mismatched destination and mask has been configured.

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 869 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 869 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 869 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 869 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 869 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 869. 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 869 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 869. 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 869 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 869 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 869 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. 869 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 869 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 869 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 869 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 869 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 869 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 869 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 869 configuration software, EnerVista 8 Series Setup software.

The IEC 61850 Configurator

The 869 supports the IEC 61850 protocol which is identified by order code option “**2E**”.

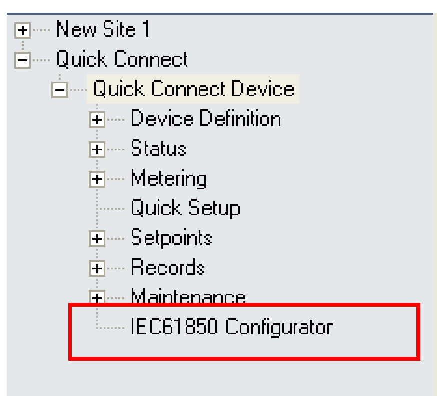
The IEC 61850 configurator is found in both the online and offline section of the EnerVista 8 Series Setup software for configuring the online 869 and offline 869 settings file respectively.

Online and Offline Setup

ONLINE SETTINGS FILE

Two options are available to configure the relay’s online settings file.

1. Configuration
   - Configure the 869 (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.

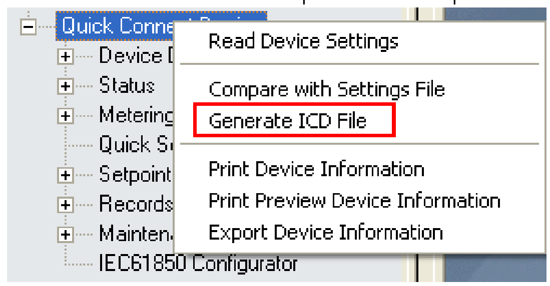


   - Launch the online IEC 61850 configurator screen, by double-clicking on the **IEC61850 Configurator** “tree” item.
   - Select the required settings from the different tab displays (in the configurator screen) to complete the IEC 61850 configuration.
2. Online right-click option

– 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 869 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.

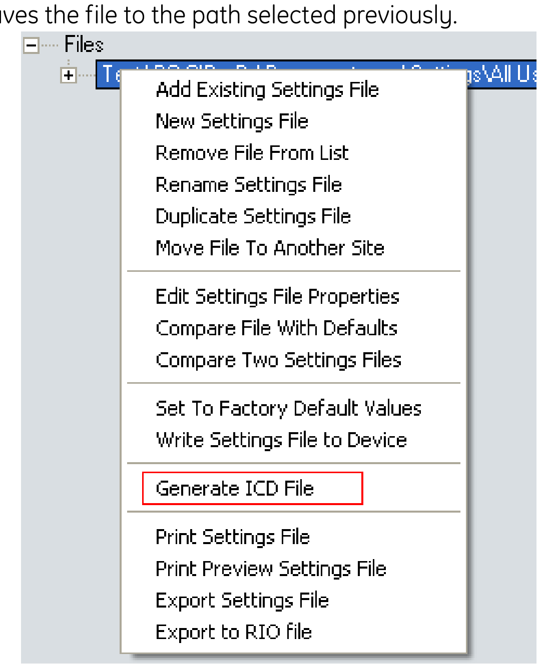
– The maximum allowed services must be equal or below the specified limits as in ICD/CID.

– 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

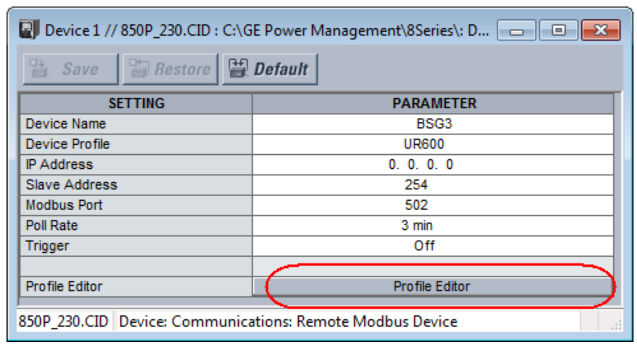
fault: Off

Remote Modbus Device Editor

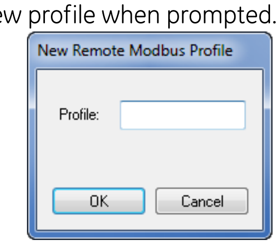
The Remote Modbus Device Editor allows customization of the generic Modbus device. Using this feature, data can be read from another device on the network. The data retrieved is mapped from Digital Points to FlexLogic operands, and from Analog Points to FlexAnalog values for use in relay logic operations.

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.

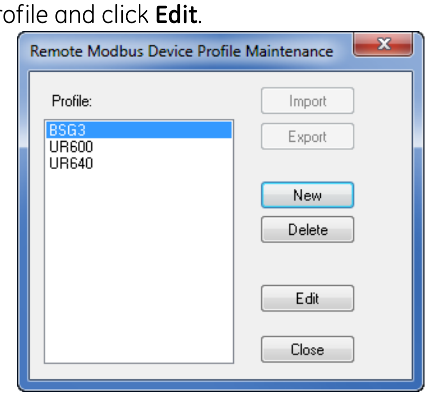


   Click **OK** to create the new profile.

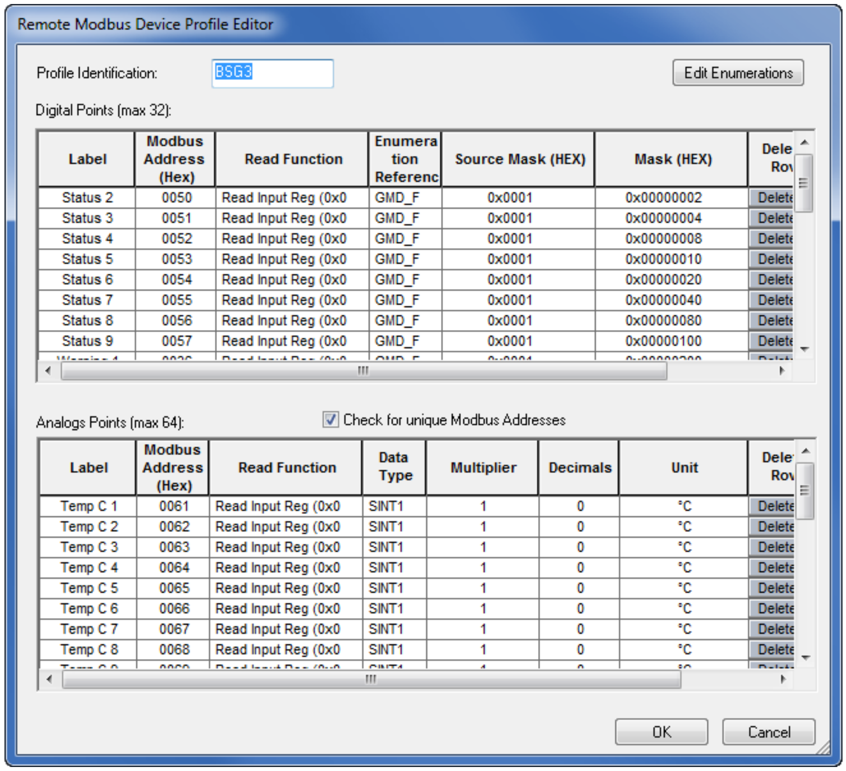
   – Profiles are stored in the directory C:\Users\Public\Documents\GE Power Management\8SeriesPC\RMD_Profiles for a default installation, or in a similar path corresponding to the EnerVista 8 Series Setup installation path.

   – Profile files have the extension .8gmd, and are XML files.

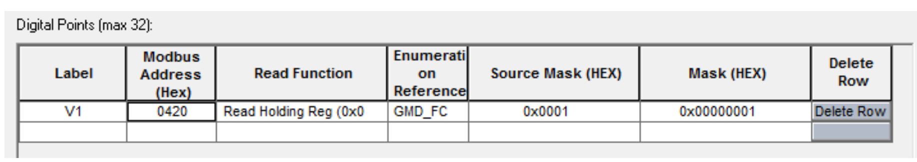
4. Select an existing profile and click **Edit**.



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.

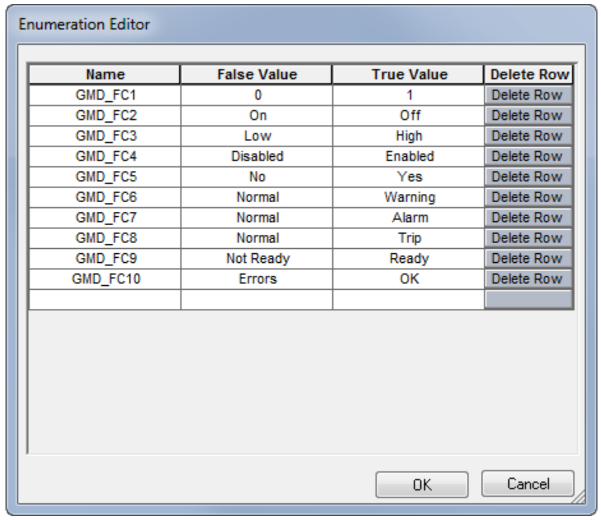
– **Source Mask**: The bit from the source to use as a source for the point. For example, if the Source Mask is 16, bit 4 will be used. (Bits are numbered 0 to 15.)

```
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.

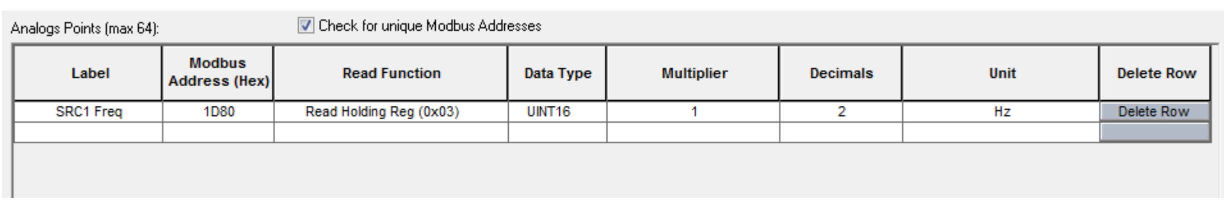


Name	False Value	True Value	Delete Row
GMD_FC1	0	1	Delete Row
GMD_FC2	On	Off	Delete Row
GMD_FC3	Low	High	Delete Row
GMD_FC4	Disabled	Enabled	Delete Row
GMD_FC5	No	Yes	Delete Row
GMD_FC6	Normal	Warning	Delete Row
GMD_FC7	Normal	Alarm	Delete Row
GMD_FC8	Normal	Trip	Delete Row
GMD_FC9	Not Ready	Ready	Delete 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.



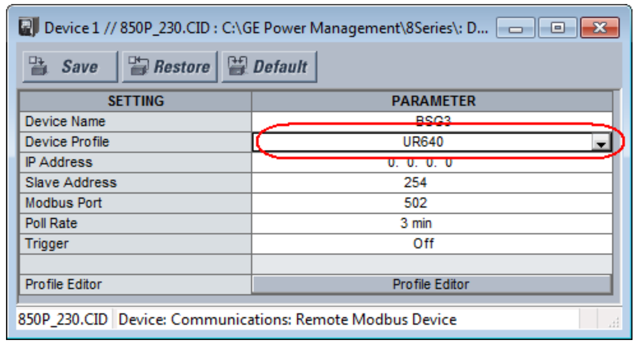
Label	Modbus Address (Hex)	Read Function	Data Type	Multiplier	Decimals	Unit	Delete Row
SRC1 Freq	1D80	Read Holding Reg (0x03)	UINT16	1	2	Hz	Delete Row

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

The 869 relay supports up to 15 fault reports. The trigger conditions and the analog quantities to be stored are entered in this menu.

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 869 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:

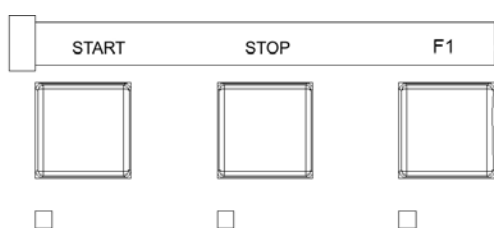
- **LED 1: IN-SERVICE** – non-programmable. The LED is hardcoded to show a green light when the relay is fully functional and an orange light when the relay is not programmed, or experiences a self-test error.
- **LED 2: TRIP** - see the default setpoint above and the description
- **LED 3: ALARM** - 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.

The digital state of the pushbuttons can be entered only locally (by directly pressing the front panel pushbutton). Typical applications include switching device control and settings groups changes. The user-programmable pushbuttons are under the control level of password protection.The user-configurable pushbuttons for the enhanced faceplate are shown below.

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: Start (PB1), Stop (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

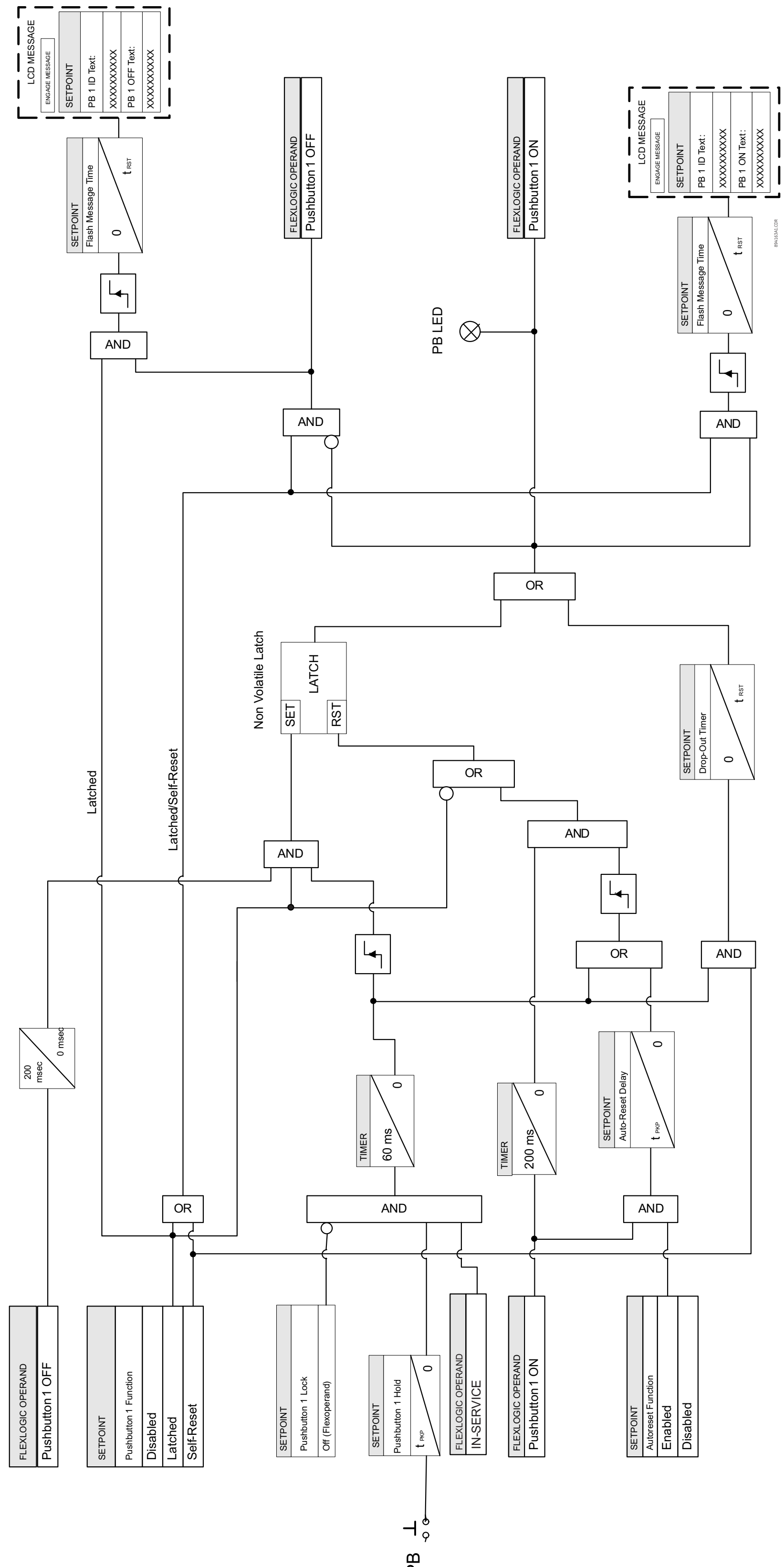
Range: Disabled, Enabled

Default: Enabled

Table 5-5: PB1 to PB3 Default Values (Membrane and Rugged Front Panels)

	PB1	PB2	PB3
Function	Self-Reset	Self-Reset	Self-Reset
ID Text	Start	Stop	F1
ON Text	PB1 ON	PB2 ON	PB3 ON
OFF Text	PB1 OFF	PB2 OFF	PB3 OFF
LED Trigger	PB1 ON	PB2 ON	PB3 ON
Hold Pressed	0.1s	0.1s	0.1s
Autoreset	Disabled	Disabled	Disabled
Autoreset Delay	1.0s	1.0s	1.0s
Lock	Off	Off	Off
Dropout Time	0.0s	0.0s	0.0s
Events	Enabled	Enabled	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

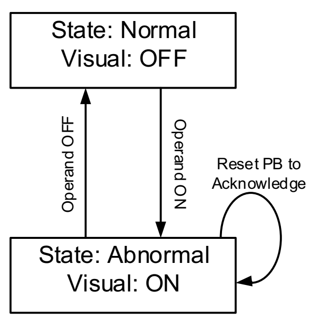
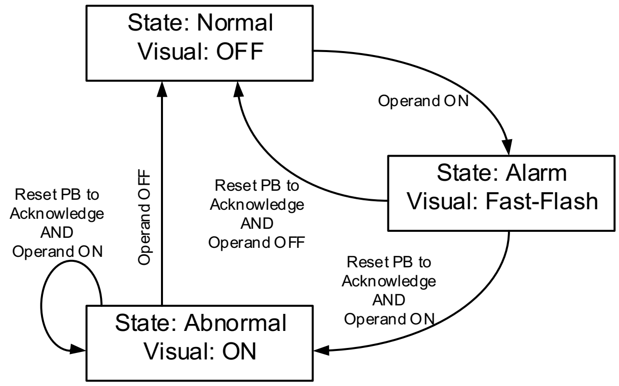


Figure 5-12: Latched Mode



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

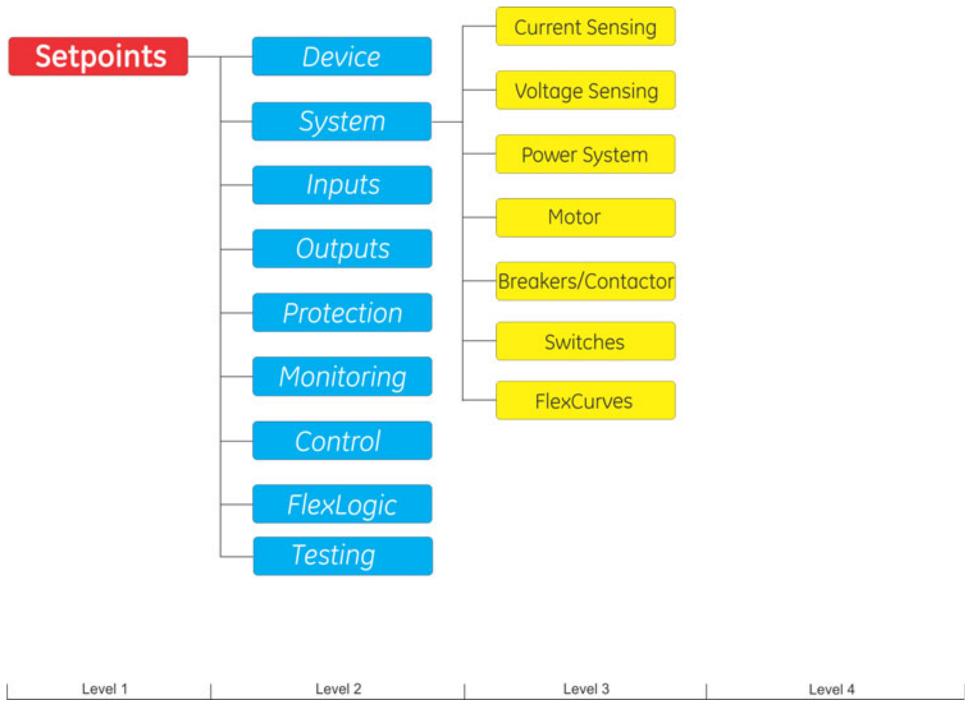
Default: 1.0 V

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



Current Sensing

The Current Sensing menu provides the setup menu for the Current Transformers (CTs) connected to the 869 terminals. The setup of the three-phase CTs, and the Ground CT requires a selection of primary CT ratings. The secondary CT ratings are selected in the 869 Order code. The CT inputs are grouped in banks of four currents on the 869 – three inputs for phase currents A, B, and C, and one input for ground current. The basic AC card has two AC banks, one bank currents and one bank voltages.

The 869 basic Motor Protection System has 8 AC inputs, which reside on the card inserted in slot J.

There are four options for the 8 AC inputs from card J as follows:

Option 1 (P5G5/P1G1):

- four AC input currents, 3 CTs for phase currents and 1 CT for the ground or residual connection current, and
- four AC input voltages, 3 VTs for phase voltages, and 1 VT for auxiliary voltage

Option 2 (P50B/P10B):

- four AC input currents, 3 CTs for phase currents and 1 CT for Sensitive 50:0.025A ground or residual connection current, and
- four AC input voltages, 3 VTs for phase voltages, and 1 VT for auxiliary voltage

Option 3 (P5S1/P1S1):

- four AC input currents, 3 CTs for phase currents and 1 CT for ground or residual connection current, and
- four AC input voltages, 3 VTs for phase voltages, and 1 VT for auxiliary voltage

Option 4 (P55B):

- four AC inputs currents, 3 CTs for phase currents and 1 Sensitive 50:0.025A CT for ground or residual connection current, and
- four AC inputs voltages, 3 VTs for phase voltages, and 1 VT for auxiliary voltage

Additionally, a second card can be inserted into slot K. There are four options for the four AC input currents as follows:

Option 1 (P1B1/P5B5):

- 3 CTs for phase currents and 1 CT for Sensitive 50:0.025A ground current

Option 2 (NNS1):

- 1A CT for sensitive ground current

Option 3 (C5G5/C55B):

- four AC inputs currents, 3 CTs for phase currents and 1 CT for ground or residual connection current
- three synchronous motor input, 1 Field AC Voltage, 1 Field DC Voltage, 1 Field DCMA Current and 1 PF Regulation Voltage Output

Option 4 (D5G5/D55B):

- four AC inputs currents, 3 CTs for phase currents and 1 CT for ground or residual connection current
- three synchronous motor input, 1 Field AC Voltage, 1 Field DC Voltage, 1 Field VDC Current and 1 PF Regulation Voltage Output

The Current sensing selection for the 869 is found in the following menus:

Path: Setpoints > System > Current Sensing > CT Bank 1-J1

Path: Setpoints > System > Current Sensing > CT Bank 2-K1

CT BANK NAME

This setting allows the user to specify CT bank name which will appear in all menus and metering screens.

PHASE CT PRIMARY

Range: 1 A to 12000 A
Default: 500 A

Enter the primary rating of the three-phase feeder CTs wired to the relay phase CT terminals. With the phase CTs connected in wye (star), the calculated phasor sum of the three phase currents (Ia + Ib + Ic = Neutral Current = 3I0) is used as the input for the neutral.

GROUND CT PRIMARY

Range: 1 A to 12000 A
Default: 500 A

Enter the primary rating of the ground CT wired to the relay ground CT terminals. When the ground input is used for measuring the residual 3I0 current, the primary current must be the same as the one selected for the phase CTs.

SENSITIVE GROUND CT PRIMARY (displayed only if the Sensitive ground input is installed)

Range: 1 A to 12000 A
Default: 500 A

Enter the primary rating of the sensitive ground CT wired to the relay sensitive ground CT terminals.

NOTE

The Sensitive Ground CT Primary setpoint is available only with ground current order code option S1.

NOTE

The cut-off for current measurements is 0.02 x CT. This is the minimum value above which metering functions.

Synchronous Motor Field Current Sensing

This menu provides configures the synchronous motor field current input. Depending on the order code selection, the 869 provides either dcmA or VDC type input to measure the DC field current. Selection of the DC field input type (dcmA or VDC) depends on the DC Current Transducer (DCCT) installed.

These settings are available only with synchronous motor order codes (Phase Current options C5/D5 for Slot K).

Path: Setpoints > System > Current Sensing > SM FLD A-K2

NAME

This setting allows the user to specify the name to appear in all menus and metering screens.

RANGE

Slot K with order code option C5:

Range: 0 to 20 mA, 4 to 20 mA
Default: 4 to 20 mA

Slot K with order code option D5:

Range: 0 to 10 VDC
Default: 0 to 10 VDC

Max FLD Amps Primary (MFA)

Range: 1.00 to 3000.00 A in steps of 0.01 A

Default: 100.00 A

This value specifies the maximum primary side DC field current that corresponds to the maximum of the range selected under setpoint 'Range'.

For example:

A DCCT installed to measure the DC field current has the following specifications: primary DC current range, I_{in}: 0 - 200 ADC; secondary DC current range, I_{out}: 0 - 20 mA.

In order to correctly calculate the primary field DC current from the measured secondary DCMA, setpoints 'Max FLD Amps Primary (MFA)' and 'Range' must be set to 200 A and 0-20 mA, respectively.

Figure 5-14: DC Field Current Input Characteristics

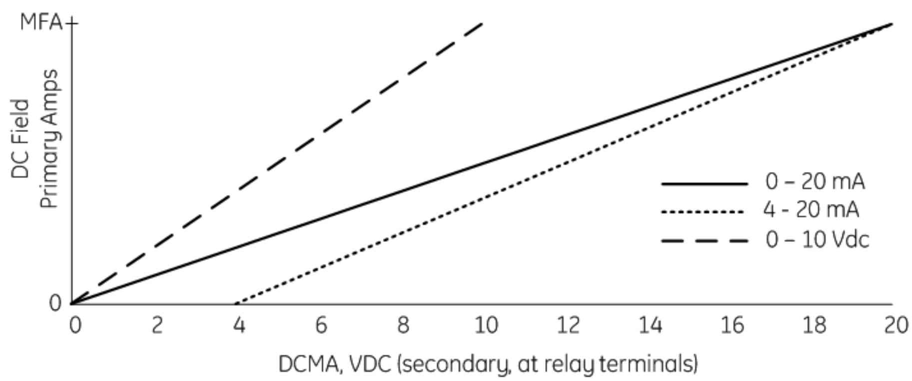
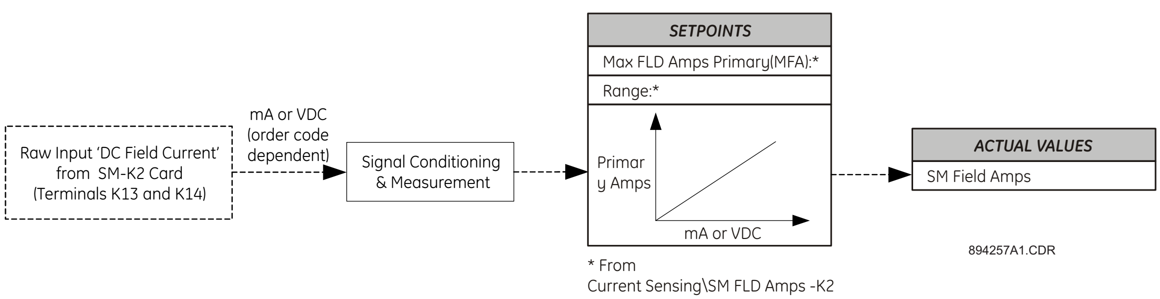


Figure 5-15: DC Field Current Input



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 869 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

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) or operand derived by the Time of Day Timer element. Time-based shift schedules can be set in the Time of Day Timer element.

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.

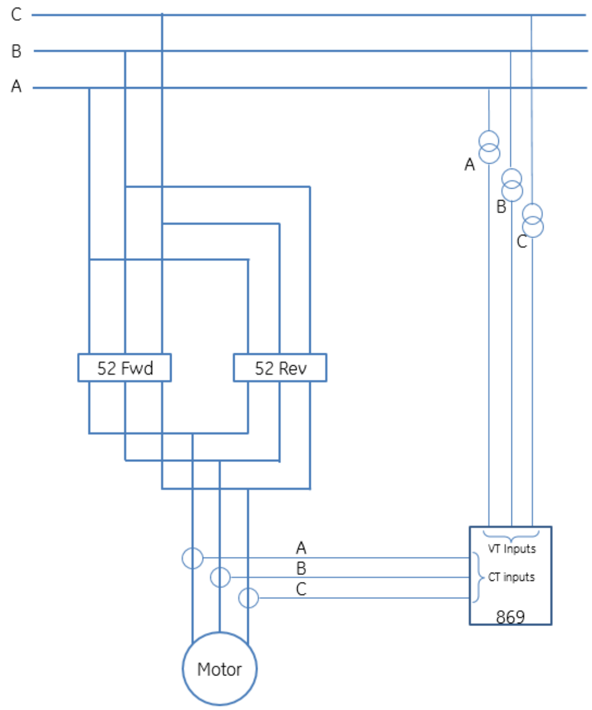
REVERSE PH ROTATION - CT Bnks
REVERSE PH ROTATION - VT Bnks

Default: Off

Range: Off, Any FlexLogic operand

The 869 relay provides the flexibility of dynamically reversing the phase rotation (ABC <-> ACB) of both current and voltage phases. These setpoints can be used to reverse phase rotation of CT bank(s) and VT bank independent of each other. There may be a reverse motor application when only current phase rotation is reversed (ABC <-> ACB) while voltage phase rotation remains the same. An example of such an application is illustrated in the figure below.

Figure 5-16: Reverse motor application, current phase rotation reversed



These settings dynamically reverse the phase rotation of all currents/voltages set under **Setpoints > System > Power System > Phase Rotation**. For example, if the nominal phase rotation is ABC but the condition (FlexLogic operand) becomes true (high), then the phase rotation switches to ACB.

The reverse phase rotation feature is only intended for use in special applications such as pumped storage schemes, reverse motor application, etc. As soon as the reverse phase rotation condition (FlexLogic operand) status becomes false (low), the phase rotation returns to the nominal value set under **Setpoints > System > Power System > Phase Rotation**.

NOTICE

Dynamic switching of the phase rotation (ABC <-> ACB) using this feature blocks all relay functions that use current and voltage measurements for 3 cycles as soon as phase rotation switches from forward to reverse or reverse to forward.

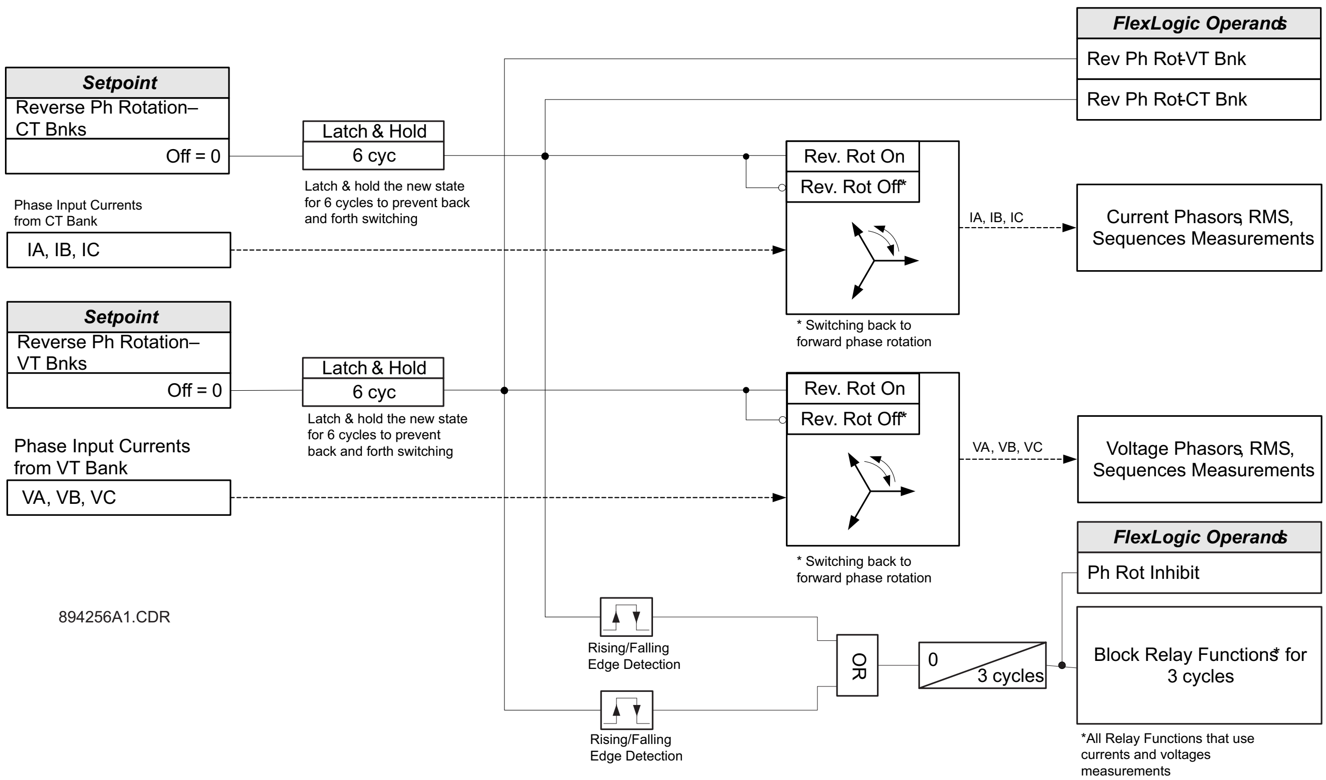
⚠CAUTION

Any FlexElement that uses FlexAnalog values (current, voltage, power, impedance) must be blocked using the FlexLogic operands 'Ph Rotation Inhibit' in order to secure element operation during the phase rotation switching process.

⚠CAUTION

In applications when only the current phase rotation reverses while voltage phase rotation remains same, as illustrated by the figure below, different CT and VT phase rotations may result in unexpected operation of the functions that use power, power factor, and impedance. It is recommended to block these functions.

Figure 5-17: Reverse phase rotation logic diagram



FREQUENCY TRACKING

Range: Disabled, Enabled

Default: Enabled

The frequency reference is provided by composite signal derived by the Clarke transformation ($V_{FREQUENCY} = (2V_A - V_B - V_C) / 3$) for better performance during fault, open pole, and VT and CT fail conditions.

- If present, the three-phase voltages are used for frequency tracking. Phase A voltage is used as a phase reference.
- Frequency tracking is switched automatically by an algorithm, to the three-phase currents (or auxiliary voltage signal for the tie-breaker configuration), if the frequency detected from the three-phase voltage inputs is declared invalid. The switching is not performed if the frequency from the alternative reference signal is detected invalid.
- Upon detecting valid frequency on the main frequency and phase reference signal, tracking is switched back to that reference.

NOTICE

FREQUENCY TRACKING should be set to “Disabled” only under very unusual circumstances. Consult the factory for special variable-frequency applications.

Motor

Setup

The following settings reflect the design and configuration of the motor that the relay will protect. Note that some protection elements are dependent on these settings for correct operation.

Path: **Setpoints > System > Motor > Setup**

SYNCHRONOUS MOTOR TYPE

Range: None, Brushless, Brush-type

Default: None

NOTICE

This setpoint is only available when the order code Phase Currents - Slot K options is one of C5/D5.

This setting specifies the type of synchronous motor. Proper selection of the synchronous motor type enables the corresponding settings and functions, which are different for the two different motors and alter operation of the relay.

MOTOR FULL LOAD AMPS (FLA)

Range: 1 to 5000 A in steps of 1 A

Default: 100 A

This setting represents the full load current (FLA) of the motor. FLA is a standard motor parameter that can be found on the motor nameplate.

MOTOR OVERLOAD FACTOR

Range: 1.00 to 1.50 in steps of 0.01

Default: 1.00

This setting defines the current level at which the motor is considered to be overloaded. If the motor current exceeds the Motor Overload Factor threshold, the 869 Thermal Model reacts by accumulating thermal capacity. Normally, this factor is set slightly above the motor service factor to account for inherent load measuring errors (CTs and limited relay accuracy). The typical total inaccuracy factor is 8 to 10%; as such, for motors with a thermal capability at a rated service factor of 1 or 1.15, the Motor Overload Factor must be set to 1.1 or 1.25 respectively.

MOTOR NAMEPLATE VOLTAGE

Range: 100 to 50000 V in steps of 1 V

Default: 600 V

This setting represents the rated phase-to-phase motor voltage. The Motor Nameplate Voltage setting is used as a reference for the voltage dependent thermal overload curve feature and indicates a 100% voltage starting condition.

MOTOR HORSEPOWER

Range: 100 to 200000 HP in steps of 1 HP

Default: 4000 HP

This setting represents the motor rated horsepower (HP).

NOTE

This setting is only needed in the Stator-Inter-Turn Fault element to calculate negative sequence impedance when the setpoint Neg Seq Imp Autoset (see Monitoring > Stator-Inter-Turn Fault) is programmed as Auto.

MOTOR RATED EFFICIENCY

Range: 0.0 to 100.0% in steps of 1.0

Default: 100.0%

This setting represents the motor rated efficiency and is used by the ESA (electrical signature analysis) element found under Monitoring. This setting is only available with order code option Extended (E) Monitoring.

EMERGENCY RESTART

Range: FlexLogic operand

Default: Off

This feature must only be used in an emergency, as it defeats the purpose of the relay – protecting the motor. The input selected by the setting is used to reset the motor thermal capacity used from its current value to 0%, so that a hot motor may be restarted. The selected input also sets start inhibit block functions Thermal Inhibit, Maximum Starting Rate and Time Between Starts lockout time to zero. However, a Restart Delay inhibit lockout will remain active (it may be used as a backspin timer) and any trip condition that remains (such as a hot RTD) will still cause a trip.

In the event of a real emergency, the Emergency Restart input must remain asserted until the emergency is over. All the associated output relays reset until the Emergency Restart Input is removed. However, the TCU does not remain reset to zero if the Emergency Restart input remains asserted, the thermal model continues calculating the TCU.

The Emrg Restart Alarm operand is asserted if the Emergency Restart input remains asserted for 10 seconds.

NUMBER OF STARTS TO LEARN

Range: 1 to 5 in steps of 1

Default: 3

This setting selects number of motor start and stop records to calculate learned data presented in the **Setpoints > Records > Motor Learned Data**.

LOAD AVERAGE CALC. PERIOD

Range: 1 to 90 min in steps of 1 min

Default: 15 min

This setting adjusts the period of time over which the average motor load and power is calculated. The calculation is ignored during motor starting.

SWITCHING DEVICE TYPE

Range: Breaker, Contactor

Default: Breaker

This setting specifies the type of switching device installed to Stop/Start motor.

FIELD SWITCHING DEVICE TYPE

Range: Breaker, Contactor

Default: Breaker

This setting specifies the type of switching device installed to connect/disconnect the synchronous motor field.

NOTICE

This setpoint is not available when the setpoint SYNCHRONOUS MOTOR TYPE is set to None or the unit order code does not have synchronous motor selected.

MOTOR LOAD FILTER INTERVAL

Range: 0 to 32 cycles in steps of 1 cycle

Default: 0 cycles

This value (when non-zero) averages current and power factor for the programmed number of cycles using a running average technique.This setting is intended for use on driving reciprocating loads or variable frequency drives (VFD).

With the reciprocating load application, the number of cycles to average can be determined from current waveform capture using the Oscillography/Datalogger features in 869. The second way to determine this setpoint is by using the following relation:

N = P / 2, where N is the number of cycles to average and P is the number of poles on the motor.

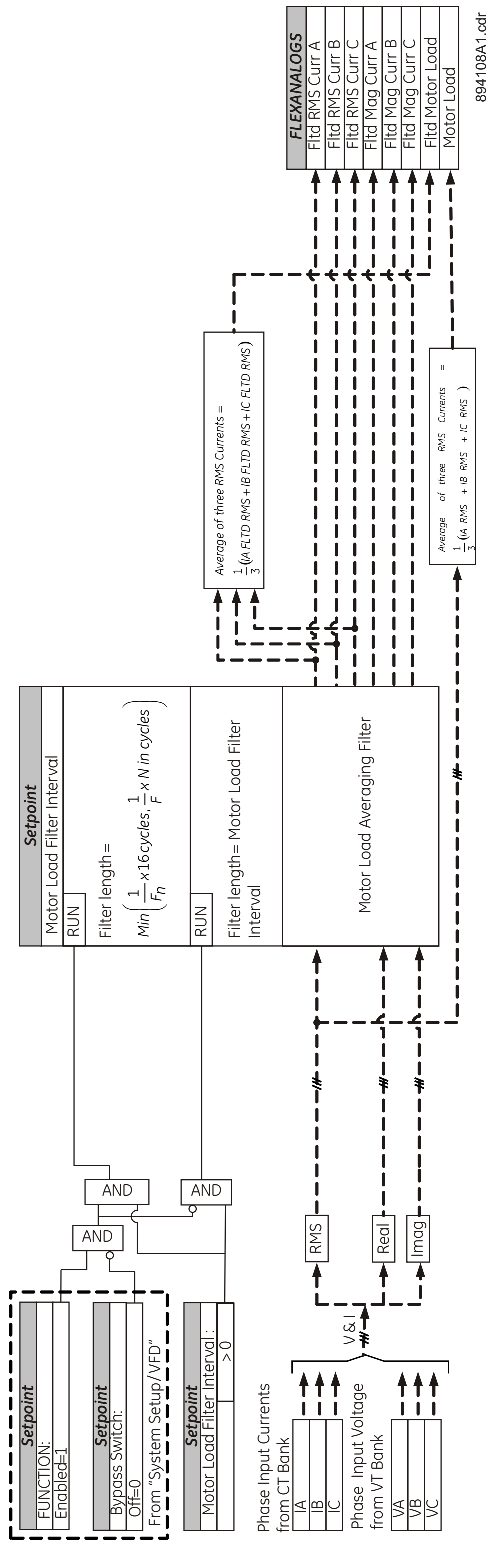
For example: Set the "Motor Load Filter Interval" equal to 3 cycles for a motor driving reciprocating load with 6 number of poles.

The latter approach of determining the cyclic load only applies to the applications where loads are coupled directly to the motor (with no gear box).

NOTICE

When set greater than one cycle, Motor Load Filter Interval may increase trip/alarm times for the following protection elements: Acceleration Time, Current Unbalance, Mechanical Jam, Overload, Thermal Model, Undercurrent, Power Factor, Three-Phase Apparent Power, Three-Phase Reactive Power, Three-Phase Real Power and Under Power. No other elements are affected. Trip/alarm times increase 16.7 ms (or 20msec @50Hz) for each additional cycle in the filter interval. The details are described in the VFD section.

Figure 5-18: Motor Load Averaging Filter for VFD and Cyclic Load Motor Applications



NUMBER OF POLES

Range: 2 to 64 in steps of 2

Default: 2

This setting represents the number of poles of the motor.

MAX. ACCELERATION TIME

Range: 1.00 to 180 s in steps of 0.01 s

Default: 10.00 s

This setting specifies the maximum acceleration time. This setting can be estimated experimentally by starting a given motor several times under various load and electrical conditions and measuring the starting time. Some security margin should be applied.

This setting is used by the Acceleration Time element (see Protection > Motor) and Motor Start Statistics (see Records).

The Acceleration Time element operates if the motor is not in the Running state when this time expires.

Regardless of whether the Acceleration Time element is Enabled or Disabled, this setting is also required to calculate the Motor Start Statistics when the motor doesn't go in the Running state from the Start state, i.e. unsuccessful motor start. For a successful motor start, motor Starting and Running states are used to calculate the motor start statistics.

2-SPEED MOTOR PROTECTION

Range: Disabled, Enabled

Default: Disabled

NOTICE

2-Speed Motor Protection is not applicable when the relay is used for synchronous motor applications (when setpoint SYNCHRONOUS MOTOR TYPE is set to 'Brush-type' or 'Brushless').

This setting is used to enable the two-speed motor function. This function provides proper protection for a two-speed motor where there are two different full load values.

The two-speed functionality is required for motors having two windings wound into one stator. One winding, when energized, provides one of the speeds. When the second winding is energized, the motor takes on the speed determined by the second winding.

The 869 algorithm integrates the heating at each speed into one thermal model using a common thermal capacity used register value for both speeds. Using the 869 for such applications provides several options, allowing the removal of traditional wiring and interlocking.

- Use the 869 front panel pushbuttons and provide necessary operate and interlock logic via FlexLogic.
- Use the external pushbuttons and provide necessary operate and interlock logic using FlexLogic as shown below.
- Use a traditional external control schematic with some connections to the 869 for control and protection.

SPEED2 MOTOR SWITCH

Range: Off, any FlexLogic Operand

Default: Off

If the two-speed motor feature is used, this setting specifies a FlexLogic operand to indicate the current motor speed. This is typically an indication that the contactor at speed 2 is energized. When the assigned FlexLogic operand (typically a contact input operand) is asserted, the algorithm switches to speed 2 (high speed). If the assigned FlexLogic operand is de-asserted, the algorithm switches to speed 1 (low speed). This allows the 869 to determine which settings must be active at any given time.

SPEED2 SWITCH 2-1 DELAY

Range: 0.00 to 600.00 s in steps of 0.01 s

Default: 5.00 s

This setting specifies the time delay to transfer from high to low speed. This allows the motor to slow down before energizing at low speed. When the motor is switched from high speed to low speed, the Speed2 Trans 2-1 Op FlexLogic operand is set for time defined by the Speed2 Switch 2-1 Delay setting to allow inputs for control logic of contactors and breakers at both speeds. FlexLogic operands required for contactor and breaker control are provided.

SPEED2 MAX. ACCEL TIME

Range: 1.00 to 180.00 s in steps of 0.01 s

Default: 10.00 s

This setting is used by the Speed2 Acceleration Time element (see Protection > 2-speed Motor) and Speed2 Motor Start (see Records).

When the setpoint 2-Speed Motor Protection is programmed as enabled, regardless of the Acceleration Time element being Enabled or Disabled, this setting is also required to calculate the motor start statistics (under Records > Motor Start Statistics) when the motor does not go into the Running state from the Start state, i.e. unsuccessful motor start. Otherwise, in the successful motor start case, motor Starting and Running states are used to calculate the motor start statistics.

SPEED2 CT PRIMARY

Range: 1 to 12000 A in steps of 1 A

Default: 500 A

This setting specifies the primary rating of the three-phase CTs installed at the speed 2 stator winding terminals.

SPEED2 MOTOR FLA

Range: 1 to 5000 A in steps of 1 A

Default: 100 A

This setting specifies the motor full load current for speed 2.

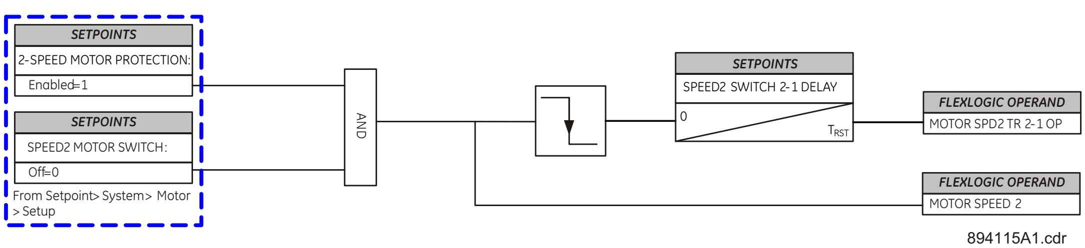
SPEED2 RATED SPEED

Range: 100 to 7200 RPM in steps of 1 RPM

Default: 3600 RPM

This setting specifies the motor rated speed for speed 2. In addition, this setting is also used by the Speed element as the rated value.

Figure 5-19: Two-Speed Motor Protection



Variable Frequency Drives

Path: **Setpoints > System > Motor > VFD**

NOTICE

The VFD function is not available when the relay is used for synchronous motor applications (setpoint SYNCHRONOUS MOTOR TYPE set to Brush-type or Brushless at **Path: Setpoints > System > Motor > Setup**).

Some Variable Frequency Drives (VFD), for example pulse width modulated drives, generate significant distortion in voltages introducing harmonics. However, distortion due to these harmonics is not as significant in currents as in voltages. The functionality of various 869 protection elements is made adaptive to the VFD motor applications depending on the system configurations. Figure 1 shows two typical VFD motor applications, the possible system configurations can be: (a) motor start and run through the VFD only, (b) VFD with Bypass (BP) Switch i.e., motor run through the bypass switch without VFD but the VFD is required for starting.

The VFD Function must be set to “Enabled” in order to ensure proper performance of the 869 relay for motor applications with VFD. In the motor application when VFD can be bypassed via the Bypass Switch as shown in Figure 1(B), status of the bypass switch must be configured as a selected input under setpoint “Bypass Switch”.

If the VFD Function is “Enabled” and the Bypass Switch operand is not asserted (i.e., bypass switch is “open”) then 869 algorithms adopt the following changes:

- Frequency tracking source is switched from three-phase voltages to three-phase currents. For the case where currents are not available or system frequency cannot be measured from the available ac signals then power system Nominal Frequency is used as a default. All elements will function properly for frequency range of 3Hz to 72Hz.
- Thermal Model Voltage Dependent (VD) function is blocked automatically.
- VFD Not Bypassed operand is asserted, which could be used to block the voltage elements via Block setting of the elements.
- All motor current functions except Short Circuit, Ground Fault and Differential elements are using the Motor Load Averaging Filter of length setpoint “Motor Load Filter Interval” set under System Setup/Motor in order to mitigate oscillations.
- However, when VFD configuration support “Function” is enabled and Bypass Switch operand is now asserted (i.e. bypass switch is “close”) then frequency tracking source will be switched from currents to voltages, all voltages elements will work as normal, VFD Not Bypassed operand will be de-asserted while VFD Bypass operand will be asserted and all motor functions will then be using the normal RMS currents.

NOTICE

Voltage inputs to the 869 motor protection relay are normally measured at the busbar side of the VFD that are substantially sinusoidal, however; the output phase voltages from a VFD are not sinusoidal and are distorted due to harmonics generated by the VFD. Therefore, it is recommended to block the voltage elements via Block setting of the elements using VFD Not Bypassed operand. On the other hand, when voltages are measured at the motor side of the VFD, voltages at the motor terminals and relay inputs are the same, hence, blocking of the voltage element is not required. Secondly, significant distortion in the voltage waveforms is not always the case and depends on the VFD type. If the input voltages are substantially sinusoidal, which can be verified from 869 metering, oscillography and data logger, then blocking of the voltage elements is not required.

With the VFD motor application, the 869 motor protection relay uses the running average technique (described in detail under setpoint “Motor Load Filter Interval” (in section Setpoints/System Setup/Motor) in order to smooth out the phasor’s ripple due to the distortion generated by the VFD. When setpoint Motor Load Filter Interval is set equal to non-zero cycles, Motor Load Averaging Filter can increase Trip/Alarm times for the following protection elements: Acceleration Time, Current Unbalance, Mechanical Jam, Overload, Thermal Model, Reduced Voltage Start, Undercurrent, Power Factor, Three-Phase Apparent Power, Three-Phase Reactive Power, Three-Phase Real Power, Under Power. No other elements are affected.

However, this filter when used for the VFD motor application running at low frequency results in a very long Trip/Alarm times delay. For example: if setpoint Motor Load Filter Interval is set 10 cycles and motor is running at 20Hz (tracking frequency), then the Trip/Alarm delay is increased by 0.5 sec.

In order to avoid long Trip/Alarm delay, especially when the Motor is running at low frequencies, the Trip/Alarm delay is limited internally to the number of cycles equal to the minimum of the maximum delay @Nominal Frequency and average filter delay @Tracking Frequency, per relation as follows:

Eq. 1

$$Min\left(\frac{1}{F_n}x16\ cycles, \frac{1}{F}x\ N\ in\ cycles\right)$$

Where

N	is the setpoint "Motor Load Filter Interval" in number of cycles in the range 0 – 32
F_n	is the Nominal System Frequency in Hz i.e. 50Hz or 60Hz
F	is the tracking frequency in Hz

This adjustment to the filter length to avoid large Trip/Alarm delay is only applicable when VFD Function is enabled and Bypass Switch operand is not asserted. This adjustment is not applicable when this filter is applied to motor application with reciprocating load.Following examples shows the Trip/Alarm times delay calculation with the above mentioned adjustment to the filter length when the average filter of length "Motor load Filter Interval" is applied for the VFD applications:

Example 1:

- Setpoint "Motor Load Filter Interval", N = 20 cycles
- Tracking frequency, F = 40Hz
- Setpoint "Nominal Frequency", F_n = 60Hz
- Maximum time delay @ Nominal Frequency = (1/F_n) x 16 cycles x 1000 = ~270 msec
  Actual time delay @ or tracking Frequency = (1/F) x 20 cycles x 1000 = ~500 msec

The Trip/Alarm time delay is then = Min(270, 500) = 270msec

Example 2:

- Setpoint "Motor Load Filter Interval", N = 4 cycles
- Tracking frequency, F = 70 Hz
- "Nominal Frequency", F_n = 60 Hz
- Maximum time delay @ Nominal Frequency = (1/F_n) x 16 cycles x 1000 = ~270 msec
  Actual time delay @ Actual or tracking Frequency = (1/F) x 4 cycles x 1000 = ~60 msec

The Trip/Alarm time delay is then = Min(270, 60) = 60 msec

For the VFD motor application, setpoint Motor Load Filter Interval (under Setpoint/System Setup/Motor) can be determined from the captured load waveforms obtained from the Datalogger or Oscillography features by following the steps below:

1. Capture the pre-filtered load analog value from the Datalogger/Oscillography. This analog value is defined as "Motor Load" in the Thermal Model analog values. Motor Load is the average of three RMS input currents and is applied at the input of motor load averaging filter.
2. By analyzing the captured waveform in Step 1, estimated the length of oscillation that repeats itself at regular intervals. Estimation of length must be done in nominal power cycles.
3. Set the Motor Load Filter Interval equal to the value estimated in Step 2 plus a recommended margin of 1 cycle.

4. Capture the “Fltd Motor Load” analog value from the Datalogger/Oscillography. “Fltd Motor Load” is the motor load current after filtration of “oscillations” due to VFD.
5. Analyze the captured waveform in Step 4 to see if the estimate value from Step 2 is appropriate enough to mitigate the oscillations. If needed, repeat Steps 1-4 in order to achieved the appropriate value of the setpoint “Motor Load Filter Interval” until oscillations become negligible.

FUNCTION

Range: Disabled, Enabled

Default: Disabled

This setting enables the VFD configuration support in 869.

BYPASS SWITCH

Range: FlexLogic operand

Default Off

This setting defines the digital input to determine if motor is powered by the VFD or directly from the AC source through bypass switch. The VFD Bypassed operand will be asserted when VFD is bypassed i.e. motor is directly powered by the AC system or the utility. This operand can be used to block the voltage based elements via Block setting of the desired elements if this operand is not asserted i.e. VFD is not bypassed.

NOTE

It is highly recommended to block the voltage based elements via Block setting of the desired elements if VFD Not Bypassed is asserted.

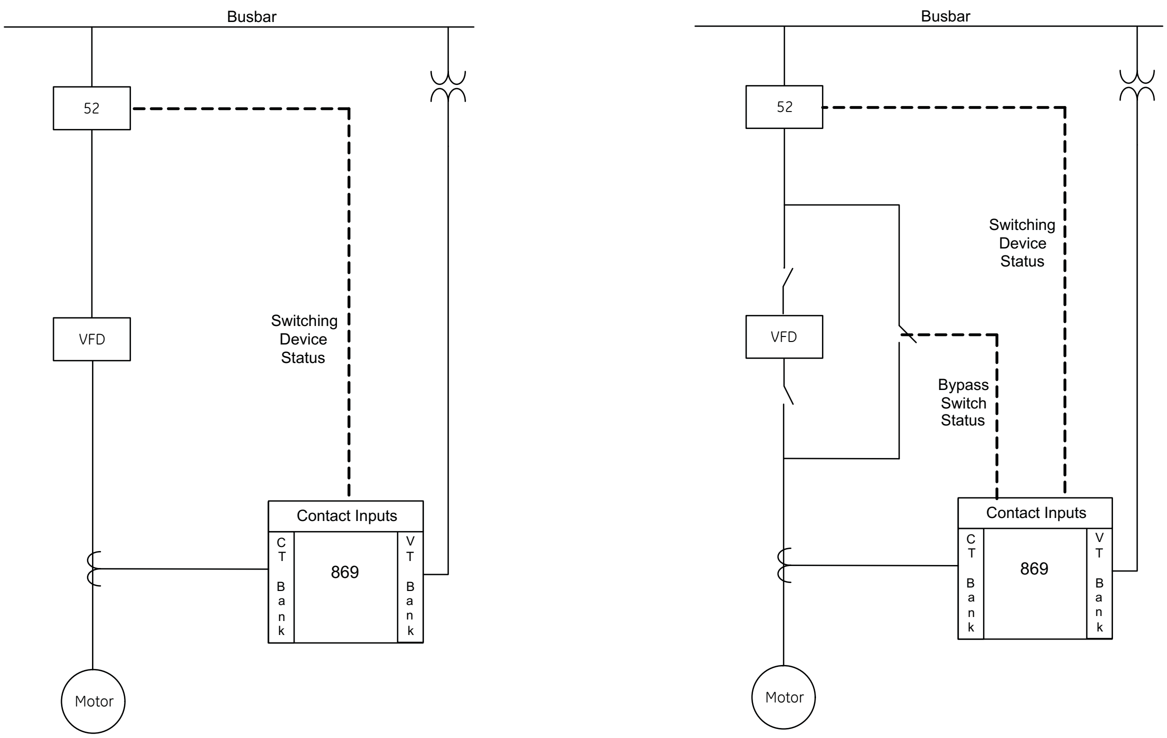
STARTING FREQUENCY

Range: 3.0 to 72.0 Hz in steps of 0.1 Hz

Default: 10.0 Hz

This setting defines starting frequency, which provides faster tracking to the frequency once motor is energized. For example, in the motor application when VFD is required at the starting and normally the starting frequency is 10 Hz then set the Starting Frequency equal to 10 Hz rather than nominal system frequency. If this value is not known then simply set this value equal to the system Nominal Frequency.

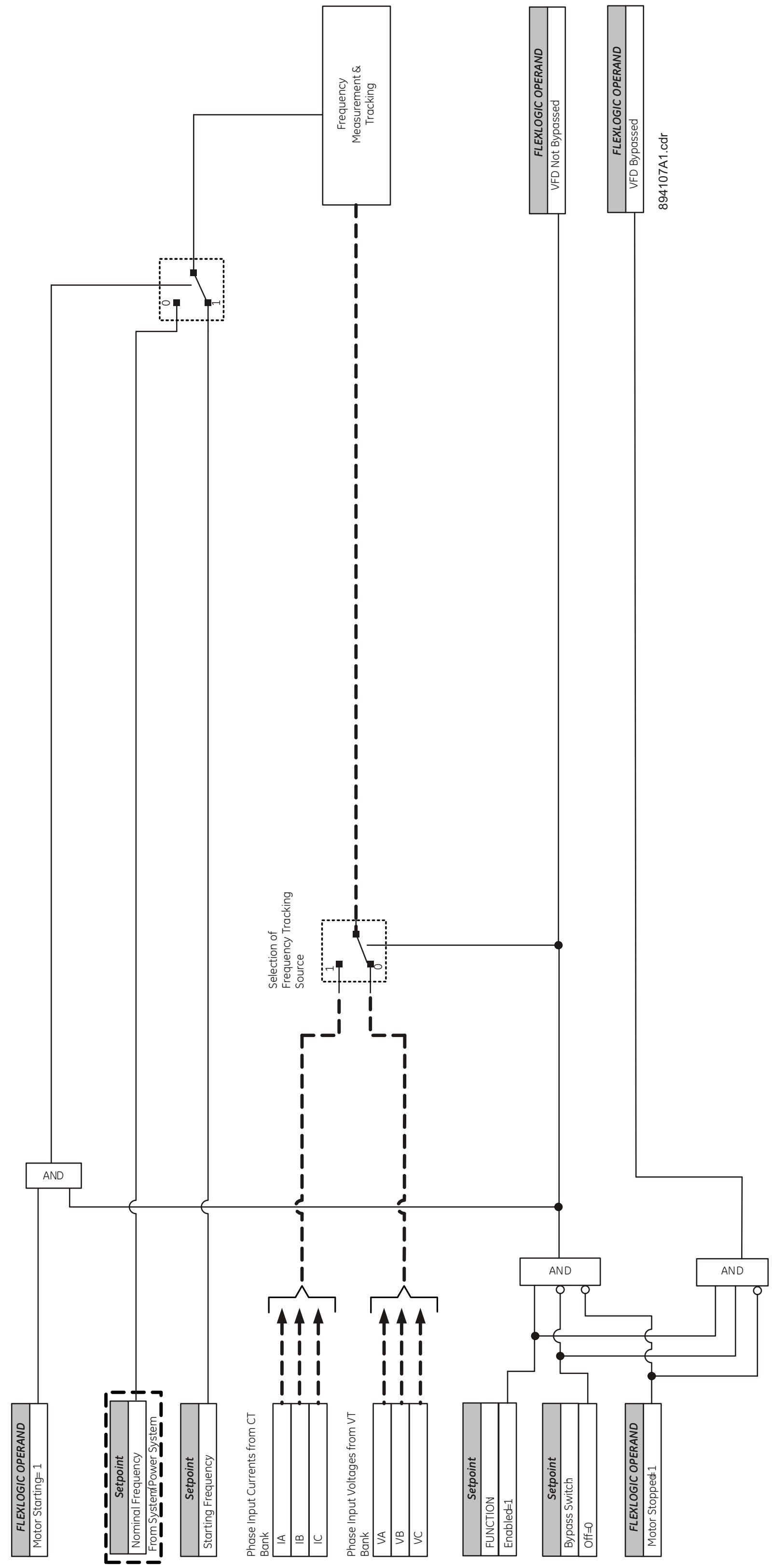
Figure 5-20: Typical Motor Applications with VFD and Bypass Switch



(A) Motor powered through the VFD

(B) Motor powered through the VFD with Bypass Switch

Figure 5-21: VFD Logic



Preset Values

In 869, user can preset the following actual value accumulators. When accumulator is preset with a new value, the 869 overwrites previous actual value and continues accumulation starting from the new value. The accumulated value is displayed in Status or Metering.

Path: **Setpoints > System > Motor > Preset Values**

MOTOR RUNNING HOURS

Range: 0 to 99999 hrs *Steps: 1 hr*

This value sets the running hours of the existing motor. The accumulated Motor Running Hours is shown in **STATUS > MOTOR > MOTOR RUNNING HOURS**.

POS(NEG) WATT HOURS

Range: 0.000 to 999999.999 MWh *Steps: 0.001 MWh*

This value sets the Positive (negative) Watt Hours of the existing motor. The accumulated Positive and Negative Watt Hours are shown in **METERING > ENERGY 1 > PWR1 POS (NEG) WATTHOURS**. Clearing the Energy Use Data sets the displayed value to the preset value.

POS(NEG) VAR HOURS

Range: 0.000 to 999999.999 Mvarh *Steps: 0.001 Mvarh*

This value sets the Positive (negative) Var Hours of the existing motor. The accumulated Positive and Negative Var Hours are shown in **METERING > ENERGY 1 > PWR1 POS (NEG) VARHOURS**. Clearing the Energy Use Data sets the displayed metering value to the preset value.

Switching Device

The 869 supports two types of motor switching devices: breakers and contactors. A breaker operation is controlled by two coils labeled “Trip” and “Close”. Each of them has to be separately energized with a short pulse in order to change the state of the breaker. A contactor operation is controlled by a single coil. When the coil is energized, the main contacts are closed and when the coil is de-energized, the main contacts are open.

The user has to select either “Breaker” or “Contactor” and the selection has to match the actual device type used. The selection is made in **Setpoints > System > Motor > Switching Device Type.**

Breakers

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.

Path: **Setpoints > System > Breakers > Breaker X**

NAME

Range: Up to 13 alphanumeric characters
Default: BKR1

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.

CLOSE RELAY SELECT

Range: Off, Relay 2

Default: Relay 2

Selection of "Relay 2" assigns the START command to Output Relay 2 (CLOSE/AUX). If "Off" is selected, Auxiliary Relay 2 is available for selection in all elements with auxiliary relay selection in the 869 and it is not activated by START command.

NOTICE

If “Relay 2” is selected, Auxiliary Relay 2 is not available for selection in any element.

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 5-22: Breaker Connected/Disconnected (Racked-In/Racked-Out) Detection

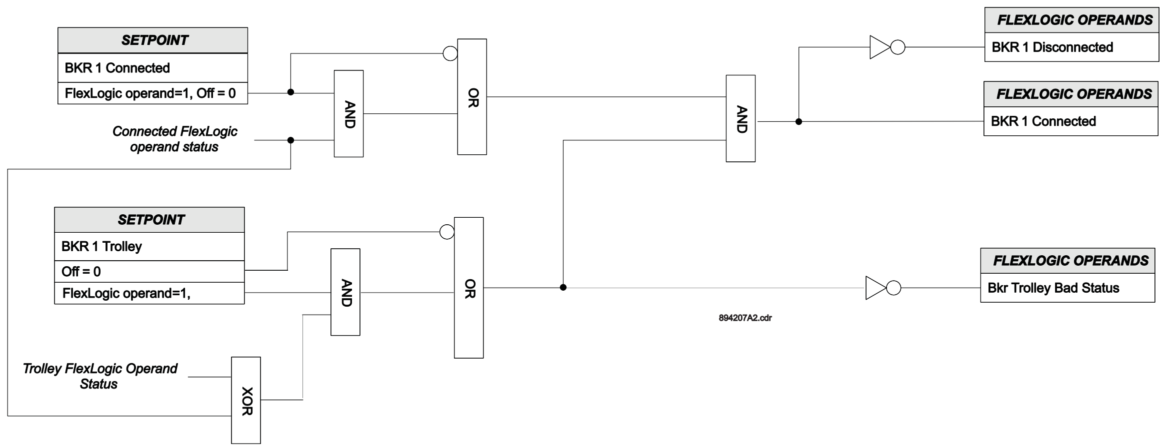
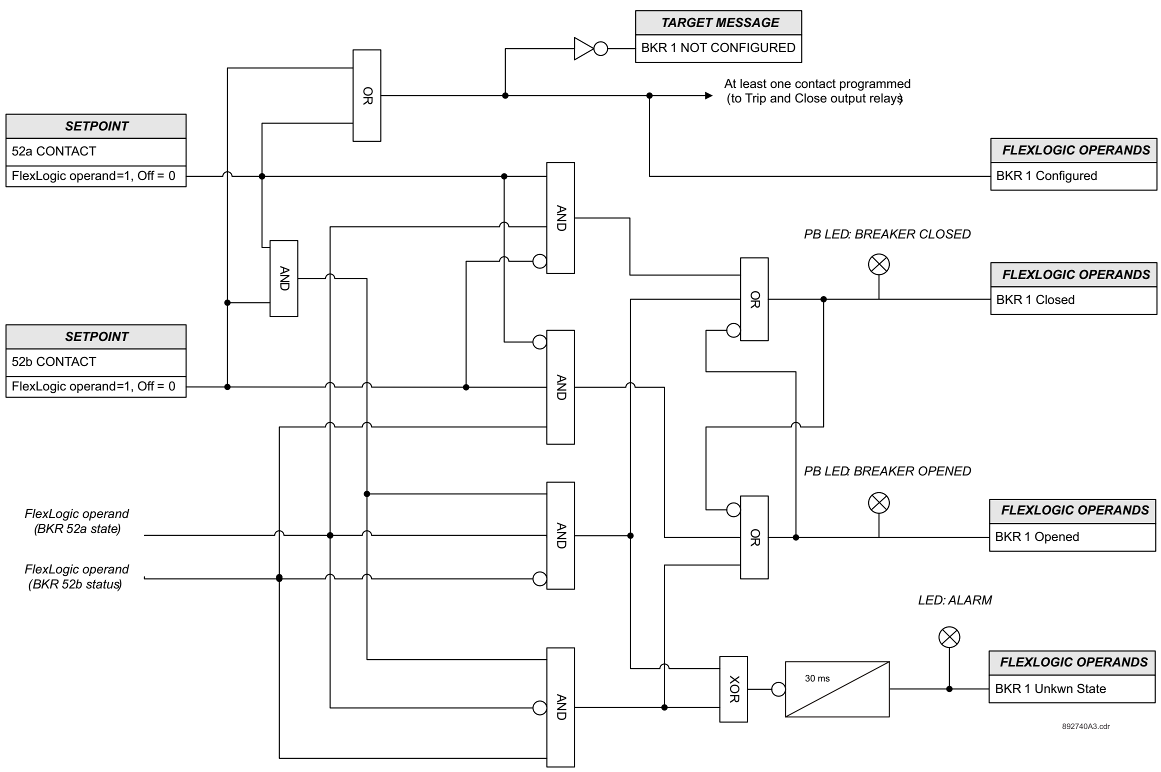


Figure 5-23: Breaker State Detection logic diagram



SM Field Breaker

Synchronous motor field breaker detection is performed on the 869 relay by monitoring the state/states of either one or preferably two contact inputs. It is highly recommended to monitor the status of the field breaker using both breaker auxiliary contacts 41a, and 41b. However, using only one of them is also acceptable.

NOTE

These settings are only available when the setpoint Switching Device Type is set to 'Breaker' in the path: **Setpoints > System > Motor > Setup**.

Path: **Setpoints > System > Breakers > SM Field Breaker**

NAME

Range: Up to 13 alphanumeric characters
Default: Field BKR

CONTACT INPUT 41a

Range: Off, Any FlexLogic operand
Default: Off

Selects the Contact Input connected to the field breaker auxiliary contact 41a.

CONTACT INPUT 41b

Range: Off, Any FlexLogic operand
Default: Off

Selects the Contact Input connected to the field breaker auxiliary contact 41b.

TRIP RELAY SELECT

Range: Off, Relay 1, ..., Relay X
Default: Relay 2

Select an available output relay to use to trip the field breaker.

CLOSE RELAY SELECT

Range: Off, Relay 1, ..., Relay X
Default: Relay 2

Select an available output relay to use to close the field breaker.

The logic for Breaker configuration and the Open and Close status is shown in the tables below:

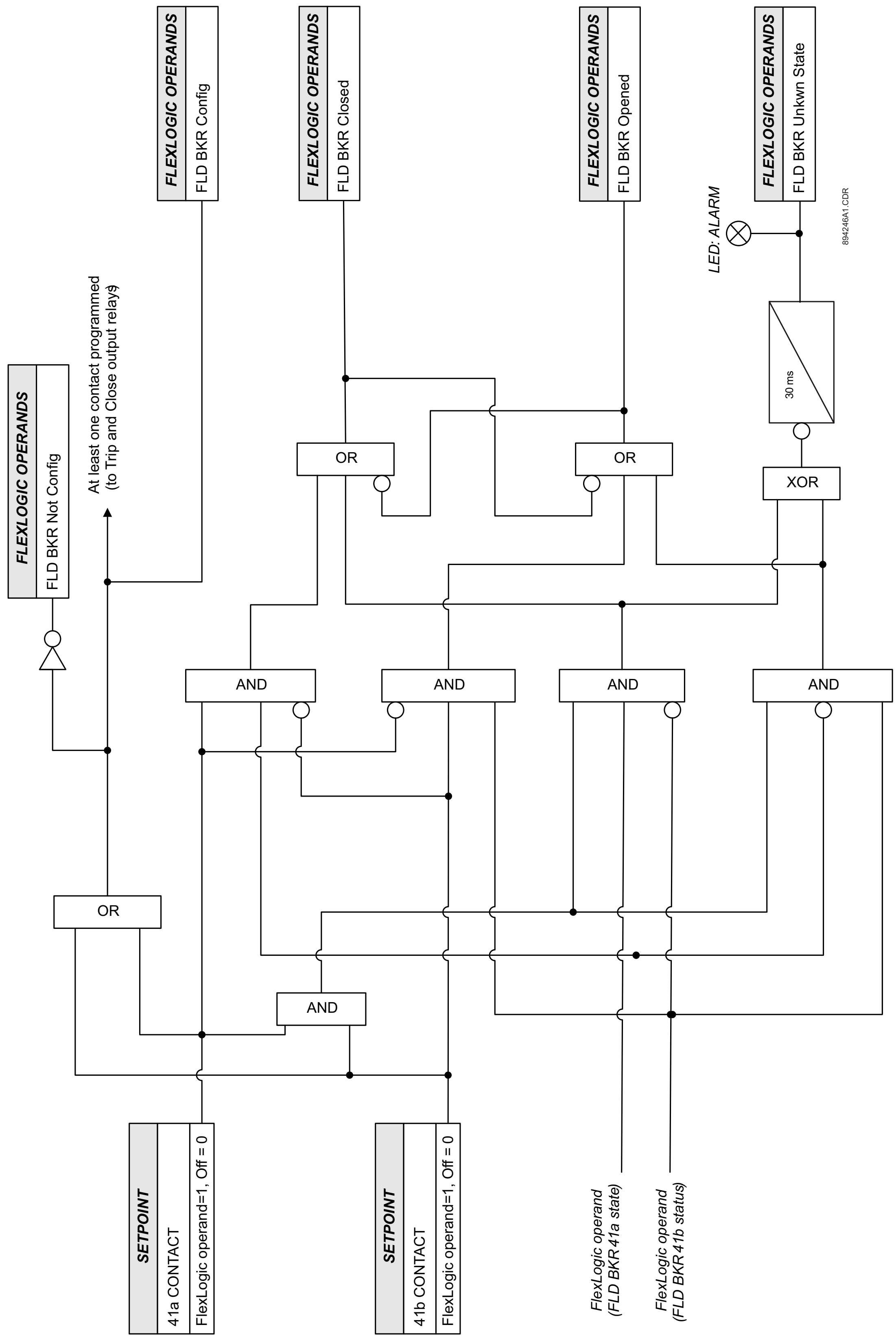
Table 5-8: Breaker status depending on availability of contacts 41a and 41b

41a Contact Configured	41b Contact Configured	Field Breaker Status	
		Open	Closed
Yes	Yes	41a contact open 41b contact closed	41a contact closed 41b contact open
Yes	No	41a contact open	41a contact closed
No	Yes	41b contact closed	41b contact open
No	No	Field Breaker Not Configured	

Table 5-9: Breaker status with both contacts 41a and 41b configured

41a Contact Status	41b Contact Status	Field Breaker Status
Off	On	FLD BKR Opened
On	Off	FLD BKR Closed
On	On	FLD BKR Unknown State
Off	Off	FLD BKR Unknown State

Figure 5-24: Field Breaker status detection



Contactor

Path: **Setpoints > System > Contactor > Contactor 1**

If the selection in **Setpoints > System > Motor > Switching Device Type** is Contactor the menu shows the following:

NAME

Range: Up to 13 alphanumeric characters
Default: Contactor 1

This setting allows the user to enter a breaker or contactor name. It can be any alphanumeric character combination up to 13 characters long.

CONTACT INPUT 52a

Range: Off, Any FlexLogic operand
Default: Off

Select the contact input connected to the contactor auxiliary contact 52a.

CONTACT INPUT 52b

Range: Off, Any FlexLogic operand
Default: Off

Select the contact input connected to the contactor auxiliary contact 52b.

CONNECTED

Range: Off, Any FlexLogic operand
Default: Off

Select a contact input to show whether the contactor is connected (Racked-in, or disconnect switches switched-on) or disconnected (racked-out, or disconnect switches switched-off) to the system. This setpoint is only applicable to the withdrawable type of contactors.

CLOSE RELAY SELECT

Range: Off, Relay 2
Default: Off

Selection of Relay 2 assigns the START command to Output Relay 2 (CLOSE/AUX).

NOTICE

If “Relay 2” is selected, Auxiliary Relay 2 is not available for selection in any element in the 869. If “Off” is selected, Auxiliary Relay 2 is available for selection in all elements with auxiliary relay selection in the 869 and it is not activated by the START command.

The logic for contactor configuration and the Open/Close status is shown in the tables below:

Table 5-10: Contactor Status

52a Contact configured	52b Contact configured	Contactor 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	Contactor not configured	

Contactor status with both contacts 52a and 52b configured:

Table 5-11: Contactor Status with both 52a and 52b configured

52a Contact configured	52b Contact configured	Contactor Status
Off	On	Contactor open
On	Off	Contactor closed
On	On	Contactor unknown state
Off	Off	Contactor unknown state

The following logic diagrams shos the detection logic for the contactor.

Figure 5-25: Contactor Connected/Disconnected (Racked-In/Racked-Out) detection for withdrawable contactors

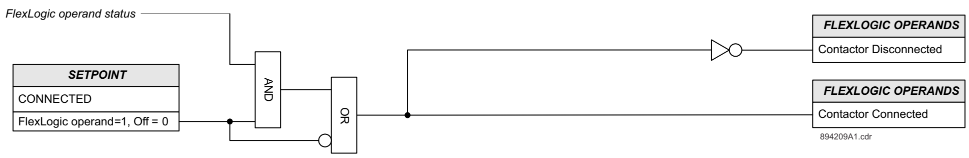
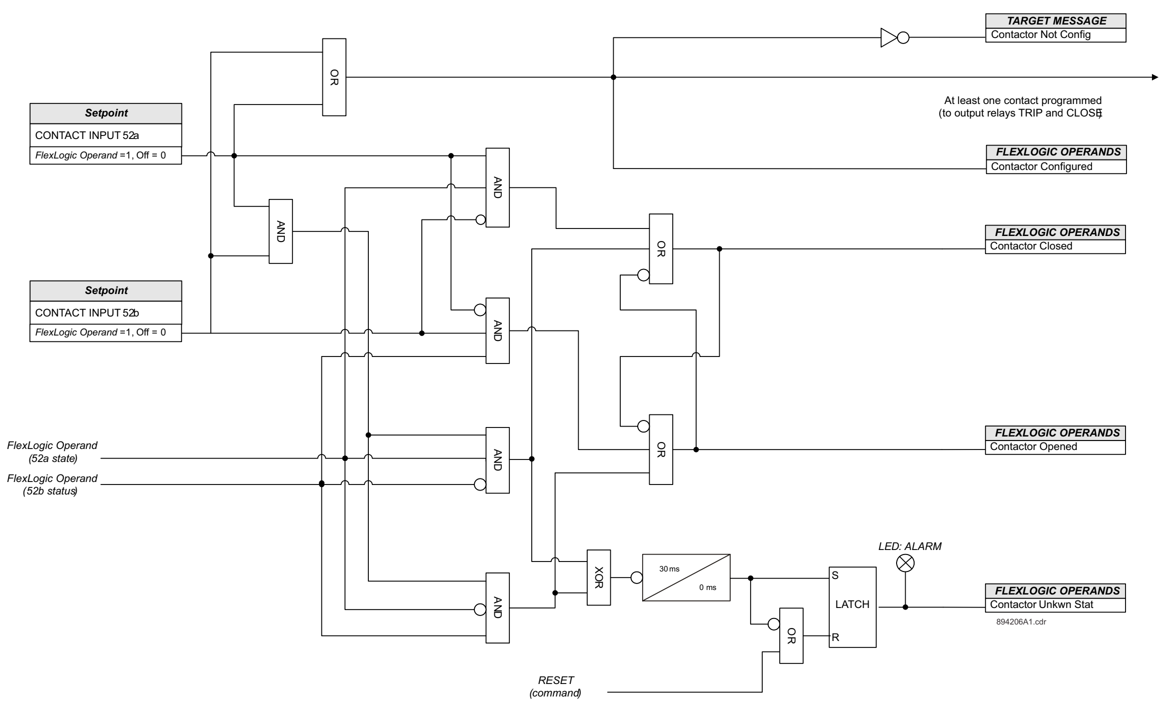


Figure 5-26: Contactor State Detection logic diagram



SM Field Contactor

Synchronous motor field contactor detection is performed on the 869 relay by monitoring the state/states of either one or preferably two contact inputs. It is highly recommended to monitor the status of the field contactor using both contactor auxiliary contacts 41a, and 41b. However, using only one of them is also acceptable.

NOTE

These settings are only available when the setpoint Switching Device Type is set to 'Contactor' in the path: **Setpoints > System > Motor > Setup**.

Path: **Setpoints > System > Breakers > SM Field Contactor**

NAME

Range: Up to 13 alphanumeric characters
Default: Field CONT

CONTACT INPUT 41a

Range: Off, Any FlexLogic operand
Default: Off

Selects the Contact Input connected to the field contactor auxiliary contact 41a.

CONTACT INPUT 41b

Range: Off, Any FlexLogic operand
Default: Off

Selects the Contact Input connected to the field contactor auxiliary contact 41b.

TRIP RELAY SELECT

Range: Off, Relay 1, ..., Relay X
Default: Off

Select an available output relay to use to trip the field contactor.

CLOSE RELAY SELECT

Range: Off, Relay 1, ..., Relay X
Default: Off

Select an available output relay to use to close the field contactor.

The logic for Contactor configuration and the Open and Close status is shown in the tables below:

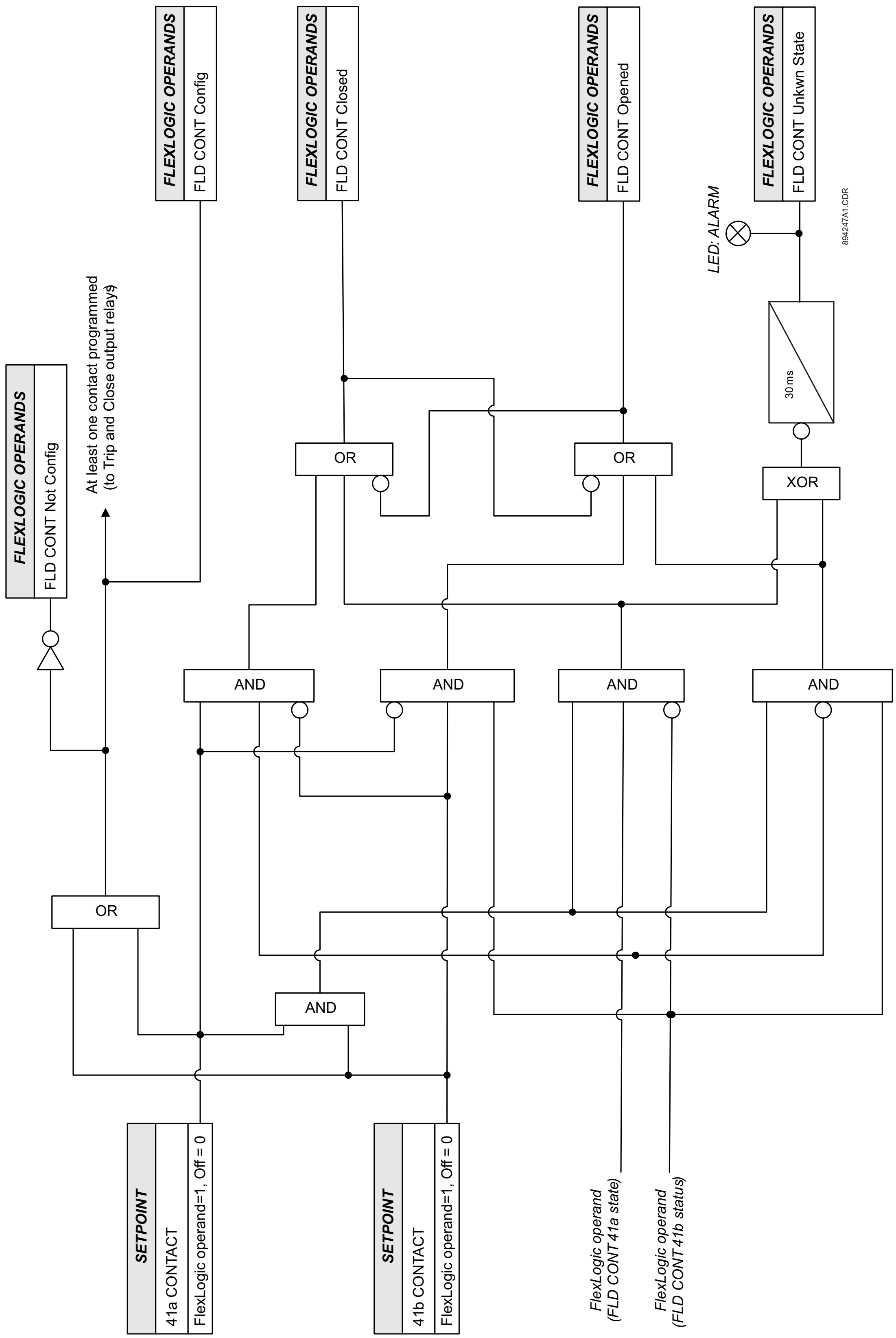
Table 5-12: Contactor status depending on availability of contacts 41a and 41b

41a Contact Configured	41b Contact Configured	Field Contactor Status	
		Open	Closed
Yes	Yes	41a contact open 41b contact closed	41a contact closed 41b contact open
Yes	No	41a contact open	41a contact closed
No	Yes	41b contact closed	41b contact open
No	No	Field Contactor Not Configured	

Table 5-13: Contactor status with both contacts 41a and 41b configured

41a Contact Status	41b Contact Status	Field Contactor Status
Off	On	FLD CONT Opened
On	Off	FLD CONT Closed
On	On	FLD CONT Unknown State
Off	Off	FLD CONT Unknown State

Figure 5-27: Field Contactor status detection



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.

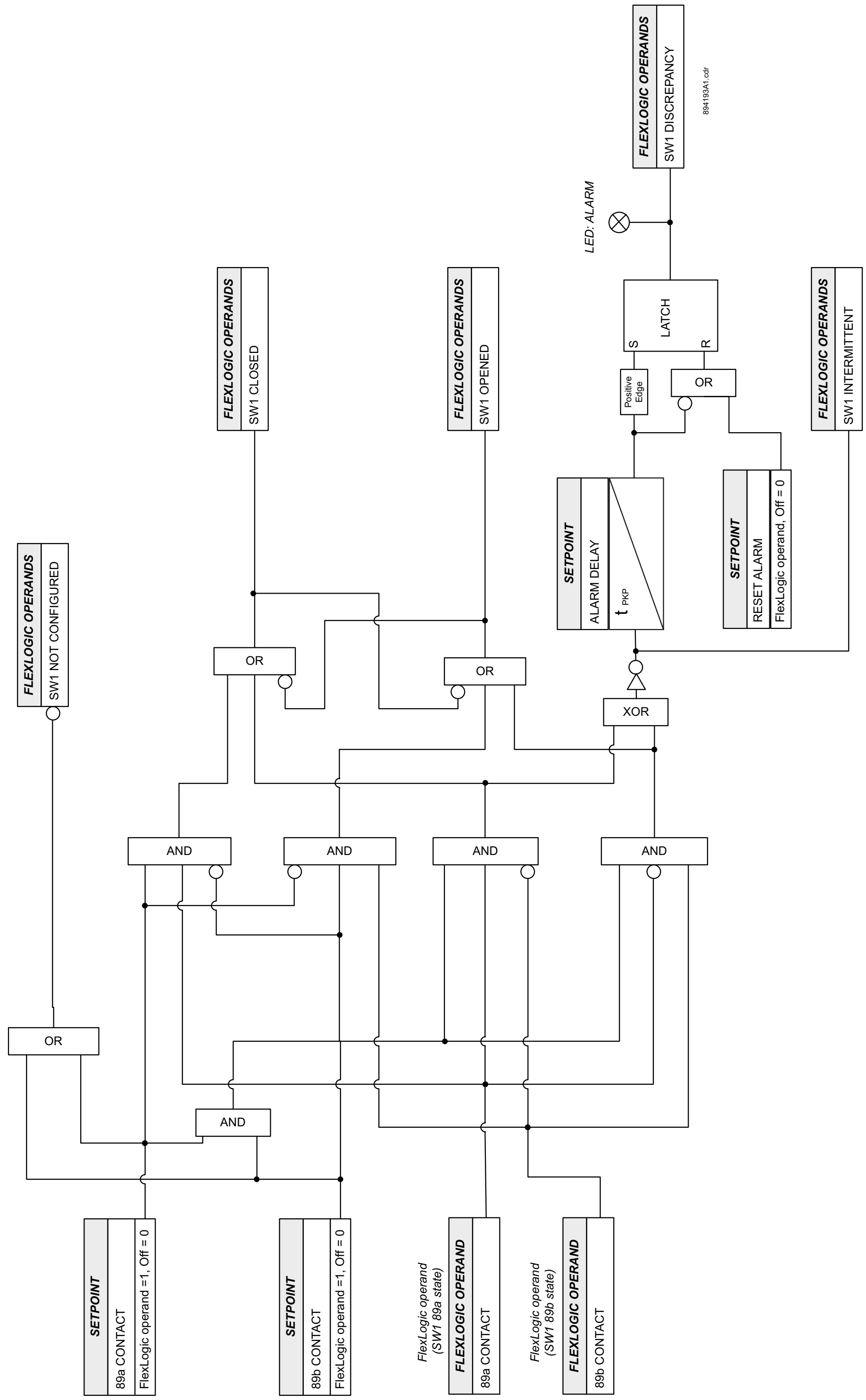
Table 5-14: Switch configuration with Open and Close status

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 5-15: 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 six programmable FlexCurves - FlexCurve A, B, C, D, OL and ST. The points for these curves are defined in the EnerVista 8 Series Setup software. User-defined curves can be used for Time Overcurrent and Speed-dependent Thermal protection in the same way as IEEE, IAC, ANSI, and IEC curves. Each of FlexCurves A, B, C, and D 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).

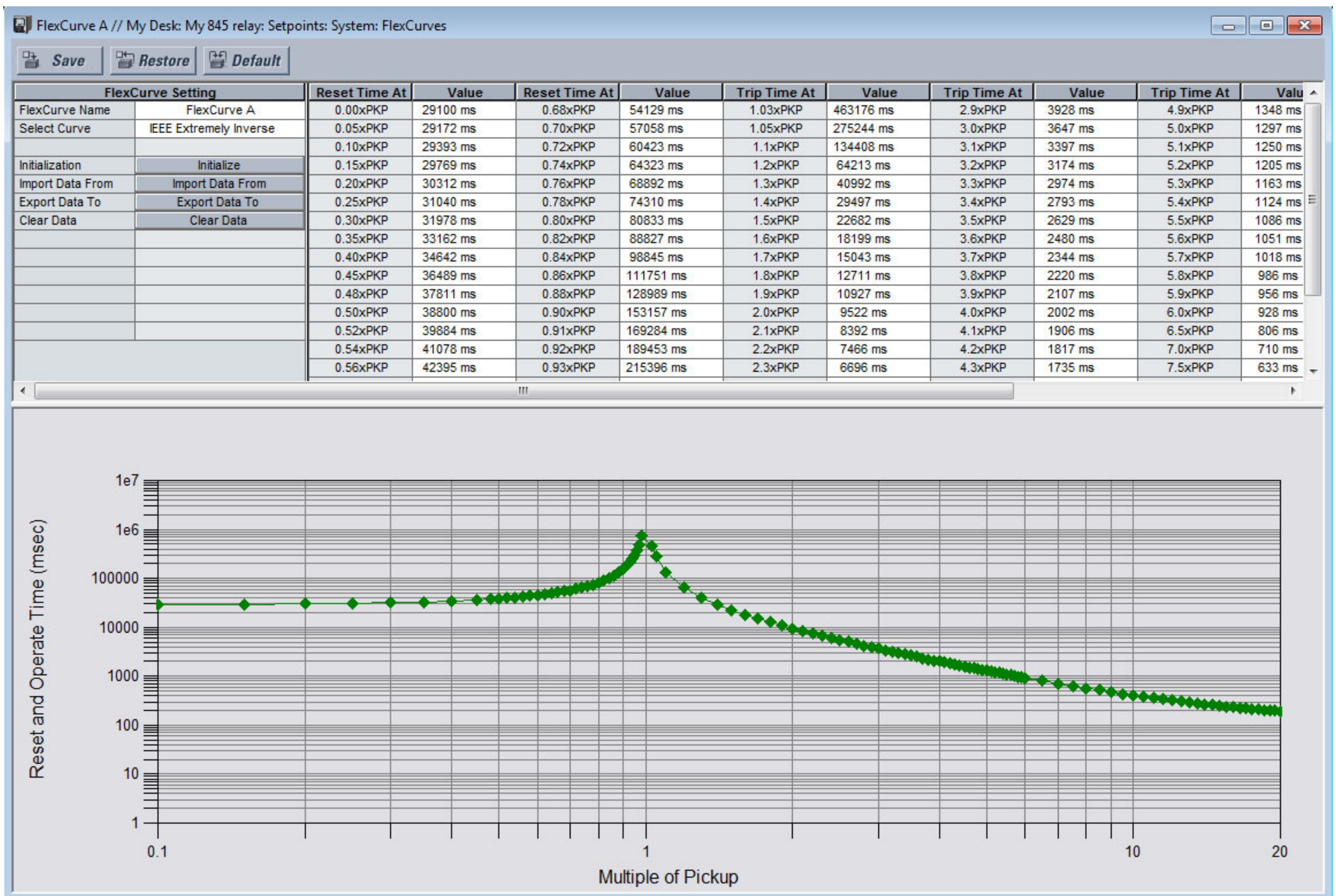
FlexCurve OL provides the flexibility to choose the number of operating points, entering time values as well as operate quantity values (multiples of FLA). This data is converted into a continuous curve by linear interpolation between data points. In the thermal model element, this curve can be selected as a thermal overload curve.

FlexCurve ST provides the flexibility to choose the number of operating points, entering time values as well as operate quantity values (% of speed). This data is converted into a continuous curves by linear interpolation between data points. In the speed-dependent thermal model element, this curve can be selected as a time-speed curve.

Path: Setpoints > System > FlexCurves

NOTE

Use the EnerVista 8 Series Setup software program to select, design or modify any of the FlexCurves.



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.

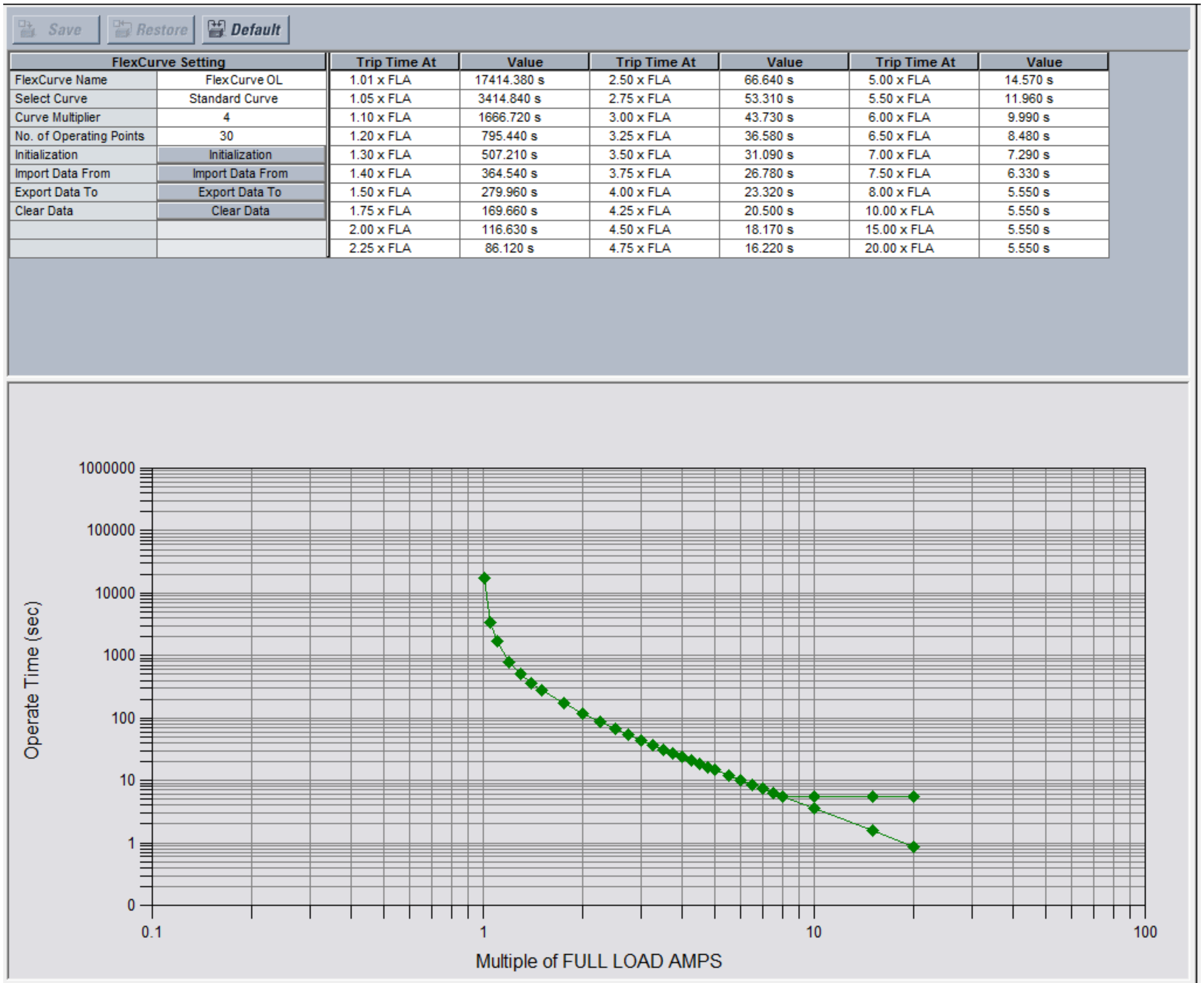
FLEXCURVE A, B, C, D CONFIGURATION WITH ENERVISTA 8 SERIES SETUP SOFTWARE

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.

FLEXCURVE OL CONFIGURATION WITH ENERVISTA 8 SERIES SETUP SOFTWARE

FlexCurve OL is customized by editing the operating time values as well as the operate quantity, which is a multiple of FLA.



FlexCurve Setting		Trip Time At	Value	Trip Time At	Value	Trip Time At	Value
FlexCurve Name	FlexCurve OL	1.01 x FLA	17414.380 s	2.50 x FLA	66.640 s	5.00 x FLA	14.570 s
Select Curve	Standard Curve	1.05 x FLA	3414.840 s	2.75 x FLA	53.310 s	5.50 x FLA	11.960 s
Curve Multiplier	4	1.10 x FLA	1666.720 s	3.00 x FLA	43.730 s	6.00 x FLA	9.990 s
No. of Operating Points	30	1.20 x FLA	795.440 s	3.25 x FLA	36.580 s	6.50 x FLA	8.480 s
Initialization	Initialization	1.30 x FLA	507.210 s	3.50 x FLA	31.090 s	7.00 x FLA	7.290 s
Import Data From	Import Data From	1.40 x FLA	364.540 s	3.75 x FLA	26.780 s	7.50 x FLA	6.330 s
Export Data To	Export Data To	1.50 x FLA	279.960 s	4.00 x FLA	23.320 s	8.00 x FLA	5.550 s
Clear Data	Clear Data	1.75 x FLA	169.660 s	4.25 x FLA	20.500 s	10.00 x FLA	5.550 s
		2.00 x FLA	116.630 s	4.50 x FLA	18.170 s	15.00 x FLA	5.550 s
		2.25 x FLA	86.120 s	4.75 x FLA	16.220 s	20.00 x FLA	5.550 s

The following table shows the configurable operating quantity (x FLA) and operating times (in seconds) for the maximum configurable range of 30 operating points. The minimum number of operating points is 10.

Table 5-16: Example FlexCurve OL Values with 30 Operating Points

Trip Time		Operating Time (s)		Trip Time		Operating Time (s)
1.01	x FLA	17414.38		3.75	x FLA	26.78
1.05	x FLA	3414.84		4.00	x FLA	23.32
1.10	x FLA	1666.72		4.25	x FLA	20.50
1.20	x FLA	795.44		4.50	x FLA	18.17
1.30	x FLA	507.21		4.75	x FLA	16.22
1.40	x FLA	364.54		5.00	x FLA	14.57
1.50	x FLA	279.96		5.50	x FLA	11.96
1.75	x FLA	169.66		6.00	x FLA	9.99

Trip Time		Operating Time (s)		Trip Time		Operating Time (s)
2.00	x FLA	116.63		6.50	x FLA	8.48
2.25	x FLA	86.12		7.00	x FLA	7.29
2.50	x FLA	66.64		7.50	x FLA	6.33
2.75	x FLA	53.31		8.00	x FLA	5.55
3.00	x FLA	43.73		10.00	x FLA	5.55
3.25	x FLA	36.58		15.00	x FLA	5.55
3.50	x FLA	31.09		20.00	x FLA	5.55

NOTE

For FlexCurve OL to properly work, it is important to enter the current pickup levels (x FLA) in ascending order, while the trip times can be entered in descending or ascending order.

The FlexCurve OL points are configured in the Enervista 8 Series Setup software, which incorporates a graphical user interface. The final curve is created by means of a linear interpolation from the points defined by the user.

Figure 5-29: FlexCurve OL Initialization

FlexCurve OLName

Default: FlexCurve OL

No. of Operating Points

Range: 10 to 30 insteps of 1

Default: 30

Select Curve

Range: Standard Curve

Default: Standard Curve

Curve Multiplier

Range: 1 to 25 in steps of 1

Default: 4

FLEXCURVE ST CONFIGURATION WITH ENERVISTA 8 SERIES SETUP SOFTWARE

NOTE

FlexCurve ST is only applicable to SC Speed-dependent Thermal Protection for brush-type synchronous motors with squirrel-cage (SC) windings. This protection is only available with synchronous motor order code options.

FlexCurve ST is customized by editing the operating time values as well as the operate quantity, which is a multiple of synchronous speed (x Speed), which is proportional to Nominal Frequency.

The following table shows the configurable operating quantity (x Speed) and operating times (in seconds) for the maximum configurable range of 30 operating points. The minimum number of operating points is 10.

Table 5-17: Example FlexCurve ST Values with 30 Operating Points

Run Time		Operating Time (s)		Run Time		Operating Time (s)
0.00	x Speed	10.000		0.50	x Speed	14.696
0.03	x Speed	10.014		0.53	x Speed	15.689
0.07	x Speed	10.177		0.56	x Speed	16.909
0.10	x Speed	10.330		0.59	x Speed	18.421
0.13	x Speed	10.480		0.63	x Speed	20.318
0.17	x Speed	10.635		0.66	x Speed	22.737
0.20	x Speed	10.805		0.69	x Speed	25.879
0.23	x Speed	11.000		0.73	x Speed	30.064

Run Time		Operating Time (s)		Run Time		Operating Time (s)
0.26	x Speed	11.224		0.76	x Speed	35.814
0.30	x Speed	11.500		0.79	x Speed	44.042
0.33	x Speed	11.811		0.83	x Speed	56.479
0.36	x Speed	12.200		0.86	x Speed	76.774
0.40	x Speed	12.655		0.89	x Speed	113.955
0.43	x Speed	13.210		0.92	x Speed	197.024
0.46	x Speed	13.900		0.96	x Speed	486.868

NOTE

For FlexCurve ST to properly work, it is important to enter the current pickup levels (x Speed) in ascending order, while the trip times can be entered in descending or ascending order.

The FlexCurve ST points are configured in the EnerVista 8 Series Setup software, which incorporates a graphical user interface. The final curve is created by means of a linear interpolation from the points defined by the user.

Figure 5-30: FlexCurve ST Initialization

FlexCurve STName

Default: FlexCurve ST

No. of Operating Points

Range: 10 to 30 insteps of 1

Default: 30

Select Curve

Range: Est Time-Speed

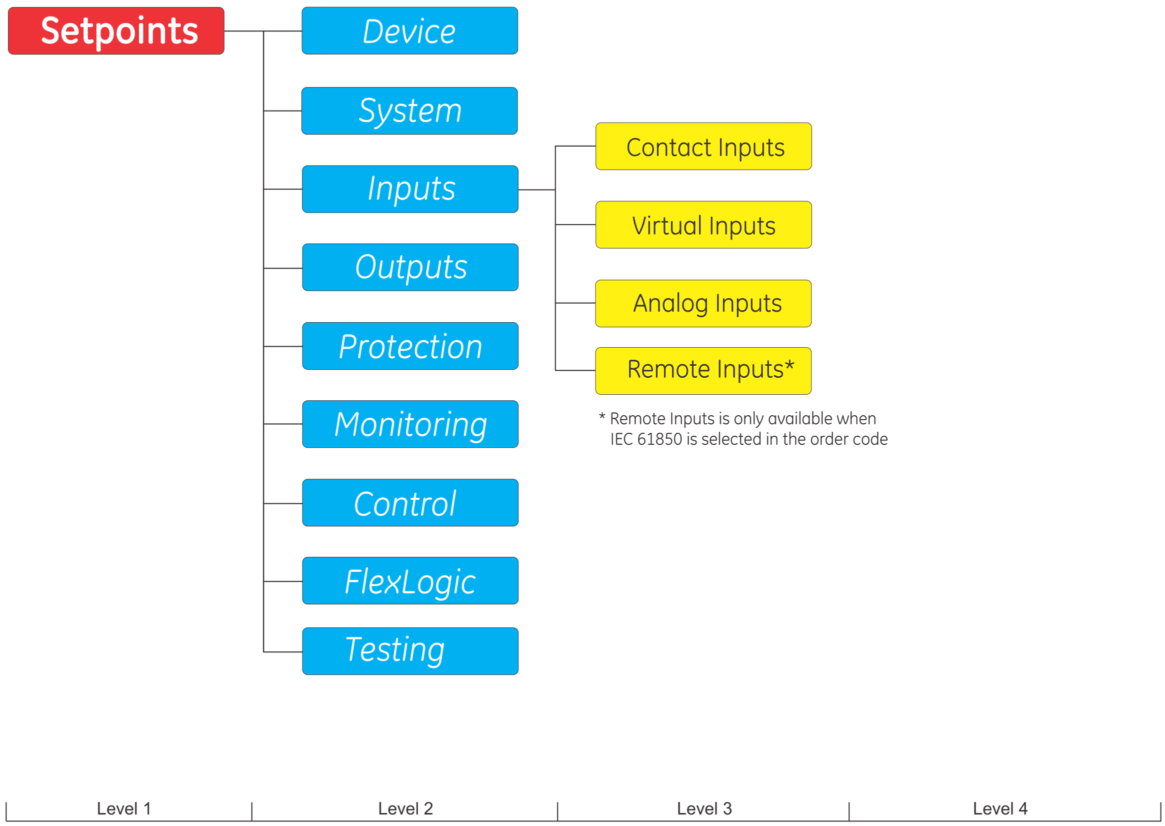
Default: Est Time-Speed

This setting only takes effect when FlexCurve ST is initialized for the 869 from the EnerVista 8 Series Setup software.

When the FlexCurve ST feature is initialized from the EnerVista 8 Series Setup software, the EnerVista 8 Series Setup estimates values for the custom curve. This is in place of entering values for a specific time-speed curve, and should be used in situations where speed-time values are not available from the motor manufacturer. The Run Time and Stall Time setpoints under **Path:** **Setpoints > Protection > Group 1(6) > Motor > SM SC Spd-Dept Thermal Prot** must be set properly for the EnerVista 8 Series Setup to build the estimated curve.

Inputs

Figure 5-31: Inputs Display Hierarchy



Contact Inputs

The 869 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.

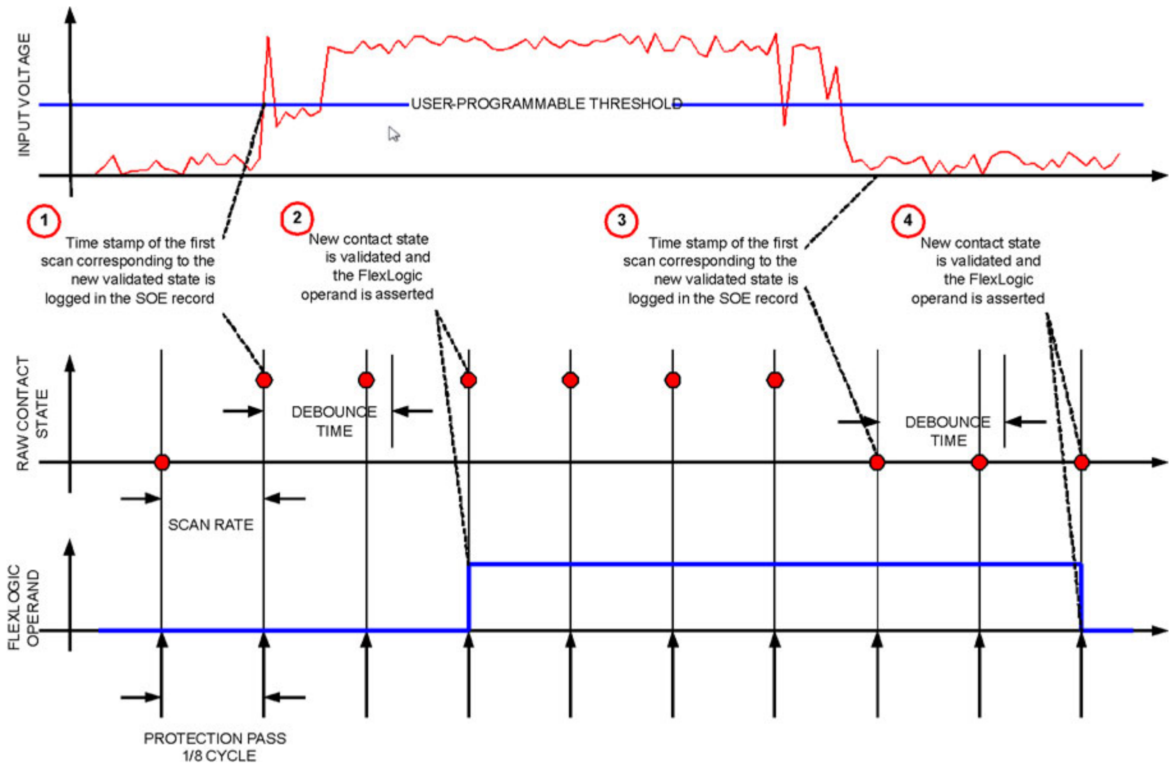
A raw status is scanned for all Contact Inputs synchronously at the constant rate of one protection pass (1/8 cycle) as shown in the figure below. The DC input voltage is compared to a user-settable threshold. A new Contact Input state must be maintained for a user-configurable debounce time in order 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.

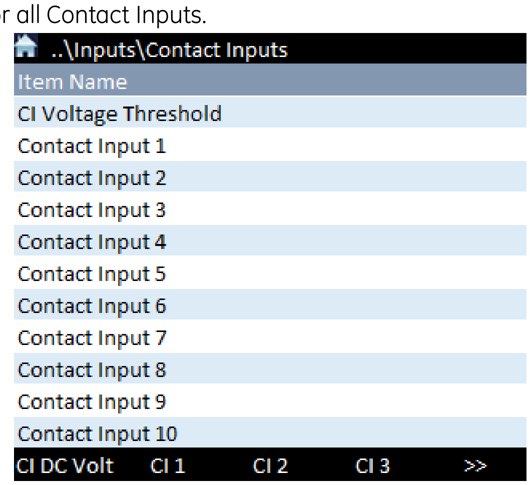
Regardless of the contact debounce time setting, the Contact Input event is time-stamped with 1 protection pass accuracy using the time of the first scan corresponding to the new state (mark no. 1 below). Therefore, the time stamp reflects a change in the DC voltage across the Contact Input terminals 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 5-32: 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.



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, 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: 33 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 869 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

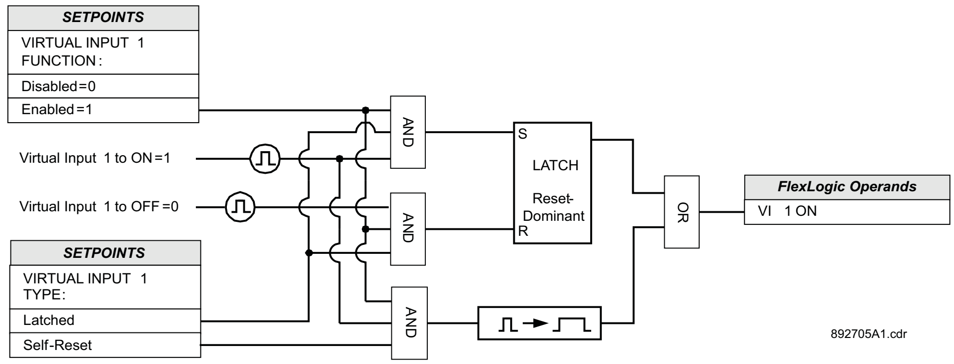
The self-reset operating mode generates the output operand for a single evaluation of the FlexLogic equations (i.e., a pulse of one protection pass). If the operand is to be used anywhere other than internally in a FlexLogic equation, it will likely have to be lengthened in time. A FlexLogic timer with a delayed reset time can perform this function.

EVENTS

Range: Enabled, Disabled

Default: Enabled

Figure 5-33: Virtual Inputs Scheme Logic



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 enables or disables the Analog Input function.

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.

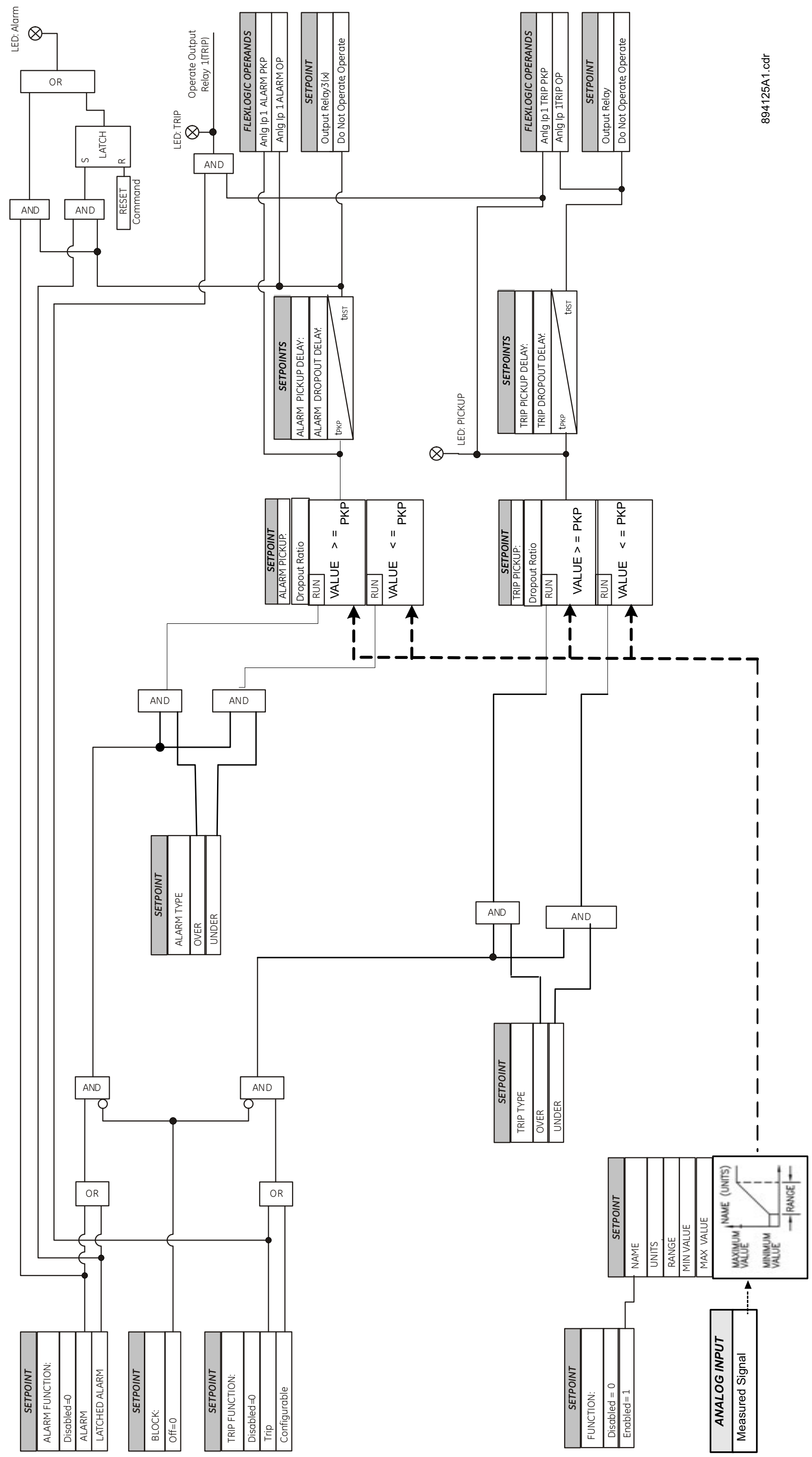
TARGETS

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 5-34: Analog Input Threshold Logic Diagram



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.

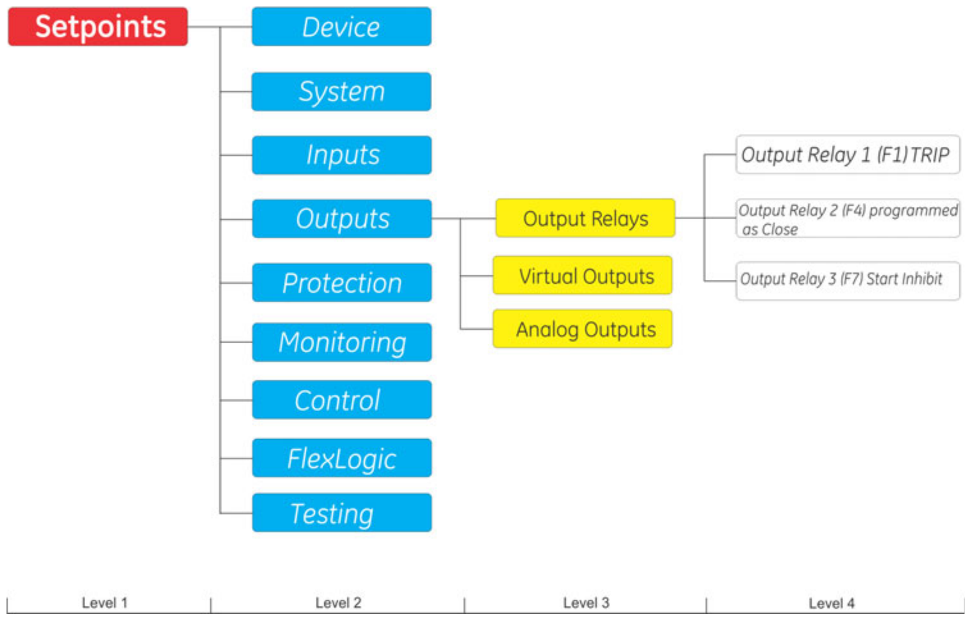
EVENTS

Range: Enabled, Disabled
Default: Enabled

This setting enables event generation whenever **Remote Input Status** is updated.

Outputs

Figure 5-35: Outputs Display Hierarchy



Output Relays

The 869 relay is equipped with a number of electromechanical output relays specified at the time of ordering. Each of the available modules for slot F provides 5 contact outputs the first two of which are designated as Trip and Close (Relay 1 “Trip”, Relay 2 “Close”). The “Trip” and “Close" relays have fixed operating characteristics as they depend on switching device feedback for resetting. These relays can be triggered by the protection elements with functions configured as Trip. The second relay can also be used as an auxiliary relay (user selected). It is labeled “Close/Aux”.

TRIP AND CLOSE RELAYS

Operation of these switching device control relays is designed to be controlled by the state of the switching device as monitored by a 52a contact, 52b contact, or both.

- The Trip and Close relays reset after the switching device is detected in a state corresponding to the command. When a command is sent to one of these special relays, it remains operated until the requested change of the switching device state is confirmed and the initiating condition has reset.
- If the command resets without a change of the switching device state, the output relay is reset after a default interval of 2 seconds.
- If neither of the switching device auxiliary contacts 52a nor 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. If a delay is programmed for the Trip or Close contact seal-in time, then this delay is added to the reset time. Note that the default setting for the seal-in time is 100 ms

The Trip and Close relay operation follows the logic described above only if the Relay Type setpoint selected is Pulsed. If the selection is Latched, the 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 Self-reset type is selected, 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	Trip Relay and Close Relays continue operating until the switching device is detected opened or closed using both 52a and 52b contacts as per switching device detection logic.
Yes	No	The Trip Relay continues operating until 52a indicates an open switching device. The Close Relay continues operating until 52a indicates a closed switching device.
No	Yes	The Trip Relay continues operating until 52b indicates an open switching device. The Close Relay continues operating until 52b indicates a closed switching device.
No	No	The 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.

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.

Output Relay 1 (F1) Trip

Path: **Setpoints > Outputs > Output Relays > Trip**

NAME

Range: Up to 13 alphanumeric characters
Default: Trip

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 869. 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 869 (if not already activated by a protection element).

The default value depends on the selection made in: Setpoints > System > Motor > Setup > Switching Device Type. If the Switching Device Type is “Breaker”, the Operation default is “Non-Failsafe”. If the Switching Device Type is “Contactor”, the Operation default is “Failsafe”.

NOTE

These defaults are applied in EnerVista when you are creating a set point file. If settings are done using the relay HMI, the user must ensure that the “Operation” set point for the breaker or contactor is as noted above.

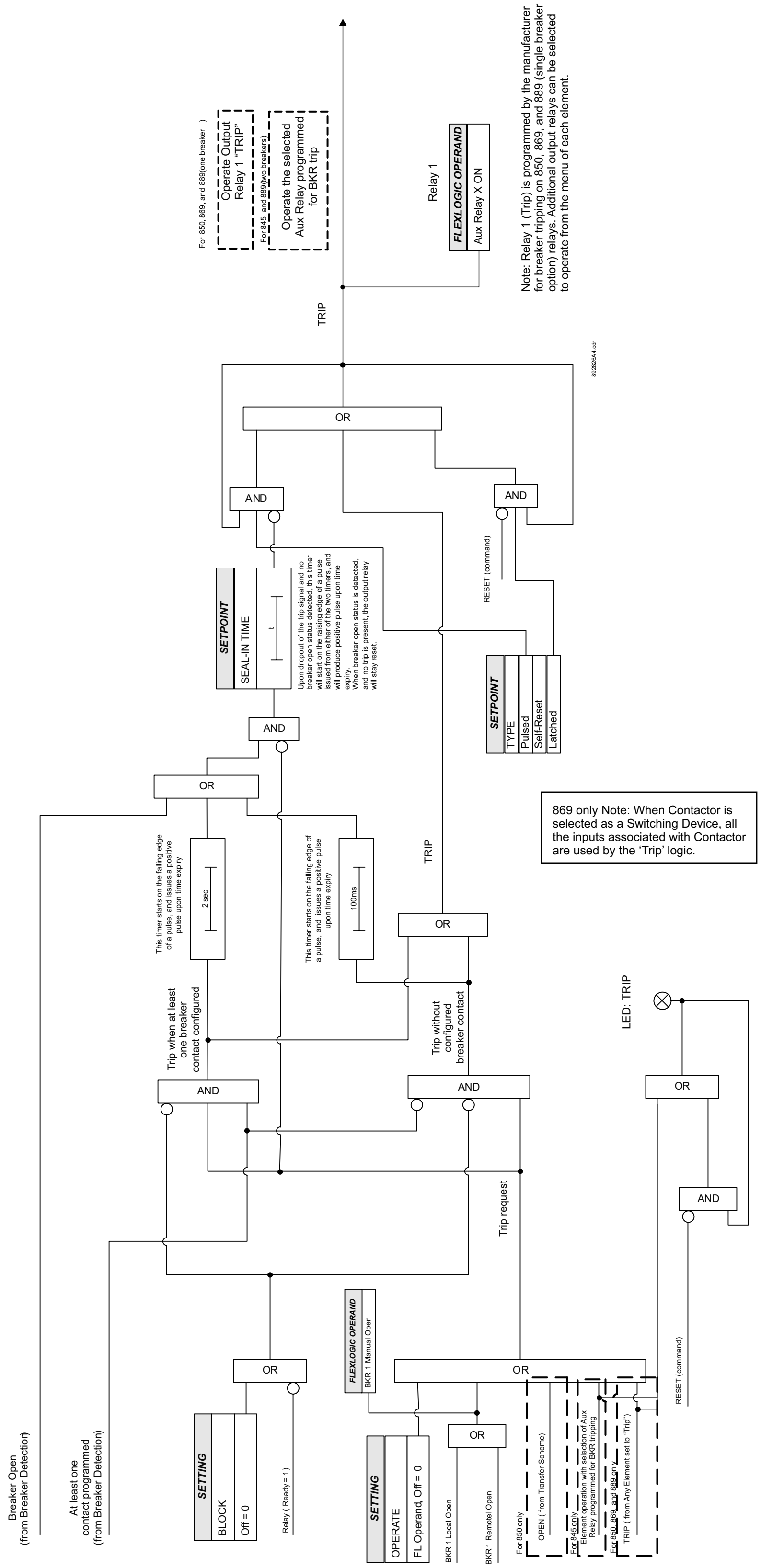
CAUTION

A failsafe relay changes state when control power is removed from the relay. When the Switching Device Type is "Contactor", an output relay in failsafe mode can result in tripping off the motor when relay power is removed.

EVENTS

Range: Disabled, Enabled
Default: Enabled

Figure 5-36: Relay 1 “TRIP” Selected for Breaker 1 logic diagram



Output Relay 2 (F4) programmed as Close

Output Relay 2 (F4) is labeled CLOSE/AUX on the wiring diagram. As suggested by that name, it can be used as a Close relay or an Auxiliary relay. This selection is made at **Setpoints > System > Breakers (Contactor) > Breakers 1 (Contactor 1) > Close Relay Select**. If the selected value of the Close Relay Select setting is Off, Output Relay 2 functions as an Auxiliary relay. If the selected value is Relay 2, Output Relay 2 functions as a Close relay. The default value is Off. The description below applies to both Relay 2 “Close” functionality. For the Relay 2 “auxiliary” functionality; see the figure Figure 5-38:Auxiliary Relays generic logic.

Path: **Setpoints > Outputs > Output Relays > Aux Relay 2 (Close)**

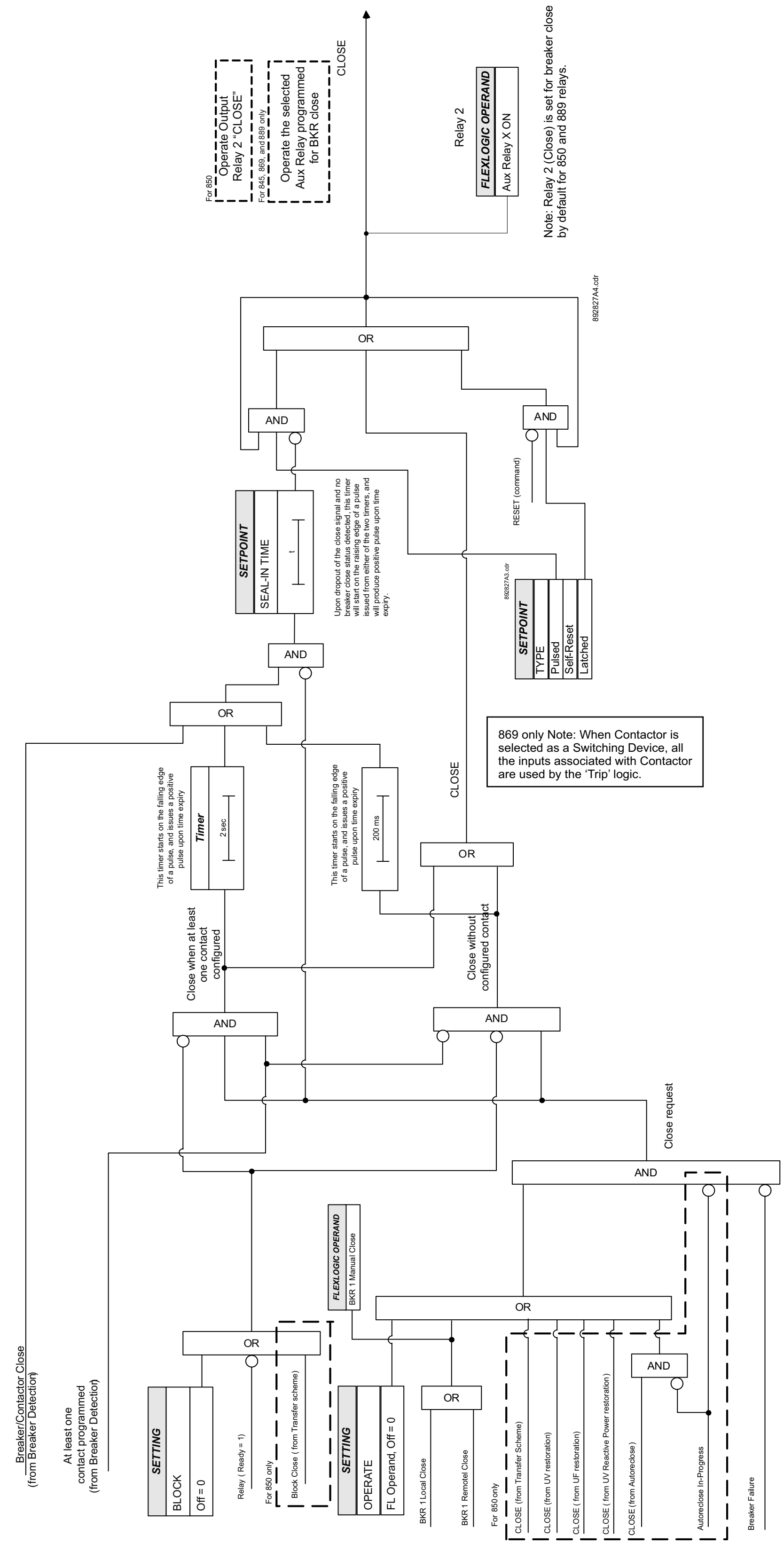
NOTE

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.

NOTE

If Aux Relay 2 is selected for Breaker Close or Contactor Close, the relay name from the Output Relays menu changes to “Close”. If Aux Relay 2 is not selected, the name reverts to “Aux Relay 2”.

Figure 5-37: "Close" Selected for Breaker 1 logic diagram



Output Relay 3 (F7) programmed as Start Inhibit

Auxiliary Relay 3 is reserved on 869 for the Start Inhibit function. The default setting to trigger the relay, (setpoint Operation) is set to the Start Inhibit FlexLogic operand. To avoid erroneously using the output for any other purpose, Aux. Relay 3 is always hidden from the list of available relays. The use of start inhibit is to prevent the start of the motor, as is illustrated in Figure 2-18:Typical Wiring (892769A3).

Path: **Setpoints > Outputs > Output Relays > Start Inhibit**

NAME

Range: Up to 13 alphanumeric characters

Default: Start Inhibit

This setpoint is used to name the auxiliary output relay by selecting up to 13 alphanumeric characters. The relay is named Start Inhibit as the factory default.

OPERATE

Range: Off, On, Any FlexLogic operand

Default: Start Inhibit

This setpoint provides for the selection of any operand from the list of FlexLogic or communications operands, which can be used to energize auxiliary Output Relay 3. The Start Inhibit operand is programmed as factory default to energize this 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.

Descriptions for all the other setpoints under Start Inhibit are identical to those of the Auxiliary Relay Outputs.

Auxiliary Output Relays

The 869 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 869 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

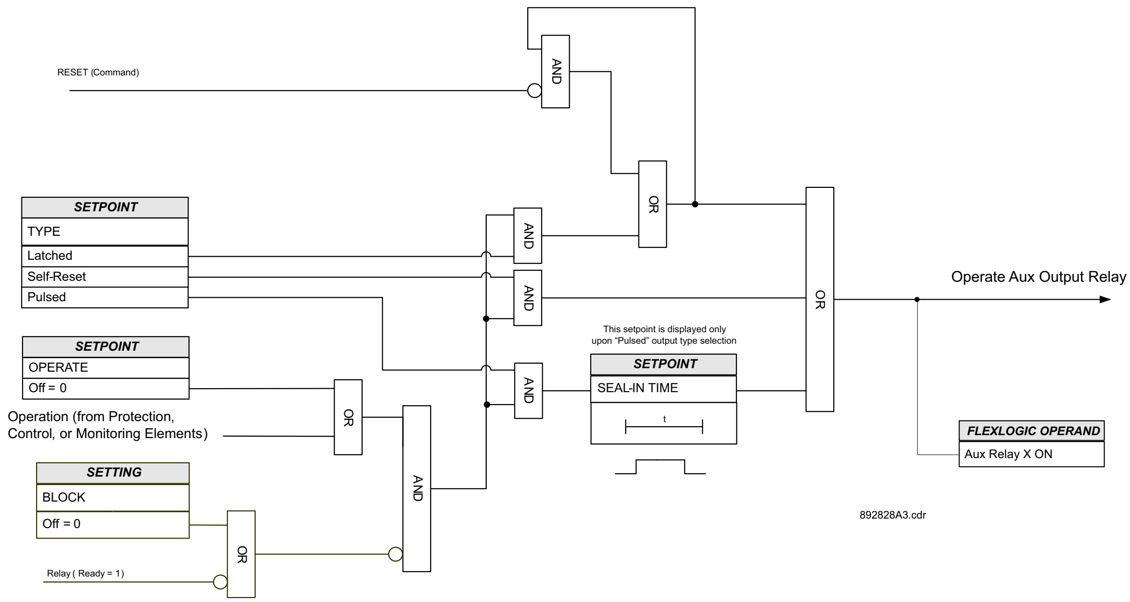
Failsafe operation causes the output relay to be energized when the operand assigned to the OPERATE AUX RLY # setting is low and de-energized when the same operand is high. A failsafe relay also changes state (if not already activated by an operand driving this output relay) when control power is removed from the 869. 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 869 (if not already activated by a protection element).

The choice of failsafe or non-failsafe operation is usually determined by the motor's application. In situations where the process is more critical than the motor, non-failsafe operation is typically programmed. In situations where the motor is more critical than the process, failsafe operation is programmed.

EVENTS

Range: Disabled, Enabled
Default: Enabled

Figure 5-38: Auxiliary Relays generic logic



Virtual Outputs

The 869 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

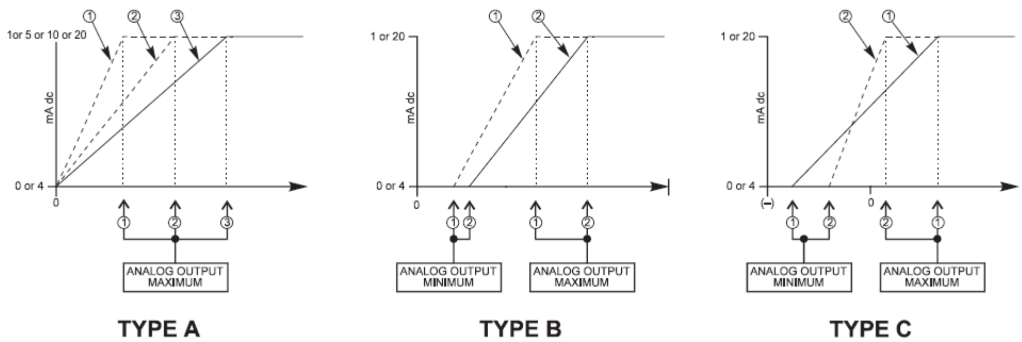
Range: Disabled, Enabled
Default: Disabled

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.

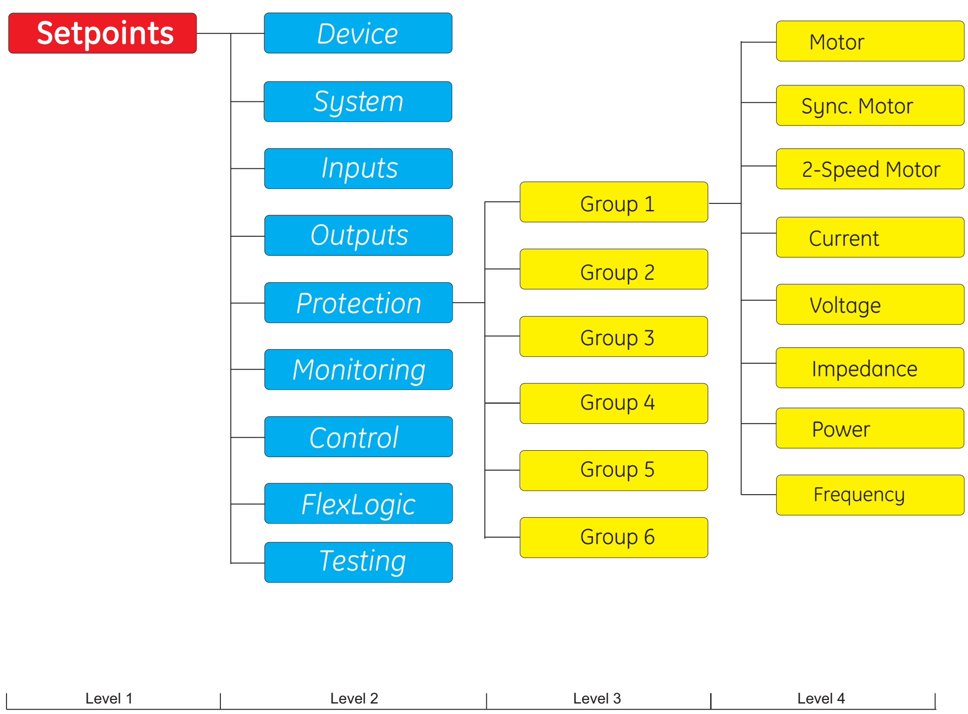
GE
Grid Solutions

869 Motor Protection System

Chapter 6: Protection

The 869 protection elements are organized in six (6) identical setpoint groups: Setpoint Group 1 to Setpoint Group 6.

Figure 6-1: Protection Display Hierarchy



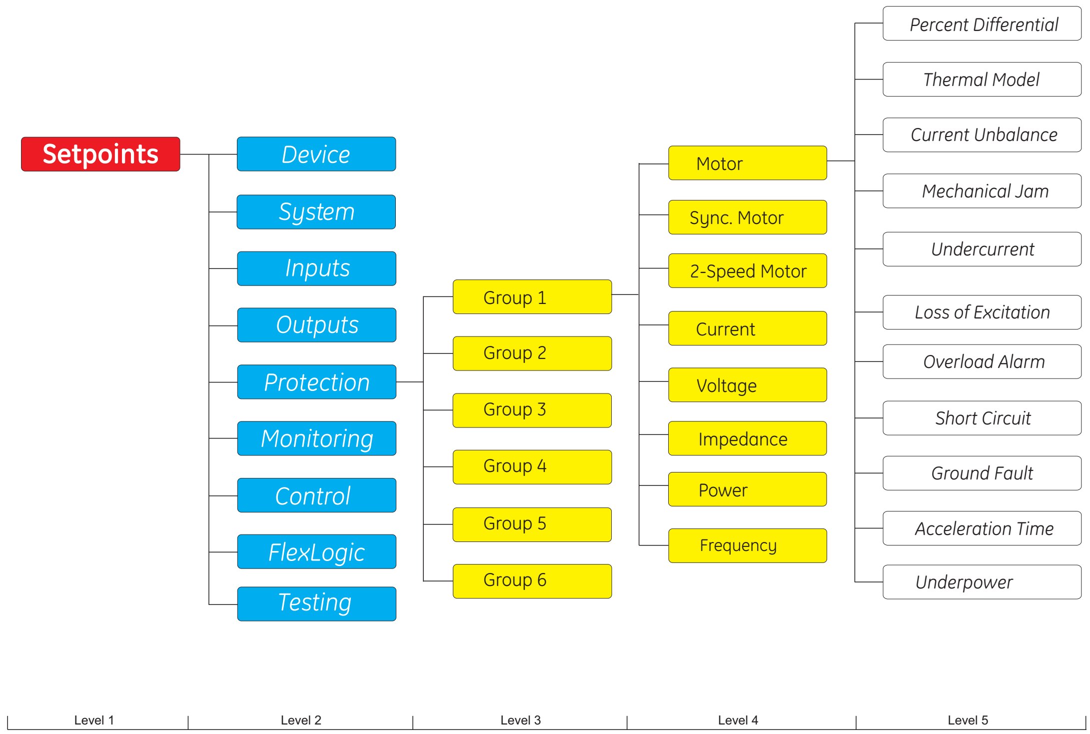
Each Setpoint Group has the same protection functions, depending on the relay order code.

Motor Elements

- Percent Differential
- Thermal Model (49)
- Current Unbalance (46)
- Mechanical Jam (50LR)
- Undercurrent (37)

Motor Elements

Figure 6-2: Motor Elements Display Hierarchy



Percent Differential

The 869 relay provides one Percent Differential element per protection group using an internal summation method (described below). It is intended for use on the stator windings of the rotating machinery. This element is available only if the second AC analog input card with the K1-CT bank is properly installed in slot K. Two methods are available, depending upon the power wiring option used: Internal Summation percent differential and Core Balance percent differential. For wiring options, please refer to Installation/Electrical Installation/Differential CT Inputs chapter of the manual.

For internal summation percent differential, it is recommended that the terminal side CTs and neutral side CTs have the same ratios but it is allowed for the ratios to be different. The maximum allowable ratio mismatch is 10:1. In the case of a mismatch, the 869 scales the currents to the primary of the CT with the higher primary value which is used as the CT reference for the percent differential element.

Internal summation and core balance percent differential both operate in per phase basis (phase-segregated). The key variables used in the element are the Restraining current (I_r) and the Differential current (I_d). The way they are calculated depends on the used differential method as follows:

Internal Summation Method

For internal summation method, differential current Id and restraint current I_r are defined below:

Eq. 1

$$I_d = |I_{ts} - I_{ns}|$$
$$I_r = MAX\{|I_{ts}|, |I_{ns}|\}$$

Where: I_{ts} is the current phasor of the terminal side CTs (J1-CT bank), in per unit normalized to the reference CT nominal; I_{ns} is the current phasor of the neutral side CTs (K1-CT bank), in per unit normalized to the reference CT nominal; They are calculated based on the following equations:

Eq. 2

$$I_{ts} = I_{ts\_sec\_amp} * \frac{CT_{ts\_pri\_rating}}{CT_{ts\_sec\_rating} * CT_{ref\_pri\_rating}}$$
$$I_{ns} = I_{ns\_sec\_amp} * \frac{CT_{ns\_pri\_rating}}{CT_{ns\_sec\_rating} * CT_{ref\_pri\_rating}}$$

Where:

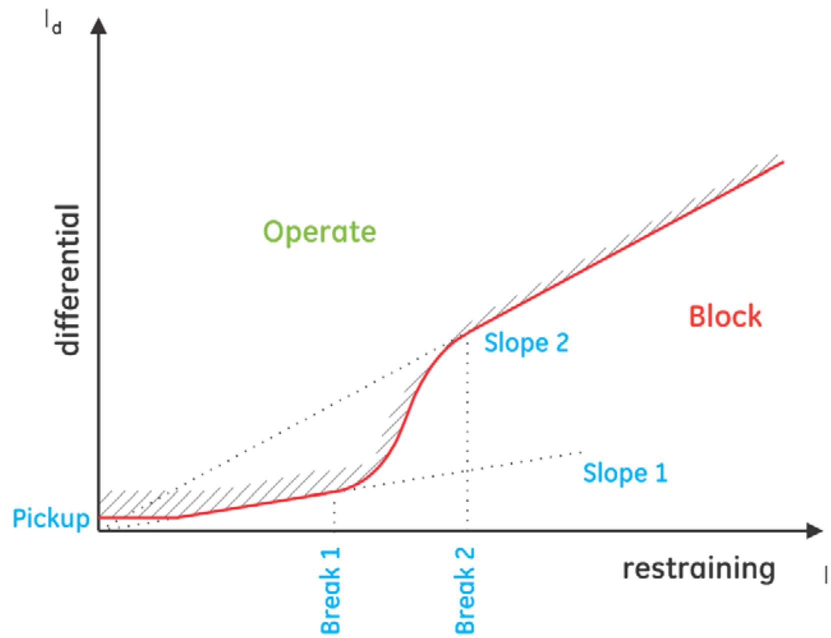
$I_{ts\_sec\_amp}$	the terminal side CT current phasor in secondary amps
$I_{ns\_sec\_amp}$	the neutral side CT current phasor in secondary amps
$CT_{ts\_sec\_rating}$	the terminal side CT secondary current rating
$CT_{ns\_sec\_rating}$	the neutral side CT secondary current rating
$CT_{ts\_pri\_rating}$	the terminal side CT primary current rating
$CT_{ns\_pri\_rating}$	the neutral side CT primary current rating
$CT_{ref\_pri\_rating}$	the reference CT primary current rating
reference CT	the CT with the maximum primary current rating

The Percent Differential element with the internal summation method selected uses dual slope dual break point differential/restraint characteristic. The main purpose of the percent-slope characteristic is to prevent improper operation caused by unbalances between CTs during external faults. CT unbalances arise as a result of the following factors:

1. CT accuracy errors
2. CT saturation

The characteristic allows for very sensitive settings when fault current is low and less sensitive settings when fault current is high and CT performance may produce incorrect operate signals. The dual slope characteristic is shown in the following figure.

Figure 6-3: Percent Differential Characteristic



The horizontal axes value of the percent differential characteristic is the Restraining current (I_r) and the vertical axes value is the Differential current (I_d).

Each pair of measured restraining and differential currents represents a point on the previous figure: Percent Differential Characteristic. If this point is located above the limit line (area labeled "Operate"), then the differential flag is set (DIF=1). If the point is located below or on the limit line (area labeled "Block"), then the differential flag is reset (DIF=0).

Core Balance Method

The Percent Differential element with core balance method selected does not use the dual slope dual break point differential/restraint characteristic. Instead, unrestraint differential measured directly from a core balance CT is used in this element. The differential element operates as per the equations shown below, where r is the restraint factor on motor starting, a user setting, and STARTING is a flag (either equal to 1 or equal to 0), which is an indication whether the motor is starting. Note that the setpoints related to biased differential with internal summation method, including slopes and break points, are not used in core balance method.

Eq. 3

$$DIF = I_d - r*STARTING*I_r > pickup$$

$$I_d = |I_{dcb}|$$
$$I_r = |I_p|$$
$$STARTING = \text{Motor Starting Flag}$$

Where I_p is the terminal side CT current phasor in per unit based on the terminal CT nominal; I_{dcb} is the core balance CT differential current phasor in per unit based on the core balance CT nominal. They are calculated as shown:

Eq. 4

$$I_p = \frac{I_{ts\_sec\_amp}}{CT_{ts\_sec\_rating}}$$

$$I_{dcb} = \frac{I_{dcb\_sec\_amp}}{CT_{dcb\_sec\_rating}}$$

Where,

$I_{ts\_sec\_amp}$	the terminal side CT current phasor in secondary amps
$I_{dcb\_sec\_amp}$	the core balance CT current phasor in secondary amps
$CT_{ts\_sec\_rating}$	the terminal side CT secondary current rating
$CT_{dcb\_sec\_rating}$	the core balance CT secondary current rating

Setpoints

Path: **Setpoints > Protection > Group 1 > Motor > Percent Differential**

FUNCTION

Range: Disabled, Trip, Configurable
Default: Disabled

TYPE

Range: Internal Sum, Core Balance
Default: Internal Sum

The setting defines the method used for differential protection and requires proper CT connections per method employed. Refer to the wiring diagram in the Electrical Installation chapter.

PICKUP

Range: 0.05 to 1.00 x CT in steps of 0.01
Default: 0.20

The setting is applicable to both the internal summation method and core balance method. In addition, this setting defines the minimum differential current required for operation. The setting is based on the amount of differential current that can be seen under normal operating conditions. A setting of 0.1 to 0.3 pu is generally recommended. The CT base of the setting is the reference CT nominal (the CT with the maximum primary current rating) for the internal summation method, and the core balance CT nominal for the core balance method.

SLOPE 1

Range: 1 to 100% in steps of 1
Default: 25%

The setting is applicable for restraint currents from zero to BREAK 1, and defines the ratio of differential to restraint current above which the element operates. The slope is set to ensure sensitivity to internal faults at normal operating current levels. The criterion for setting this slope is to allow for maximum expected CT mismatch error when operating at the maximum permitted current. This maximum error is generally in the range of 5 to 10% of CT rating.

BREAK 1

Range: 0.50 to 2.00 x CT in steps of 0.01
Default: 1.50

The setting defines the end of the Slope 1 region and the start of the transition region. It should be set just above the maximum normal operating current level of the machine.

BREAK 2

Range: 2.00 to 30.00 x CT in steps of 0.01
Default: 4.00

The setting defines the end of the transition region and the start of the SLOPE 2 region. It must be set to the level at which any of the protection CTs are expected to begin to saturate. To avoid discontinuity in the cubic spline calculation, the relay applies a minimum margin of 0.3 CT between BREAK 1 and BREAK 2.

SLOPE 2

Range: 1 to 100% in steps of 1

Default: 95%

The setting is applicable for restraint currents above the BREAK 2 setting. The slope is set to ensure stability under heavy external fault conditions that could lead to high differential currents as a result of CT saturation. A setting of 80 to 100% is recommended. The transition region (as shown on the percent differential characteristic) is a cubic spline, automatically calculated by the relay to result in a smooth transition between SLOPE 1 and SLOPE 2 with no discontinuities.

RESTRAINT FACTOR STARTING

Range: 0.000 to 1.000 in steps of 0.001

Default: 0.100

This setting defines the restraint factor during machine starting for the core balance method applications only. A portion (defined by this setting) of the current from the terminal CT is subtracted from the core balance CT differential current to avoid possible faulty operation caused by inrush current during motor starting. It must be noted that current from the terminal CT and current from the core balance CT are in per unit based on their own CT nominal with the application of this restraint factor in the relay.

PICKUP DELAY

Range: 0.000 to 10.000 in steps of 0.001

Default: 0.000

This setting defines the pickup time delay of the percent differential element.

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: Latched

NOTE

The values of the setpoints for minimum pickup, Break 1 and Break 2 are expressed in terms of CT reference. Please see the definition of CT reference which is described in the second paragraph of this section.

DC Saturation Detection:

D.C. components of both J1-CT and K1-CT bank currents, in phases A, B and C must be first calculated. The calculation is performed only if the internal summation method is selected. The method is described below.

Eq. 5

$$I_{dc(n)} = \frac{1}{N} abs\left(\sum_{k=0}^{N-1} i_{(n-k)}\right)$$

In other words, the d.c. component is an absolute value of the average of current samples over one last cycle of data.

Eq. 6

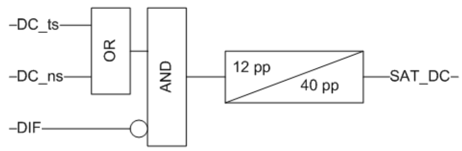
$$DC_{Ph} = (I_{dcts} > D_1 \times |I_{ts}|) \text{ AND } (|I_{ts}| > PKP)$$

Operation 2 (Eq. 6) is performed three times for each phase separately.

Eq. 7

$$DC_{NS} = (I_{dcns} > D_1 \times |I_{ns}|) \text{ AND } (|I_{ns}| > PKP)$$

D_1 is a factory constant of 1/2. A new component of the saturation condition is derived as in the figure below:



Saturation Detection

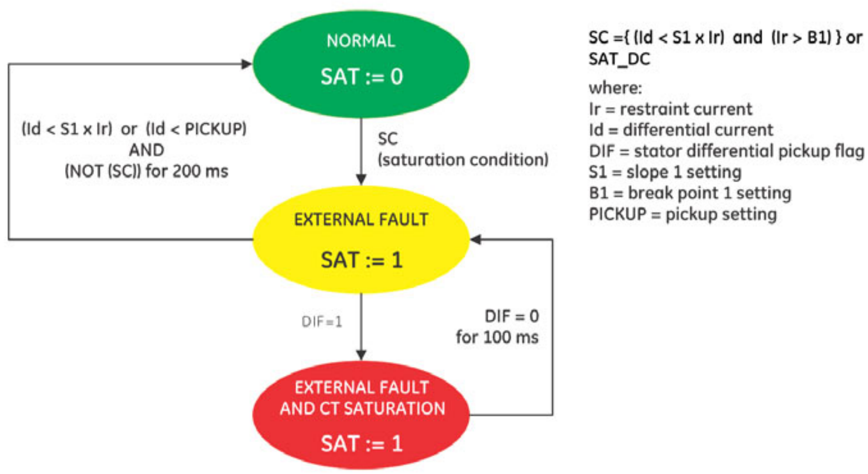
External faults near rotating machines typically result in very large time constants of DC components in the fault currents. Also, when energizing a step-up transformer, the inrush current being limited only by the machine impedance can be significant and can last for a very long time. In order to provide additional security against improper operations during these events, the 869 incorporates saturation detection logic. When saturation is detected the element makes an additional check on the angle between the terminal side CT and differential CT currents. If this angle indicates an internal fault then tripping is permitted. The latter applies only when the Internal summation method is used.

The saturation detector is implemented as a state machine (see next figure). "NORMAL" is the initial state of the machine. When in "NORMAL" state, the saturation flag is not set (SAT = 0). The algorithm calculates the saturation condition, SC. If SC = 1 while the state machine is "NORMAL", the saturation detector goes into the "EXTERNAL FAULT" state and sets the saturation flag (SAT = 1). The algorithm returns to the "NORMAL" state if the differential current is below the first slope, S1, for more than 200 ms. When in the "EXTERNAL FAULT" state, the algorithm goes into the "EXTERNAL FAULT & CT SATURATION" state if the differential flag is set (DIF = 1). When in the "EXTERNAL FAULT & CT SATURATION" state, the algorithm keeps the saturation flag set (SAT = 1). The state machine returns to the "EXTERNAL FAULT" state if the differential flag is reset (DIF = 0) for 100 ms.

There are three SAT flags (one per phase). The corresponding FlexLogic operands are:

- Percent Diff Sat A
- Percent Diff Sat B
- Percent Diff Sat C

Figure 6-4: Saturation detection state machine



Phase comparison principle:

The test for direction can be summarized by the following equation:

If $(|I_{ts}| > B_1$ **or** $(|I_{ts}| > K \times I_r$ and $|I_{ts}| > PKP))$ **and** $(|I_{ns}| > B_1$ **or** $(|I_{ns}| > K \times I_r$ **and** $|I_{ns}| > PKP))$

Then $DIR = abs (\angle Its - \angle Ins) > 90°$

else DIR = 1

where:

I_r = restraining current

DIR = flag indicating that the phase comparison principle is satisfied,

B_1 = breakpoint 1 setting,

I_{ts}, I_{ns} = current phasor at the terminal and neutral side banks, respectively

K = factory constant of 0.25

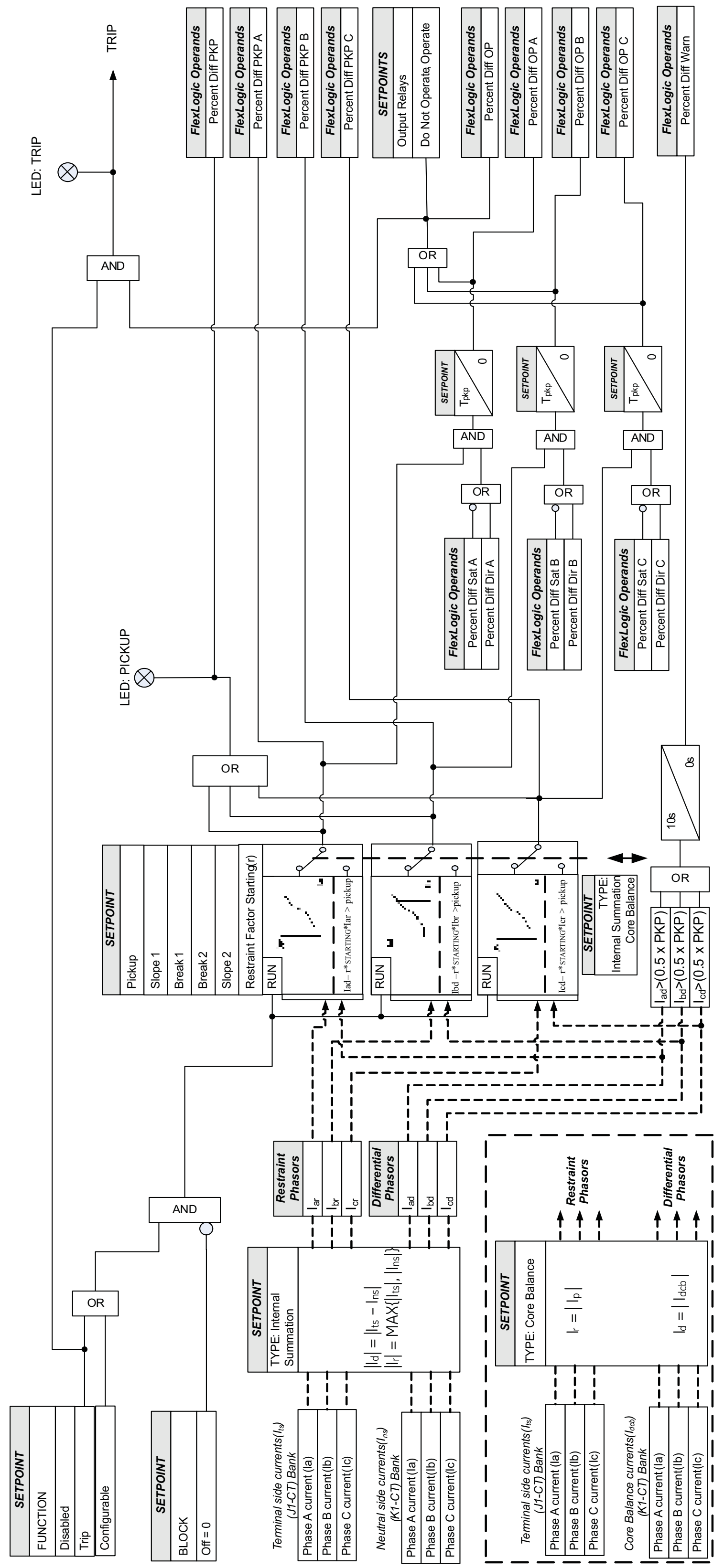
There are three DIR flags (one per phase). The corresponding FlexLogic operands are:

- Percent Diff Dir A
- Percent Diff Dir B
- Percent Diff Dir C

NOTE

That the above CT saturation (SAT) and phase direction (DIR) checking are applicable to internal summation method only. If the Core balance method is selected, neither SAT nor DIR check is performed, the fixed values SAT=0 and DIR = 1 are used.

Figure 6-5: Percent Differential logic diagram



Thermal Model (49)

The Thermal model is the primary protective function of the 869. It consists of five key elements:

- Thermal model curve (overload)
- Overload pickup level
- Unbalance biasing of the motor current while the motor is running
- Motor cooling time constants
- Biasing of the thermal model based on hot/cold information and/or measured stator temperature

The algorithm integrates both stator and rotor heating into a single model. The motor heating level is maintained in the Thermal Capacity Used (TCU) register. If the motor has been stopped for a long time, it will be at ambient temperature and the Thermal Capacity Used will be zero. If the motor is in overload, the output operand is set once the thermal capacity used reaches 100%.

Once the motor load current exceeds the overload level (FLA x overload factor), it enters an overload phase; that is, the heat accumulation becomes greater than the heat dissipation. The 869 thermal model reacts by incrementing the Thermal Capacity Used at a rate dependent on the selected thermal curve and overload level. When the thermal capacity reaches 100%, the Thermal TRIP OP operand (typically configured to trip the motor) is set.

Resetting of Thermal OP and output relays depends on the selection of configurable Trip Mode.

- When Trip Mode is set to Self-Reset, thermal model outputs (output relay(s) and operand 'Thermal OP') reset automatically as soon as the TCU level drops to 97%.
- When Trip Mode is set to Latched, Thermal Trip OP and output relays remain asserted until the current drops below OL*FLA level and a Reset command is initiated or Emergency Restart input is asserted.

In the event of a loss of control power to the relay while the motor status is not Motor Stopped or Tripped, the thermal capacity will remain unchanged when control power is restored.

If the motor status is Motor Stopped or Tripped when control power is lost, the thermal capacity will decay for the duration of the loss of control power based on the stopped motor cooling rate if the real time clock (RTC) was working properly during the power loss. However, if clock was not working properly, the TCU value will remain unchanged when the relay power is restored.

Path: **Setpoints > Protection > Group 1 > Motor > Thermal Model**

TRIP FUNCTION

Range: Disabled, Trip, Configurable
Default: Disabled

The setting enables the Thermal Model trip functionality.

OVERLOAD CURVE

Range: Motor, FlexCurve A, FlexCurve B, FlexCurve C, FlexCurve D, FlexCurve OL, IEC
Default: Motor

The thermal model curve determines the thermal limit overload conditions that can damage the motor. This curve accounts for motor heating in both the stator and rotor during stall, acceleration, and running conditions. The overload curve can take one of six formats: Motor, FlexCurve A, FlexCurve B, FlexCurve C, FlexCurve D, FlexCurve OL, or IEC. The selected curve (except IEC) can also serve as a base for a voltage dependent overload curve if the Voltage Dependent Function setting is "Enabled". The algorithm uses memory in the form of a register called Thermal Capacity Used. This register is updated every power cycle using the following equation:

Eq. 8

$$TC_{used(t)} = TC_{used(t-1)} + \frac{T_{system}}{t_{trip}} \times 100\ \%$$

Where

tcorresponding to the equivalent motor current detected within any power cycle period of motor overload. In text, it is also specified as time to trip.

T_{system} — represents the period in seconds corresponding to the nominal power system frequency.

Always set the overload curve slightly lower than the thermal limits provided by the motor manufacturer. This ensures that the motor is tripped before the thermal limit is reached.

The "Motor" curve is based on typical motor thermal limit curves and is normally used for standard motor applications (see the following Standard Motor Curves figure and Standard TD Multipliers table). The pickup level for the "Motor" curve is calculated as Motor Overload Factor setting (OL) times the Motor Full Load Amps setting (FLA). The Motor Full Load Amps (FLA) setting can be found in the **Setpoints > System > Motor** menu.The IEC motor curve is described in the IEC Curve k Factor setting.

Table 6-1: Pickup Level vs. Standard "Motor" Curve TD Multipliers

Pickup Level	869 STANDARD "Motor" Curve TD MULTIPLIERS														
	x 1	x 2	x 3	x 4	x 5	x 6	x 7	x 8	x 9	x 10	x 11	x 12	x 13	x 14	x 15
1.01	4353.6	8707.2	13061	17414	21768	26122	30475	34829	39183	43536	47890	52243	56597	60951	65304
1.05	853.7	1707.4	2561.1	3414.9	4268.6	5122.3	5976.0	6829.7	7683.4	8537.1	9390.8	10245	11098	11952	12806
1.10	416.68	833.36	1250.0	1666.7	2083.4	2500.1	2916.8	3333.5	3750.1	4166.8	4583.5	5000.2	5416.9	5833.6	6250.2
1.20	198.86	397.72	596.58	795.44	994.30	1193.2	1392.0	1590.9	1789.7	1988.6	2187.5	2386.3	2585.2	2784.1	2982.9
1.30	126.80	253.61	380.41	507.22	634.02	760.82	887.63	1014.4	1141.2	1268.0	1394.8	1521.6	1648.5	1775.3	1902.1
1.40	91.14	182.27	273.41	364.55	455.68	546.82	637.96	729.09	820.23	911.37	1002.5	1093.6	1184.8	1275.9	1367.0
1.50	69.99	139.98	209.97	279.96	349.95	419.94	489.93	559.92	629.91	699.90	769.89	839.88	909.87	979.86	1049.9
1.75	42.42	84.83	127.24	169.66	212.07	254.49	296.90	339.32	381.73	424.15	466.56	508.98	551.39	593.81	636.22
2.00	29.16	58.32	87.47	116.63	145.79	174.95	204.11	233.26	262.42	291.58	320.74	349.90	379.05	408.21	437.37
2.25	21.53	43.06	64.59	86.12	107.65	129.18	150.72	172.25	193.78	215.31	236.84	258.37	279.90	301.43	322.96
2.50	16.66	33.32	49.98	66.64	83.30	99.96	116.62	133.28	149.94	166.60	183.26	199.92	216.58	233.24	249.90
2.75	13.33	26.66	39.98	53.31	66.64	79.96	93.29	106.62	119.95	133.27	146.60	159.93	173.25	186.58	199.91
3.00	10.93	21.86	32.80	43.73	54.66	65.59	76.53	87.46	98.39	109.32	120.25	131.19	142.12	153.05	163.98
3.25	9.15	18.29	27.44	36.58	45.73	54.87	64.02	73.16	82.31	91.46	100.60	109.75	118.89	128.04	137.18
3.50	7.77	15.55	23.32	31.09	38.87	46.64	54.41	62.19	69.96	77.73	85.51	93.28	101.05	108.83	116.60
3.75	6.69	13.39	20.08	26.78	33.47	40.17	46.86	53.56	60.25	66.95	73.64	80.34	87.03	93.73	100.42
4.00	5.83	11.66	17.49	23.32	29.15	34.98	40.81	46.64	52.47	58.30	64.13	69.96	75.79	81.62	87.45
4.25	5.13	10.25	15.38	20.50	25.63	30.75	35.88	41.00	46.13	51.25	56.38	61.50	66.63	71.75	76.88
4.50	4.54	9.09	13.63	18.17	22.71	27.26	31.80	36.34	40.88	45.43	49.97	54.51	59.05	63.60	68.14
4.75	4.06	8.11	12.17	16.22	20.28	24.33	28.39	32.44	36.50	40.55	44.61	48.66	52.72	56.77	60.83
5.00	3.64	7.29	10.93	14.57	18.22	21.86	25.50	29.15	32.79	36.43	40.08	43.72	47.36	51.01	54.65
5.50	2.99	5.98	8.97	11.96	14.95	17.94	20.93	23.91	26.90	29.89	32.88	35.87	38.86	41.85	44.84
6.00	2.50	5.00	7.49	9.99	12.49	14.99	17.49	19.99	22.48	24.98	27.48	29.98	32.48	34.97	37.47
6.50	2.12	4.24	6.36	8.48	10.60	12.72	14.84	16.96	19.08	21.20	23.32	25.44	27.56	29.67	31.79
7.00	1.82	3.64	5.46	7.29	9.11	10.93	12.75	14.57	16.39	18.22	20.04	21.86	23.68	25.50	27.32

Pickup Level	869 STANDARD "Motor" Curve TD MULTIPLIERS														
	x 1	x 2	x 3	x 4	x 5	x 6	x 7	x 8	x 9	x 10	x 11	x 12	x 13	x 14	x 15
7.50	1.58	3.16	4.75	6.33	7.91	9.49	11.08	12.66	14.24	15.82	17.41	18.99	20.57	22.15	23.74
8.00	1.39	2.78	4.16	5.55	6.94	8.33	9.71	11.10	12.49	13.88	15.27	16.65	18.04	19.43	20.82
10.00	1.39	2.78	4.16	5.55	6.94	8.33	9.71	11.10	12.49	13.88	15.27	16.65	18.04	19.43	20.82
15.00	1.39	2.78	4.16	5.55	6.94	8.33	9.71	11.10	12.49	13.88	15.27	16.65	18.04	19.43	20.82
20.00	1.39	2.78	4.16	5.55	6.94	8.33	9.71	11.10	12.49	13.88	15.27	16.65	18.04	19.43	20.82

PickupLevel	869 STANDARD "Motor" Curve TD MULTIPLIERS-continued									
	x 16	x 17	x 18	x 19	x 20	x 21	x 22	x 23	x 24	x 25
1.01	69658	74011	78365	82719	87072	91426	95779	100133	104487	108840
1.05	13659	14513	15367	16221	17074	17928	18782	19635	20489	21343
1.10	6666.92	7083.60	7500.28	7916.96	8333.64	8750.33	9167.01	9583.69	10000	10417
1.20	3181.78	3380.64	3579.50	3778.36	3977.22	4176.08	4374.94	4573.80	4772.66	4971.52
1.30	2028.86	2155.67	2282.47	2409.28	2536.08	2662.88	2789.69	2916.49	3043.30	3170.10
1.40	1458.18	1549.32	1640.46	1731.59	1822.73	1913.87	2005.00	2096.14	2187.28	2278.41
1.50	1119.84	1189.83	1259.82	1329.81	1399.80	1469.79	1539.78	1609.77	1679.76	1749.75
1.75	678.63	721.05	763.46	805.88	848.29	890.71	933.12	975.54	1017.95	1060.37
2.00	466.53	495.69	524.84	554.00	583.16	612.32	641.48	670.63	699.79	728.95
2.25	344.49	366.02	387.55	409.08	430.62	452.15	473.68	495.21	516.74	538.27
2.50	266.56	283.22	299.88	316.54	333.20	349.86	366.52	383.18	399.84	416.50
2.75	213.24	226.56	239.89	253.22	266.55	279.87	293.20	306.53	319.86	333.18
3.00	174.91	185.85	196.78	207.71	218.64	229.57	240.51	251.44	262.37	273.30
3.25	146.33	155.47	164.62	173.76	182.91	192.06	201.20	210.35	219.49	228.64
3.50	124.38	132.15	139.92	147.70	155.47	163.24	171.02	178.79	186.56	194.34
3.75	107.11	113.81	120.50	127.20	133.89	140.59	147.28	153.98	160.67	167.37
4.00	93.28	99.11	104.94	110.77	116.60	122.43	128.26	134.08	139.91	145.74
4.25	82.00	87.12	92.25	97.37	102.50	107.62	112.75	117.87	123.00	128.12
4.50	72.68	77.22	81.76	86.31	90.85	95.39	99.93	104.48	109.02	113.56
4.75	64.88	68.94	72.99	77.05	81.11	85.16	89.22	93.27	97.33	101.38
5.00	58.29	61.94	65.58	69.22	72.87	76.51	80.15	83.80	87.44	91.08
5.50	47.83	50.82	53.81	56.80	59.79	62.78	65.76	68.75	71.74	74.73
6.00	39.97	42.47	44.97	47.46	49.96	52.46	54.96	57.46	59.96	62.45
6.50	33.91	36.03	38.15	40.27	42.39	44.51	46.63	48.75	50.87	52.99
7.00	29.14	30.97	32.79	34.61	36.43	38.25	40.07	41.89	43.72	45.54
7.50	25.32	26.90	28.48	30.07	31.65	33.23	34.81	36.40	37.98	39.56
8.00	22.20	23.59	24.98	26.37	27.76	29.14	30.53	31.92	33.31	34.69
10.00	22.20	23.59	24.98	26.37	27.76	29.14	30.53	31.92	33.31	34.69
15.00	22.20	23.59	24.98	26.37	27.76	29.14	30.53	31.92	33.31	34.69
20.00	22.20	23.59	24.98	26.37	27.76	29.14	30.53	31.92	33.31	34.69

CURVE EFFECT

Range: Cutoff, Shift

Default: Cutoff

This setting affects the trip time thermal curves when the Overload Curve is selected as Motor or FlexCurve OL. This setting takes into account the design of the machine with respect to overload capability as determined by the overload (service) factor. For motor designs where temperature rise above ambient is based on full load current, this setting should be selected as "Cutoff". The trip time is then calculated using the following equation:

Eq. 9

$$t_{trip} = \frac{TDM \times 2.2116623}{0.02530337 \times \left(\frac{I_{motor}}{FLA} - 1\right)^2 + 0.05054758 \times \left(\frac{I_{motor}}{FLA} - 1\right)}$$

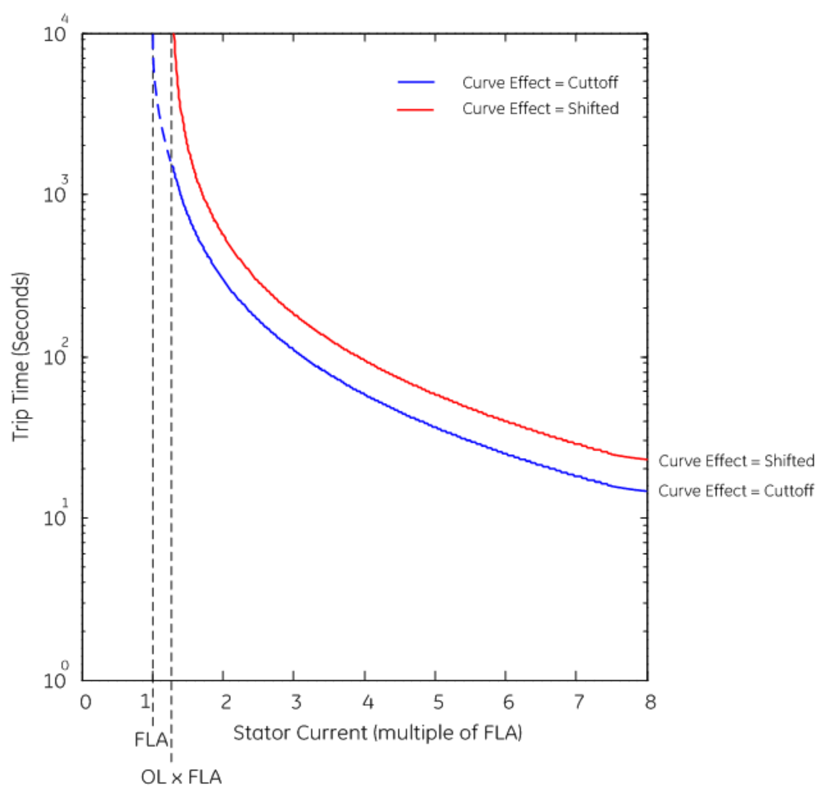
For specialized motor designs where temperature rise above ambient is based on the product of the overload factor and full load current (OL × FLA), this setting must be selected as "Shifted". The trip time is then calculated using the following equation:

Eq. 10

$$t_{trip} = \frac{TDM \times 2.2116623}{0.02530337 \times \left(\frac{I_{motor}}{OL \times FLA} - 1\right)^2 + 0.05054758 \times \left(\frac{I_{motor}}{OL \times FLA} - 1\right)}$$

In both the above equation, the motor stator current ($I_{motor} = I_{eq}$ as defined by equation (13) and motor rated current (FLA) are expressed in Amps. In case of uncertainty, the more conservative "Cutoff" value should be used. The following figure illustrates the impact of this setting on the time to trip thermal curves.

Figure 6-6: Impact of Thermal Model Curve Effect Setting



CURVE k FACTOR

Range: 1.00 to 1.50 in steps of 0.05

Default: 1.10

The setting applies only to the IEC motor curve and is applied as described below. Refer to the IEC 255-8 standard for additional details on its application.

If "IEC" is selected as the Overload Curve, the 869 can apply the IEC 255-8 hot and cold curve characteristics to the thermal model. In 869, appropriate selection of Hot/Cold curve characteristic is based on the motor status and Thermal Capacity (TC) Used as per the following table.

Prior to overload condition		**Upon overload condition**	**Selection of IEC curve Characteristic by 869**
Motor Status	**TC Used**	**Motor Status**	
Stopped	Less than 5%	Starting	Cold
Stopped	Greater than or equal to 5%	Starting	Hot
Running	Less than 5%	Overload	Hot
Running	Greater than or equal to 5%	Overload	Hot

The IEC255-8 cold curve trip time is defined as follows:

Eq. 11

$$t_{trip} = \tau \times \ln\left(\frac{I^2_{motor}}{I^2_{motor} - (k \times FLA)^2}\right)$$

The IEC255-8 hot curve trip time is defined as follows:

Eq. 12

$$t_{trip} = \tau \times \ln\left(\frac{I^2_{motor} - I^2_p}{I^2_{motor} - (k \times FLA)^2}\right)$$

where:

- t_{trip} = time to trip
- τ = IEC time constant defined by IEC Curve Time Constant 1 or IEC Curve Time Constant 2 settings. For more details, see the description of IEC Curve Time Constant 1(2).
- I_{motor} = I_{eq} measured motor load current as defined in equation 13
- I_p = Motor load current before overload occurs
- k = k-factor (overload factor) defined by IEC Curve k Factor setting applied to FLA
- FLA = Motor rated current specified by the Motor Full Load Amps setting, can be found in the **Setpoints > System > Motor** menu

IEC CURVE TIME CONSTANT 1(2)

Range: 0 to 1000 min in steps of 1

Default: 45 min

The thermal model specifies two IEC thermal time constants defined by setpoints IEC Curve Time Constant 1 and IEC Curve Time Constant 2. These settings specify thermal time constants for IEC motor curves in the preceding equations as per the IEC 255-8 standard.

Motor during starting (*Ieq > 2 x k x FLA*) is rotor-limited, and subjected to extensive heating. The thermal model requires a separate heating constant specified by IEC Curve Time Constant 2 in order to properly reflect the rotor heating. However, during running overload (*k FLA < Ieq ≤ 2 x k x FLA*) the motor is stator-limited, and the thermal model uses the stator heating time constant specified by IEC Curve Time Constant 1.

Thermal model automatically selects the IEC Curve Time Constant 1 or IEC Curve Time Constant 2 based on the motor load current as per the following table.

Table 6-2: Selection of IEC Curve Time Constant 1 or 2 by 869

IEC Time Constant	Selection Criteria
IEC Curve Time Constant 1	(k x FLA) < I_{eq} ≤ (2 x k x FLA)
IEC Curve Time Constant 2	I_{eq}> (2 x k x FLA)

When the IEC motor curves are selected, the 869 calculates the time to trip using the IEC255-8 cold curve and IEC255-8 hot curve equations and increases Thermal Capacity Used as defined by the Thermal Capacity Used equation above. If the overload disappears or the motor is tripped (stopped), then the Thermal Capacity Used decreases as per the equation (Eq. 8 in Cool Time Constant section) to simulate motor cooling, depending on the motor status and the values programmed for the Cool Time Constant Running and Cool Time Constant Stopped settings. If the IEC curve is selected, then the following applies:

1. For two-speed motor applications, the IEC Curve k Factor and IEC Curve Time Constant 1(2) settings are used at both speeds.
2. Voltage dependent overload curves are not applicable.
3. The motor status is evaluated using motor FLA and the IEC Curve k Factor setting.

TD MULTIPLIER

Range: 1.00 to 25.00 in steps of 0.01 - for thermal model curve is Motor,
0.00 to 600.00 in steps of 0.01 - for thermal model curve is Flexcurve A/B/C/D/OL

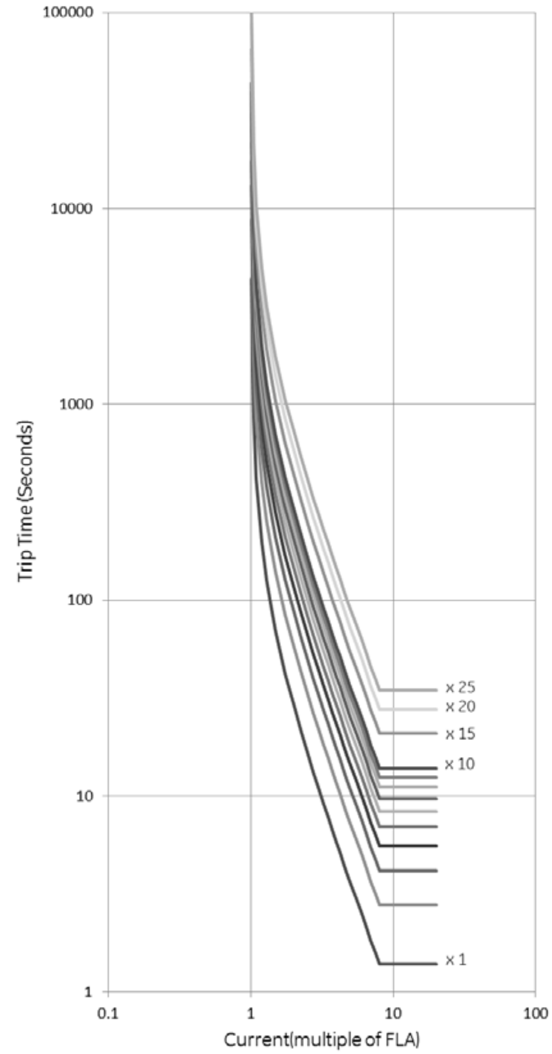
Default: 1.00

The multiplier is used to shift the overload curve on the time axis to create a family of the different curves. The TD Multiplier value is used to select the curve that best matches the thermal characteristics of the protected motor.

NOTE

If thermal model curve is selected as “Motor”, then the TD Multiplier (TDM) can be specified between “1.00” and “25.00” as indicated in the Standard Motor Curves diagram below.

Figure 6-7: Standard Motor Curves



NOTE

During the interval of discontinuity, the longer of the two trip times is used to reduce the chance of nuisance tripping during motor starts.

FLEXCURVES

In some applications, the shape of the motor thermal damage curve substantially deviates from the standard. Furthermore, the characteristics of the starting (locked rotor and acceleration) and running thermal damage curves may not correspond smoothly. In these cases, it may be necessary to use a custom curve so the motor can be started successfully and used to its full potential without compromising protection. For these conditions, it is recommended that the FlexCurves A, B, C, D, or OL be used.

FLEXCURVES A, B, C, D

The relay incorporates four programmable FlexCurves - A, B, C and D that allow the programming of selected trip times for pre-determined current levels. The points for these curves are defined by the user in the EnerVista 8 Series Setup software. 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). However, when these curves are used as an Overload Curve in Thermal Model protection, the 40 points for reset are not required.

NOTE

The thermal model applies FlexCurve (A to D) to estimate TCU% until the current drops below 0.97 x I_{pickup} (97% hysteresis). 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 OL

FlexCurve OL, on the other hand, provides the flexibility of choosing the number of operating points, including programmable trip time values as well as operate quantity values as multiple of FLA. The following Table shows comparison between FlexCurves (A, B, C and D) and FlexCurve OL.

Table 6-3: Comparison between FlexCurves A, B, C and D and FlexCurve OL

Features	FlexCurve A, B, C, D	FlexCurve OL
Total Number of Operating Points:	120 (Fixed)	10 to 30 (Configurable)
Number of Reset and Trip Points:	40 Reset and 80 Trip points	Maximum 30 points for Trip only (no reset curve)
Operating Current Quantities are:	Fixed (multiple of PKP)	Configurable (multiple of FLA)
Operating Trip Times are:	Configurable (units msec)	Configurable (units seconds)
Operating Current Quantities are:	Fixed	Configurable
Can be Initialization by:	Various Curves including Standard Motor Curves	Only Standard Motor Curves

NOTE

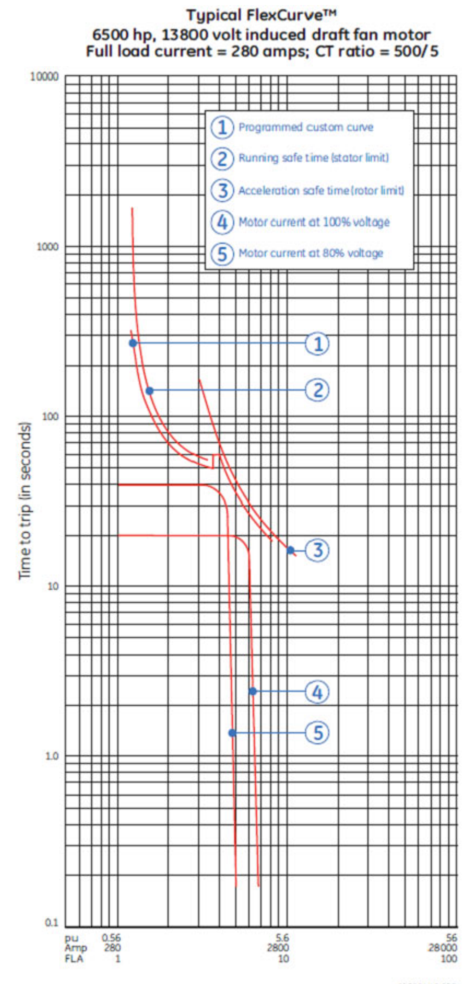
If thermal model curve is selected as FlexCurve (A/B/C/D) or FlexCurve OL, then the TD Multiplier can be specified between 0.00 and 600.00. The time dial multiplier (TDM) setting allows the selection of a multiple of the base curve shape (where the time dial multiplier = 1) with the curve shape setting. For example, all times for a TDM = 10 are ten times the multiplier 1 or base curve values.

The EnerVista 8 Series Setup software allows for easy configuration and management of FlexCurves and their associated data points. Prospective curves can be configured from a selection of standard curves to provide the best approximate fit, then specific data points can be edited afterwards. Alternately, curve data can be imported from a specified file (.csv format) by selecting the Import Data from EnerVista 8 Series Setup setting.

As seen below, if the running (2) and the locked rotor thermal limit curves were smoothed into one standard overload curve, the motor could not start at 80% line voltage. A custom curve (1) is required.

For high inertia load applications (when the Voltage Dependent Function is enabled), the locked rotor thermal limit section of the programmed motor or the FlexCurve overload curve is modified and becomes dynamically adaptive to system voltage changes. The detailed explanation of this function is covered later in this section.

Figure 6-8: FlexCurve Example



The relay incorporates four programmable FlexCurves - FlexCurve A, B, C, and D. The points for these curves are defined by the user in the EnerVista program. User-defined curves can be used for Thermal Model protection in the same way as standard Motor Curves 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). However, when these curves are used as an Overload Curve in Thermal Model protection, the 40 points for reset are not required.

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 the EnerVista 8 Series Setup setting.

NOTE

If a thermal model curve is selected as "FlexCurve" then the TD Multiplier can be specified between "0.00" and "600.00". The time dial multiplier (TDM) setting allows the selection of a multiple of the base curve shape (where the time dial multiplier = 1) with the curve shape setting. For example, all times for a TDM = 10 are ten times the multiplier 1 or base curve values.

UNBALANCE BIAS K FACTOR

Range: 0 to 19 in steps of 1

Default: 0

Unbalanced phase currents cause rotor heating that is not shown in the motor thermal damage curve. When the motor is running, the rotor rotates in the direction of the positive sequence current at near synchronous speed. Negative sequence current, which has a phase rotation that is opposite to the positive sequence current, and hence opposite to the direction of rotor rotation, generates a rotor voltage that produces a substantial current in the rotor. This current has a frequency that is approximately twice the line frequency: 100 Hz for a 50 Hz system or 120 Hz for a 60 Hz system. Skin effect in the rotor bars at this frequency causes a significant increase in rotor resistance and therefore, a significant increase in rotor heating. This extra heating is not accounted for in the thermal limit curves supplied by the motor manufacturer as these curves assume positive sequence currents from a perfectly balanced supply voltage and motor design.

The thermal model may be biased to reflect the additional heating that is caused by negative sequence current when the motor is running. This biasing is done by creating an equivalent motor heating current rather than simply using the average current. This equivalent current is calculated using the equation shown below.

Eq. 13

$$I_{eq} = \sqrt{I^2{}_{avg} \cdot \left(1 + K \cdot \left(\frac{I\_2}{I\_1}\right)^2\right)}$$

where:

I_{eq} = thermal model biased motor load current

I_{avg} = average of the three RMS currents

I_1 = positive sequence current

I_2 = negative sequence current

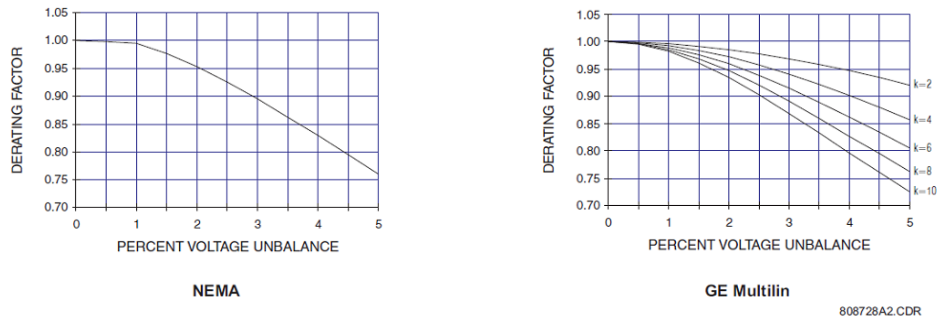
K = constant

The motor derating as a function of voltage unbalance as recommended by NEMA (National Electrical Manufacturers Association) is shown below. Assuming a typical induction motor with an inrush of 6 x FLA and a negative sequence impedance of 0.167, voltage unbalances of 1, 2, 3, 4, and 5% equals current unbalances of 6, 12, 18, 24, and 30% respectively. Based on this assumption, the amount of motor derating for different values of K entered for setting Unbalance Bias K Factor is also shown in the following figure.

NOTE

The curve created when K = 8 is almost identical to the NEMA derating curve.

Figure 6-9: Medium Motor Derating Factor Due to Unbalanced Voltage



If a value of K = 0 is entered, unbalance biasing is defeated and the overload curve times out against the measured per unit motor positive sequence current. The following equations can be used to calculate k.

Eq. 14

$$K = \frac{175}{I_{LR}^2} \text{ (typical estimate); } K = \frac{230}{I_{LR}^2} \text{ (conservative estimate),}$$

where I_{LR} is the per unit locked rotor current.

COOL TIME CONSTANT RUNNING

Range: 1 to 1000 minutes in steps of 1 minute

Default: 15 minutes

The thermal capacity used value is reduced in an exponential manner when the motor current is below the full load amps times overload factor (OL x FLA) settings to simulate motor cooling. The motor Cool Time Constant Running should be entered for running case. Motor cooling is calculated as follows:

Eq. 15

$$TCU = (TCU_{start} - TCU_{end})(e^{-t/\tau_{cool}}) + TCU_{end}$$

Eq. 16

$$TCU_{end} = \left(\frac{I_{eq}}{OL \times FLA}\right)\left(1 - \frac{hot}{cold}\right) \times 100\%$$

where:

- TCU = thermal capacity used.
- TCU_{start} = TCU value caused by overload condition.
- TCU_{end}= TCU value dictated by the hot/cold curve ratio when the motor is running. This value is 0 when the motor is stopped).
- t = time in minutes.
- τ_{cool}= Cool Time Constant Running.
- I_{eq} = Equivalent motor heating current (also defined as Thermal Model Biased Motor Load Current).
- OL = Overload factor specified by the Motor Overload Factor setting.
- FLA = Motor rated current specified by the Motor Full Load Amps setting.

- hot / cold = hot/cold curve ratio

For the case when the motor is running cyclic or reciprocating load of small load cycle, it is recommended to calculate the value of Cooling Time Constant Running using the below equation.

Eq. 17

$$\tau = \frac{87.4 \times TDM}{60} \quad (min)$$

where

TDM is the TD Multiplier.

However, the Cool Time Constant Running can be only selected using the above equation when Overload Curve is selected "Motor".

COOL TIME CONSTANT STOPPED

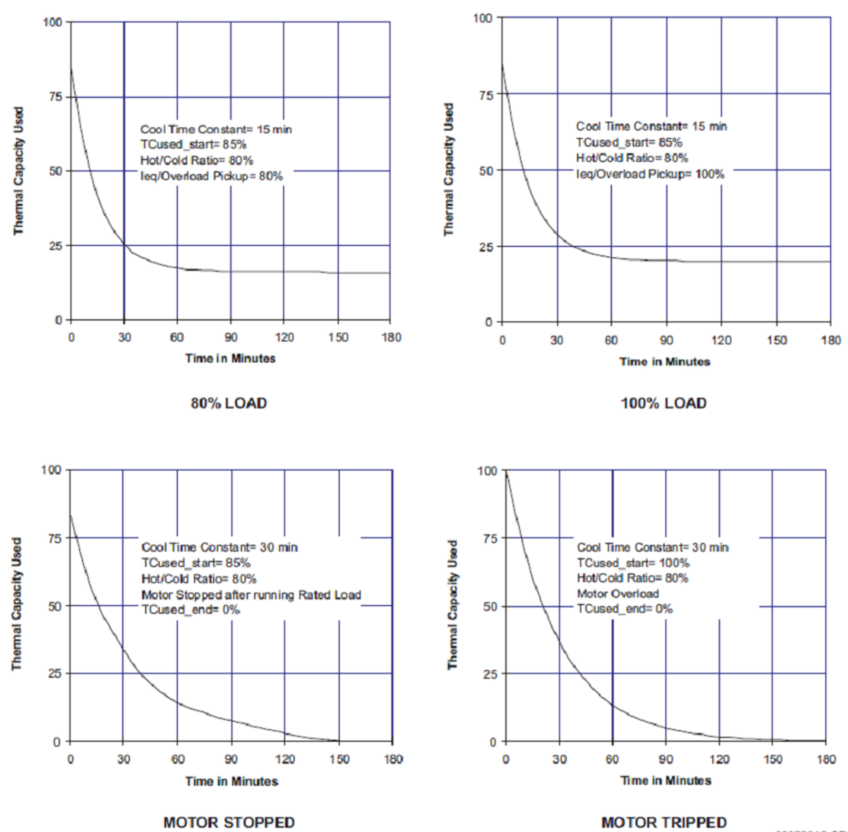
Range: 1 to 1000 minutes in steps of 1 minute

Default: 30 minutes

The Thermal Capacity Used value is reduced in an exponential manner when the motor current is stopped after running rated load or tripped due to overload. The motor Cool Time Constant Stopped must be entered for the stopped cases. A stopped motor normally cools significantly slower than a running motor.

For the motor stopped case, motor cooling is also calculated using the same equation above, however; the value of the cool time constant (τ) is now Cool Time Constant Stopped and TCU_{end} is now 0.

Figure 6-10: Thermal Model Cooling



HOT/COLD SAFE STALL RATIO

Range: 0.01 to 1.00 in steps of 0.01

Default: 1

The motor manufacturer sometimes provide thermal limit information for a hot/cold motor. The algorithm uses this data if this setting is programmed. The value entered for the setting dictates the level at which Thermal Capacity Used settles for current that is below the motor overload factor (OL) times FLA. When the motor is running at a level that is below this limit Thermal Capacity Used rises or falls to a value based on I_{eq} (thermal model biased motor load current). Thermal Capacity Used either rises at the fixed rate of 5% per minute or falls as dictated by the running cool time constant.

Eq. 18

$$TCU_{end} = \left(\frac{I_{eq}}{OL \times FLA}\right)\left(1 - \frac{hot}{cold}\right) \times 100\%$$

where:

- TCU_{end} = Thermal Capacity Used, if I_{eq} remains steady state.
- I_{eq} = equivalent motor heating current (also defined as Thermal Model Biased Motor Load Current)
- OL = Overload factor specified by the Motor Overload Factor setting.
- FLA = Motor rated current specified by the Motor Full Load Amps setting.
- hot/cold = Hot/Cold Safe Stall Ratio setting.

RTD BIAS

Range: Disabled, Enabled

Default: Disabled

When Enabled, this feature acts as an additional check of the motor overheating through the current based thermal model. The current based thermal model estimates motor heating from the thermal overload curves and cooling time constants. The thermal overload curves are based solely on measured current, assuming a normal 40°C ambient temperature and normal motor cooling. This feature provides additional protection in cases where there is an unusually high ambient temperature, or motor cooling is malfunctioning, or motor temperature increases due to other unexpected factors, or the overload curve was selected incorrectly. Therefore, if the motor stator has embedded RTDs, the RTD Bias feature is used to augment the thermal model calculation of Thermal Capacity Used.This feature uses the hottest stator RTD temperature value to estimate the RTD Thermal Capacity Used and compare this value to the Thermal Capacity Used calculated by the current based thermal model (overload curve and cool times). The larger of the two values is used from that point onward. Since RTDs have a relatively slow response, RTD biasing is useful for slow motor heating. Other portions of the thermal model are required during starting and heavy overload conditions when motor heating is relatively fast

NOTE

1. The RTD Bias feature is active only if the optional RTD Input module has been installed.
2. Each stator RTD must be first configured as STATOR application under Setpoints/ Monitoring/RTD Temperature/RTD 1(X). RTDs configured as Stator type are used by the thermal model for determining the RTD Bias.
3. The RTD bias feature alone cannot generate a trip. Even if the RTD bias feature forces the RTD bias thermal capacity used to 100%, the load current must be above the overload pickup (OL x FLA) setting to set the output.

RTD BIAS MINIMUM

Range: 0 to 250°C in steps of 1
Default: 40°C

RTD BIAS CENTER

Range: 0 to 250°C in steps of 1
Default: 130°C

RTD BIAS MAXIMUM

Range: 0 to 250°C in steps of 1
Default: 155°C

The RTD bias feature is a two-part curve (RTD Bias Thermal Capacity Used) constructed from three points: minimum, center and maximum. If the maximum stator RTD temperature is below the RTD Bias Minimum setting (typically 40°C), no biasing occurs. If the maximum stator RTD temperature is above the RTD Bias Maximum setting (typically at the stator insulation rating or slightly higher), then the thermal memory is fully biased and RTD bias thermal capacity used is forced to 100%. At values in between, the present RTD bias thermal capacity used created by other features of the thermal model is compared to the RTD bias thermal capacity used. If the value of the RTD bias thermal capacity used is higher, then this value is used from that point onward. The RTD Bias Center setting must be set to the rated running temperature of the motor. The relay automatically determines the RTD bias thermal capacity used value for the center point using the Hot/Cold Safe Stall Ratio setting.

Eq. 19

$$\text{TCU at RTD\_Bias\_Center} = \left(1 - \frac{\text{hot}}{\text{cold}}\right) \times 100\ \%$$

At < RTD_Bias_Center temperature

Eq. 20

$$\text{RTD\_Bias\_TCU} = \frac{Temp_{actual} - Temp_{min}}{Temp_{center} - Temp_{min}} \times \text{TCU at RTD\_Bias\_Center}$$

At > RTD_Bias_Center temperature,

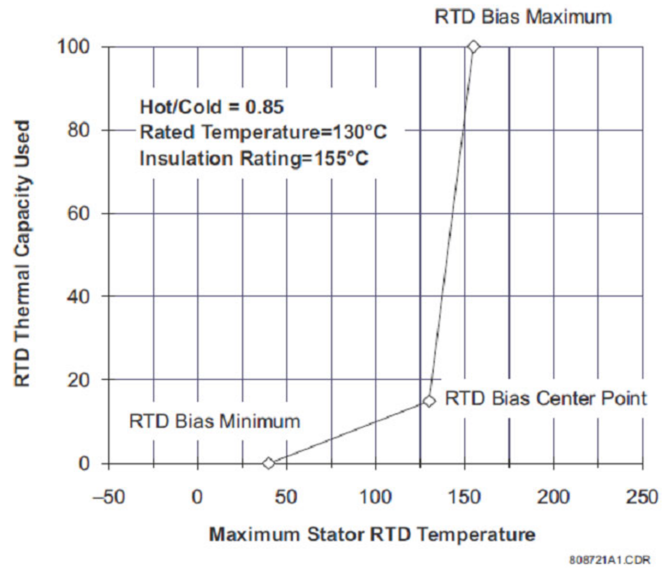
Eq. 21

$$\text{RTD\_Bias\_TCU} = \frac{Temp_{actual} - Temp_{center}}{Temp_{max} - Temp_{center}} \times (100 - \text{TCU at RTD\_Bias\_Center}) + \text{TCU at RTD\_Bias\_Center}$$

where:

- RTD_Bias_TCU = thermal capacity used due to hottest stator RTD
- $Temp_{actual}$ = current temperature of the hottest stator RTD
- $Temp_{min}$ = RTD Bias minimum setting
- $Temp_{center}$ = RTD Bias center setting
- $Temp_{max}$ = RTD Bias maximum setting
- TCU at RTD_Bias_Center = thermal capacity used defined by the Hot/Cold Safe Stall Ratio setting

Figure 6-11: RTD Bias Curve



RTD BIAS VOTING

Range: Disabled, Enabled

Default: Disabled

The RTD biasing feature selects the maximum stator RTD temperature to calculate the RTD Thermal Capacity Used. However, in the event of the malfunction of the maximum temperature RTD, the RTD Bias Voting function assures extra security. This function requires another stator RTD to be voted with the maximum temperature RTD.

Maximum stator RTD temperature will be used by the RTD Biasing feature only if both maximum stator RTD temperature and voting RTD temperature, which is the second maximum temperature, lie within the range defined by the setpoint RTD Bias Voting Band. If the maximum stator RTD temperature and voting RTD temperature don't lie within the settable range than next maximum stator RTD temperature will require voting by the next voting RTD. If voting fails, RTD Bias feature will block automatically.

NOTE

At least two RTDs have to be configured as Stator type (under Setpoints/Monitoring/RTD Temperature) for this feature to become active.

RTD BIAS VOTING BAND

Range: 0 to 50°C in steps of 1°C
Default: 10°C

This value specifies the temperature difference range between the maximum stator RTD temperature and another voting stator RTD temperature.

Examples: Assuming RTD Bias Voting is enabled and RTD Bias Voting Band is programmed as 10°C and three RTDs are programmed as Stator type under Monitoring > RTD Temperature.

Example 1: Actual temperature values of RTD1, RTD2 and RTD3 are 100°C, 95°C and 80°C, respectively.

The Voting feature selects RTD1 (100°C) as the maximum temperature RTD among the three RTDs and RTD2 (95°C) as the voting RTD. Because, temperature difference between RTD1 and RTD2 is less than the RTD Bias Voting Band of 10°C, RTD1 temperature will be selected as the maximum stator RTD temperature.

Example 2: Actual temperature values of RTD1, RTD2 and RTD3 are 100°C, 85°C and 80°C, respectively.

RTD1 (100°C) is selected as the maximum temperature RTD among the three RTDs and RTD2 (85°C) as the voting RTD. Since the temperature difference between RTD1 and RTD2 is greater than the RTD Bias Voting Band of 10°C, RTD1 temperature will not be selected as the maximum stator RTD temperature and RTD1 is declared as a malfunctioning RTD internally.

The Voting feature will then select RTD2 (85°C) as the maximum temperature RTD from the remaining two RTDs, and RTD3 (80°C) as the voting RTD. The RTD2 temperature (85°C) is chosen as input to the RTD Bias feature because the temperature difference between RTD2 and RTD3 is less than the RTD Bias Voting Band of 10°C.

SPEED BIAS

Range: Disabled, Enabled
Default: Disabled

NOTICE

This feature is only applicable to a brush-type synchronous motor with Phase Currents Slot - K order code options C5/D5 for the K2-slot card.

The brush-type synchronous motor runs in induction mode from the motor starting to the synchronized state. In the starting state, the motor is rotor-limited and the rotor is subjected to extensive heating. Speed Bias, when enabled, acts as an additional check of the amortisseur, or squirrel cage winding rotor heating. This feature takes the estimated speed-dependent thermal capacity used (actual value) and compares this value to the Thermal Capacity Used calculated by the current-based method and RTD Bias method (when enabled). The largest of these three values is used from that point onward.

NOTICE

- The Speed Bias feature is only applicable to brush-type synchronous motor and requires that the SC Speed-Dependent Thermal Protection function be enabled.
- Speed-biasing is not applicable to brushless synchronous motors and induction motors. The Speed Bias feature alone cannot generate a trip.
- Even if the SM SC Spd-Dep TC Used reaches 100%, the load current must be above the overload pickup (OL x FLA) setting to set the output.
- Speed Bias is only applicable when a brush-type synchronous motor is in induction mode (no DC field applied) with the motor in the Starting, Running or SM Resync state.

VOLT. DEPENDENT (VD) FUNCTION

Range: Disabled, Enabled

Default: Disabled

If the motor is called upon to drive a high inertia load, it is quite possible and acceptable for the acceleration time to exceed the safe stall time (keeping in mind that a locked rotor condition is different than an acceleration condition). The voltage dependent overload curve feature is tailored to protect these types of motors. This curve is composed of the three characteristics of thermal limit curve shapes as determined by the stall or locked rotor condition, acceleration, and running overload. The following figure presents the typical thermal limit curve for high inertia application.

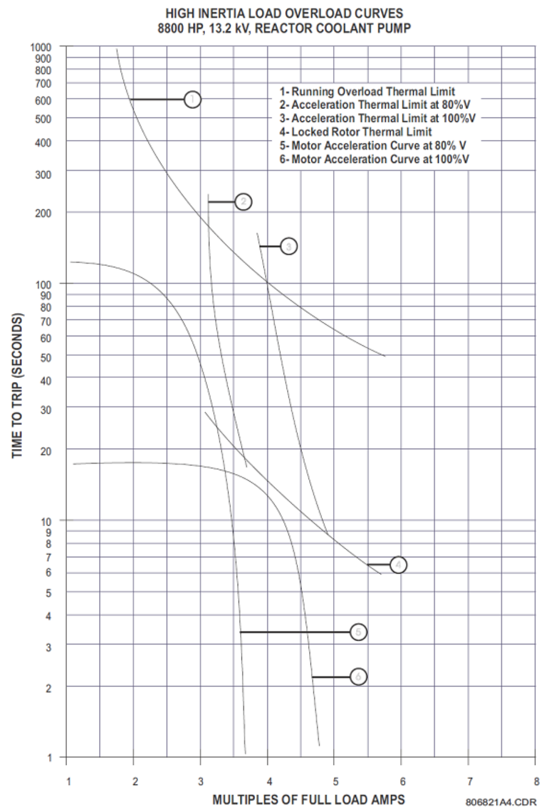
In this instance, each distinct portion of the thermal limit curve must be known and protection coordinated against that curve. The relay protecting the motor must be able to distinguish between a locked rotor condition (curve 4) and an accelerating condition for different levels of the system voltage (curves 2 and 3). Voltage is continually monitored during motor starting and the acceleration thermal limit portion of the relay overload curve is dynamically adjusted based on motor voltage variations.

The acceleration thermal limit is a function of motor speed during the start. The dynamically shifted voltage dependent overload curve inherently accounts for the change in motor speed as a function of motor impedance. The change in impedance is reflected by motor terminal voltage and line current. This method aids to set dynamically the appropriate value of the thermal limit time for any given line current at any given terminal voltage.

The Voltage Dependent Function setpoint enables the voltage dependent feature and modifies the locked rotor portion of the programmed relay overload curve with respect to the acceleration thermal limits. These thermal limits are typically available from the machine specifications provided by motor manufacturer.

NOTE

Variable frequency drives (VFD) generates significant distortion in voltage input, therefore, Voltage Dependent Function is blocked when operand “VFD Not Bypassed” is asserted. VFD Not Bypassed is asserted when VFD Function is enabled and operand Bypass Switch is not asserted. More detail can be found in section System > Motor> VFD.



VD MIN MOTOR VOLTS

Range: 60 to 99% in steps of 1

Default: 80%

The setting defines the minimum allowable line voltage applied to the motor during the acceleration if Voltage Dependent Function is enabled. This voltage is expressed as a percentage of the **Setpoints > System > Motor > Motor Nameplate Voltage** setting. If the measured line voltage drops below this setting during acceleration, the thermal curve is switched to one based on the programmed minimum voltage thermal limit:

Eq. 22

$$t_{trip} = \frac{I_1^2 \times t_1}{I^2}$$

VD VOLTAGE LOSS

Range: Any FlexLogic operand

Default: Off

The setting is used to address situations when the voltage input into thermal model has been lost. In this case, the voltage dependent algorithm readjusts the voltage dependent curve to avoid an inadequate thermal protection response. The VT fuse failure function is typically used to detect a voltage loss condition. If a voltage loss has been detected while the motor accelerates, the thermal curve is switched to one based on the programmed 100% voltage thermal limit:

Eq. 23

$$t_{trip} = \frac{I_3^2 \times t_3}{I^2}$$

VD STALL CURRENT @ MIN V

Range: 1.50 to 20.00 FLA in steps of 0.01

Default: 4.50 x FLA

The setting defines the locked rotor current level at minimum motor voltage (I_1).

VD STALL TIME @ MIN V

Range: 0.1 to 1000.0 in steps of 0.1

Default: 20.0 seconds

The setting defines the maximum time that the motor is allowed to withstand the locked rotor current at minimum motor voltage (t_1).

VD ACCEL. INTERSECT @ MIN V

Range: 1.50 to 20.00 in steps of 0.01

Default: 4.00 x FLA

The setting defines the starting current level corresponding to the crossing point between the acceleration thermal limit at minimum voltage and the programmed relay overload curve (I_2). This value can be typically determined from motor acceleration curves. The value at the breakdown torque for the minimum voltage start is recommended for this setting.

VD STALL CURRENT @ 100% V

Range: 1.50 to 20.00 FLA in steps of 0.01

Default: 6.00 x FLA

The setting defines the locked rotor current level at the rated motor voltage (I_3).

VD STALL TIME @ 100% V

Range: 0.1 to 1000.0 in steps of 0.1

Default: 10.0 seconds

The setting defines the maximum time the motor is allowed to withstand the locked rotor current at rated motor voltage (t_3).

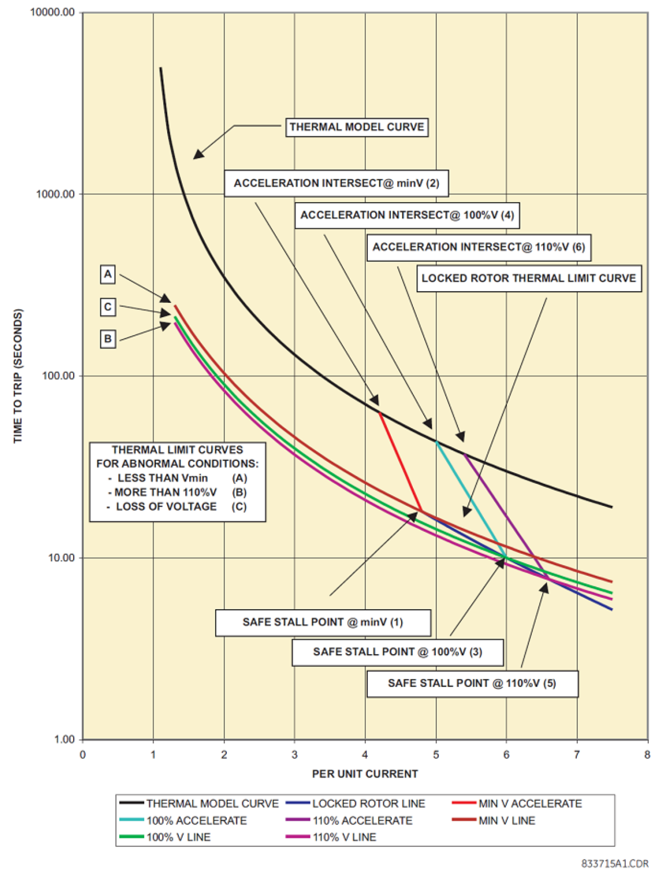
VD ACCEL. INTERSECT @ 100% V

Range: 1.50 to 20.00 in steps of 0.01

Default: 5.00 x FLA

The setting defines the starting current level corresponding to the crossing point between the acceleration thermal limit at rated voltage and the programmed relay overload curve (I_4). The value can be typically determined from the motor acceleration curves. The current value at the breakdown torque for the 100% voltage start is recommended for this setting. The voltage dependent overload curves are shown in the following figure.

Figure 6-12: Voltage Dependent Overload Curves



ALARM FUNCTION

Range: Disabled, Alarm, Latch Alarm

Default: Disabled

The setting enables the Thermal Model alarm functionality.

ALARM PICKUP

Range: 10.00 to 100.00% in steps of 1.00

Default: 75.00%

The setting specifies a pickup threshold of the Thermal Capacity Used (TCU) for the alarm function.

TRIP MODE

Range: Self-Reset, Latched

Default: Latched

When Trip Mode is set to Self-Reset, thermal model outputs (output relays and Thermal OP operand) reset automatically as soon as the TCU level drops to 97%.

When Trip Mode is set to Latched, Thermal Trip OP and output relays remain asserted until the current drops below the OL*FLA level and a Reset command is initiated or Emergency Restart input is asserted.

ALARM OUTPUT RELAY X

For details see Common Setpoints.

TRIP OUTPUT RELAY X

For details see Common Setpoints.

EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Self-reset, Latched, Disabled
Default: Latched

BLOCK (THERMAL MODEL BLOCK)

Range: Any FlexLogic operand
Default: Off

The thermal model can be blocked by any asserted FlexLogic operand. While the blocking signal is applied, the element remains running and updates the thermal memory, but the states of the Thermal Trip OP and Thermal Alarm OP operands will reset. When the element blocking signal is removed, the element logic is based on the new value of the thermal capacity and updates the status of the Thermal Trip OP and Thermal Alarm OP operands.

The following procedure, along with the previous figure, illustrates the construction of the voltage overload curves.

1. Draw a curve for the running overload thermal limit. The curve is one that has been selected in the relay as an Overload Curve.
2. Determine the point of intersection between the Overload Curve and the vertical line corresponding to the per-unit current value of VD Accel. Intersect @ MIN V (see point 2).
3. Determine the locked rotor thermal limit point for the minimum voltage motor start. The coordinates of this point are the per-unit current value of VD Stall Current @ Min Volts and the time value of VD Safe Stall Time @ Min V (see point 1).
4. The line connecting points 1 and 2 constructs the acceleration curve for the system voltage level defined by the VD Min Motor Volts setting. The acceleration time-current curve for the minimum voltage starting is calculated from the following equation:

Eq. 24

$$t_{trip} = A_{Factor} \times e^{-I/\sigma}$$

$$\text{where } \sigma = \frac{I_1 - I_2}{\ln(t_2 / t_1)} \text{ and } A_{Factor} = t_1 \times e^{-I/\sigma}$$

   - I is a variable multiplier of the motor rated current (values between I_1 and I_2),
   - I_1 is a multiplier of the rated motor current (FLA) specified by the VD Stall Current @ Min V setting,
   - t_1 is a time value specified by the VD Safe Stall Time @ Min V setting,
   - I_2 is a multiplier of the rated motor current (FLA) specified by the VD Accel. Intersect @ Min V setting, and
   - t_2 is a time coordinate of the intersection point between the thermal model curve and the vertical line corresponding to the per-unit current value of the VD Accel. Intersect @ Min V setting.
5. Determine the point of intersection between the Overload Curve and the vertical line corresponding to the multiplier of the rated current value of the VD Accel. Intersect @ 100% V setting (see point 4).
6. Draw the locked rotor thermal limit point for the 100% voltage motor start. The coordinates of this point are the multiplier of the rated current value (FLA) of the VD Stall Current @ 100% V setting and the time value of the VD Safe Stall Time @ 100% V setting (see point 3).

7. The line connecting points 3 and 4 constructs the acceleration curve for the motor rated system voltage. The acceleration time-current curve for the rated voltage starting is calculated from the same equations, but the setpoints associated with the 100% voltage starting are applied.
8. The line connecting points 1, 3 and 5 represent the motor safe stall conditions for any system voltage from the minimum to 110% of rated. Ideally, all the points on this line are characterized by the same thermal limit (I^2t), but the equivalent starting impedance at reduced voltage is greater than the impedance at full voltage. As such, the higher terminal voltages tend to reduce I^2t. The rate of I^2t reduction is dictated by the VD Stall Current and VD Safe Stall Time setpoints for rated and minimum voltage conditions. For voltage conditions above rated, the locked rotor thermal limit and acceleration curve are extrapolated up to 110% of the terminal voltage. The point coordinates (I_S, T_S) for 110% are extrapolated based on the I_1, T_1, I_3, and T_3 values. For starting currents at voltages higher than 110%, the trip time computed from 110% V thermal limit value is used.

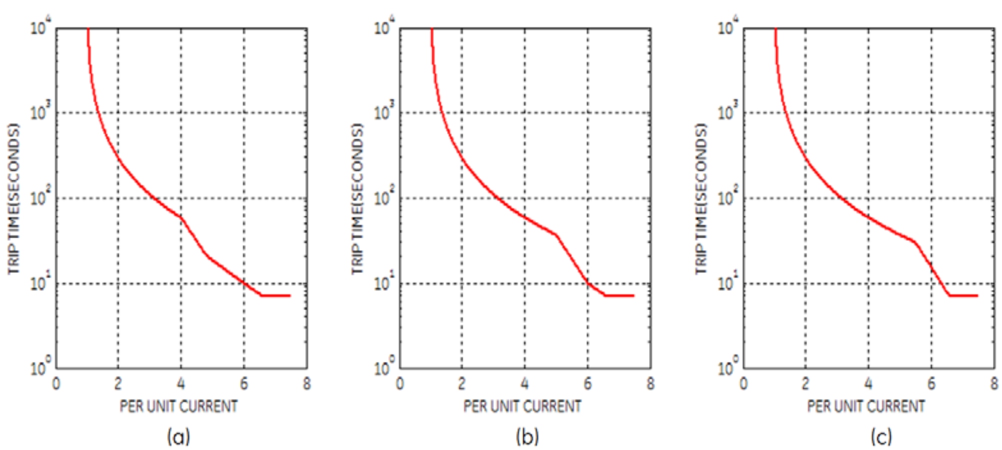
NOTE

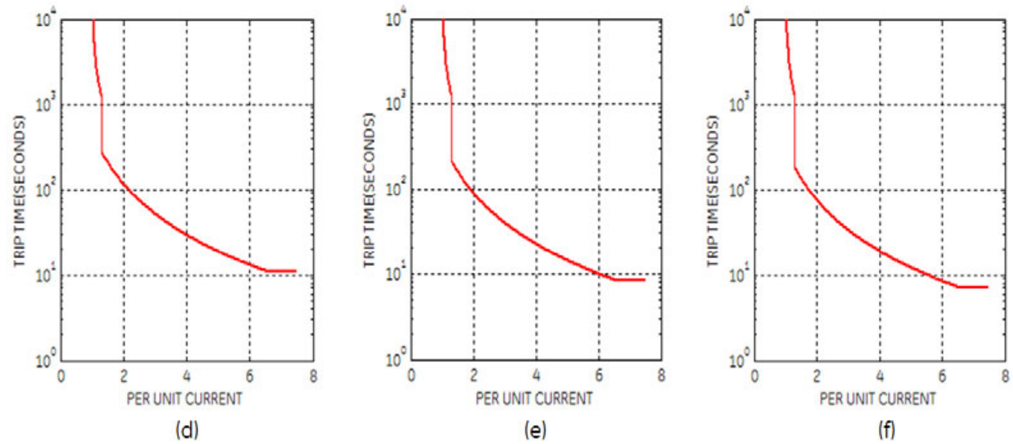
The voltage dependent curve for current values above 8 times pickup (OL x FLA) are clamped and the time to trip is frozen at the level calculated for the 8 times pickup current.

The following three figures (a), (b) and (c) illustrate the resultant overload protection curve for minimum, 100%, and maximum line voltages. For voltages between these limits, the 869 shifts the acceleration curve linearly and constantly, based on the measured line voltage during a motor start. Figures (d), (e) and (f) illustrate the motor starting curves for the following abnormal conditions: line voltages below the minimum, above 110%, and the situation for voltage loss.

For the Voltage Dependant Overload Curve Protection figure: (a) At Minimum Voltage, (b) At 100% Voltage, (c) At 110% Voltage, (d) At Less Than Minimum Voltage, (e) At Voltage Loss Condition, (f) At More Than 110% Voltage

Figure 6-13: Voltage Dependent Overload Curve Protection





NOTE

For the three abnormal voltage situations, the 869 makes a transition from the acceleration curve to Motor or FlexCurve when the Motor Running or Motor Overload operands are asserted.

Figure 6-14: Voltage Dependent Overload Curve Selection logic diagram

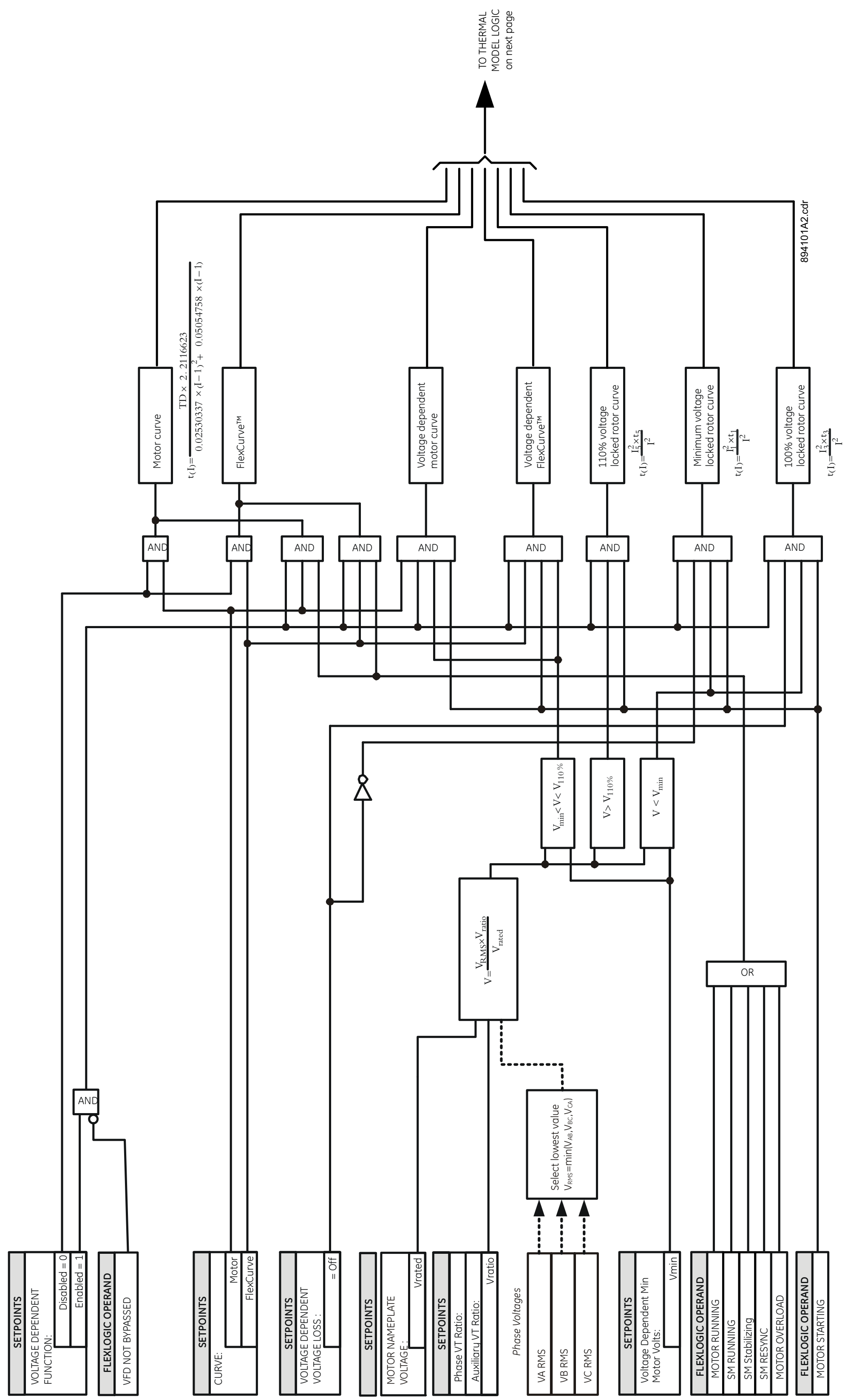
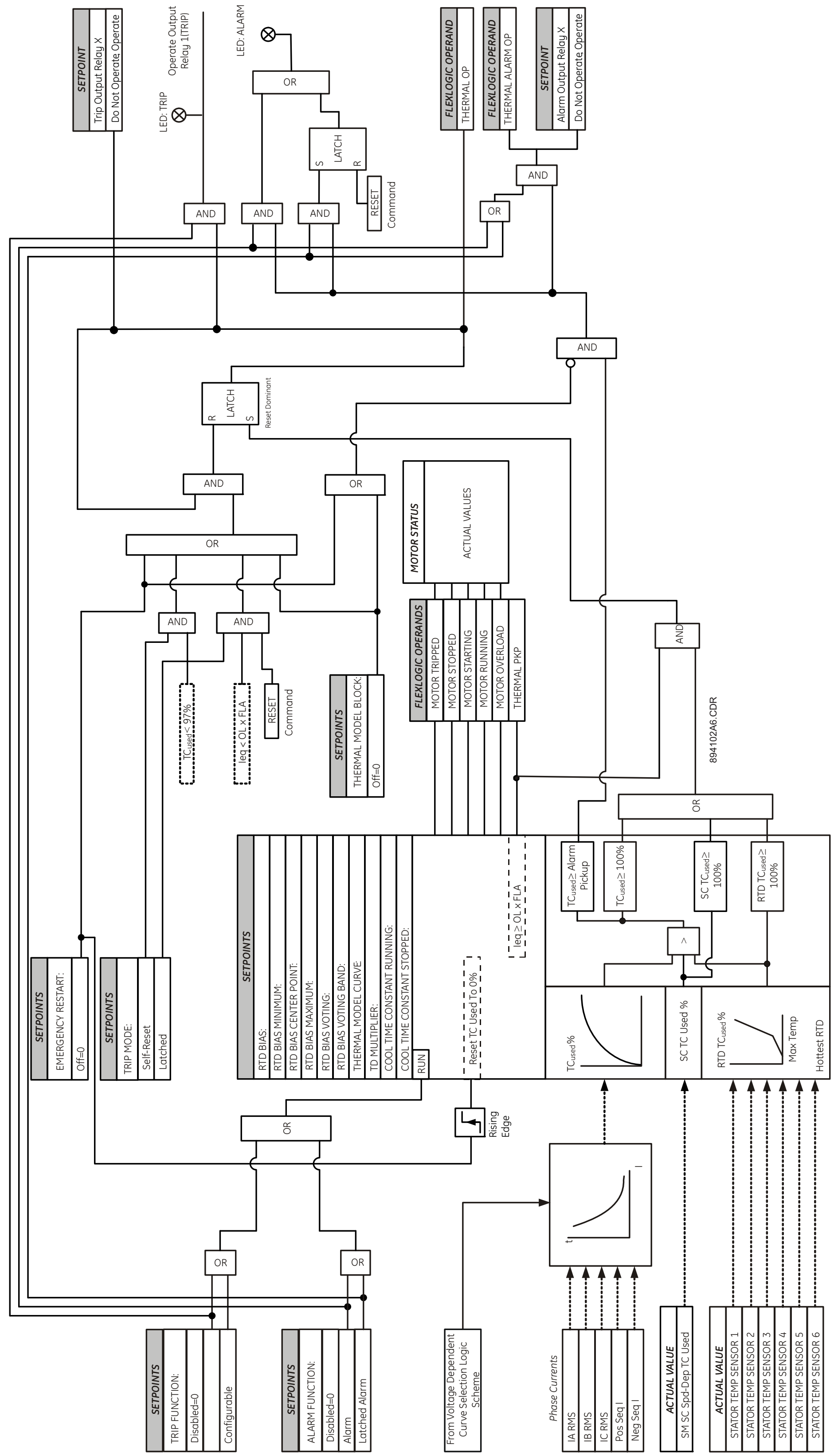


Figure 6-15: Thermal Model logic diagram



Current Unbalance (46)

Unbalance current, also known as negative sequence current or I_2, results in disproportionate rotor heating. If the thermal overload protection's unbalance bias feature has been enabled (by setting non-zero value for the Unbalance Bias K Factor under **Setpoints > Protection > Group 1(6) > Motor > Thermal Model**, the thermal overload protection protects the motor against unbalance by tripping when the motor's thermal capacity is exhausted. However, the current unbalance protection can detect this condition and alarm and /or trip before the motor has heated substantially. For the 869 relay, unbalance is defined as the ratio of negative-sequence to positive-sequence current,

Eq. 25

$$Unbal = \frac{I_2}{I_1} \times A_{factor} \times 100\%$$

where A_{factor} is the adjustment factor used to prevent nuisance trip and/or alarm at light loads.

If the motor is operating at an average current level (I_{avg}) equal to or greater than the programmed full load current (FLA, as selected by the **Setpoints > System > Motor > Setup**), the adjustment factor (A_{factor}) is one. However, if the motor is operating at an average current level (I_{avg}) less than FLA then the adjustment factor (A_{factor}) is the ratio of average current to full load current.

If this element is enabled, a trip and/or alarm occur(s) once the unbalance level equals or exceeds the set pickup for the set period of time. If the unbalance level exceeds 40% or when $I_{avg} \geq 25\%$ FLA and current in any one phase is less than the cutoff current, the motor is considered to be single phasing and a trip occurs within 2 seconds. Single phasing protection is disabled if the unbalance trip feature is "Disabled".

NOTE

Unusually high unbalance levels can be caused by incorrect phase CT wiring.

Path: **Setpoints > Protection > Group 1(6) > Motor > Current Unbalance**

TRIP FUNCTION

Range: Disabled, Trip, Configurable
Default: Disabled

This setting enables the Current Unbalance Trip functionality.

TRIP PICKUP

Range: 4.0 to 50.0% in steps of 0.1%
Default: 15%

The setting specifies a pickup threshold for the trip function. When setting the pickup level, note that a 1% voltage unbalance typically translates into a 6% current unbalance. To prevent nuisance trips or alarms, the pickup level must not be set too low. Also, since short term unbalances are common, a reasonable delay must be set to avoid nuisance trips or alarms. This setting must be greater than the corresponding setting for the alarm stage.

TRIP CURVE

Range: Definite Time, Inverse Time

Default: Definite Time

Definite Time

When the curve is programmed as definite time, the trip element operates when the operating quantity exceeds the pickup level for longer than the set time delay (programmed as Trip Pickup Delay).

Inverse Time

The curve for the unbalance current is defined as:

T= TDM/[Unbal]^2, where Unbal is defined by the preceding unbalance equation,
T= time in seconds when I^2 > pickup (minimum and maximum times are defined by setpoints),
TDM= time dial multiplier

TRIP PICKUP DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s (when TRIP CURVE = Definite Time)

Default: 1.00 s

The setting specifies a time delay for the trip function. This setting is only applicable when Trip Curve is programmed as Definite Time.

NOTE

Small power system transients or switching device operation can generate spurious negative sequence current that can result in the false operation of the Current Unbalance element. In order to prevent false operation of the element, it is strongly recommended to set Trip Pickup Delay and Alarm Pickup Delay settings greater than two power cycles.

TRIP TDM

Range: 0.00 to 180.00 in steps of 0.01 (when TRIP CURVE = Inverse Time)

Default: 10.00

The setting provides a selection for Time Dial Multiplier which modifies the operating times per the inverse curve. This setting is only applicable when Trip Curve is programmed as Inverse Time.

TRIP MAX TIME

Range: 0.00 to 1000.00 s in steps of 0.01 s

Default: 1.00 s

The Unbalance maximum time defines the maximum time that any value of negative sequence current in excess of the pickup value will be allowed to persist before a trip is issued. This setting can be applied to limit the maximum tripping time for low level unbalances. This setting is only applicable when the Trip Curve is programmed as Inverse Time.

TRIP MIN TIME

Range: 0.00 to 1000.00 s in steps of 0.01 s

Default: 0.25 s

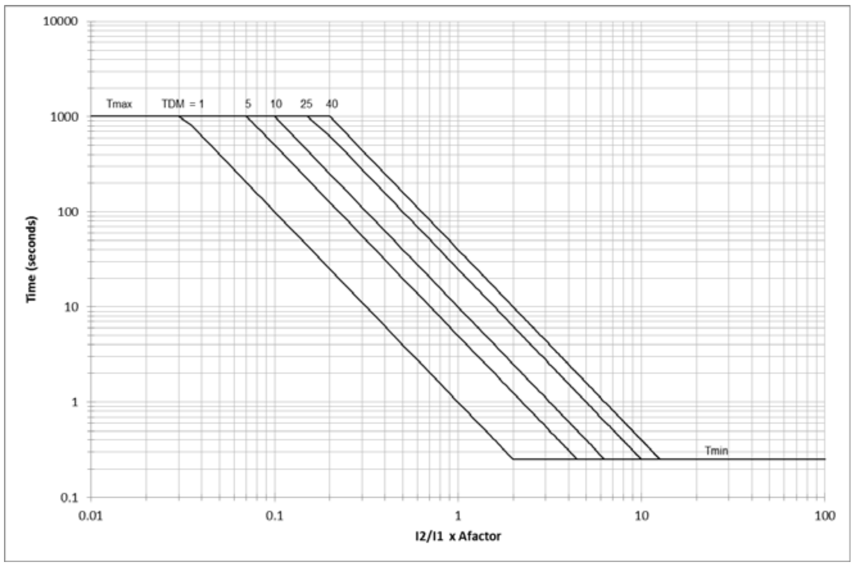
Unbalance minimum time defines the minimum time setting that can be applied to limit the minimum tripping time. Small power system transients or switching device operation can generate spurious negative sequence current that can result in the false operation of the Current Unbalance element. Unbalance minimum time must be set in order to prevent false operation of the element. This setting is only applicable when Trip Curve is programmed as Inverse Time.

TRIP RESET TIME

Range: 0.00 to 180.00 s in steps of 0.01 s
Default: 1.00 s

This setting defines the linear reset time of the trip element time accumulator. It is the maximum reset time from the threshold of tripping based on the motor unbalance inverse curve. The reset time has an accumulator/integrator to represent the thermal memory counter which increments linearly if the motor unbalance current is above the threshold, and decrements linearly if it is below the threshold. This setting is only applicable when Trip Curve is programmed as Inverse Time.

Figure 6-16: Unbalance Inverse Time Curves



TRIP DROPOUT DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s
Default: 1.00 s

The setting specifies a time delay to reset the trip command. This delay must be set long enough to allow the breaker or contactor to disconnect the motor. This setting is only applicable when Trip Curve is programmed as Definite Time.

TRIP OUTPUT RELAY X

For details see Common Setpoints.

ALARM FUNCTION

Range: Disabled, Alarm, Latched Alarm
Default: Disabled

The setting enables the Current Unbalance Alarm functionality.

ALARM PICKUP

Range: 4.0 to 50.0% in steps of 0.1%
Default: 10%

The Alarm Pickup setting specifies a pickup threshold for the alarm function.

For example, if the supply voltage is normally unbalanced up to 2%, the current unbalance seen by a typical motor is 2 × 6 = 12%. In this case, set the current unbalance alarm pickup to "15%" and the current unbalance trip pickup to "20%" to prevent nuisance tripping; 5 or 10 seconds is a reasonable delay.

ALARM PICKUP DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s
Default: 1.00 s

The setting specifies a time delay for the alarm function.

ALARM DROPOUT DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s
Default: 1.00 s

The setting specifies a time delay to reset the alarm command.

ALARM OUTPUT RELAY X

For details see Common Setpoints.

BLOCK

Range: Any FlexLogic Operand
Default: Off

The Current Unbalance can be blocked by any asserted FlexLogic operand.

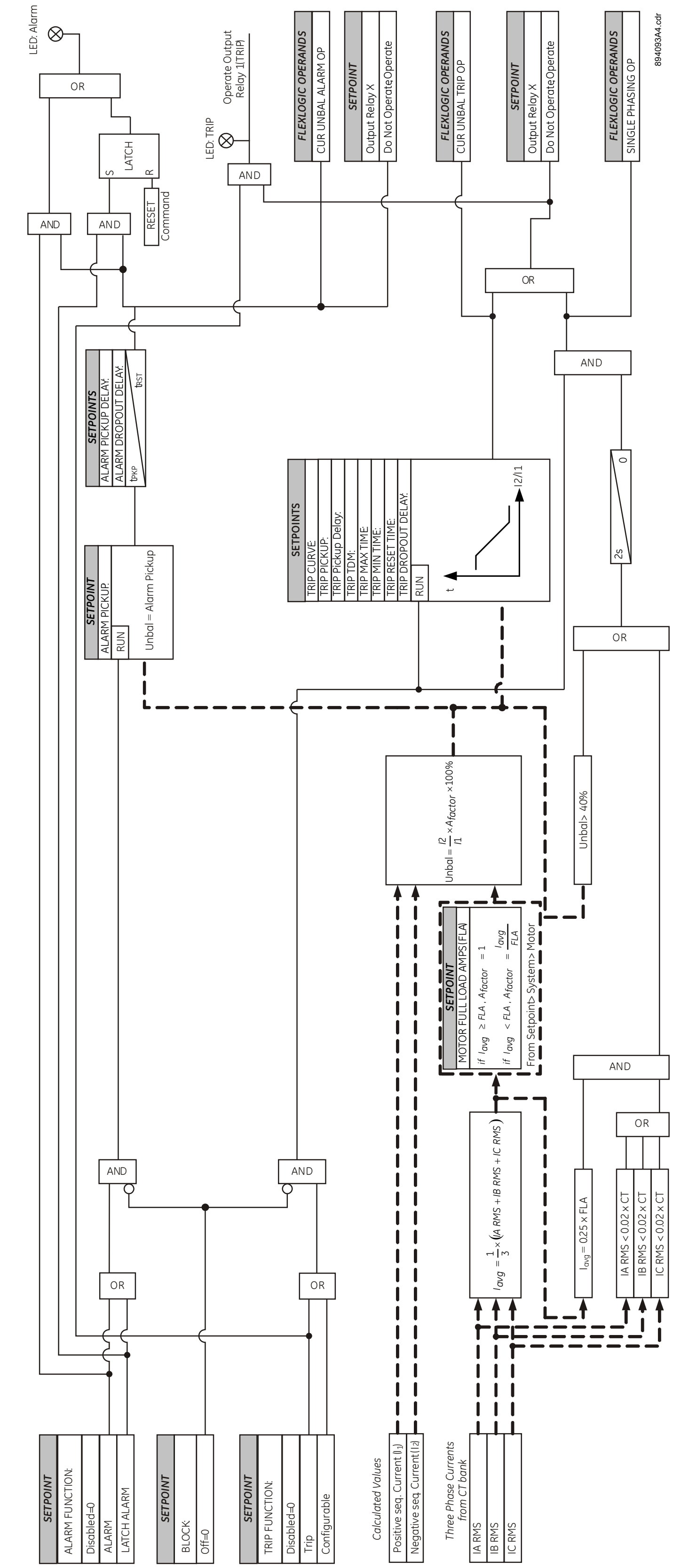
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Self-reset, Latched, Disabled
Default: Latched

Figure 6-17: Current Unbalance logic diagram



Mechanical Jam (50LR)

A motor load can become constrained (mechanical jam) during starting or running. The starting current magnitude alone cannot provide a definitive indication of a mechanical jam; however, the running current magnitude can. Therefore, the Mechanical Jam element is specially designed to operate for running load jams. Starting load jams are detected by monitoring acceleration time and speed.

After a motor has started and reached the running state, a trip or alarm occurs if the magnitude of any phase current exceeds the setting Pickup for a period of time specified by the setting Pickup Delay.

The thermal element also operates during mechanical jams but after a delay when the thermal capacity reaches 100%. Not only does the Mechanical Jam protect the motor by tripping it quicker than the thermal protection, it can also prevent or limit damage to the driven equipment in the event of a locked rotor during running.

The Mechanical Jam is armed as long as the motor status is not "Starting" or "Stopped"; this includes "Running" and "Overload". As soon as any phase current exceeds the user-selectable threshold, the element picks up and operates after the programmed time delay. The element uses currents configured under **Setpoints > System > Current > Sensing** and motor status asserted by the thermal model element. Both the signal source and thermal protection must be configured properly in order for the mechanical jam protection to operate.

When the 2-Speed Motor Protection functionality is employed, the 869 will block Mechanical Jam Protection during the acceleration time from Speed 1 to Speed 2 until the motor current has dropped below overload pickup level (OL x FLA) or the **ACCEL TIME Fr. SPD 1-2** has expired. At a point in time when the motor has reached the Speed 2 running stage, the Mechanical Jam will be re-enabled using the setpoint **Speed2 Motor FLA** set under **Setpoints > System > Motor > Setup**. The Pickup level must be set higher than the motor loading during normal operation, but lower than the motor stall level for both speeds. Normally the delay is set to the minimum time delay or set so that no nuisance trips occur due to momentary load fluctuations.

Path: Setpoints > Protection > Group 1(6) > Motor > Mechanical Jam

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

The setting enables the Mechanical Jam functionality.

PICKUP

Range: 1.00 to 10.00 x FLA in steps of 0.01
Default: 2.00 x FLA

The setting defines the excessive current condition that identifies a mechanical jam. As the element is not armed during start conditions, this threshold can be set below the starting current. Since the element is armed during overload conditions, this setting must be higher than the maximum overload current. The setting is entered in multiplies of FLA (programmed under **Setpoints > System > Motor > Setup** menu).

PICKUP DELAY

Range: 0.10 to 180.00 s in steps of 0.01 s
Default: 1.00 s

The setting specifies the pickup delay of the element. In the case of large motors that could feed close-in feeder faults, this setting can coordinate with feeder protection to avoid false tripping due to excessive fault currents fed by the motor.

DROPOUT DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s

Default: 1.00 s

The setting defines the reset delay of the element. Typical application includes time seal-in of the tripping command

BLOCK

Range: Any FlexLogic Operand

Default: Off

The mechanical jam can be blocked by any asserted FlexLogic operand.

OUTPUT RELAY X

For details see Common Setpoints.

EVENTS

Range: Enabled, Disabled

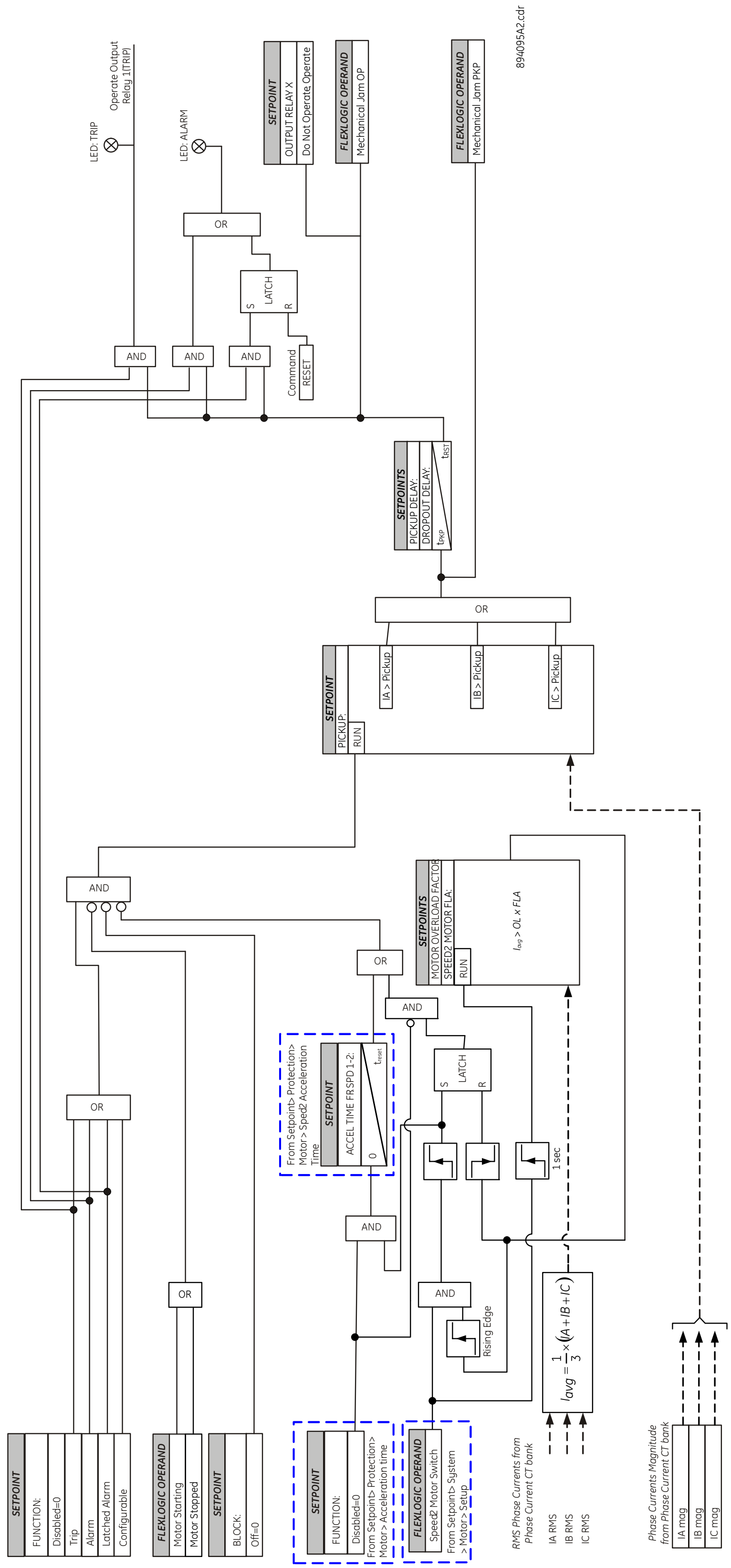
Default: Enabled

TARGETS

Range: Self-reset, Disabled

Default: Latched

Figure 6-18: Mechanical Jam logic diagram



Undercurrent (37)

The 869 relay provides one Undercurrent element per protection group. The element responds to a per-phase current. When the motor is in the running state, an alarms occurs if the magnitude of any phase current falls below the undercurrent alarm pickup level for the time specified by the undercurrent alarm delay. Furthermore, a trip occurs if the magnitude of any phase current falls below the undercurrent trip pickup level for the time specified by the undercurrent trip delay. The alarm and trip pickup levels must be set lower than the lowest motor loading during normal operations.

The Undercurrent element is active only when the motor is running and is blocked upon the initiation of a motor start for a period of time defined by the setting Start Block Delay. This block may be used to allow pumps to build up head before the undercurrent element trips or alarms. A second independent Undercurrent protection element is provided for Speed 2. If 2 speed functionality is enabled, the 869 relay relies on the motor speed indication; so the main Undercurrent protection element is only active when the motor is running at speed 1 (low speed), and the Speed2 Undercurrent protection element is only active when the motor is running at high speed (speed 2).

Path: **Setpoints > Protection > Group 1 > Motor > Undercurrent 1**

TRIP FUNCTION

Range: Disabled, Trip, Configurable

Default: Disabled

This setting enables the Undercurrent Trip functionality.

START BLOCK DELAY

Range: 0.00 to 600.00 s in steps of 0.01 s

Default: 0.50 s

The Undercurrent element is active only when the motor is running and it is blocked upon the initiation of a motor start for a period of time defined by the START BLOCK DELAY setting (e.g., this block can be used to allow pumps to build up head before the undercurrent element trips or alarms).

TRIP PICKUP

Range: 0.10 to 0.95 x FLA in steps of 0.01 x FLA

Default: 0.70 x FLA

This setting specifies a pickup threshold for the trip function.

TRIP PICKUP DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s

Default: 1.00 s

This setting specifies a time delay for the trip function.

TRIP DROPOUT DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s

Default: 1.00 s

This setting specifies a specifies a time delay to reset the trip command. This delay should be set long enough to allow the breaker or contactor to disconnect the motor.

TRIP OUTPUT RELAY X

For details see Common Setpoints.

ALARM FUNCTION

Range: Disabled, Alarm, Latched Alarm

Default: Disabled

This setting enables the Undercurrent Alarm functionality.

ALARM PICKUP

Range: 0.10 to 0.95 x FLA in steps of 0.01 x FLA
Default: 0.70 x FLA

This setting specifies a pickup threshold for the alarm function.

ALARM PICKUP DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s
Default: 1.00 s

This setting specifies a time delay for the alarm function.

ALARM DROPOUT DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s
Default: 1.00 s

This setting specifies a time delay to reset the alarm command.

ALARM OUTPUT RELAY X

For details see Common Setpoints.

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

The Undercurrent can be blocked by any asserted FlexLogic operand.

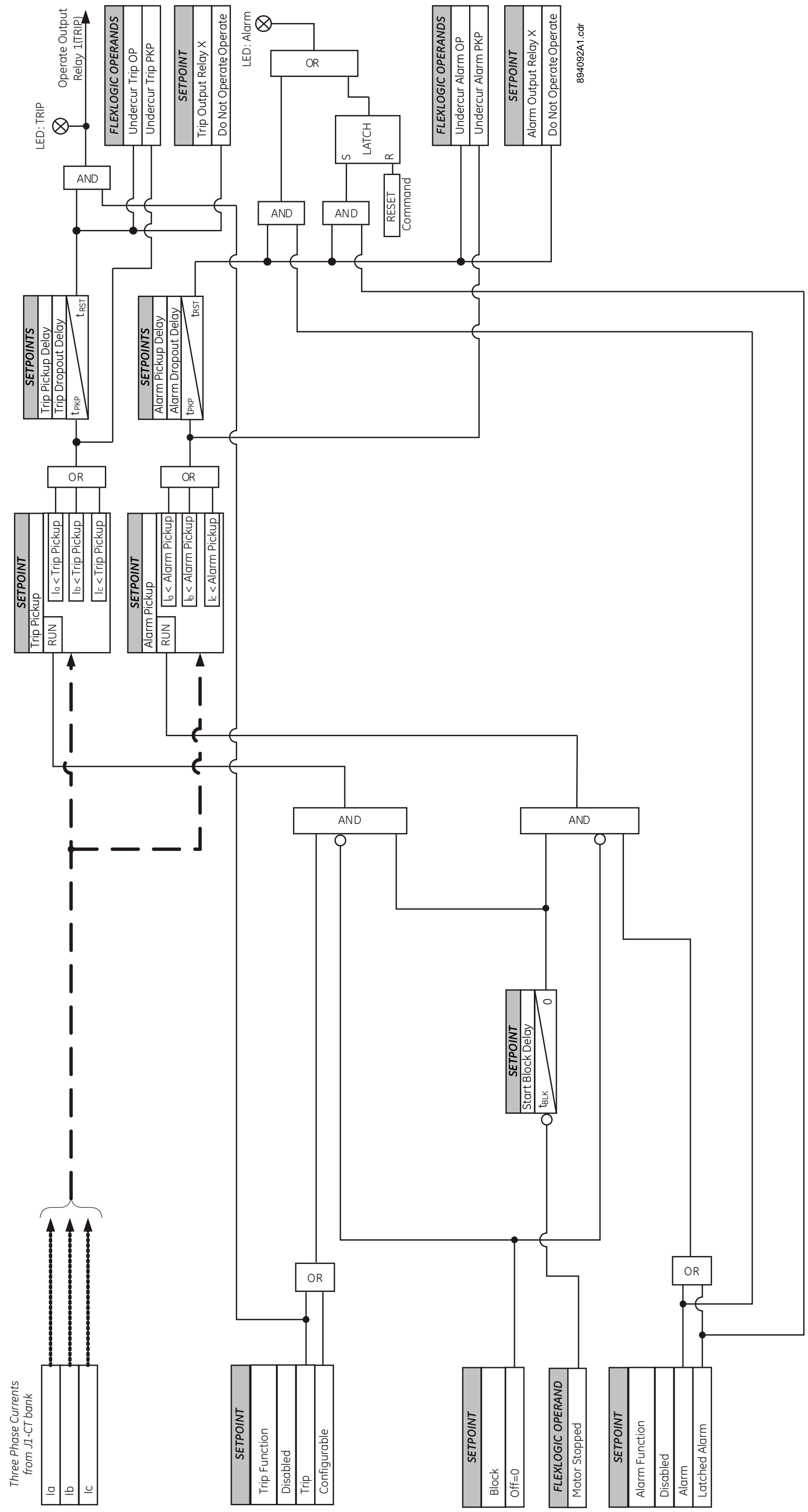
EVENTS

Range: Disabled, Enabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Latched

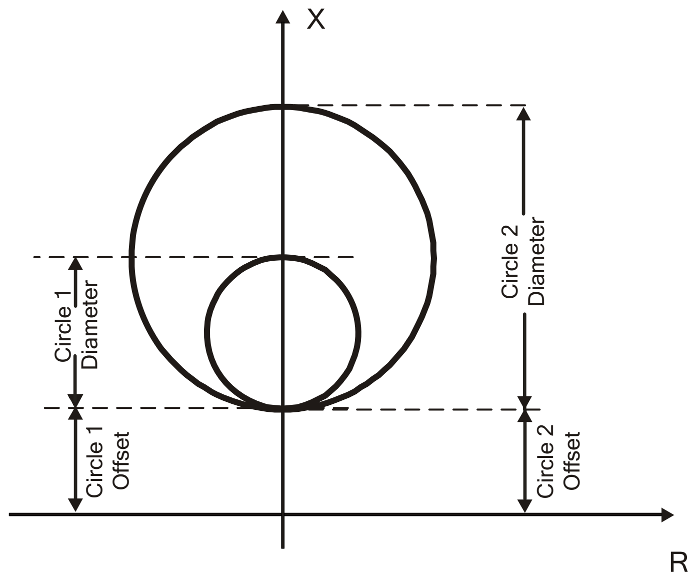
Figure 6-19: Undercurrent logic diagram



Loss of Excitation (40)

Typically, a synchronous machine has an excitation system, which supplies DC (Direct Current) to energize the rotor/field winding. This excitation to the machine rotor may be completely or partially lost due to various abnormal conditions, such as field circuit open or short, loss of supply to the excitation system, or unintentional trip of a field breaker and so on. Due to loss of excitation, the synchronous machine may act as an induction machine, which may cause the machine to over-speed (above synchronous speed) and also draw reactive power (Var) from the system. Therefore, Loss Of Excitation (LOE) protection is applied to protect synchronous machines from over-speeding, as well as to recover systems from voltage collapse.

Figure 6-20: Loss of excitation Characteristic



Loss of excitation protection is achieved using positive sequence impedance measurements (from J-slot voltage and currents), and two inverted offset (Mho) circles, as shown. User configurable Under-Voltage (UV) supervision and sufficient positive sequence current (>0.05 x CT) are applied for additional protection of this element. Each individual circle characteristic can be applied independently. In the case where a circle element is enabled and the measured positive sequence impedance falls within this circle, the element operates with the corresponding time delay setting. Further, a 20 ms reset delay is applied to the element logic which enhances protection dependability, especially when measured impedance jitters around a circle boundary.

NOTE

All impedance (in ohms) settings refer to the relay side impedance quantity, i.e. the CT/VT secondary side when looking into the machine.

Base impedance should be calculated on secondary side.

$$Z_{base,prim} = \frac{base\ kV^2}{base\ MVA}\ in\ \Omega$$

$$Z_{base,sec} = Z_{base,prim} * \frac{CT\ Ratio}{VT\ Ratio}\ in\ \Omega$$

The following is the guideline used to derive the setting of this element.

The inner circle (Circle 1) diameter is set to machine base impedance (i.e. 1 pu), which considers the loss of field during full loading to medium loading of the machine. An offset is one half of the direct axis transient reactance (X'd) - both impedances referring to the relay side. The corresponding time delay for the inner circle needs to be higher than the worst case power swing scenario, and hence this value is determined from stability studies (typically, this value may be in the range of 0.2 s to 0.5 s).

$$Circle\ 1\ Diameter = Z_{base,sec}\ in\ \Omega$$

$$Circle\ 1\ Offset = \frac{X'_{d\ (pu)}}{2} * Z_{base,sec}\ in\ \Omega$$

On the other hand, the outer circle (e.g. Circle 2) diameter is set to the synchronous reactance of the machine (Xd) and an offset equal to one half of the direct axis transient reactance (X'd) - both impedances referring to the relay side. This allows the machine to be protected during light load conditions or with reduced field excitation. The corresponding time delay for the outer circle should be high enough to prevent mis-operations due to power swings, and hence this value is determined from stability studies (typically, this value may be in the range of 0.5 s to 2 s).

$$Circle\ 2\ Diameter = X_{d(pu)} * Z_{base,sec}\ in\ \Omega$$

$$Circle\ 2\ Offset = \frac{X'_{d(pu)}}{2} * Z_{base,sec}\ in\ \Omega$$

Path: **Setpoints > Protection > Group 1(6) > Motor > Loss of Excitation**

SIGNAL INPUT

Range: Positive Impedance 1, Positive Impedance 2
Default: Positive Impedance 1

The signal input selection to apply this element at the terminal or neutral side CT. The CT and VT sources used by Positive impedance 1 and 2 are specified in **Path**: **Metering > Impedance > Pos Seq Impedance**.

NOTE

This selection is only available with "P1 or P5" option from 'Phase Currents-Slot K Bank 1' in the Order Code table. Otherwise, the positive sequence 1 value is considered by the loss of excitation element.

CIRCLE 1 FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

CIRCLE 1 DIAMETER

Range: 0.1 to 300.0 ohms in steps of 0.1 ohms
Default: 25.0 ohms

This setting is the diameter of the Circle 1 characteristic in ohms, referring to the CT/VT secondary (relay).

CIRCLE 1 OFFSET

Range: 0.1 to 300.0 ohms in steps of 0.1 ohms
Default: 2.5 ohms

This setting is the offset of the Circle 1 characteristic in ohms, referring to the CT/VT secondary (relay).

CIRCLE 1 PICKUP DELAY

Range: 0.00 to 600.00 s in steps of 0.01 s
Default: 0.30 s

CIRCLE 1 UV SUPERVISION

Range: Disabled, Enabled
Default: Disabled

Under-voltage supervision of the element can be enabled or disabled. If Enabled for Circle 1, the positive sequence voltage at the machine terminal should be lower than setting value in "UV Supervision" in order to execute the Circle 1 impedance element, i.e. LOE Circle 1 is enabled only in case voltage drops below the "UV supervision" level. This additional check ensures the drop in machine terminal voltage in case of loss of excitation.

CIRCLE 1 OUTPUT RELAY X

For details see Common Setpoints.

CIRCLE 2 FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

CIRCLE 2 DIAMETER

Range: 0.1 to 300.0 ohms in steps of 0.1 ohms
Default: 35.0 ohms

This setting is the diameter of the Circle 2 characteristic in ohms, referring to the CT/VT secondary (relay).

CIRCLE 2 OFFSET

Range: 0.1 to 300.0 ohms in steps of 0.1 ohms
Default: 2.5 ohms

This setting is the offset of the Circle 2 characteristic in ohms, referring to the CT/VT secondary (relay).

CIRCLE 2 PICKUP DELAY

Range: 0.00 to 600.00 s in steps of 0.01 s
Default: 1.00 s

CIRCLE 2 UV SUPERVISION

Range: Disabled, Enabled
Default: Disabled

Under-voltage supervision of the element can be enabled or disabled. If Enabled for Circle 2, the positive sequence voltage at the machine terminal should be lower than setting value in "UV Supervision" in order to execute the Circle 2 impedance element, i.e. LOE Circle 1 is enabled only in case voltage drops below the "UV supervision" level. This additional check ensures the drop in machine terminal voltage in case of loss of excitation.

CIRCLE 2 OUTPUT RELAY X

For details see Common Setpoints.

UV SUPERVISION

Range: 0.00 to 1.50 x VT in steps of 0.01 x VT
Default: 0.70 x VT

This setting specifies the pickup value for under-voltage supervision for one or both circles (if enabled).

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Self-reset, Latched, DIsabled
Default: Latched

Figure 6-21: Loss of Excitation Logic Diagrams: (a) circle 1

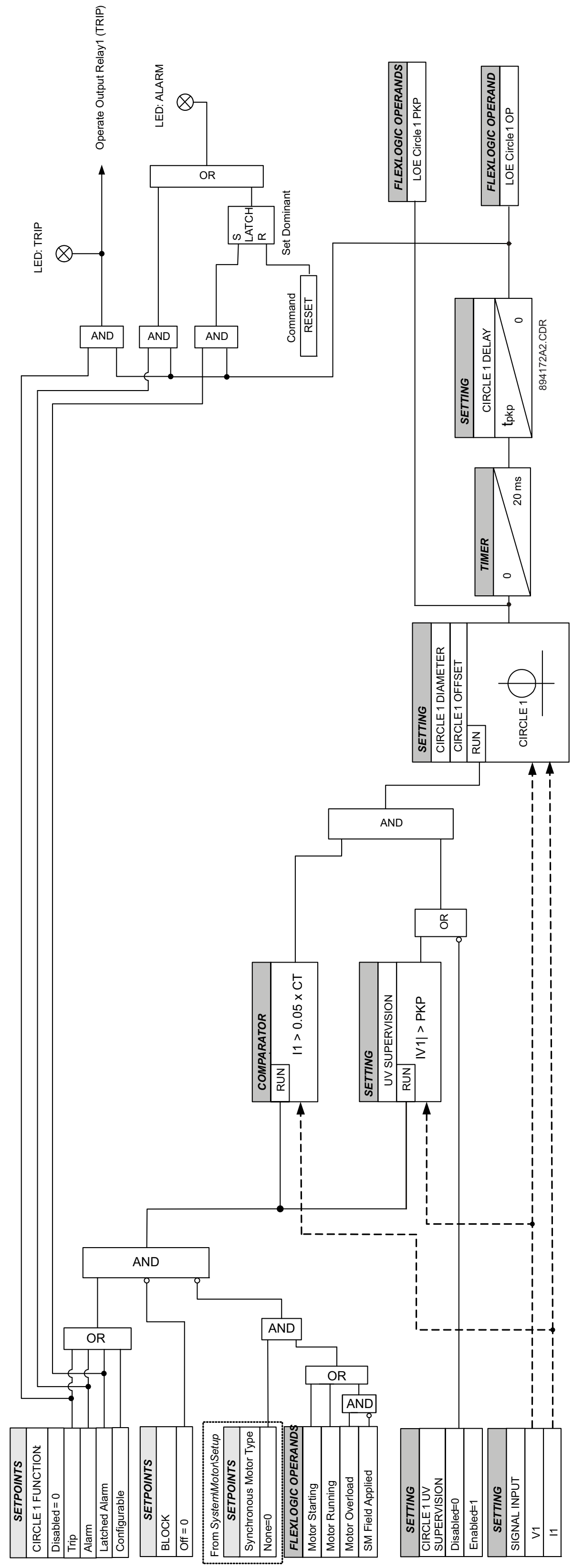
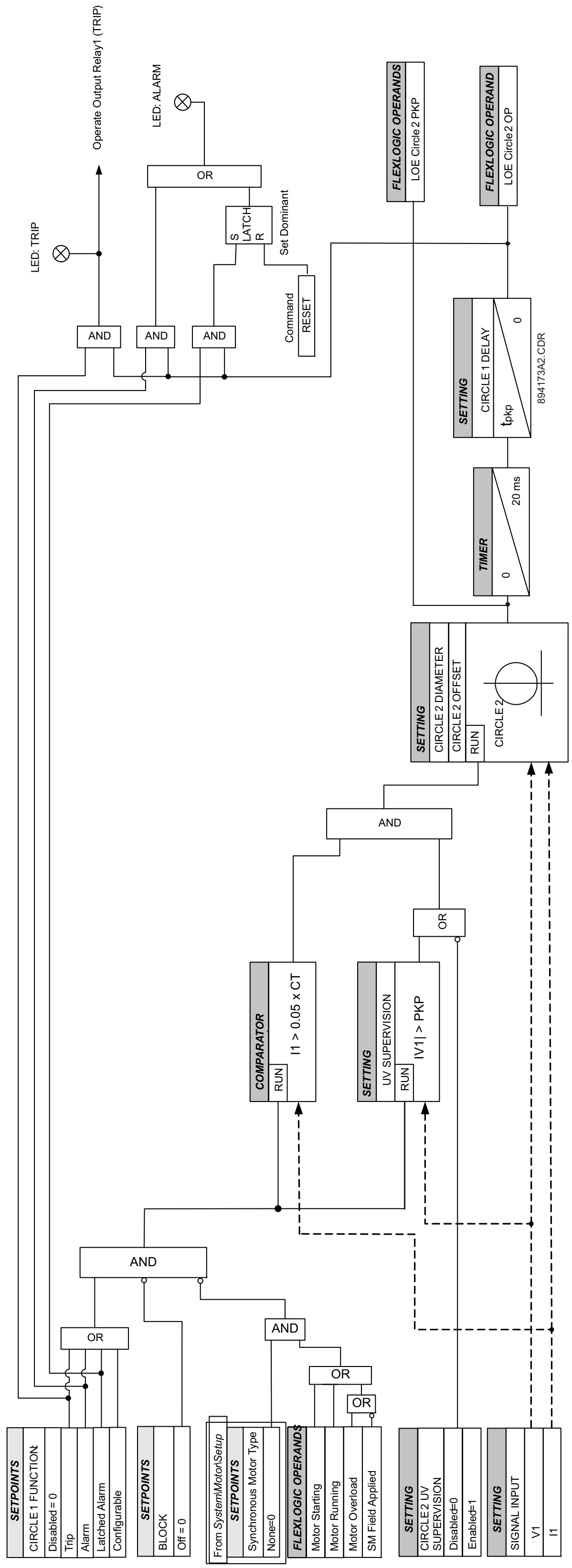


Figure 6-22: Loss of Excitation Logic Diagrams: (b) circle 2



Overload Alarm

The Overload Alarm is used to alarm abnormal load increases that can indicate problems with the process. An alarm is enabled only after the acceleration stage is complete and the motor has entered the running or overload stage. Once enabled, the alarm is generated when the biased motor load current (Eq. 13 in the Thermal Model (49)section) exceeds the Pickup setting for the time delay specified by the setting Pickup Delay. When the current has subsided, the alarm stays active for the time specified by the setting Dropout Delay.

Path: Setpoints > Protection > Group 1 > Motor > Overload Alarm

FUNCTION

Range: Disabled, Alarm, Latched Alarm, Configurable
Default: Disabled

PICKUP

Range: 0.50 to 3.00 x FLA in steps of 0.01 x FLA
Default: 0.70 x FLA

PICKUP DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s
Default: 1.00 s

DROPOUT DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s
Default: 1.00 s

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

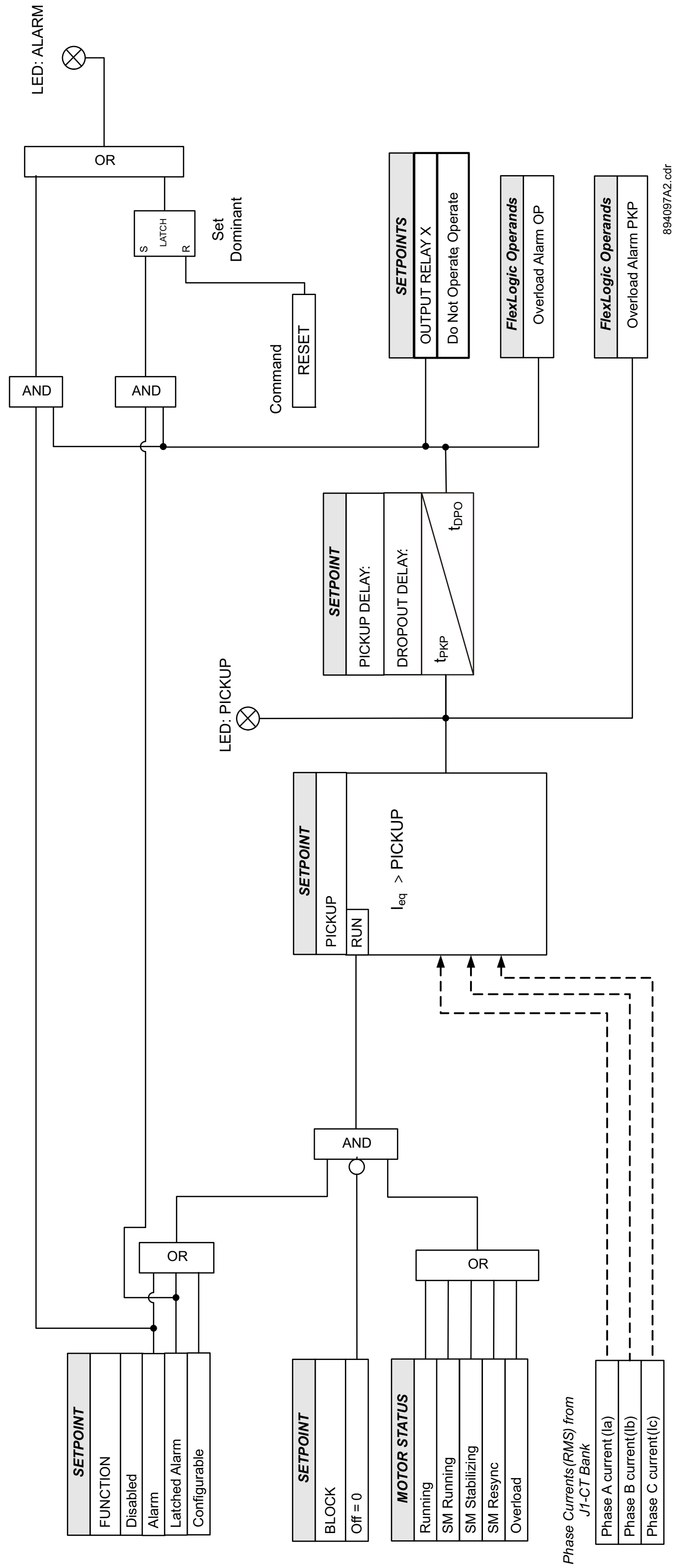
EVENTS

Range: Disabled, Enabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Latched

Figure 6-23: Overload Alarm logic diagram



Short Circuit

If Short Circuit is enabled, a trip or alarm occurs once the magnitude of any phase current exceeds the setting Pickup for the time specified by the setting Pickup Delay.

WARNING

Care must be taken when turning on this feature. If the interrupting device (contactor or circuit breaker) is not rated to break the fault current, the function of this feature must not be programmed as TRIP. Alternatively, this feature may be programmed as ALARM or LATCHED ALARM and assigned to an auxiliary relay connected to an upstream device which is capable of breaking the fault current.

Path: Setpoints > Protection > Group 1(6) > Motor > Short Circuit

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

The setting enables the Short Circuit functionality. The selection of Trip, Alarm or Latched Alarm for the setting value enables the Short Circuit function.

If the operating condition is satisfied when Trip is selected as the function, the logic operands Short Circuit PKP and Short Circuit OP are asserted, which in turn operates the LED “TRIP” and trip output relay.

If Alarm is selected, the LED “ALARM” flashes upon the Short Circuit operation, and it automatically resets when the activating condition clears.

If Latched Alarm is selected, the LED “ALARM” flashes upon Short Circuit operation, and stays “ON” after the condition clears, until a reset command is initiated. The TRIP output relay does not operate if Latched Alarm or Alarm function is selected. Any assignable output relays can be selected to operate when the Short Circuit function is selected as Latched Alarm, Alarm or Trip.

OVERREACH FILTER

Range: Off, On
Default: Off

When a motor starts, the starting current (typically 6 × FLA for an induction motor) has an asymmetrical component. This asymmetrical current may cause one phase to see as much as 1.6 times the normal RMS starting current. If the Pickup was set at 1.25 times the symmetrical starting current, it is probable that there would be nuisance trips during motor starting. A rule of thumb has been developed over time that short circuit protection be at least 1.6 times the symmetrical starting current value. This allows the motor to start without nuisance tripping. The overreach filter removes the DC component from the asymmetrical current present at the moment of fault. This eliminates overreach; however, the response time slows slightly (10 to 15 ms) but remains within specification.

PICKUP

Range: 1.00 to 30.00 x CT in steps of 0.01
Default: 6.00 x CT

The setting specifies a pickup threshold for the Short Circuit element.

If 2-Speed Motor Protection functionality is employed, then the CT primary is the value of setting “2-Speed CT Primary” that can be found under Setpoints > System > Motor.

NOTE

Special care must be taken when setting Pickup for motor applications with low and high speed windings. Pickup must be set with enough margin such that short circuit elements do not malfunction when switching from one speed to another.

PICKUP DELAY

Range: 0.00 to 180.00 s in steps of 0.01
Default: 0.00 s

The setting specifies the pickup delay for the Short Circuit element.

DROPOUT DELAY

Range: 0.00 to 180.00 s in steps of 0.01
Default: 0.00 s

The setting defines the reset delay of the element.

BLOCK

Range: Any FlexLogic Operand
Default: Off

The Short Circuit can be blocked by any asserted FlexLogic operand.

OUTPUT RELAY X

For details see Common Setpoints.

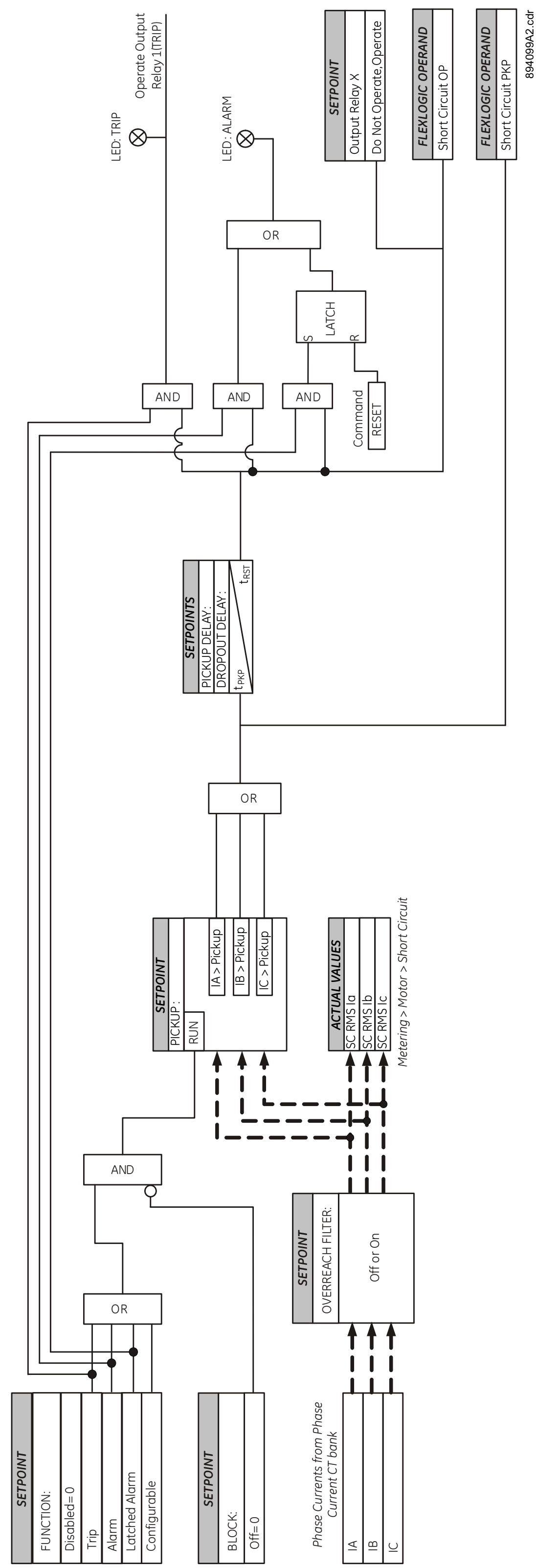
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Self-reset, Latched, Disabled
Default: Latched

Figure 6-24: Short Circuit logic diagram



Ground Fault (50SG)

When motor stator windings become wet or otherwise suffer insulation deterioration, low magnitude leakage currents often precede complete failure and resultant destructive fault currents. This ground fault protection provides early detection of such leakage current, so that the motor can be tripped in time to limit motor damage. However, if a high magnitude ground fault occurs that is beyond the capability of the contactor to interrupt, it is desirable to program the function of Ground Fault as Control to signal an upstream device or wait for the fuses to do the interruption. Various situations (e.g. contactor bounce) can cause transient ground currents during motor starting that can exceed the Pickup level for a very short period of time. The Trip Pickup Start Delay setting can be fine-tuned to an application such that it still responds very quickly, but rides through normal operational disturbances. Normally, the Ground Fault time delays are set as short as possible, that is, 0.00 seconds. However, time to trip might have to be increased if nuisance tripping occurs. Special care must be taken when the ground input is wired to the phase CTs in a residual connection. When a motor starts, the starting current (typically 6 × FLA for an induction motor) has an asymmetrical or DC component. This momentary DC component causes each of the phase CTs to react differently, and cause a net current into the ground input of the relay. A 20 ms block of the ground fault element when the motor starts normally enables the relay to ride through this momentary ground current signal.

Path: **Setpoints > Protection > Group 1(6) > Motor > Ground Fault**

TRIP FUNCTION

Range: Disabled, Trip, Configurable
Default: Disabled

This setting enables the Ground Fault Trip functionality.

GROUND CT TYPE

Range: 1/5A, 50:0.025A, 1A SG
Default: 1/5A

For high resistance grounded systems, sensitive ground current detection is possible if the 50:0.025A or 1A sensitive ground input is used. To use the 50:0.025A input, select "50:0.025A" for the Ground CT Type. On solidly grounded systems where fault currents can be quite large, the 1/5A (1A or 5A depending on the order code) secondary ground CT input must be used for either zero-sequence or residual ground sensing. If the connection is residual, the Ground CT secondary and primary values must be the same as the phase CT. If however, the connection is zero-sequence, the Ground CT secondary and primary values must be entered.

NOTE

The Ground CT type setting is only applicable when 50:0.025A or 1A sensitive ground is selected in the order code. Otherwise, this setting is hidden and 1/5A secondary Ground CT Type is used as the base value.

TRIP PICKUP

For 1/5A Ground CT Type:

Range: 0.01 to 10.00 x CT in steps of 0.01 x CT
Default: 0.20 x CT

For 50:0.025 Ground CT Type (Ground Current order code option B1/B5/0B):

Range: 0.50 to 15.00 A in steps of 0.01 A
Default: 10.00 A

For 1A Sensitive Ground CT Type (Ground Current order code option S1):

Range: 0.005 to 3.000 x CT in steps of 0.001 x CT
Default: 0.200 x CT

This setting specifies a pickup threshold for the trip function.

TRIP PICKUP START DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s
Default: 1.00 s

This setting specifies the amount of time motor ground current must exceed pickup to generate a trip when the motor is in a starting condition.

NOTE

The Trip Pickup Start Delay must be set less than the motor starting time in order to avoid any delayed operation of the element in an event of a ground fault that occurs during motor start and continues while the motor enters into running state.

TRIP PICKUP RUN DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s
Default: 1.00 s

This setting specifies the amount of time motor ground current must exceed pickup to generate a trip when the motor is in a running condition.

TRIP DROPOUT DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s
Default: 0.01 s

This setting specifies a time delay to reset the trip command. This delay must be set long enough to allow the breaker or contactor to disconnect the motor.

TRIP OUTPUT RELAY X

For details see Common Setpoints.

ALARM FUNCTION

Range: Disabled, Alarm, Latched Alarm
Default: Disabled

This setting enables the Ground Fault Alarm functionality.

ALARM PICKUP

For 1/5A Ground CT Type:

Range: 0.01 to 10.00 x CT in steps of 0.01 x CT
Default: 0.10 x CT

For 50:0.025 Ground CT Type (Ground Current order code option B1/B5/0B):

Range: 0.50 to 15.00 A in steps of 0.01 A
Default: 5.00 A

For 1A Sensitive Ground CT Type (Ground Current order code option S1):

Range:0.005 to 3.000 x CT in steps of 0.001 x CT
Default: 0.100 x CT

This setting specifies a pickup threshold for the alarm function.

ALARM PICKUP DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s
Default: 1.00 s

This setting specifies the amount of time motor ground current must exceed pickup to generate an alarm.

ALARM DROPOUT DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s
Default: 0.01 s

This setting specifies a time delay to reset the alarm command.

ALARM OUTPUT RELAY X

For details see Common Setpoints.

BLOCK

Range: Any FlexLogic Operand
Default: Off

The Ground Fault can be blocked by any asserted FlexLogic operand.

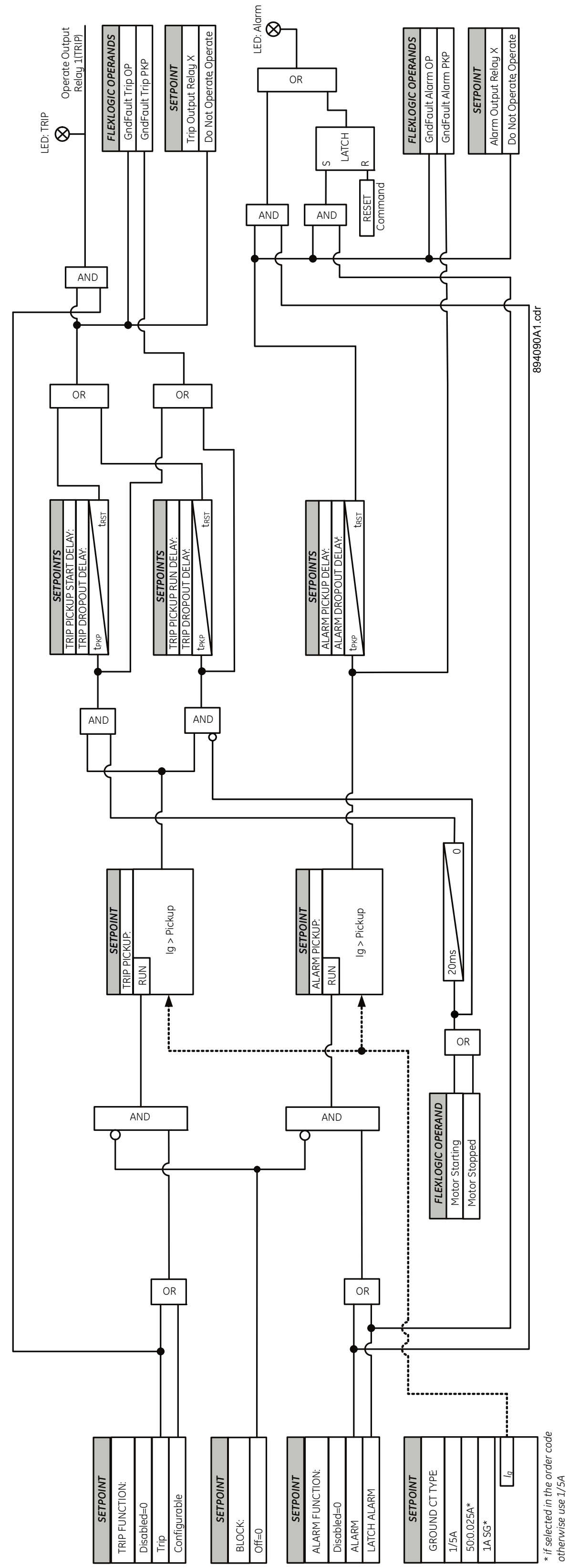
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Self-reset, Disabled
Default: Latched

Figure 6-25: Ground Fault logic diagram



Acceleration Time

Many motors have quite a time margin between acceleration-time and the stall limit. It is advantageous to detect stalling during a start as early as possible to minimize re-starting delays once the cause of the stall is remedied, e.g. neglecting to release a fan brake.

The Acceleration Time element compares actual starting time with a pre-determined time setting (defined under **System > Motor** as Max. Acceleration Time) and operates when it is exceeded. This element has the functionality to adapt the tripping time for starts with lower starting current, and it stores acceleration time and current of the last five starts. The element uses currents configured under **Setpoints > System > Current Sensing** and motor status asserted by the Thermal Model protection element. Both the signal source and thermal protection must be configured properly in order for the Acceleration Time protection to operate.

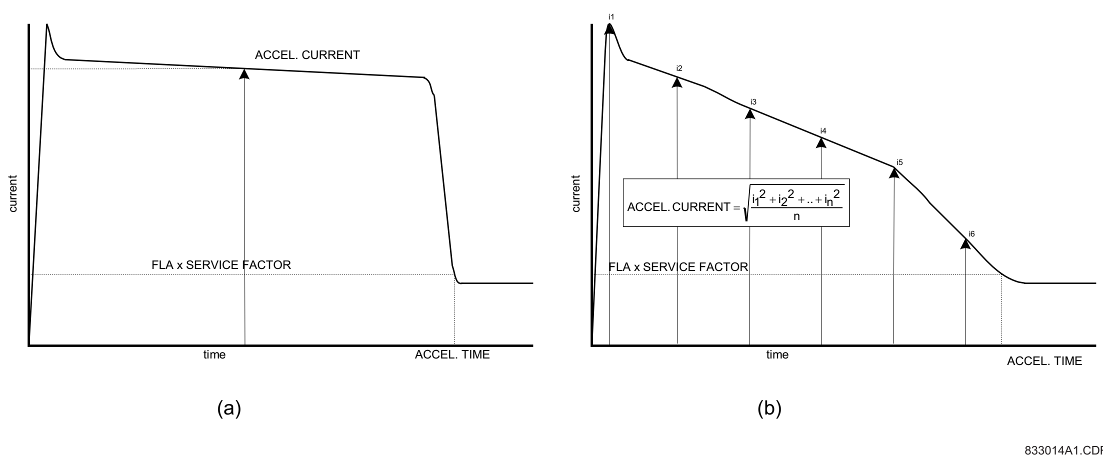
The following figure shows examples of constant and variable acceleration currents and explains measurement of the acceleration time and current. Part “a” represents a constant current start and part “b” represents a variable current start.

The element stores the basic statistics for the last five successful starts. The following values are retained, available for display and accessible via communications:

- Date and time of starting.
- Acceleration time (seconds).
- Effective acceleration current (multiples of FLA).
- Peak acceleration current (multiples of FLA).

Recorded effective acceleration current and time could be used for fine-tuning of the relay settings.

Figure 6-26: Sample Acceleration Currents: (a) Constant Current Start and (b) Variable Current Start



Path: **Setpoints > Protection > Group 1(6) > Motor > Acceleration Time**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

The setting enables the Acceleration Time functionality.

CURRENT

Range: 1.00 to 10.00 x FLA in steps of 0.01

Default: 6.00 x FLA

The setting is only used in the Adaptive mode. The setting defines a constant current that when applied to the motor accelerates the motor within the normal acceleration time. The setting is used to adapt the tripping action when the current is changing significantly during the start, such as due to voltage dips.

MODE

Range: Definite Time, Adaptive

Default: Definite Time

The setting defines the operating mode of the Acceleration Time element. When set to "Definite Time", the element times duration of the motor start and operates when the starting time exceeds the Max. Acceleration Time (defined under **System > Motor**). When set to "Adaptive", the element uses the effective accelerating current to adapt to the starting conditions. The operating equation assumes that the accelerating power is proportional to the square of the current and neglects any current unbalance or impact of the rotor slip. Consequently, in the Adaptive mode, the element operates when the square of the current integrated from the beginning of the start up to a given time exceeds the product of acceleration Current^2 x Max. Acceleration Time.

OUTPUT RELAY X

For details see Common Setpoints.

BLOCK

Range: Any FlexLogic Operand

Defatul: Off

The Acceleration Time element can be blocked by any asserted FlexLogic operand.

EVENTS

Range: Enabled, Disabled

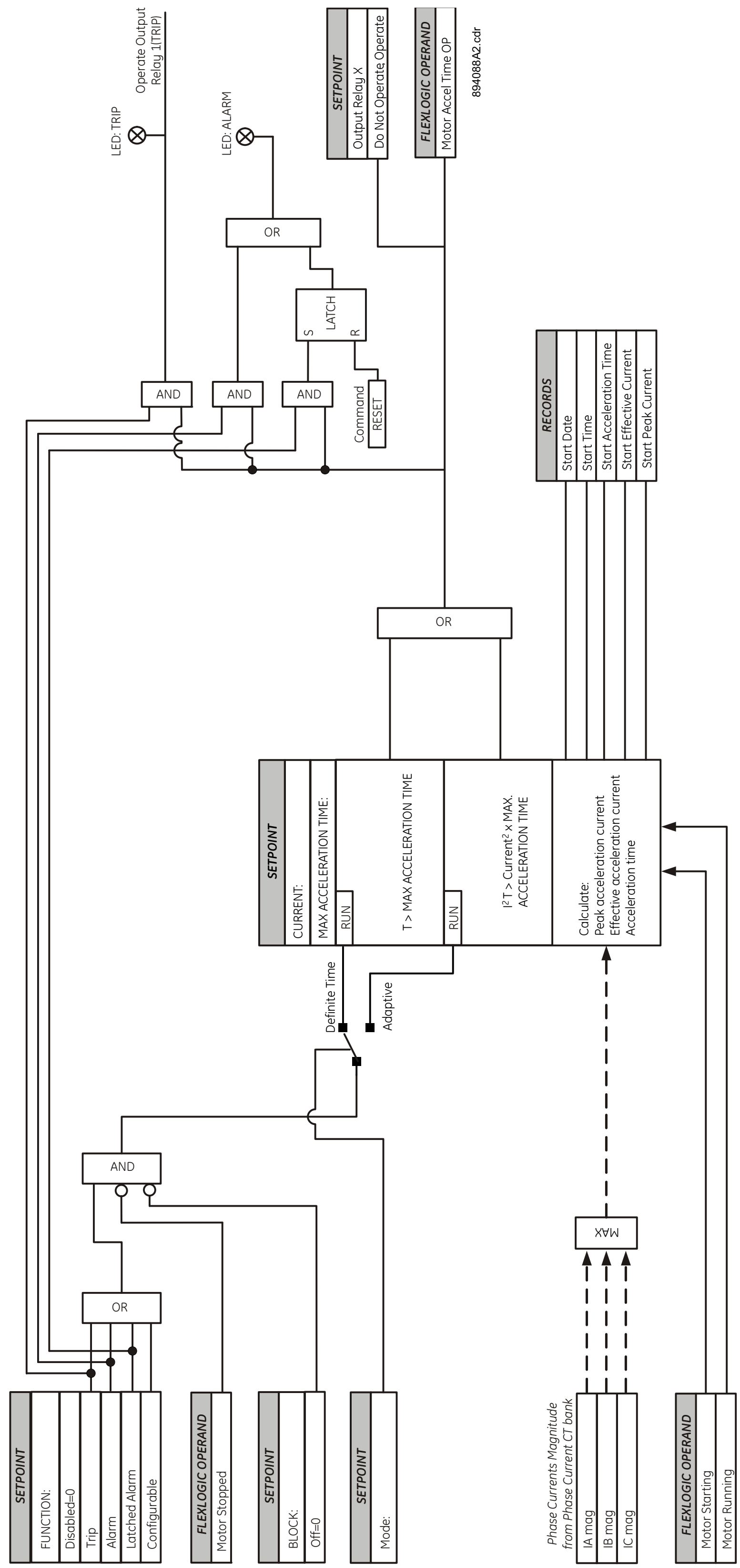
Default: Enabled

TARGETS

Range: Self-reset, Disabled

Default: Latched

Figure 6-27: Acceleration Time logic diagram



Underpower (37P)

The Underpower element responds to total three-phase real power (kW) measured from the phase currents and voltages. When the motor is in the running state, a trip and/or alarm occurs once the magnitude of three-phase real power falls below the pickup level for a period of time specified by the Trip Pickup Delay and/or Alarm Pickup Delay. The pickup levels (Trip Pickup and Alarm Pickup) are based on the rated power obtained using setpoints Motor Nameplate Voltage and Motor Full Load Amps, which are set under **Setpoints > System > Motor > Setup**. The pickup must be set lower than the lowest motor loading during normal operations. For example, Underpower may be used to detect loss of load conditions. Loss of load conditions does not always cause a significant loss of current. Power is a more accurate representation of loading and may be used for more sensitive detection of load loss or pump cavitation. This may be especially useful for detecting process related problems.

Path: **Setpoints > Protection > Group 1(6) > Motor > Underpower**

TRIP FUNCTION

Range: Disabled, Trip, Configurable
Default: Disabled

The setting enables the Underpower Trip functionality.

START BLOCK DELAY

Range: 0.00 to 15000.00 s in steps of 0.01 s
Default: 0.50 s

The setting specifies the length of time to block the Underpower function when the motor is starting. The Underpower element is active only when the motor is running and is blocked upon the initiation of a motor start for a period of time specified by this setting. For example, this block may be used to allow pumps to build up head before the Underpower element trips or alarms. A value of 0 specifies that the feature is not blocked from start. For values other than 0, the feature is disabled when the motor is stopped and also from the time a start is detected until the time entered expires.

TRIP PICKUP

Range: 1 to 25000 kW in steps of 1 kW
Default: 1 kW

The setting specifies a pickup threshold for the trip function. This setting is typically set at a level less than the corresponding setting for the alarm function.

TRIP PICKUP DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s
Default: 0.01 s

The setting specifies a time delay for the trip function. The time delay must be long enough to overcome any short lowering of the load (e.g. during system faults).

TRIP DROPOUT DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s
Default: 0.01 s

The setting specifies a time delay to reset the trip command. This delay must be set long enough to allow the breaker or contactor to disconnect the motor.

TRIP OUTPUT RELAY X

For details see Common Setpoints.

ALARM FUNCTION

Range: Disabled, Alarm, Latched Alarm
Default: Disabled

The setting enables the Underpower Alarm functionality.

ALARM PICKUP

Range: 1 to 25000 kW in steps of 1 kW

Default: 2 kW

The setting specifies a pickup threshold for the alarm function. The alarm pickup threshold must be less than the motor load during normal operation.

ALARM DROPOUT DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s

Default: 0.01 s

The setting specifies a time delay to reset the alarm command.

ALARM OUTPUT RELAY X

For details see Common Setpoints.

BLOCK

Range: Any FlexLogic Operand

Default: Off

The Underpower can be blocked by any asserted FlexLogic operand.

EVENTS

Range: Enabled, Disabled

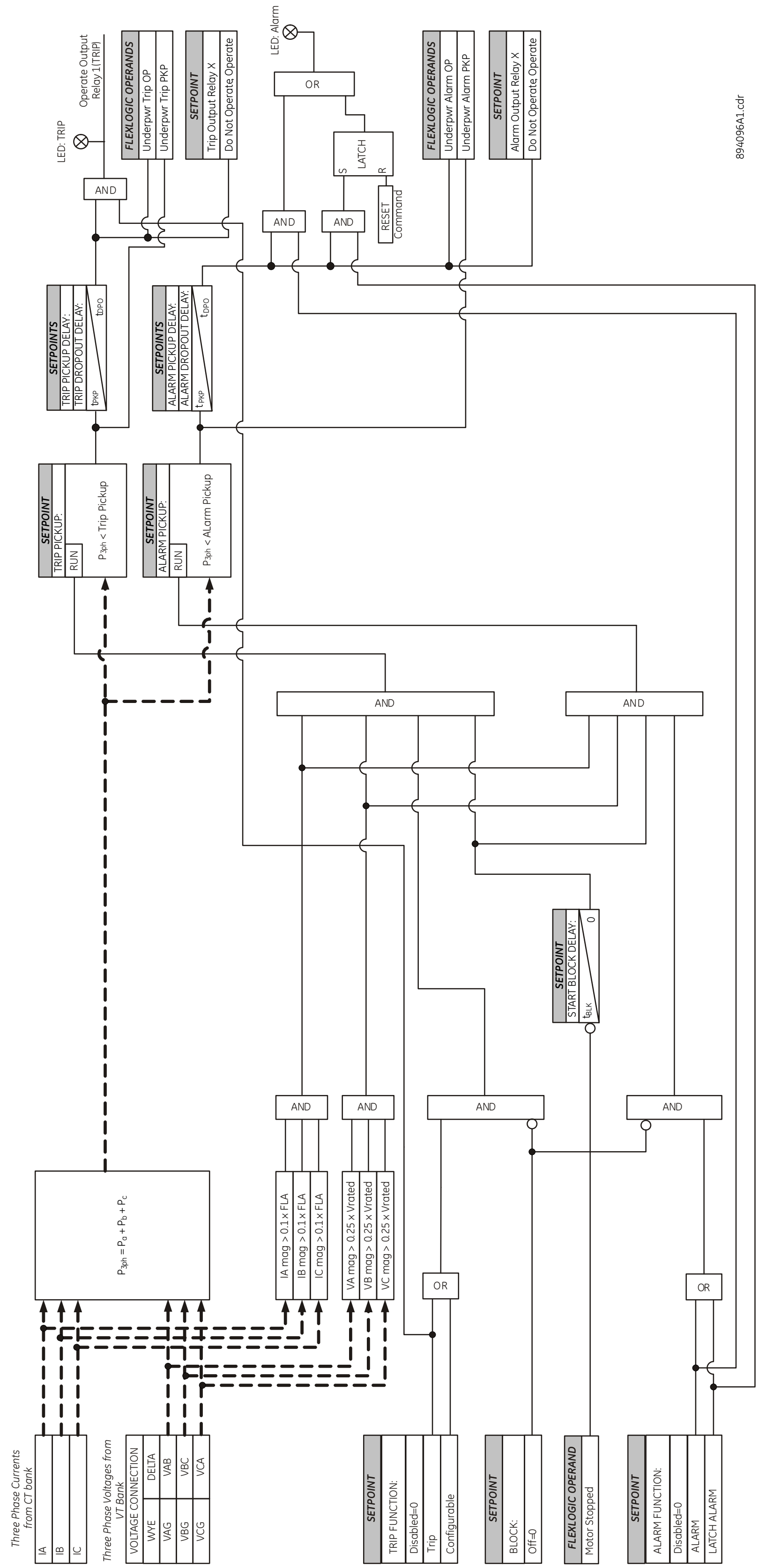
Default: Enabled

TARGETS

Range: Self-reset, Disabled

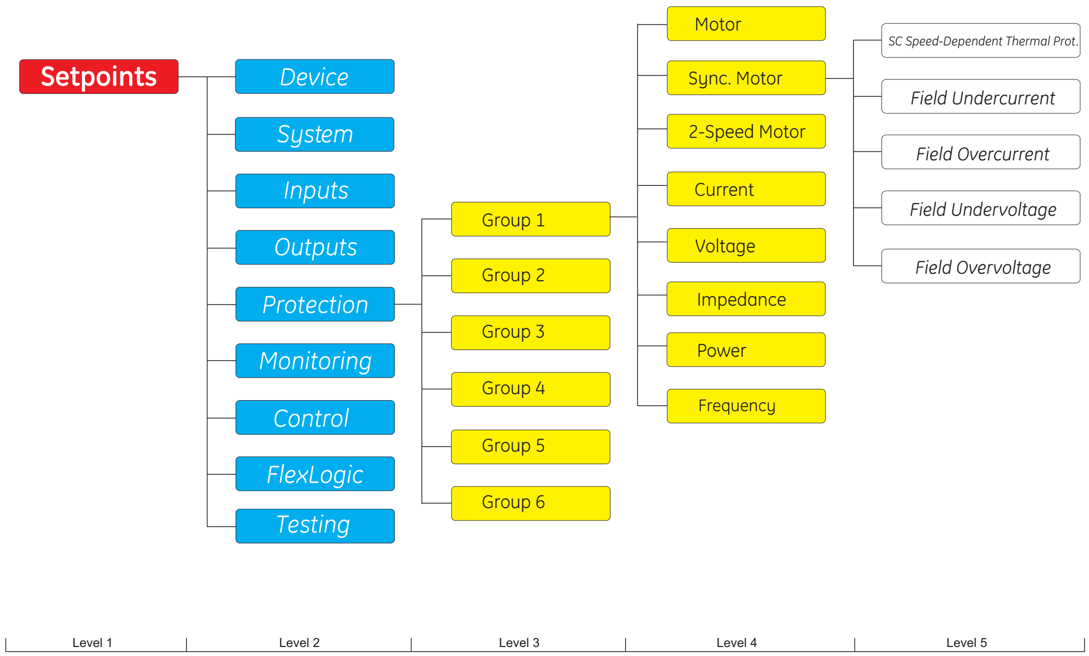
Default: Latched

Figure 6-28: Underpower logic diagram



Synchronous Motor

Figure 6-29: Motor Elements Display Hierarchy



SC Speed-Dependent Thermal Protection

NOTE

SC Speed-Dependent Thermal Protection is only applicable to brush-type synchronous motors with squirrel-cage (SC) windings.

The amortisseur, or squirrel-cage (SC) winding, of a brush-type synchronous motor is one of the motor elements most susceptible to thermal damage. Used only during motor starts, and with limitations on available space, it is usually made of lighter material than the cage winding of an induction motor. The cage is also vulnerable to overheating should the motor be allowed to run out of synchronism with no excitation. In this case, it runs as an induction motor at some value of slip which produces cage current that develops running torque. The cage of a synchronous motor is not designed for continuous operation, therefore, an important protective function of the controller is to prevent overheating of the cage both during starting, and running out of synchronism.

Monitoring the starting condition of a brush-type synchronous motor can be accomplished by looking at the frequency of induced field current, as is done to establish synchronism. The allowable stall time of a specific motor quantifies the limited time the motor can safely remain stalled (as provided by the motor manufacturer). Combining these two concepts, an acceleration schedule can be established for the motor in terms of running time at any speed less than synchronous, as a percent of allowable stall time. Increased air circulation from the rotor fan reduces the heating rate as the motor accelerates, allowing running time to increase. Frequency can be measured directly as an indication of speed, and the curves for Time vs Speed provided by the motor manufacturer can be used for protection by the 869 that integrates the time-speed function.

NOTE

Speed-dependent thermal protection is a stand-alone feature that does not require feedback from the main thermal model. The thermal capacity calculated by speed-dependent thermal protection only takes speed into account, without allowing for motor starting current. In contrast, the main thermal model is current-based, but can include the effect of speed when the Speed Bias feature is enabled. For more details on current-based thermal model speed biasing, see the Speed Bias section under Thermal Model (49).

Path: Setpoints > Protection > Group 1(6) > Motor > SM SC Spd-Dept Thermal Prot

TRIP FUNCTION

Range: Disabled, Trip, Configurable

Default: Disabled

This setting enables the squirrel-cage (SC) speed-dependent thermal protection functionality. Speed-dependent thermal protection is only active when motor is in the Starting or Resync state.

TIME-SPEED CURVE

Range: SPM 1.05, SPM 1.46, SPM 2.05, SPM 3.00, FlexCurve ST

Default: SPM 1.05

The speed-dependent thermal overload curve determines the thermal limit conditions that can damage the amortisseur, or squirrel-cage rotor winding of a brush-type synchronous motor. This curve accounts for motor heating during starting, i.e. during stall and acceleration conditions. The curve can take one of the five curves. The selected curve can also serve as a base for a voltage dependent (VD) curve if Voltage Dependent function is Enabled. The algorithm uses memory in the form of a register called SC Thermal Capacity Used. This register is updated every two power cycles using the following equation

$$SC\ TC_{used(t)} = SC\ TC_{used(t-1)} + \frac{T_{system}}{t_{run}} \times 100\%$$

where:

t_{run} represents the time coordinate on the time-speed curve, corresponding to the motor speed,

T_{system} represents the period in seconds corresponding to the two nominal power system frequency cycles.

NOTE

The 869 initiates a trip operation and displays **SC Thermal OP** if the calculated thermal limit of the cage winding reaches 100%.

Cooling

Squirrel-cage thermal protection enters a cool-down mode when the motor state changes to Stopped from Running (unsuccessful start) or to SM Stabilizing from Running (successful start). In either condition, the SC thermal capacity used value is reduced in an exponential manner. The algorithm applies the same cooling time constants found in the main (current-based) thermal model (see Thermal Model (49)) referred to as 'Cool Time Constant Stopped' and 'Cool Time Constant Running'. When the main thermal model is disabled, the cooling algorithm applies a time constant of 20 minutes. This, after every 20 minutes of elapsed time, the SC thermal capacity used value should be decremented approximately by 37% of its initial value.

Motor cooling is calculated as follows:

$$SC\ TC_{used} = SC\ TC_{used}(t-1) \times e^{-t/\tau_{cool}}$$

where:SC TC_{used} is the squirrel-cage winding thermal capacity used,t is the time in minutes,$\tau_{cool}$is the Cool Time Constant.

NOTE

- After a successful start, such that motor state changes to SM Stabilizing from Running, τ_{cool} is the Cool Time Constant Running found under the description of the main thermal model (see Thermal Model (49)).
- After an unsuccessful start, such that motor state changes to Stopped from Running, τ_{cool} is the Cool Time Constant Stopped found under the main thermal model (see Thermal Model (49)).

When the main Thermal Model is Disabled, regardless of the motor state, SC Speed-Dependent Thermal Protection takes τ_{cool} as equal to 20 min.

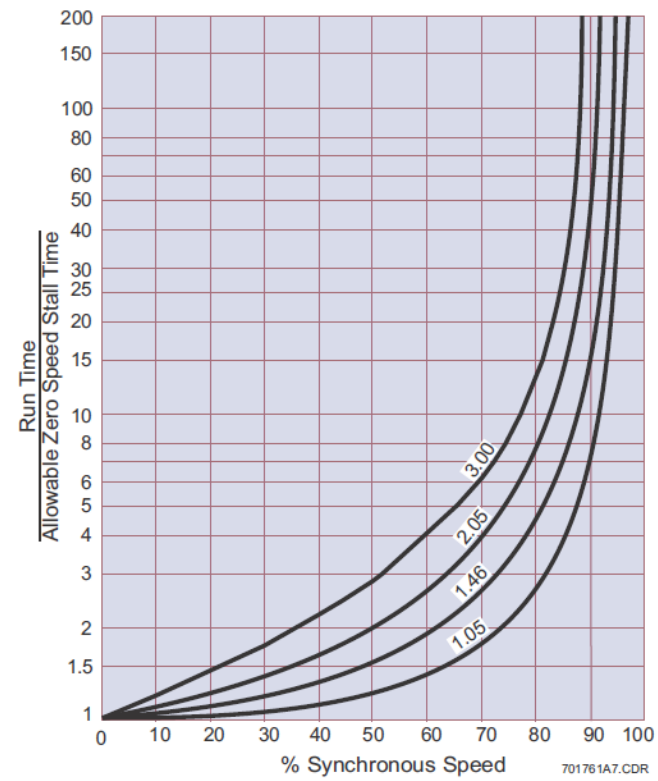
Description of SPM 1.05, SPM 1.46, SPM 2.05, and SPM 3.00

The following figure shows the predefined time vs. speed curves for the squirrel-cage winding used by the SC heating protection during acceleration. The motor speed is determined from the induced field voltage frequency. Maximum allowable stall time at zero speed is programmed as 'Stall Time'. Curve name suggests the time multiple that motor may run at 50% speed and is expressed as a multiple of the allowable motor Stall Time (ST).

Example: If the motor Stall Time is programmed as 10 seconds and SPM 3.00 is selected, then motor can run at:

3.00 x 10 sec. = 30 seconds at 50% speed

Figure 6-30: Amortisseur (squirrel-cage) winding protection



Description of Custom curve

When none of the four pre-defined curves (SPM 1.05 through 3.00) is applicable, the FlexCurve ST setting provides the option of a customized time vs. speed curve. The number of operating points, time, and speed value as multiple of nominal speed can be defined based on the nominal frequency.When values of time vs. speed are not available for use building a custom curve, the EnerVista 8 Series Setup software can estimate the curve using the option Est Time-Speed available under the FlexCurve ST menu. The Run Time and Stall Time setpoints must be set properly for the EnerVista 8 Series Setup software to build the estimated curve.

FlexCurve ST settings are found under **Path:** **System > FlexCurves** (see FlexCurves).

VD Function

Range: Disabled, Enabled

Default: Disabled

Many synchronous motor starting applications involve either reduced voltage (starting reactor or autotransformer) or part-winding starting methods. When these methods are used, the available torque for acceleration is reduced compared to the torque resulting from a full-voltage start. In addition, the allowable stall time of a motor is extended during a reduced-voltage start due to the reduced heating-rate resulting from lower inrush currents.

This voltage-dependent (VD) setpoint, when enabled, allows the 869 to take advantage of the motor's extended stall time so that the motor and load can accelerate to synchronous speed over a longer time period than is allowed for a full voltage start. The acceleration torque is reduced as the square of the ratio of reduced voltage to full voltage, and the motor-heating rate is proportional to the square of the starting current.

Since the motor inrush current is reduced proportionally with the voltage reduction (due to the constant impedance of the synchronous motor at stall) the following allowable stall time factor K applies:

$$K = \left(\frac{V_{rated}}{V_{RMS} \times V_{ratio}} \right)^2$$

Where

V_{rated} is from the Motor Nameplate Voltage and can be found under **Path: System > Motor > Setup**,

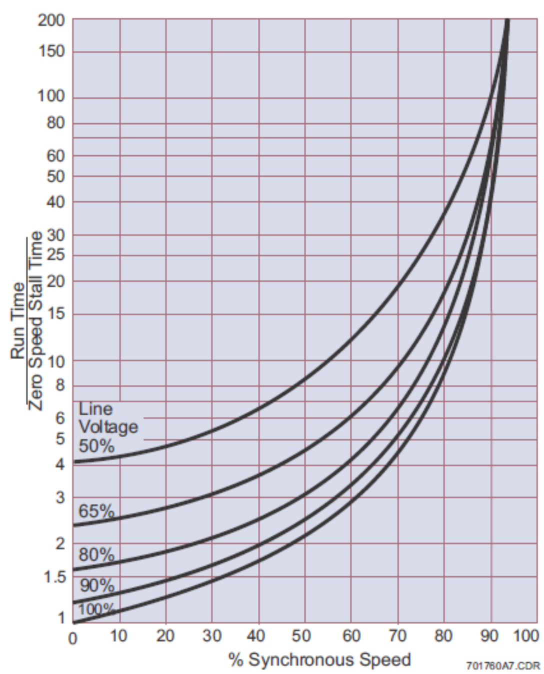
$V_{ratio}$is the Phase VT Ratio or Auxiliary VT Ratio can be found under **Path: Setpoints > System > Voltage Sensing**,

V_{RMS} is the measured secondary phase to phase voltage. V_{RMS} is the lowest RMS value between VAB, VBC, and VCA.

For the selected Time-Speed Curve, the 869 uses the factor 'K' for increasing the stall time above the full voltage allowable stall time for any given speed, as shown in the following figure.

In case of voltage loss, the speed-time curve is switched to one based on the programmed 100% voltage by considering factor K equals 1.

Figure 6-31: Protection for reduced voltage starts



STALL TIME @ 0% Speed

Range: 1.00 to 180.00 s in steps of 0.01 s
Default: 10.00 s

This setpoint determines the allowable time that power may be applied to the motor during locked rotor conditions. This information is usually found on the motor control data sheet provided by the motor manufacturer.

RUN TIME

Range: 1.05 to 3.00 x ST in steps of 0.01 x ST

Default: 1.05 x ST

This setpoint is only used when FlexCurve ST is initialized by the 'Est Time-Speed' curve option available under FlexCurve ST setup.

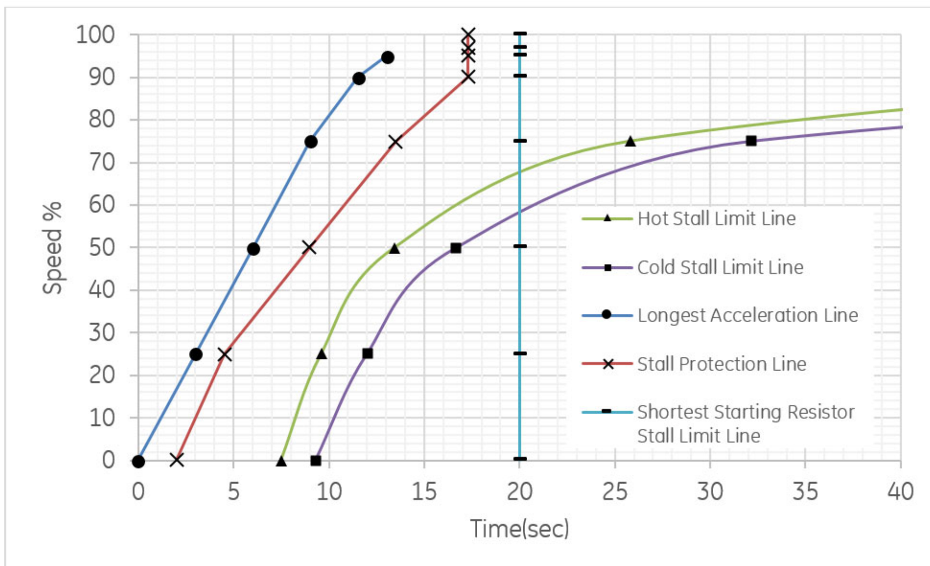
Run Time is the time that the motor may run at 50% speed and is expressed as a multiple of the allowable motor Stall Time (ST).

EXAMPLE: If the motor Stall Time is set to 10 seconds and Run Time is set to 3.00 x ST, then motor can run at: 3.00 x 10 seconds = 30 seconds at 50% speed

Application Example:

A motor manufacturer provides a series of accelerating speed-versus-time curves as shown in the figure below. These curves normally include: Longest Acceleration, Pole-Tip or Shortest Amortisseur Bar Hot & Cold Stall Limits, Shortest Starting Resistor Stall Limit, and Stall Protection.

Figure 6-32: Accelerating speed vs. time profile at 100% rated voltage



When a Speed-versus-Time profile is available, build the custom curve by selecting FlexCurve ST under the setpoint 'Time-Speed Curve'. Time-versus-speed points should be selected to match the manufacturer-recommended Stall Protection curve.

When the motor manufacturer does not include Stall Protection in this set of curves, the general rule is to draw the Stall Protection line close to the Hot Stall Limit Line, except near zero speed where it must be drawn closer to the Acceleration Line to trip sooner under full jam conditions. This is done to preserve thermal capacity for another start; once the jam has been cleared. Therefore, custom FlexCurve ST operating points (Time-versus-Speed) must be selected between the Longest Acceleration line and Shortest Starting Resistor Stall Limit line.

NOTE

When the VD Function is enabled, it is important to ensure that time-versus-speed points are entered for 100% Rated Voltage. If the motor manufacturer provides a speed-versus-time profile for reduced voltage starts then the adjusted time value should be entered. The adjusted time value can be calculated as follows: Time (@100% Rated Voltage) = Time (@80% Vrated) / K-factorwhere K-factor is defined in the previous equation.When no speed-versus-time profile is available, set the 'Time-Speed Curve' to 'FlexCurve ST' and initialize it with the 'Est Time-Speed' curve option to generate an estimated curve.

VOLTAGE LOSS

Range: Any FlexLogic Operand

Default: Off

This setting is used to address situations when the voltage input used for the voltage dependent function (the VD Function setpoint) has been lost. The VT fuse failure function is typically used to detect a voltage loss condition.

ALARM FUNCTION

Range: Disabled, Alarm, Latch Alarm

Default: Disabled

This setting enables alarm functionality.

ALARM PICKUP

Range: 10.00 to 100.00% in steps of 1.00%

Default: 75.00%

This setting specifies a pickup threshold for the thermal capacity used (TCU) for the alarm or latch alarm function.

TRIP MODE

Range: Self-Reset, Latched

Default: Latched

When trip mode is programmed as Self-Reset, as soon as SC TCU dropped to 97% the SC Slip-dependent Thermal protection automatically resets the trip command to the output TRIP Relay 1 and Trip LED becomes OFF. However, when trip mode is set as Latched, trip output and trip LED only resets when RESET command from the relay front panel is initiated.

ALARM OUTPUT RELAY X

For details see Common Setpoints.

TRIP OUTPUT RELAY X

For details see Common Setpoints.

BLOCK

Range: Any FlexLogic Operand

Default: Off

NOTE

Block, when asserted, resets the output operands Trip Latch and Trip LED. However, the protection element keeps the SC TCU calculation active and does consider elapsed time during Blocking in order to calculate the TCU.

EVENTS

Range: Enabled, Disabled

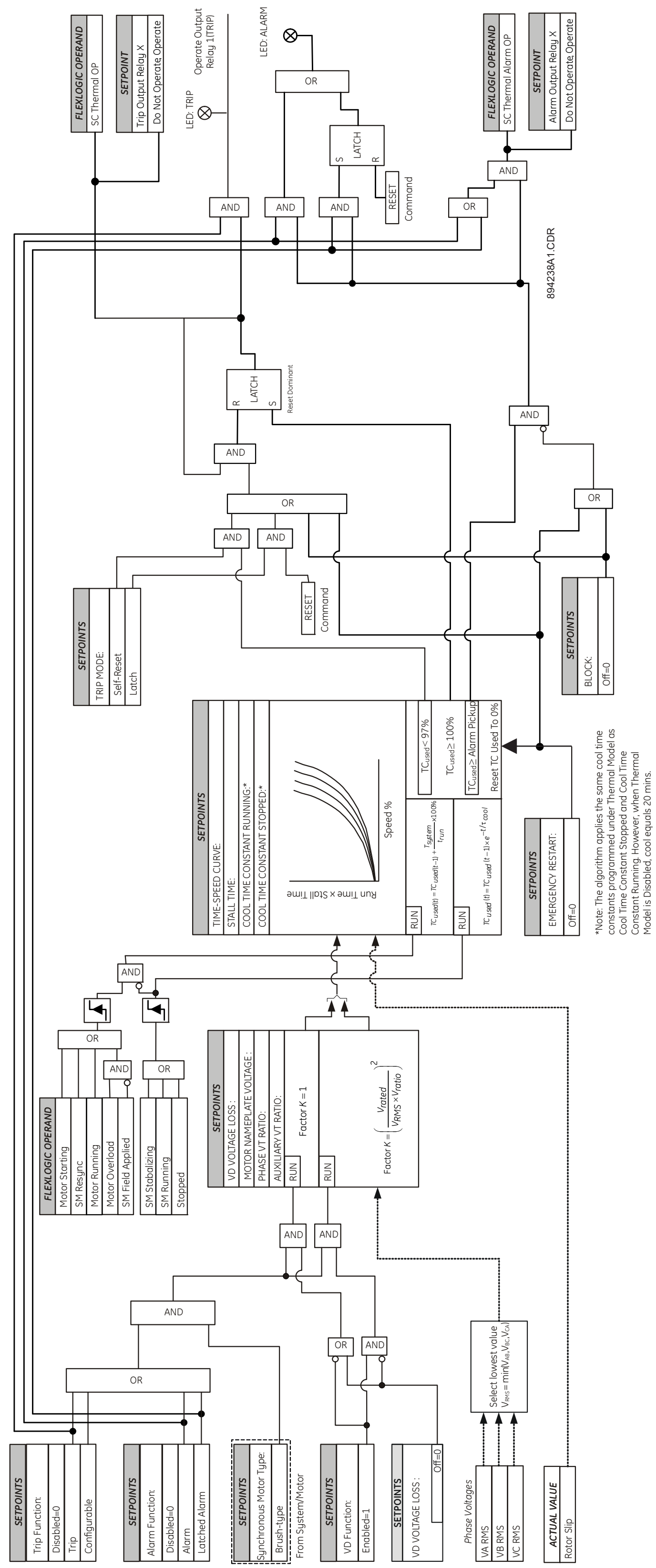
Default: Enabled

TARGETS

Range: Self-Reset, Latched, Disabled

Default: Latched

Figure 6-33: SC Speed-Dependent Thermal Protection logic diagram



Field Undercurrent (37F)

The 869 relay provides two synchronous motor (SM) Field Undercurrent elements per protection group, that respond to DC field current input. When the motor is in the SM Running or Motor Overload state, an alarm occurs if the magnitude of the field current falls below the undercurrent Pickup level for the time specified by the setpoint Pickup Delay.

SM Field Undercurrent protection is active only when the motor is in the SM Running or Motor Overload state.

NOTE

Motor Running or SM Resync motor states indicates that the induction mode of the synchronous motor is active, that is, no field is being applied to excite the rotor.

Path: Setpoints > Protection > Group 1(6) > Motor > SM Field Undercurrent

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm or Configurable
Default: Disabled

This setting enables SM Field Undercurrent functionality. When set to Trip, the protection element operates the Trip Relay (Output Relay 1) to open the main circuit breaker/ contactor. To trip the field winding breaker/contactor, the FlexLogic operand 'FLD UC[X] OP' must be used to operate the selected relay set under **Path:** Setpoints > System > Breaker 2 (or Contactor 2).

PICKUP

Range: 0.05 to 1.00 x MFA in steps of 0.01 x MFA
Default: 0.10 x MFA

This setting specifies the pickup threshold for the SM Field Undercurrent function. The pickup level is defined as a multiple of MFA (maximum field current at primary of DCCT). MFA is defined by the setpoint 'Max FLD Amps Primary (MFA)' programmed under **Path:** Setpoints > System > Current Sensing > SM FLD A-K2. MFA corresponds to the maximum output value of the DCCT (direct current transformer) or current transducer.

For example, a pickup setting of 0.50 x MFA corresponds to 1000 A primary when Max FLD Amps Primary is programmed as 2000 A. Pickup values between 0 and 1 are scaled linearly.

PICKUP DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s
Default: 1.00 s

This setting specifies a time delay for the SM Field Undercurrent function.

DROPOUT DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s
Default: 0.00 s

OUTPUT RELAY X

For details see Common Setpoints.

BLOCK

Range: Any FlexLogic Operand
Default: Off

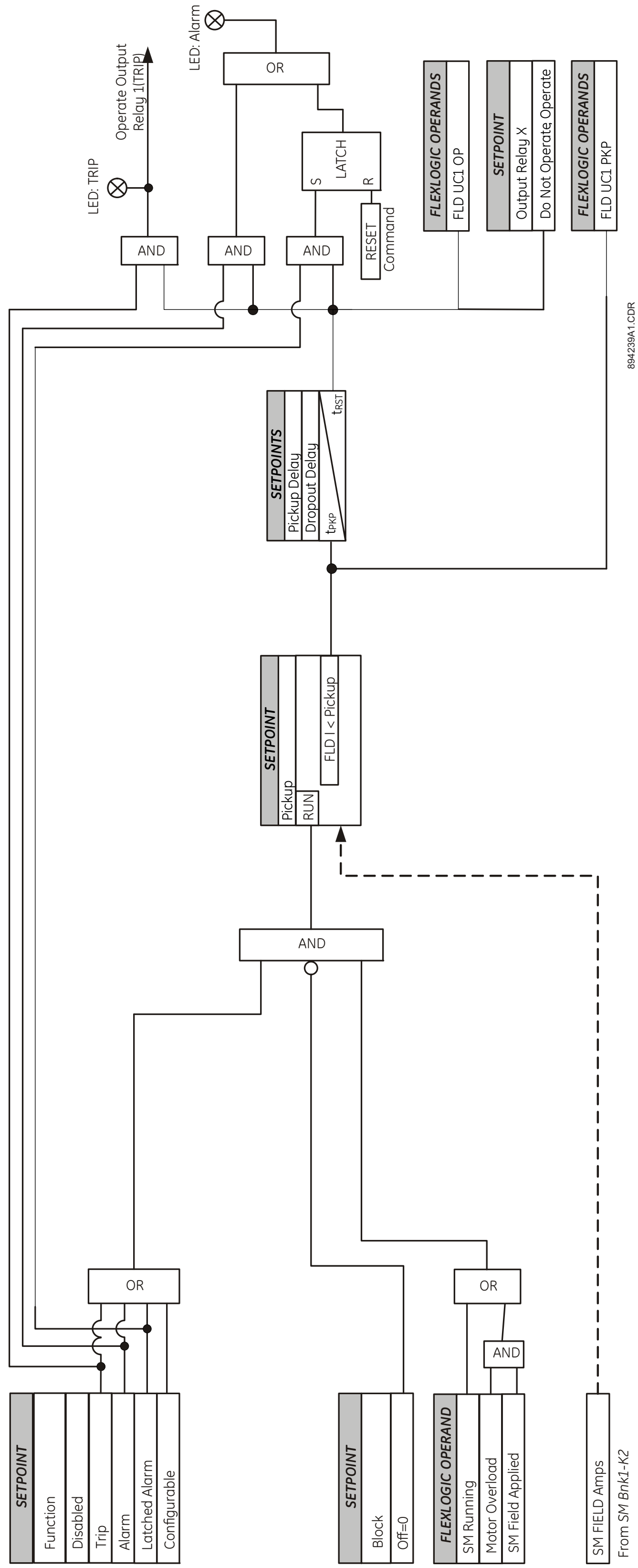
EVENTS

Range: Disabled, Enabled
Default: Enabled

TARGETS

Range: Disabled, Self-Reset, Latched
Default: Latched

Figure 6-34: Field Undercurrent logic diagram



Field Overcurrent (76F)

The 869 relay provides two synchronous motor (SM) Field Overcurrent elements per protection group, that respond to DC field current input. When the motor is in the SM Running or Motor Overload state, an alarm occurs if the magnitude of the field current exceeds the overcurrent Pickup level for the time specified by the setpoint Pickup Delay.

SM Field Overcurrent protection is active only when the motor is in the SM Running or Motor Overload state.

NOTE

Motor Running or SM Resync motor states indicates that the induction mode of the synchronous motor is active, that is, no field is being applied to excite the rotor.

Path: **Setpoints > Protection > Group 1(6) > Motor > SM Field Overcurrent**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm or Configurable

Default: Disabled

This setting enables SM Field Overcurrent functionality. When set to Trip, the protection element operates the Trip Relay (Output Relay 1) to open the main circuit breaker/ contactor. To trip the field winding breaker/contactor, the FlexLogic operand 'FLD OC[X] OP' must be used to operate the selected relay set under **Path:** **Setpoints > System > Breaker 2 (or Contactor 2)**.

PICKUP

Range: 0.05 to 1.00 x MFA in steps of 0.01 x MFA

Default: 0.90 x MFA

This setting specifies the pickup threshold for the SM Field Overcurrent function. The pickup level is defined as a multiple of MFA (maximum field current at primary of DCCT). MFA is defined by the setpoint 'Max FLD Amps Primary (MFA)' programmed under **Path:** **Setpoints > System > Current Sensing > SM FLD A-K2**. MFA corresponds to the maximum output value of the DCCT (direct current transformer) or current transducer.

For example, a pickup setting of 0.50 x MFA corresponds to 1000 A primary when Max FLD Amps Primary is programmed as 2000 A. Pickup values between 0 and 1 are scaled linearly.

PICKUP DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s

Default: 1.00 s

This setting specifies a time delay for the SM Field Overcurrent function.

DROPOUT DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s

Default: 0.00 s

OUTPUT RELAY X

For details see Common Setpoints.

BLOCK

Range: Any FlexLogic Operand

Default: Off

EVENTS

Range: Disabled, Enabled

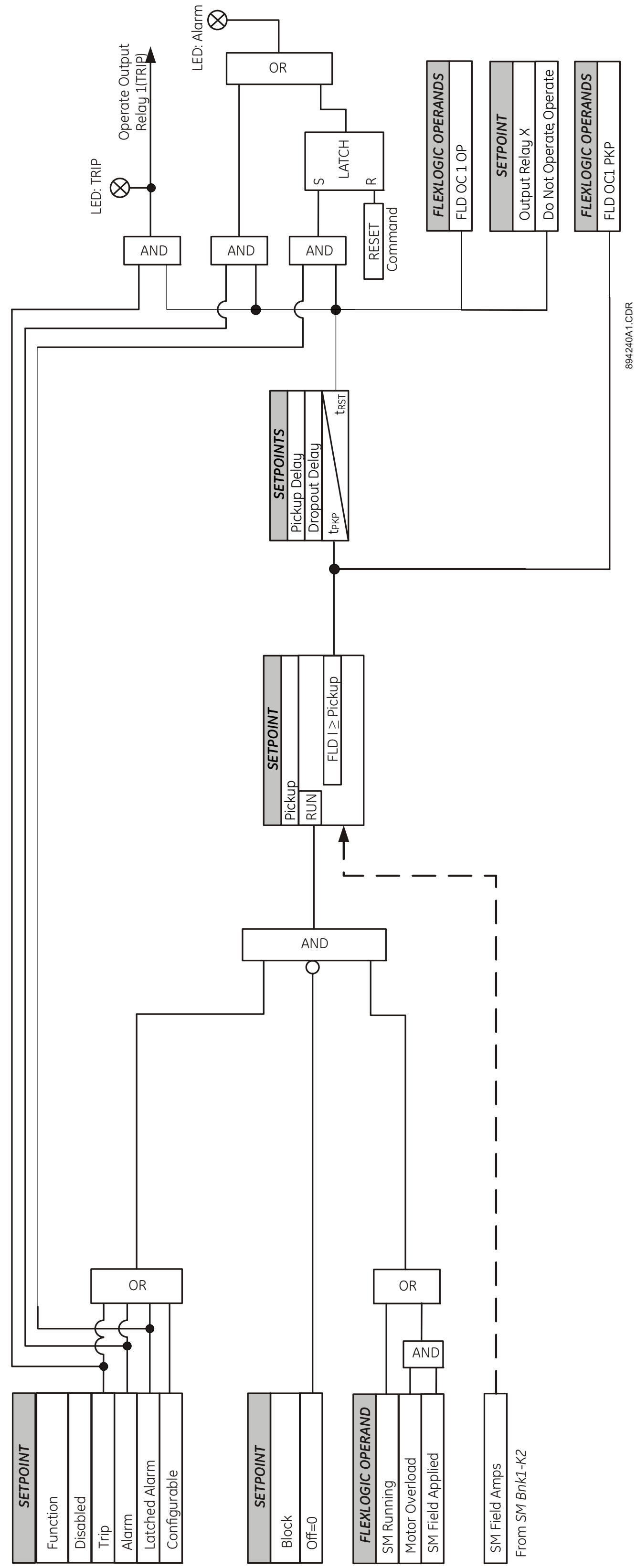
Default: Enabled

TARGETS

Range: Disabled, Self-Reset, Latched

Default: Latched

Figure 6-35: Field Overcurrent logic diagram



Field Undervoltage (27F)

The 869 relay provides two synchronous motor (SM) Field Undervoltage elements per protection group, that respond to DC field voltage input. A trip or alarm occurs if the magnitude of the field voltage falls below the undervoltage Pickup level for the time specified by the setpoint Pickup Delay.

SM Field Undervoltage protection is active in all motor states (Stopped, Starting, Running, SM Stabilizing, SM Running, SM Resync and Overload).

NOTE

This function requires a VDN Module (Voltage Divider Network Module) to connect exciter output (primary side) to relay input (secondary side) via the VDN Module.

Path: Setpoints > Protection > Group 1(6) > Motor > SM Field Undervoltage

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm or Configurable

Default: Disabled

This setting enables SM Field Undervoltage functionality. When set to Trip, the protection element operates the Trip Relay (Output Relay 1) to open the main circuit breaker/ contactor. To trip the field winding breaker/contactor, the FlexLogic operand 'FLD UV[X] OP' must be used to operate the selected relay set under **Path:** Setpoints > System > Breaker 2 (or Contactor 2).

PICKUP

Range: 0.0 to 350.0 V in steps of 0.1 V

Default: 50.0 V

This setting specifies the pickup threshold for the SM Field Undervoltage function. The pickup level is defined in primary DC voltage, which corresponds to the primary (exciter side) of the VDN Module.

PICKUP DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s

Default: 1.00 s

This setting specifies a time delay for the SM Field Undervoltage function.

DROPOUT DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s

Default: 0.00 s

MINIMUM VOLTAGE

Range: 0.0 to 100.0 V in steps of 0.1 V

Default: 20.0V

This setting sets the minimum voltage for SM Field Undervoltage function.

BYPASS STOPPED BLOCK

Range: NO, YES

Default: NO

If the exciter is designed to be energized with motor starting (as with shaft connected rotating exciters), the SM Field Undervoltage element must be blocked when the motor is in the Stopped state. For such applications, this setpoint must be set to NO.

If the exciter is energized prior to starting the motor, the SM Field Undervoltage element must be active when the motor is in the Stopped state. For such applications, this setpoint must be set to YES.

OUTPUT RELAY X

For details see Common Setpoints.

BLOCK

Range: Any FlexLogic Operand
Default: Off

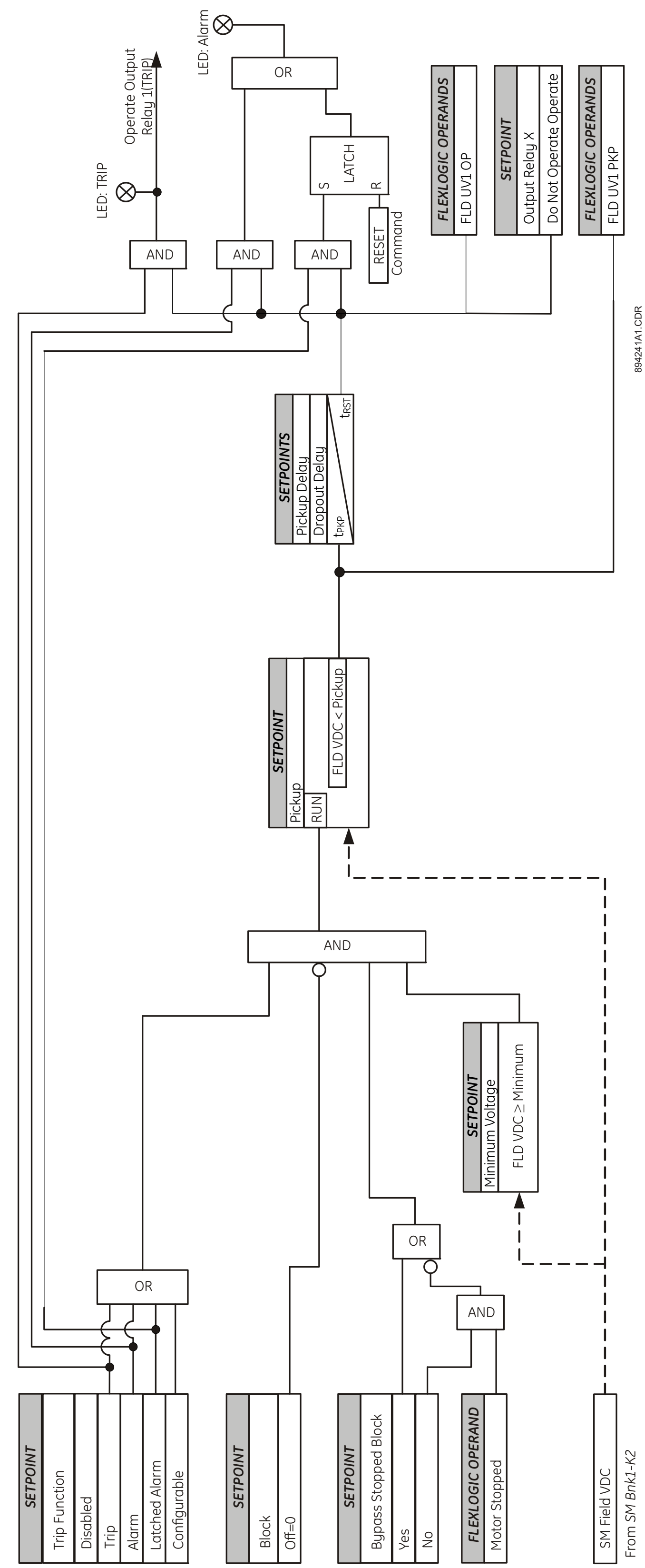
EVENTS

Range: Disabled, Enabled
Default: Enabled

TARGETS

Range: Disabled, Self-Reset, Latched
Default: Latched

Figure 6-36: Field Undervoltage logic diagram



Field Overvoltage (59F)

The 869 relay provides two synchronous motor (SM) Field Overvoltage elements per protection group, that respond to DC field voltage input. A trip or alarm occurs if the magnitude of the field voltage exceeds the overvoltage Pickup level for the time specified by the setpoint Pickup Delay.

SM Field Overvoltage protection is active in all motor states (Stopped, Starting, Running, SM Stabilizing, SM Running, SM Resync and Overload).

NOTE

This function requires a VDN Module (Voltage Divider Network Module) to connect exciter output (primary side) to relay input (secondary side) via the VDN Module.

Path: Setpoints > Protection > Group 1(6) > Motor > SM Field Overvoltage

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm or Configurable

Default: Disabled

This setting enables SM Field Overvoltage functionality. When set to Trip, the protection element operates the Trip Relay (Output Relay 1) to open the main circuit breaker/ contactor. To trip the field winding breaker/contactor, the FlexLogic operand 'FLD OV[X] OP' must be used to operate the selected relay set under **Path:** Setpoints > System > Breaker 2 (or Contactor 2).

PICKUP

Range: 1.0 to 350.0 V in steps of 0.1 V

Default: 100.0 V

This setting specifies the pickup threshold for the SM Field Overvoltage function. The pickup level is defined in primary DC voltage, which corresponds to the primary (exciter side) of the VDN Module.

PICKUP DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s

Default: 1.00 s

This setting specifies a time delay for the SM Field Overvoltage function.

DROPOUT DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s

Default: 0.00 s

OUTPUT RELAY X

For details see Common Setpoints.

BYPASS STOPPED BLOCK

Range: NO, YES

Default: NO

If the exciter is designed to be energized with motor starting (as with shaft connected rotating exciters), the SM Field Overvoltage element must be blocked when the motor is in the Stopped state. For such applications, this setpoint must be set to NO.

If the exciter is energized prior to starting the motor, the SM Field Overvoltage element must be active when the motor is in the Stopped state. For such applications, this setpoint must be set to YES.

BLOCK

Range: Any FlexLogic Operand

Default: Off

EVENTS

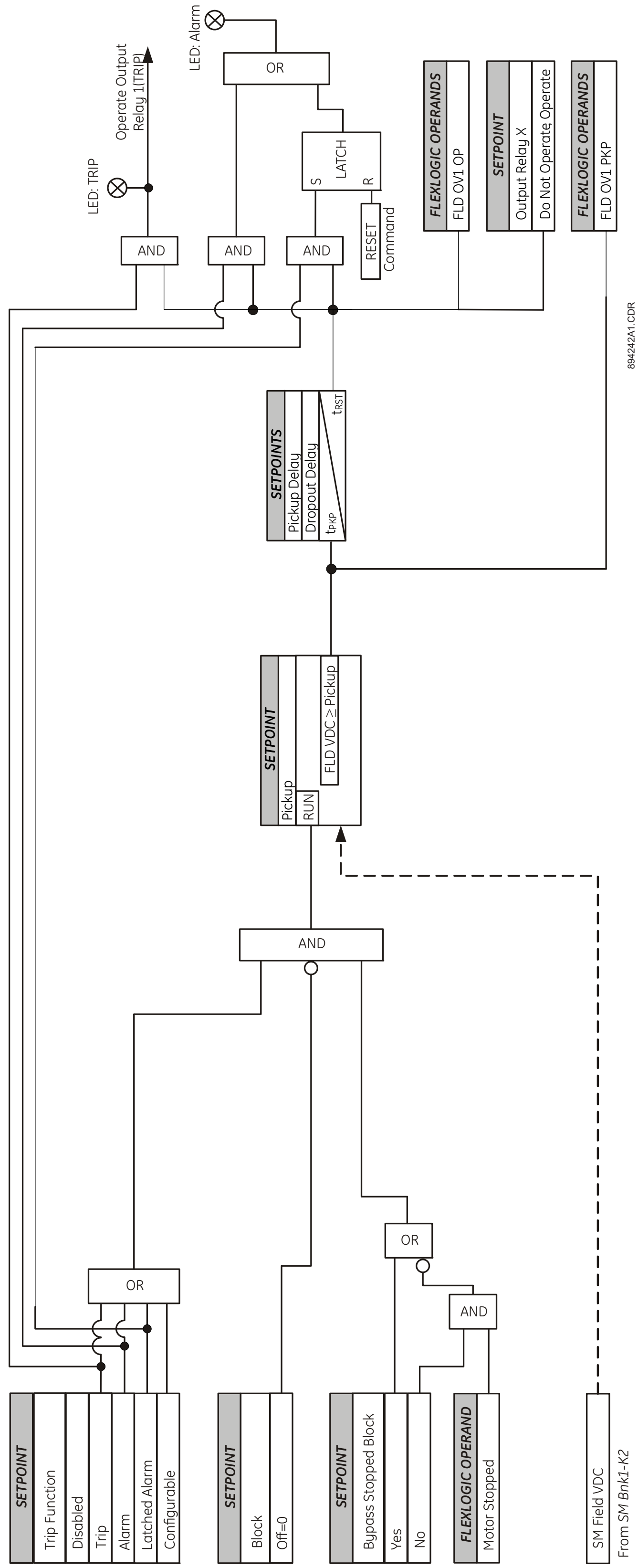
Range: Disabled, Enabled

Default: Enabled

TARGETS

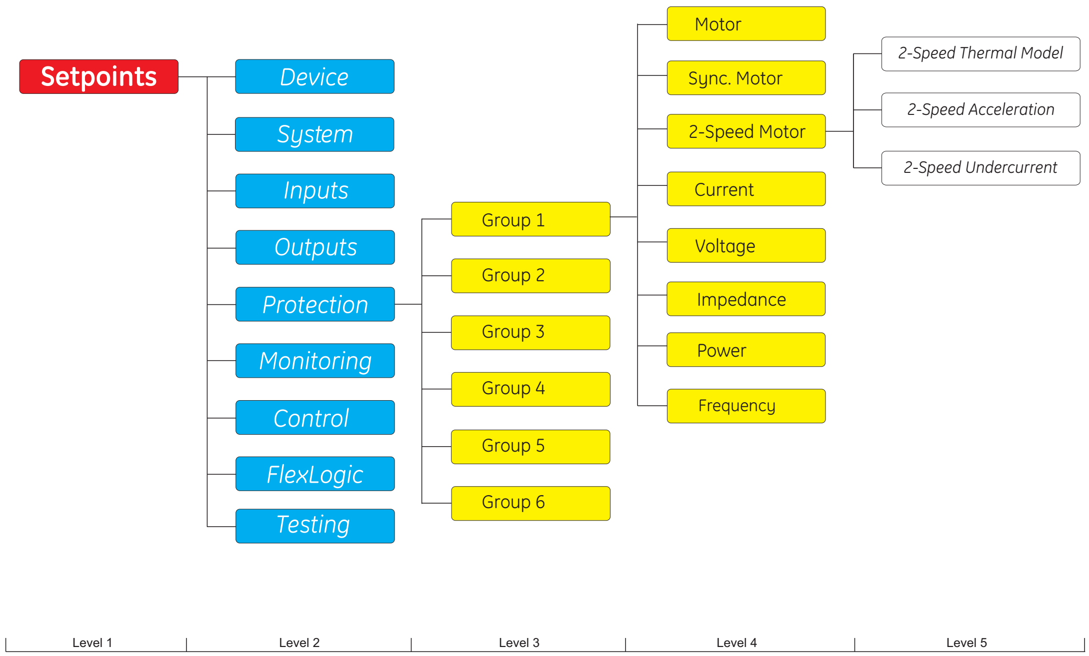
Range: Disabled, Self-Reset, Latched
Default: Latched

Figure 6-37: Field Overvoltage logic diagram



2-Speed Motor

Figure 6-38: Motor Elements Display Hierarchy



The two-speed motor feature provides proper protection for a two-speed motor where there are two different full load values. If the two-speed motor feature is used, setpoint **2-Speed Motor Protection** must be set to Enabled under **Setpoints > System > Motor > Setup**. Also, assignable input for setpoint **Speed2 Motor Switch** under **Setpoints > System > Motor > Setup** must monitor for a contact closure. Contact closure signifies that the motor is in Speed 2; if the input is open, it signifies that the motor is in Speed 1. This allows the 869 to determine which settings must be active at any given point in time.

2-Speed Thermal Model

Path: **Setpoints > Protection > Group1(6) > 2-Speed Motor > Speed2 Thermal Model**

When the two-speed motor functionality is used, these settings allow the selection of the proper parameters for the thermal model when the motor is switched to the second speed. There is one thermal model in the 869, and it has inputs for overload conditions from calculations at both speeds. As such, the accumulated thermal capacity is calculated from overload contributions at each speed.

The algorithm integrates the heating at each speed into one thermal model using a common thermal capacity used register value for both speeds.

Refer to the 2-Speed Thermal Model section for details on settings for thermal model at the second motor speed.

OVERLOAD CURVE

Range: Motor, Flexcurve A, Flexcurve B, Flexcurve C, Flexcurve D, FlexCurve OL, IEC
Default: Motor

TD MULTIPLIER

Range: 1.00 to 25.00 in steps of 0.01 when thermal model curve is Motor
Default: 1.00
Range: 0.00 to 600.00 in steps of 0.01 when thermal model curve is Flexcurve A/B/C/D/OL
Default: 0.00

VOLT. DEPENDENT (VD) FUNCTION

Range: Disabled, Enabled
Default: Disabled

VD MIN MOTOR VOLTS

Range: 60 to 99% in steps of 1
Default: 80%

VD VOLTAGE LOSS

Range: Off, Any FlexLogic operand
Default: Off

VD STALL CURRENT @ MIN V

Range: 1.50 to 20.00 FLA in steps of 0.01
Default: 4.50 x FLA

VD STALL TIME @ MIN V

Range: 0.1 to 1000.0 in steps of 0.1
Default: 20.0 s

VD ACCEL. INTERSECT @ MIN V

Range: 1.50 to 20.00 in steps of 0.01
Default: 4.00 x FLA

VD STALL CURRENT @ 100% V

Range: 1.50 to 20.00 FLA in steps of 0.01
Default: 6.00 x FLA

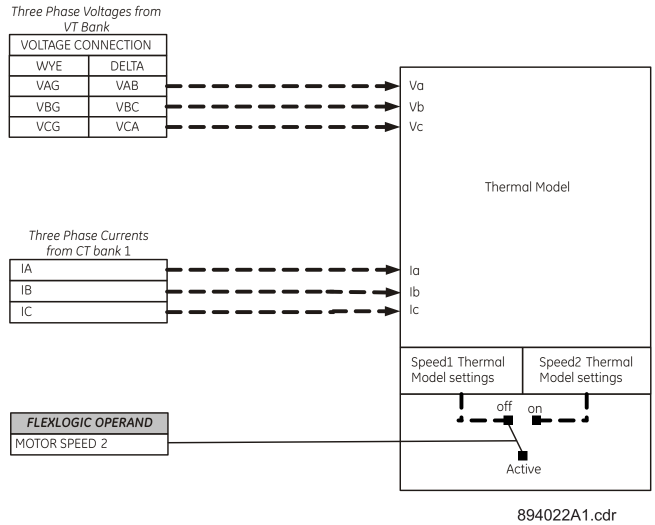
VD STALL TIME @ 100% V

Range: 0.1 to 1000.0 in steps of 0.1
Default: 10.0 s

VD ACCEL. INTERSECT @ 100% V

Range: 1.50 to 20.00 in steps of 0.01
Default: 5.00 x FLA

Figure 6-39: Speed2 Thermal Model logic diagram



2-Speed Acceleration

Path: **Setpoints > Protection > Group1(6) > 2-Speed Motor > Speed2 Acceleration**

Speed2 Acceleration Time functionality is enabled when the motor is switched from speed 1 to speed 2 and 2-Speed Motor Protection (set under Setpoints/System/Motor/Setup) is enabled.

NOTE

Speed2 Acceleration Current and Mode settings and functionality at speed 2 are identical to those of speed 1 and are described in the Acceleration Time element.

Two additional setting define the transition between speeds. A two-speed motor is usually started at a low speed (speed 1) and then switched to a higher speed (speed 2) when required. When the motor starts directly at high speed, then the Speed2 Max. Accel. Time setting (defined under Setup>Motor) specifies the maximum acceleration time at speed 2. When the motor is switched from a low-to-high speed setting, the speed 2 Accel Time Fr. Spd 1-2 setting specifies the acceleration time. When the motor is switched from high speed to low speed, the Speed2 Trans 2-1 Op FlexLogic operand is set for a time defined by the Speed2 Switch 2-1 Delay setting (under Setpoints/System/Motor/Setup) to allow inputs for control logic of contactors and breakers at both speeds. The acceleration time at speed 2 becomes functional only if the acceleration time at speed 1 is enabled. When the acceleration time at any speed is not required, it can be permanently blocked.

CURRENT

Range: 1.00 to 10.00 x FLA in steps of 0.01
Default: 6.00 x FLA

MODE

Range: Definite Time, Adaptive
Default: Definite Time

ACCEL TIME FR. SPD 1-2

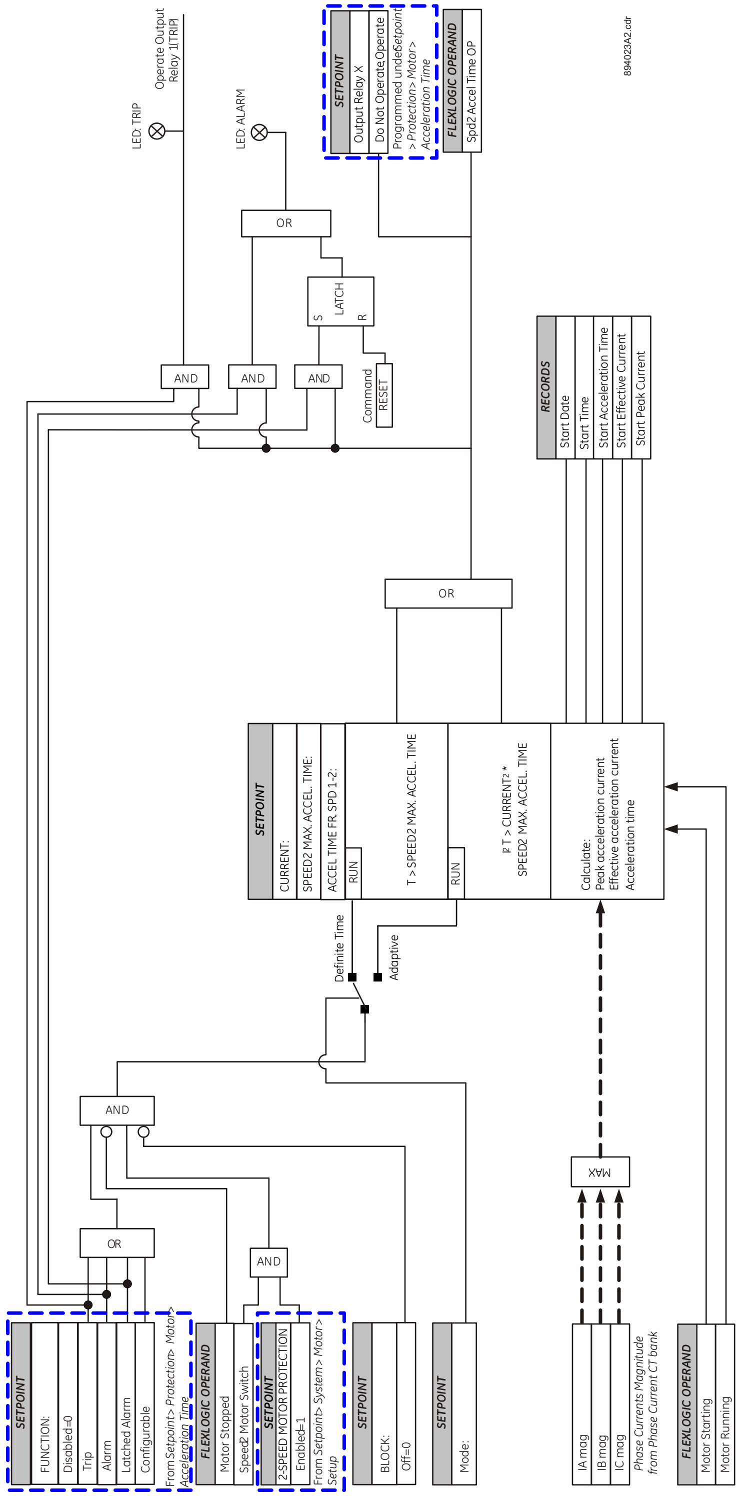
Range: 0.50 to 180.00 s in steps of 0.01
Default: 10.00 s
This setting is provided to select maximum accelerating time from speed 1 to speed 2 when motor is switched from low-to-high speed.

BLOCK

Range: Any FlexLogic Operand

Default: Off

Figure 6-40: Speed2 Acceleration Time logic diagram



2-Speed Undercurrent

Path: Setpoints > Protection > Group1(6) > 2-Speed Motor > Speed2 Undercurrent

If the Speed2 Undercurrent function is enabled, a trip or alarm is initiated once the IA, IB or IC current magnitude falls below the pickup level for a period of time specified by the delay. For example, the undercurrent can be used to detect loss-of load conditions. This can be especially useful for detecting process related problems. This element is active if the motor is running at Speed 2. The undercurrent function at speed 2 becomes functional only if undercurrent at speed 1 is enabled. When the undercurrent function at any speed is not required, it can be permanently blocked.

START BLOCK DELAY

Range: 0.00 to 600.00 in steps of 0.01
Default: 0.50 s

This setting specifies a time to block the undercurrent function when the motor is starting directly at speed 2. Prior to starting, the motor state is determined from the Motor Stopped operand. Refer to the Motor Status section for additional information on the motor stopped state determination. The speed 2 undercurrent element is active only when the motor is running at speed 2 and is blocked upon the initiation of a motor start for a period of time defined by the Start Block DLY setting (for example, this block can be used to allow pumps to build up head before the undercurrent element trips or alarms). A value of zero (0) specifies that the feature is not blocked from start. For values other than zero (0), the feature is disabled when the motor is stopped and also from the time a start is detected until the time entered expires. A one second delay is added to prevent wrong operation of the element when motor is switched from speed 1 to speed 2.

TRIP PICKUP

Range: 0.10 to 0.95 x FLA in steps of 0.01 x FLA
Default: 0.70 x FLA

TRIP PICKUP DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s
Default: 1.00 s

TRIP DROPOUT DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s
Default: 1.00 s

ALARM PICKUP

Range: 0.10 to 0.95 x FLA in steps of 0.01 x FLA
Default: 0.70 x FLA

ALARM PICKUP DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s
Default: 1.00 s

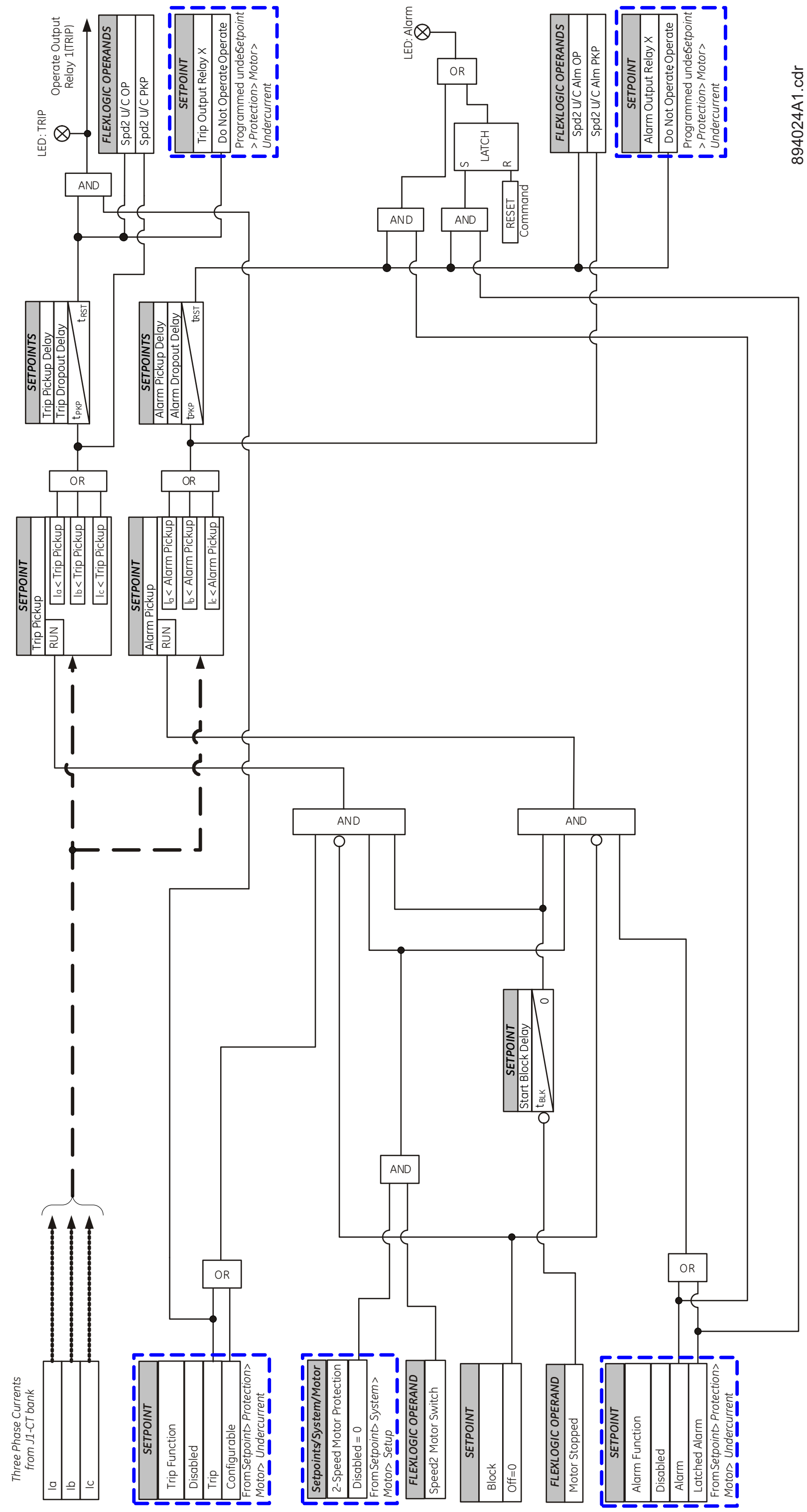
ALARM DROPOUT DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s
Default: 1.00 s

BLOCK

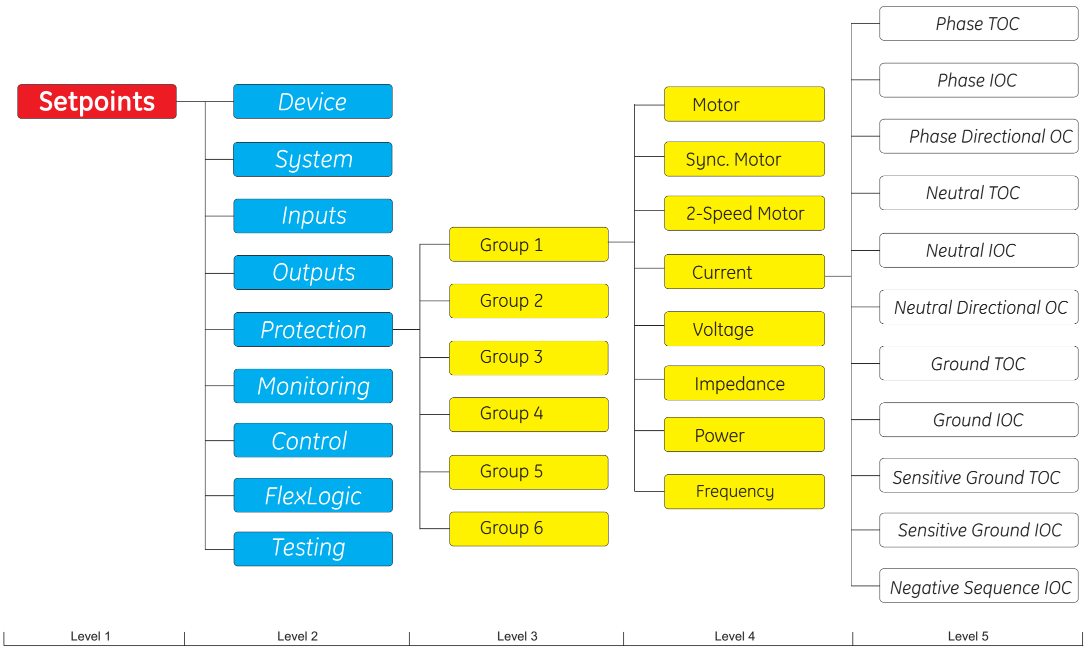
Range: Off, Any FlexLogic operand
Default: Off

Figure 6-41: Undercurrent logic diagram



Current Elements

Figure 6-42: Current Elements Display Hierarchy



Description

The relay has six setpoint groups with phase, neutral, and ground elements per group. 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.

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.

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 6-4: 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	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 6-5: 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 6-6: 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 6-7: 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 6-8: 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:

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

Where:

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

Table 6-9: 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 6-10: IEC CURVE TRIP TIMES (IN SECONDS)

MULTIPLIER (TDM)	CURRENT (I/I_{pickup})								
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
IEC CURVE A										
0.05	0.860	0.501	0.315	0.249	0.214	0.192	0.176	0.165	0.156	0.149
0.10	1.719	1.003	0.630	0.498	0.428	0.384	0.353	0.330	0.312	0.297
0.20	3.439	2.006	1.260	0.996	0.856	0.767	0.706	0.659	0.623	0.594
0.40	6.878	4.012	2.521	1.992	1.712	1.535	1.411	1.319	1.247	1.188
0.60	10.317	6.017	3.781	2.988	2.568	2.302	2.117	1.978	1.870	1.782
0.80	13.755	8.023	5.042	3.984	3.424	3.070	2.822	2.637	2.493	2.376
1.00	17.194	10.029	6.302	4.980	4.280	3.837	3.528	3.297	3.116	2.971
IEC CURVE B										
0.05	1.350	0.675	0.338	0.225	0.169	0.135	0.113	0.096	0.084	0.075
0.10	2.700	1.350	0.675	0.450	0.338	0.270	0.225	0.193	0.169	0.150
0.20	5.400	2.700	1.350	0.900	0.675	0.540	0.450	0.386	0.338	0.300
0.40	10.800	5.400	2.700	1.800	1.350	1.080	0.900	0.771	0.675	0.600
0.60	16.200	8.100	4.050	2.700	2.025	1.620	1.350	1.157	1.013	0.900
0.80	21.600	10.800	5.400	3.600	2.700	2.160	1.800	1.543	1.350	1.200
1.00	27.000	13.500	6.750	4.500	3.375	2.700	2.250	1.929	1.688	1.500
IEC CURVE C										
0.05	3.200	1.333	0.500	0.267	0.167	0.114	0.083	0.063	0.050	0.040
0.10	6.400	2.667	1.000	0.533	0.333	0.229	0.167	0.127	0.100	0.081
0.20	12.800	5.333	2.000	1.067	0.667	0.457	0.333	0.254	0.200	0.162
0.40	25.600	10.667	4.000	2.133	1.333	0.914	0.667	0.508	0.400	0.323
0.60	38.400	16.000	6.000	3.200	2.000	1.371	1.000	0.762	0.600	0.485
0.80	51.200	21.333	8.000	4.267	2.667	1.829	1.333	1.016	0.800	0.646
1.00	64.000	26.667	10.000	5.333	3.333	2.286	1.667	1.270	1.000	0.808
IEC SHORT INVERSE										

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
0.05	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:

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

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 6-11: 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 6-12: IAC CURVE TRIP TIMES (IN SECONDS)

MULTIPLIER (TDM)	CURRENT (I/I_{pickup})									
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
IAC EXTREMELY INVERSE										
0.5	1.699	0.749	0.303	0.178	0.123	0.093	0.074	0.062	0.053	0.046
1.0	3.398	1.498	0.606	0.356	0.246	0.186	0.149	0.124	0.106	0.093
2.0	6.796	2.997	1.212	0.711	0.491	0.372	0.298	0.248	0.212	0.185
4.0	13.591	5.993	2.423	1.422	0.983	0.744	0.595	0.495	0.424	0.370
6.0	20.387	8.990	3.635	2.133	1.474	1.115	0.893	0.743	0.636	0.556
8.0	27.183	11.987	4.846	2.844	1.966	1.487	1.191	0.991	0.848	0.741
10.0	33.979	14.983	6.058	3.555	2.457	1.859	1.488	1.239	1.060	0.926
IAC VERY INVERSE										
0.5	1.451	0.656	0.269	0.172	0.133	0.113	0.101	0.093	0.087	0.083
1.0	2.901	1.312	0.537	0.343	0.266	0.227	0.202	0.186	0.174	0.165
2.0	5.802	2.624	1.075	0.687	0.533	0.453	0.405	0.372	0.349	0.331

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
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 6-13: I^2T CURVE TRIP TIMES (IN SECONDS)

MULTIPLIER (TDM)	CURRENT (I/I_{pickup})									
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
0.01	0.44	0.25	0.11	0.06	0.04	0.03	0.02	0.02	0.01	0.01
0.10	4.44	2.50	1.11	0.63	0.40	0.28	0.20	0.16	0.12	0.10
1.00	44.44	25.00	11.11	6.25	4.00	2.78	2.04	1.56	1.23	1.00
10.00	444.44	250.00	111.11	62.50	40.00	27.78	20.41	15.63	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 6-14: 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.

$$T = TDM\ in\ seconds,\ when\ I > I_{pickup}$$
$$T_{RESET} = TDM\ in\ seconds$$

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 869 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

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

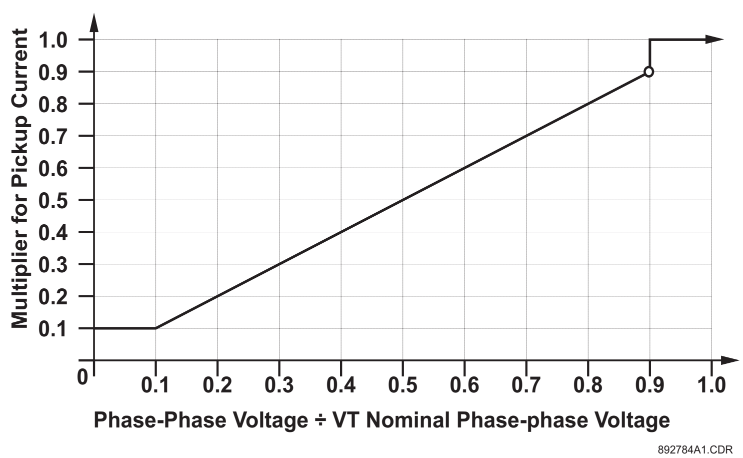
Range: Disabled, Enabled
Default: Disabled

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 6-43: Voltage Restraint characteristics for Phase TOC



BLOCK

Range: Off, Any FlexLogic operand
Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

EVENTS

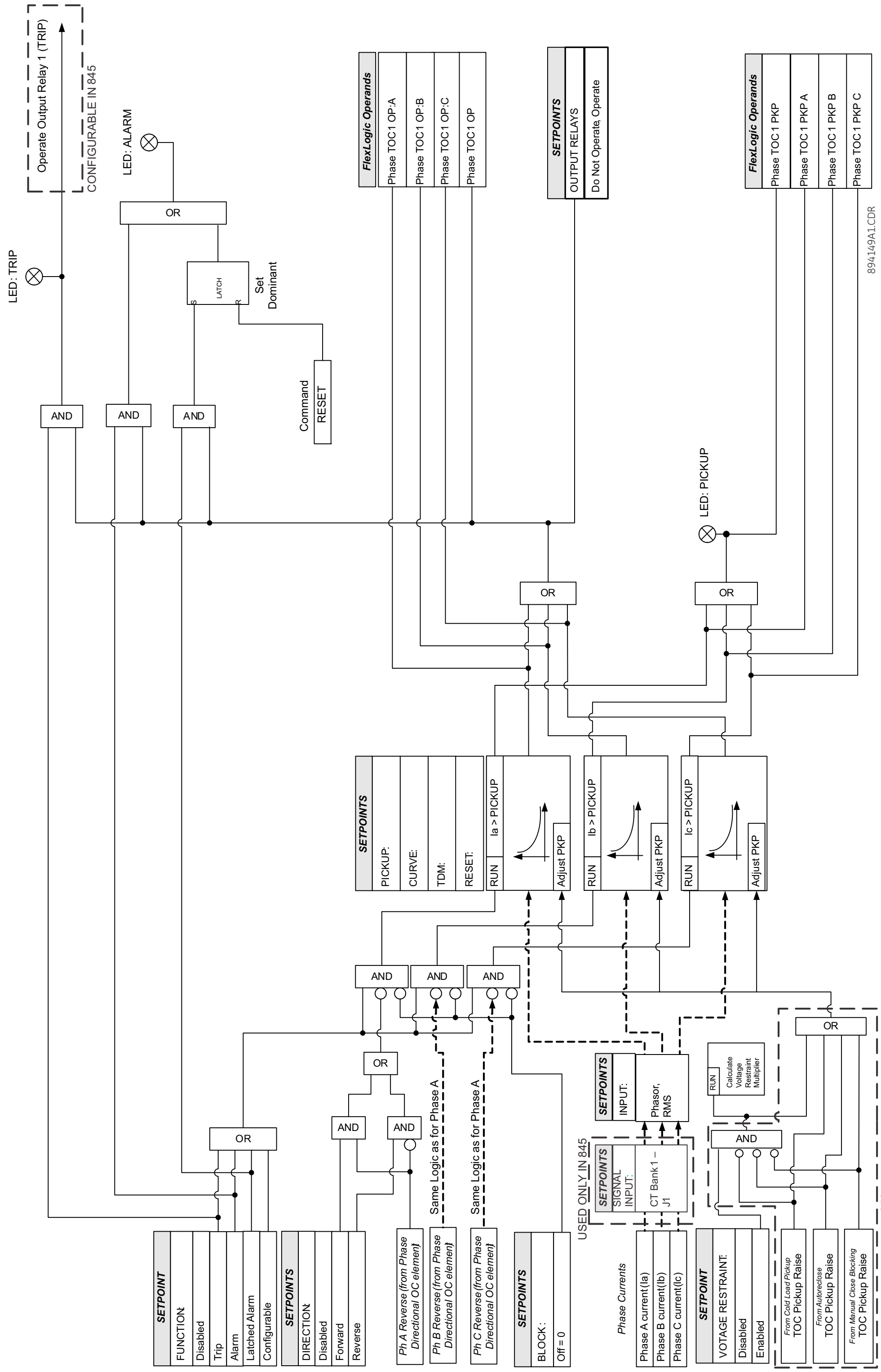
Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Self-reset, Latched, Disabled

Default: Self-reset

Figure 6-44: Phase Time Overcurrent Protection logic diagram



Phase Instantaneous Overcurrent Protection (50P)

The 869 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

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.

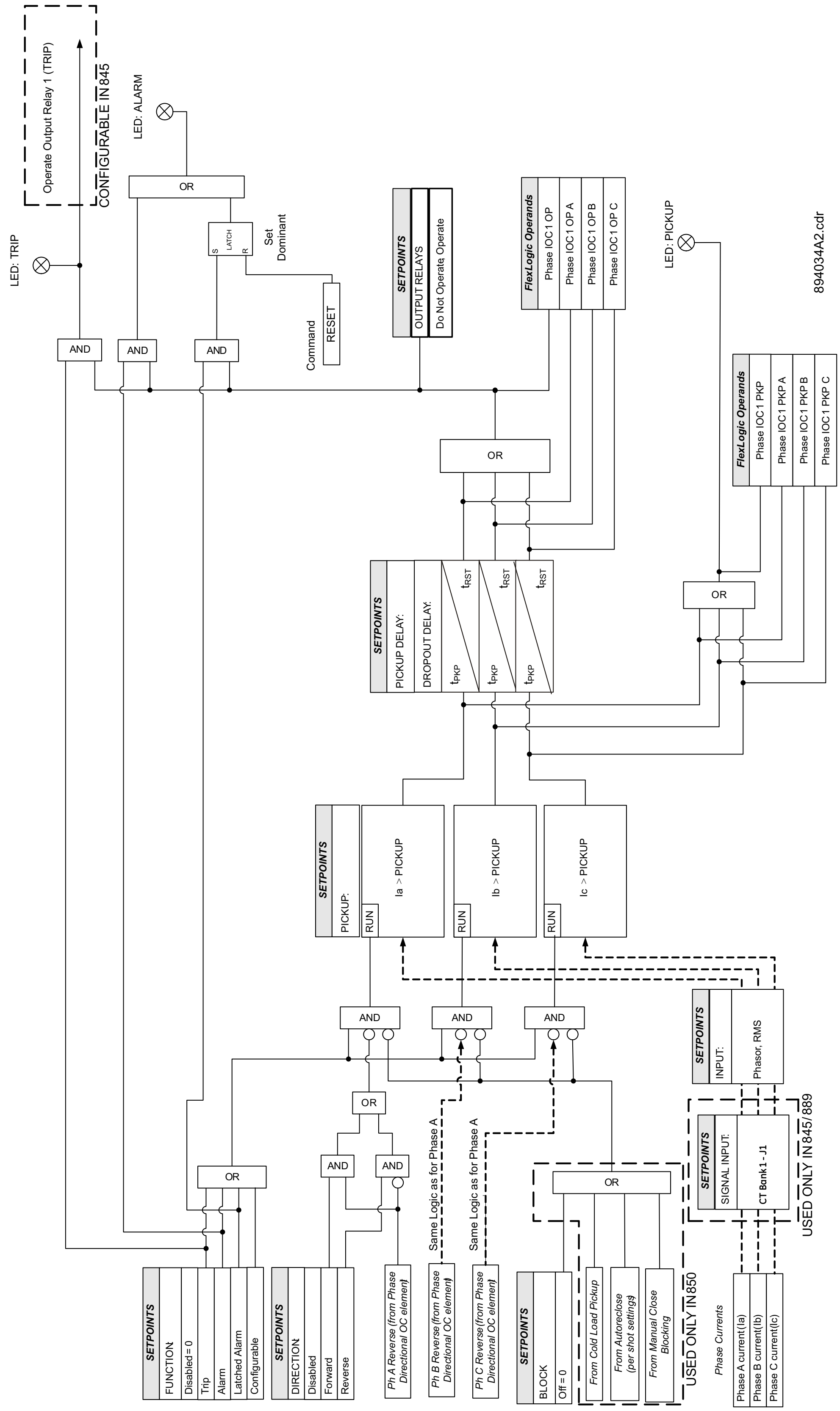
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

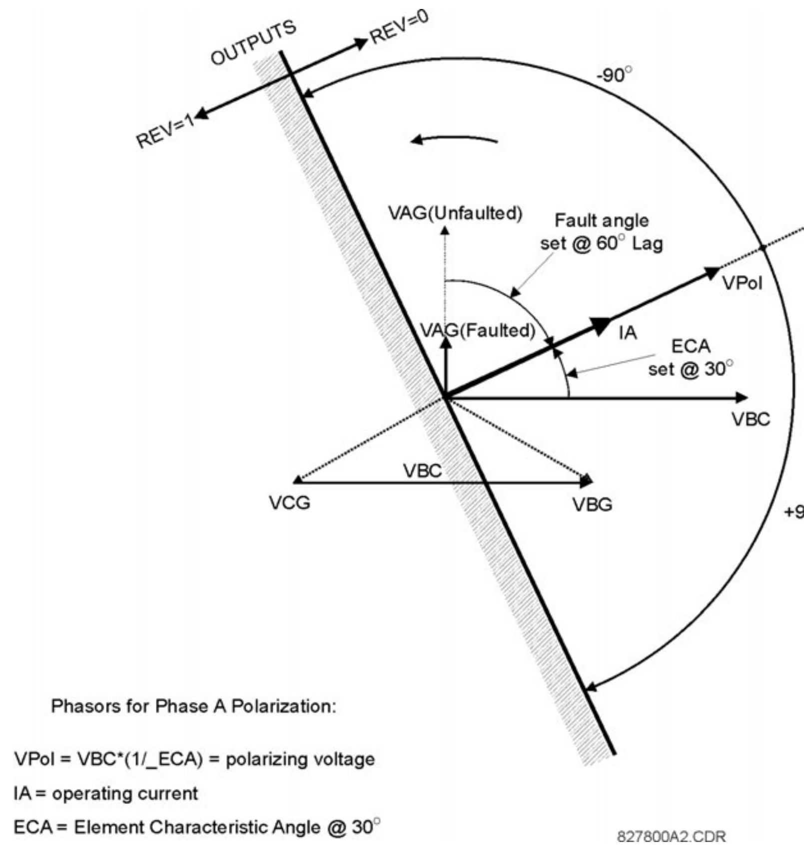
Range: Self-reset, Latched, Disabled
Default: Self-reset

Figure 6-45: Phase Instantaneous Overcurrent logic diagram



Phase Directional Overcurrent Protection (67P)

The 869 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			
		VT-Phase-Rotation: ABC CT-Phase-Rotation: ABC	VT-Phase-Rotation: ABC CT-Phase-Rotation: ACB	VT-Phase-Rotation: ACB CT-Phase-Rotation: ABC	VT-Phase-Rotation: ACB CT-Phase-Rotation: ACB
A	Angle of Ia	Angle of Vbc × (1∠ECA)	Angle of Vbc × (1∠ECA)	Angle of Vcb × (1∠ECA)	Angle of Vcb × (1∠ECA)
B	Angle of Ib	Angle of Vca × (1∠ECA)	Angle of Vab × (1∠ECA)	Angle of Vba × (1∠ECA)	Angle of Vac × (1∠ECA)
C	Angle of Ic	Angle of Vab × (1∠ECA)	Angle of Vca × (1∠ECA)	Angle of Vac × (1∠ECA)	Angle of Vba × (1∠ECA)

Path: **Setpoints > Protection > Group1(6) > Current > Phase Dir OC 1(X)**

FUNCTION

Range: Disabled, Enabled
Default: Disabled

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

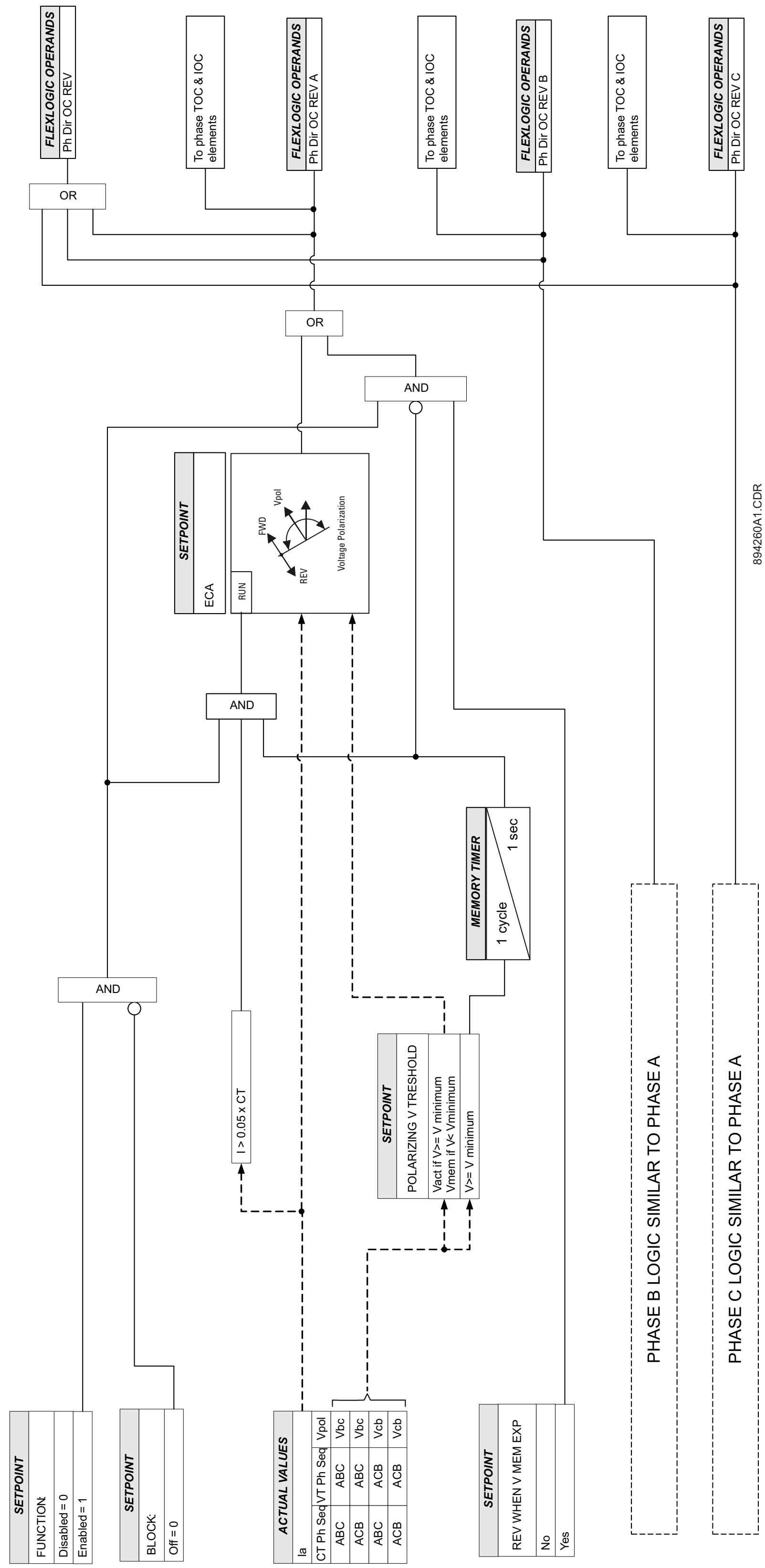
TARGETS

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 6-46: Phase Directional Overcurrent Protection logic diagram



Neutral Time Overcurrent Protection (51N)

The 869 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

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.

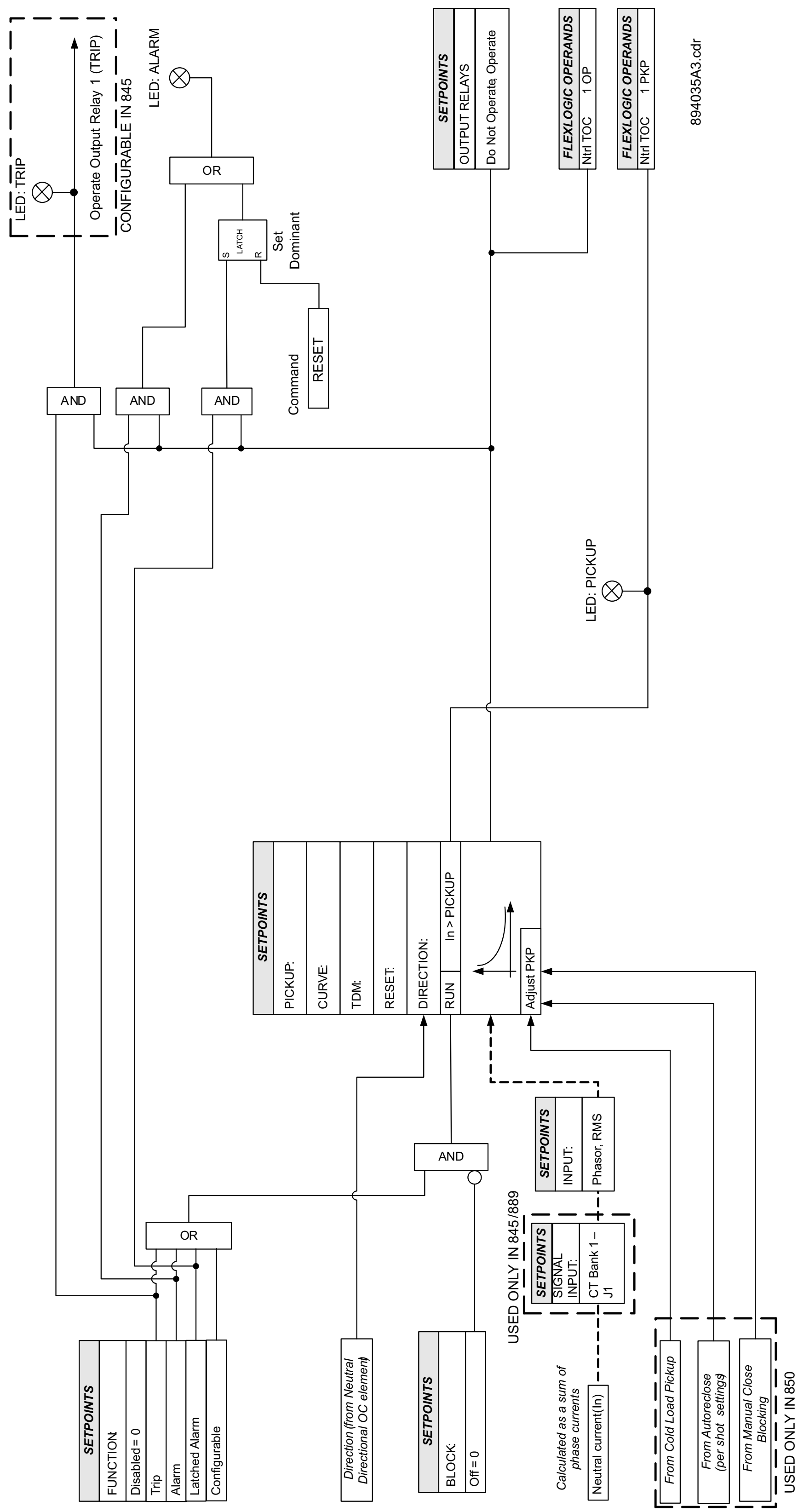
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Self-reset, Latched, Disabled
Default: Self-reset

Figure 6-47: Neutral Time Overcurrent Protection logic diagram



Neutral Instantaneous Overcurrent Protection (50N)

The 869 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

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.

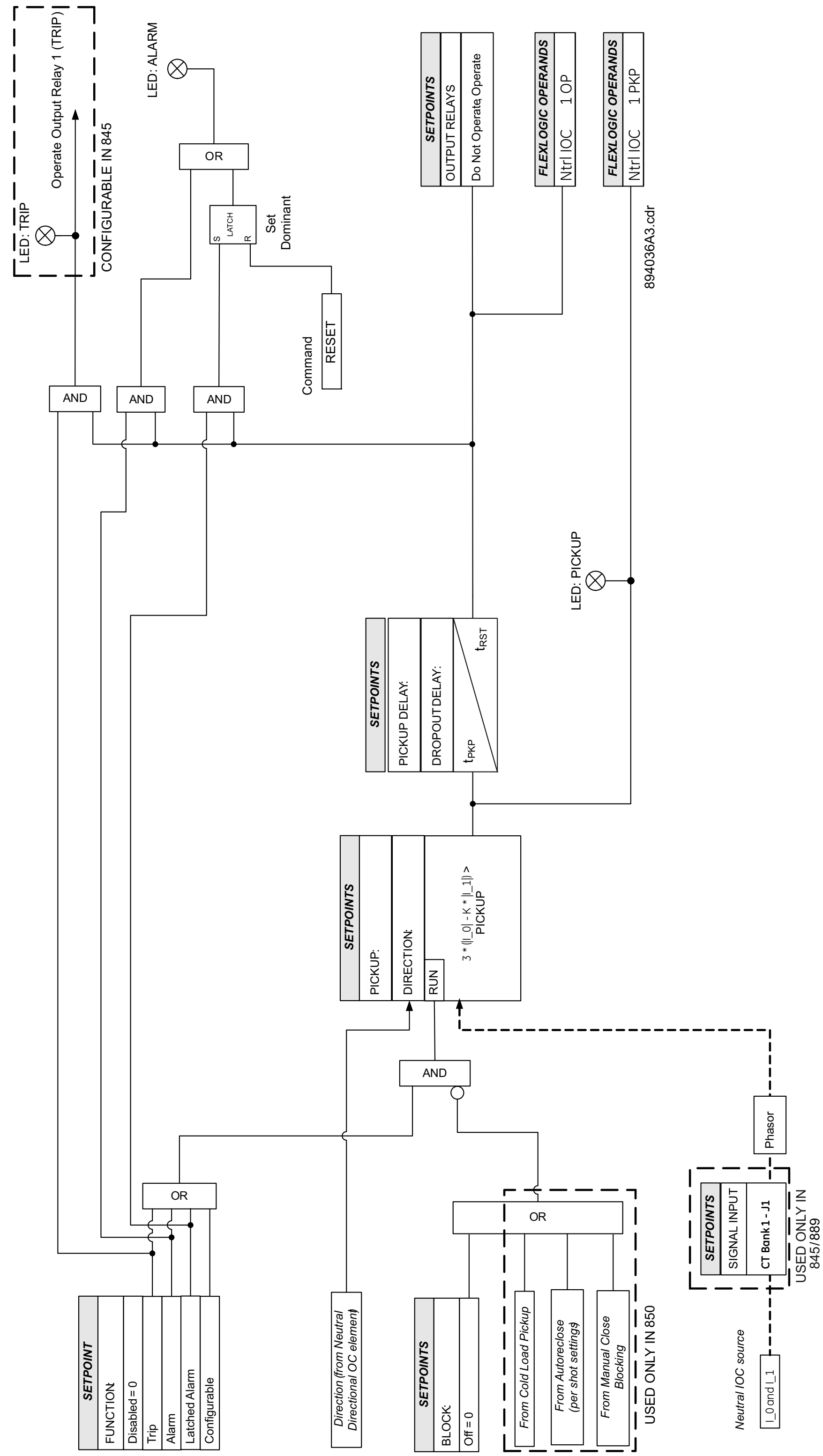
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Self-reset, Latched, Disabled
Default: Self-reset

Figure 6-48: Neutral Instantaneous Overcurrent Protection logic diagram



Neutral Directional Overcurrent Protection (67N)

The 869 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) × Iinjected ; three-phase pure zero-sequence injection: Iop = 3 × 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.

DIRECTIONAL UNIT				OVERCURRENT UNIT
POLARIZING MODE	DIRECTION	COMPARED PHASORS		
Voltage	Forward	–V_0	I_0 × 1∠ECA	Iop = 3 × (|I_0| – K × |I_1|) if |I_1| > 0.8 x CT
	Reverse	–V_0	–I_0 × 1∠ECA	
Current	Forward	Ig	I_0	
	Reverse	Ig	–I_0	
Dual	Forward	–V_0	I_0 × 1∠ECA	Iop = 3 × (|I_0|) if |I_1| ≤ 0.8 x CT
		or		
		Ig	I_0	
	Reverse	–V_0	–I_0 × 1∠ECA	
		or		
		Ig	–I_0	

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

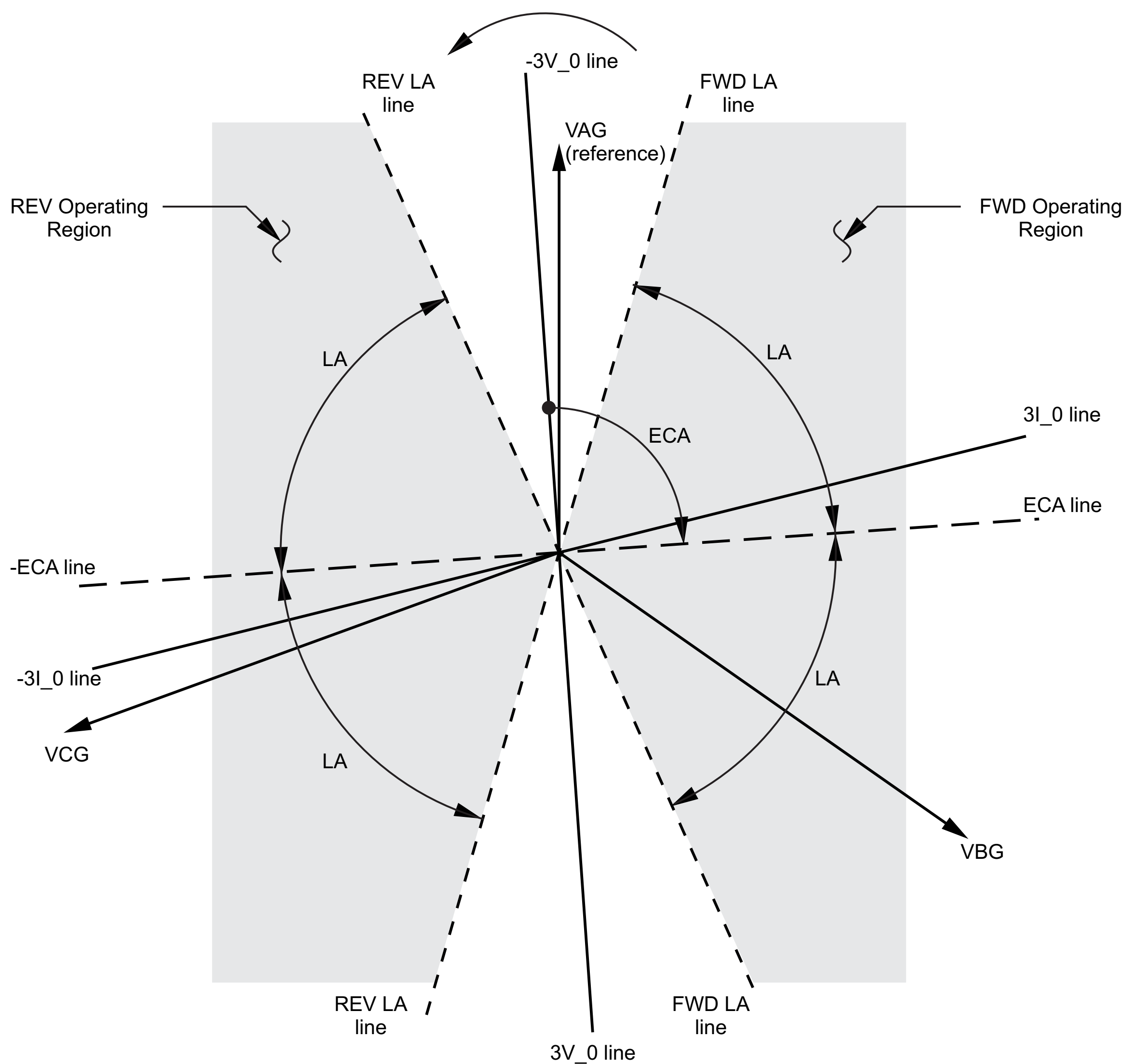
REV LA = 80° (reverse limit angle = the ± angular limit with the ECA for operation).

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.

Figure 6-49: 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 × CT in steps of 0.001 × CT
Default: 0.050 × 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 × CT in steps of 0.001 × CT
Default: 0.050 × 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

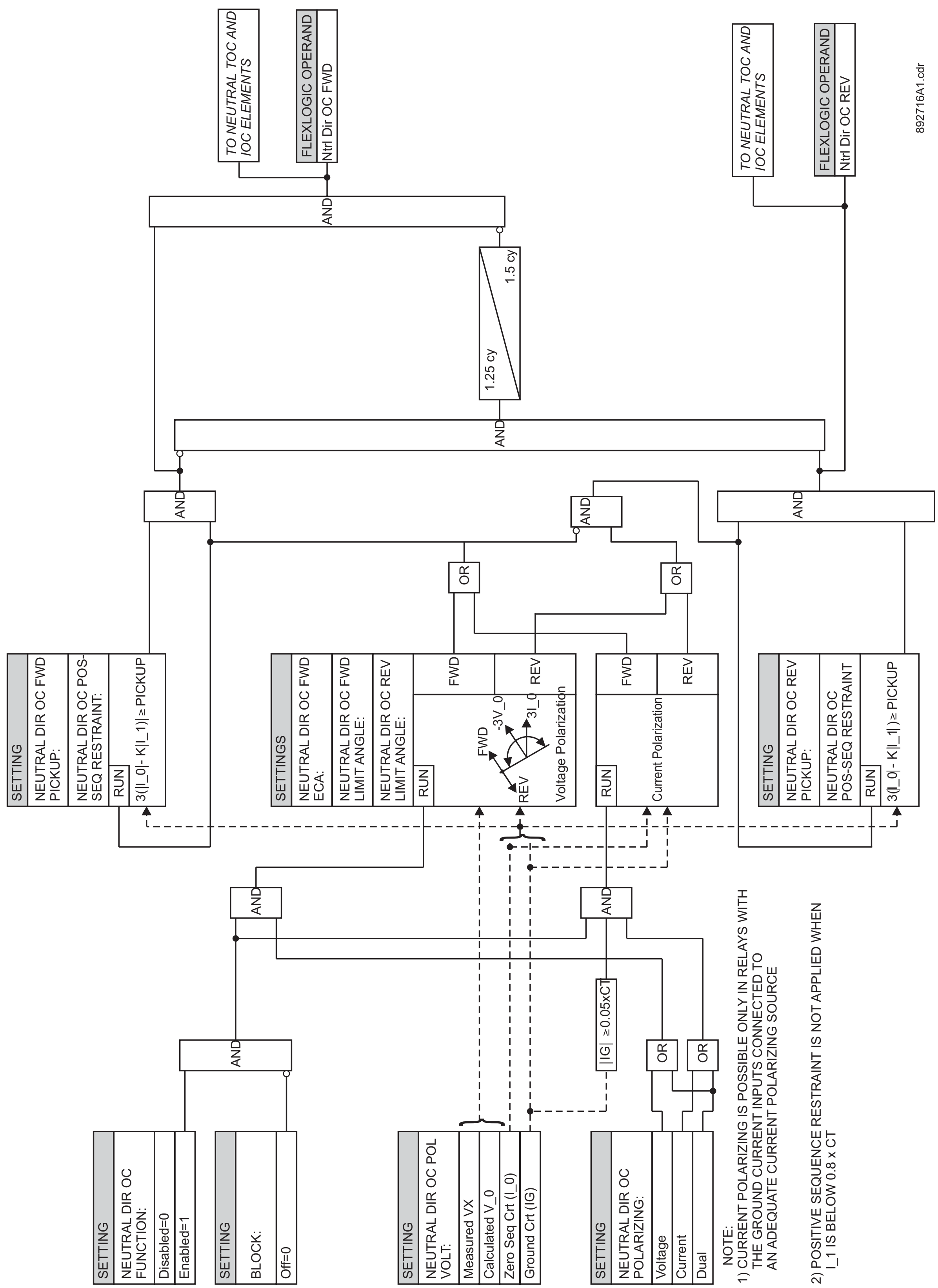
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Self-reset, Latched, Disabled
Default: Self-reset

Figure 6-50: Neutral Directional Overcurrent Protection logic diagram



Ground Time Overcurrent Protection (51G)

The 869 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.

Path: **Setpoints > Protection > Group 1(6) > Current > Ground TOC 1(X)**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

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

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

EVENTS

Range: Enabled, Disabled
Default: Enabled

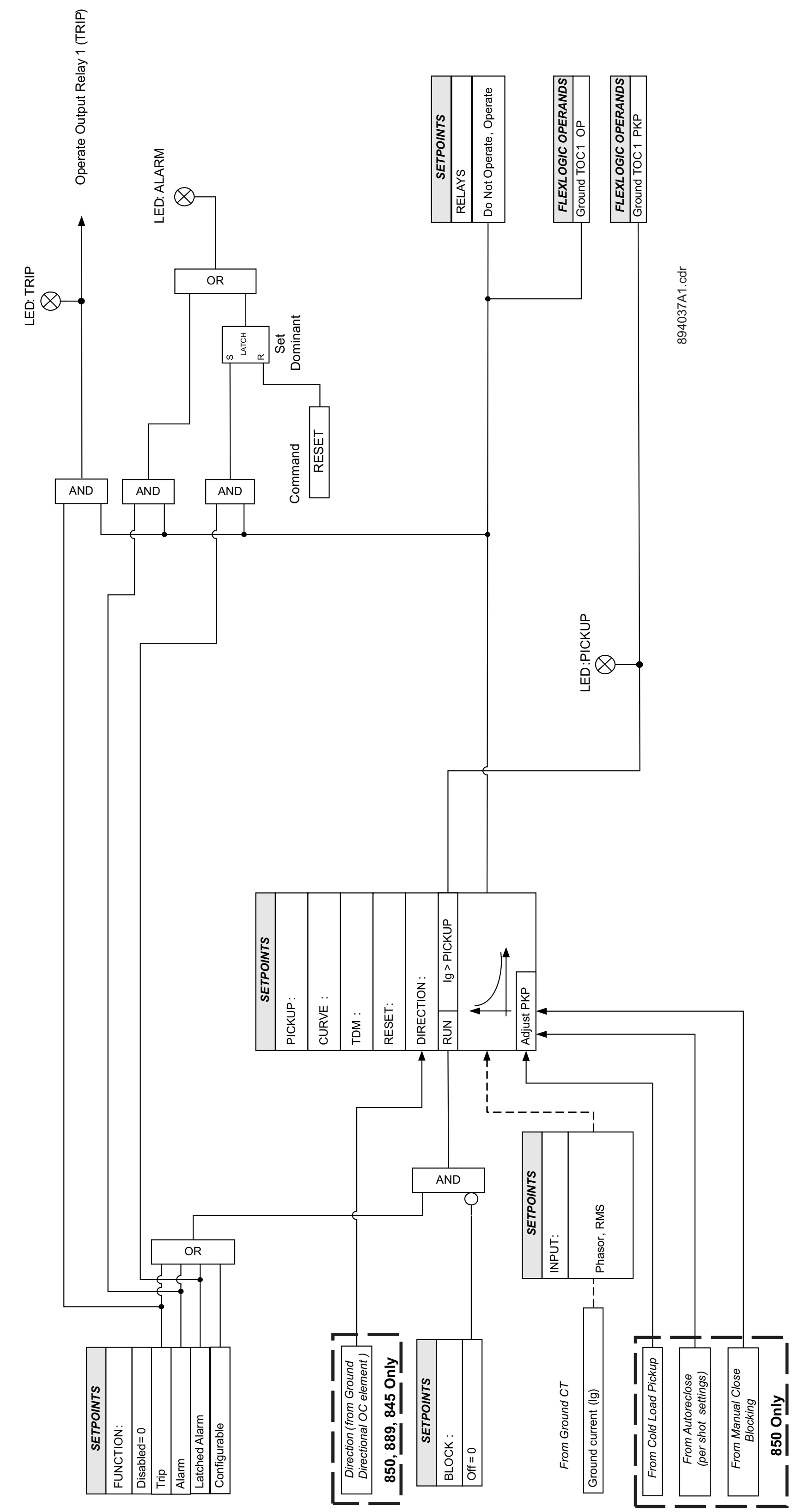
TARGETS

Range: Self-reset, Latched, Disabled
Default: Self-reset

NOTICE

In an 869 relay with ground current order code option 5B, the signal input to the Ground Time Overcurrent element is from Slot-K1 Ig; otherwise Slot-J1 Ig is used.

Figure 6-51: Ground Time Overcurrent Protection logic diagram



Ground Instantaneous Overcurrent Protection (50G)

The 869 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

PICKUP

Range: 0.050 to 30.000 x CT in steps of 0.001 x CT
Default: 1.00 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

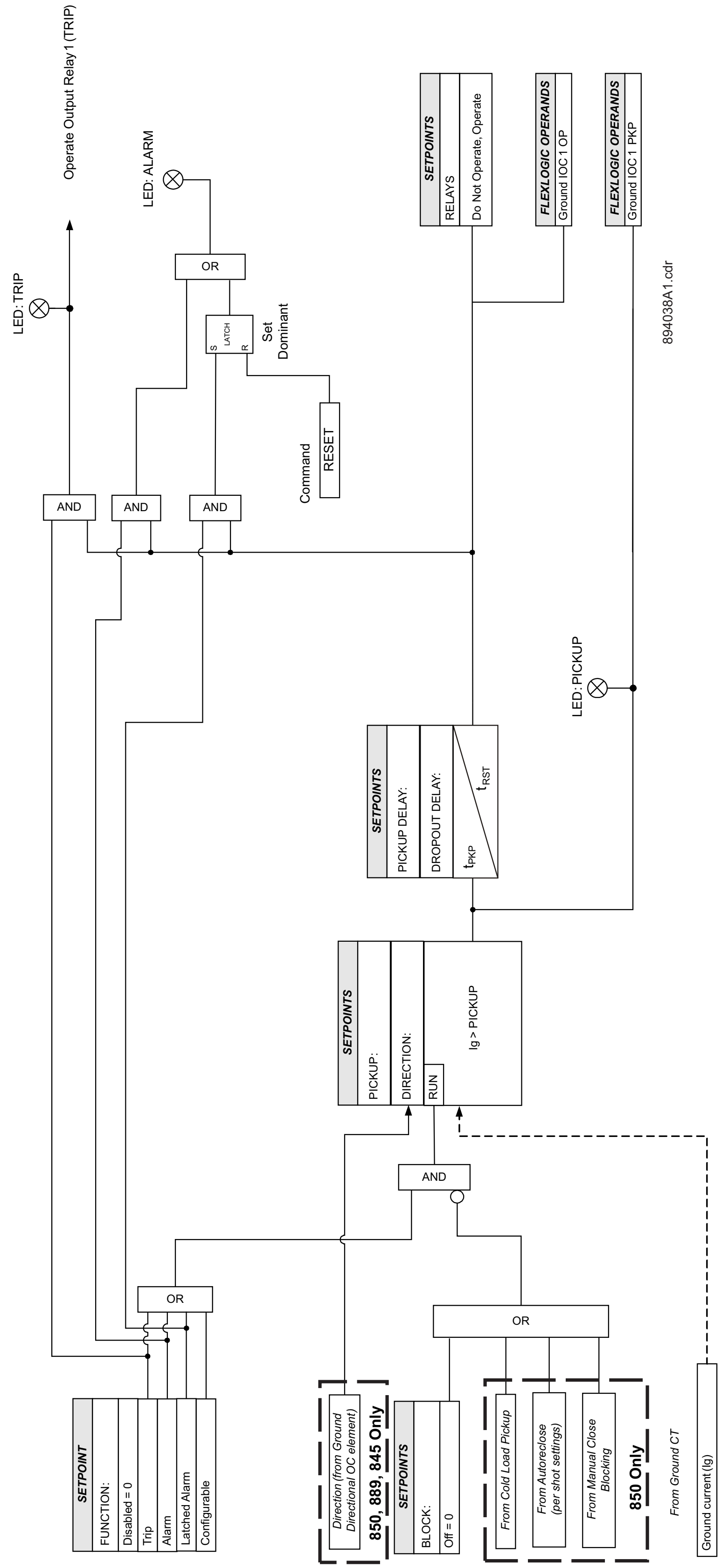
TARGETS

Range: Self-reset, Latched, Disabled
Default: Self-reset

NOTICE

In an 869 relay with ground current order code option 5B, the signal input to the Ground Time Overcurrent element is from Slot-K1 Ig; otherwise Slot-J1 Ig is used.

Figure 6-52: Ground Instantaneous Overcurrent Protection logic diagram



Sensitive Ground Time Overcurrent Protection (51SG)

The 869 is equipped with the Sensitive Ground Time Overcurrent protection element. The settings of this function are applied to the Sensitive Ground input current to produce Trip or Pickup flags. The Sensitive Ground TOC Pickup flag is asserted when the Sensitive Ground current is above the PKP value. The Sensitive 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 97-98% of the Pickup value before the time for operation is reached. When Definite Time is selected, the time for Sensitive Ground TOC operation is defined only by the TDM setting.

Path: **Setpoints > Protection > Group 1(6) > Current > Sensitive Ground TOC 1(X)**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

INPUT

Range: Phasor, RMS
Default: Phasor

This selection defines the method of processing of the current signal. It can be Root Mean Square (RMS) or Fundamental Phasor Magnitude.

PICKUP

Range: 0.005 to 3.000 x CT in steps of 0.001 x CT
Default: 1.000 x CT

The 50:0.025 Ground input (K1-Ig) range is as follows:

Range: 0.50 to 15.00 A in steps of 0.01 A
Default: 10.00 A

This setting sets the sensitive ground overcurrent pickup level specified as a multiplier of the nominal CT current. For example, a PKP setting of 0.9 x CT with 300:5 CT translates into 270A primary current.

In the case of 50:0.025 Ground input (K1-Ig as current input), the pickup level is specified as Ampere in primary. For example, with a PKP setting of 10.00 A, when ground current (primary) is 10.00A, the K1-Ig will measure 10.000 A, and this function should pick up.

CURVE

Range: IEEE Extremely/Very/Moderately Inverse,
ANSI Extremely/Very/Normally/Moderately Inverse,
IEC A/B/C and Short Inverse,
IAC Extremely/Very/Inverse/Short Inverse,
I2t, I4t, FlexCurve A/B/C/D, Definite time
Default: IEEE Mod 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 the selection for 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 occur but not before 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 by this setting. If Instantaneous reset is selected, the Sensitive Ground TOC element will reset instantaneously providing the current drops below 97-98% of the Sensitive Ground TOC PKP level, before the time for operation is reached.

DIRECTION

Range: Disabled, Forward, Reverse

Default: Disabled

This setting defines the operation direction of the Sensitive Ground TOC element. Entering the direction for the Sensitive Ground TOC element does not automatically apply the selection. The direction detection is performed by the element Sensitive Ground Directional OC, which must be enabled and configured according to the directionality criteria of the feeder currents.

BLOCK

Range: Off, Any FlexLogic operand

Default: Off

The Sensitive Ground TOC is blocked, when the selected operand is asserted.

OUTPUT RELAY X

For details see Common Setpoints.

EVENTS

Range: Enabled, Disabled

Default: Enabled

The selection of the Enabled setting enables the events of Sensitive Ground TOC function.

TARGETS

Range: Self-reset, Latched, Disabled

Default: Self-reset

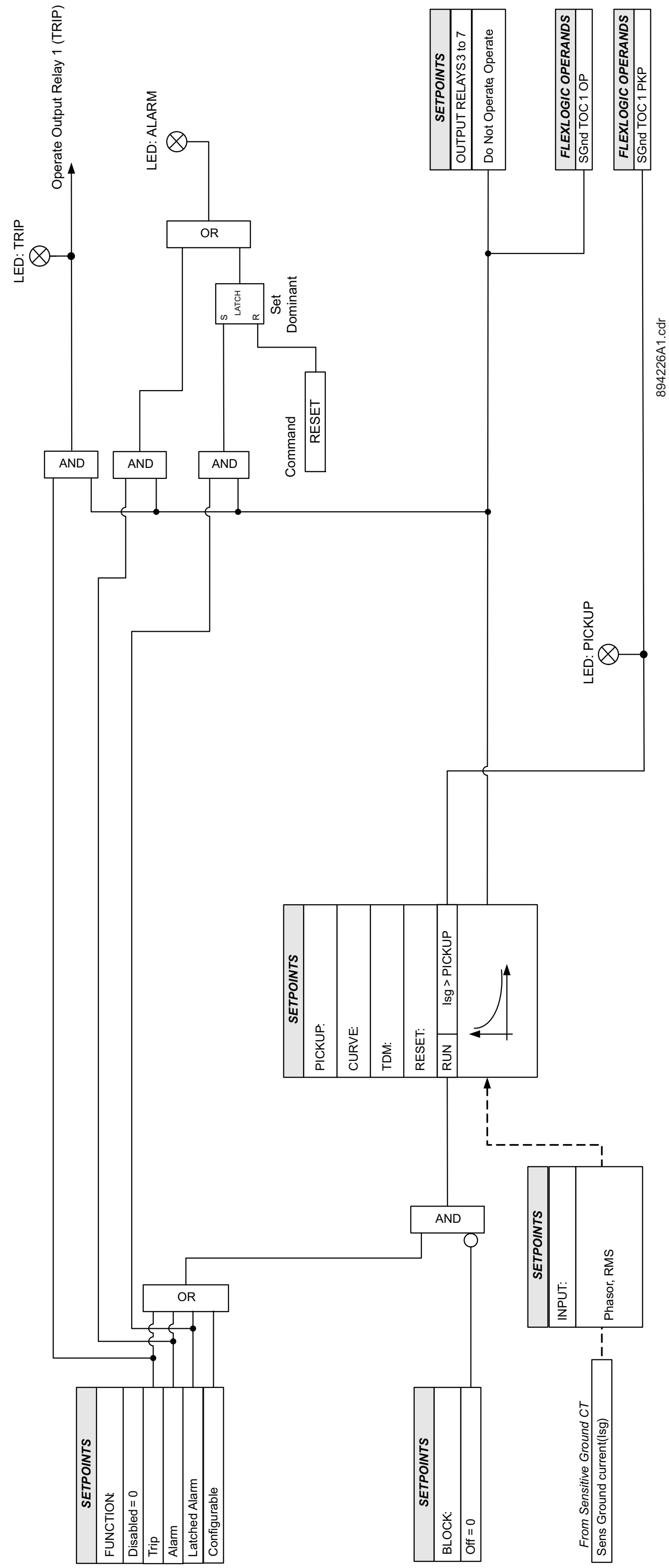
The selection of Self-reset or Latched settings enables the targets of the Sensitive Ground TOC function.

NOTICE

In an 869 relay the signal input to the Sensitive Ground Time Overcurrent element depends on the ground current order code option:

- Slot-J1 Ig (50:0.025 type) with option 5B/0B
- Slot-K1 Ig (50:0.025 type) with option B1/B5
- Slot- K1 - Sen Ig (1A/5A type) with option S1

Figure 6-53: Sensitive Ground Time Overcurrent Protection logic diagram



Sensitive Ground Instantaneous Overcurrent Protection (50SG)

The 869 relay is equipped with Sensitive Ground Instantaneous Overcurrent protection element. The settings of this function are applied to the measured Sensitive Ground current for producing Pickup and Trip flags. The Sensitive Ground IOC Pickup flag is asserted when the Sensitive Ground current is above the PKP value. The Sensitive Ground IOC Operate flag is asserted if the element stays picked-up for the time defined by the Sensitive Ground IOC PKP Delay setting. If the Pickup time delay is set to 0.00 seconds, the Pickup and Operate flags are asserted at the same time. The element drops from Pickup without operation if the Sensitive Ground current drops below 97 to 98% of the Pickup value.

Path: **Setpoints > Protection > Group 1(6) > Current > Sensitive Ground IOC 1(X)**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

PICKUP

Range: 0.005 to 3.000 x CT in steps of 0.001 x CT
Default: 1.000 x CT

The 50:0.025 Ground input (K1-Ig) range is as follows:

Range: 0.50 to 15.00 A in steps of 0.01 A
Default: 10.00 A

This setting sets the instantaneous Sensitive Ground overcurrent pickup level specified as a multiplier of the nominal CT current for sensitive CT input. For example, a PKP setting of 0.9 x CT with 300:5 CT translates into 270A primary current.

In the case of 50:0.025 Ground input (K1-Ig as current input), the pickup level is specified as Ampere in primary. For example, with a PKP setting of 10.00 A, when the ground current (primary) is 10.00A, the K1-Ig will measure 10.000 A, and this function should pick up.

PICKUP DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 0.000 s

This setting provides the selection for the pickup time delay used to delay the operation of the protection.

DROPOUT DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 0.000 s

This setting provides the selection for the dropout time delay used to delay the dropout of the detection of the overcurrent condition.

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

The Sensitive Ground IOC is blocked, when the selected operand is asserted.

OUTPUT RELAY X

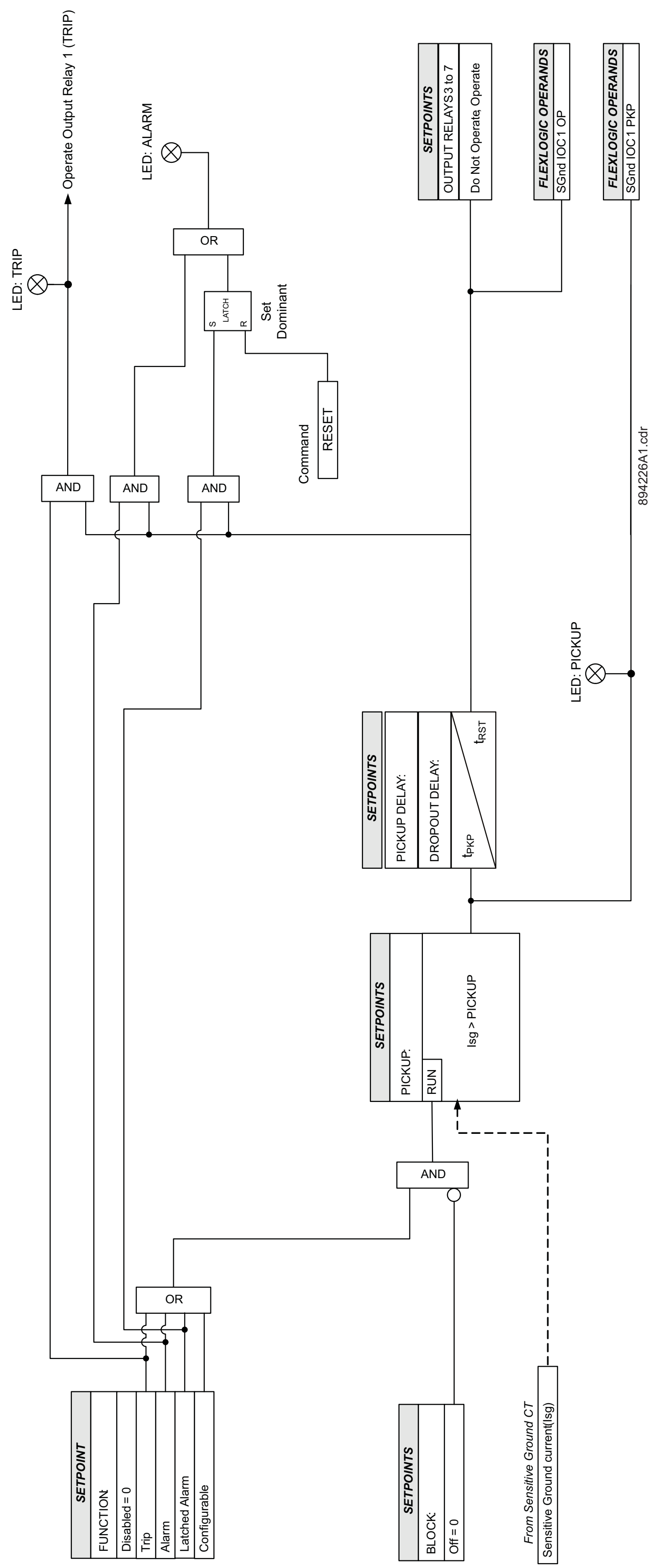
For details see Common Setpoints.

EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS
Range: Self-reset, Latched, Disabled
Default: Self-reset

Figure 6-54: Sensitive Ground Instantaneous Overcurrent Protection logic diagram



Negative Sequence Instantaneous Overcurrent Protection (50_2)

The 869 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 869 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

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.

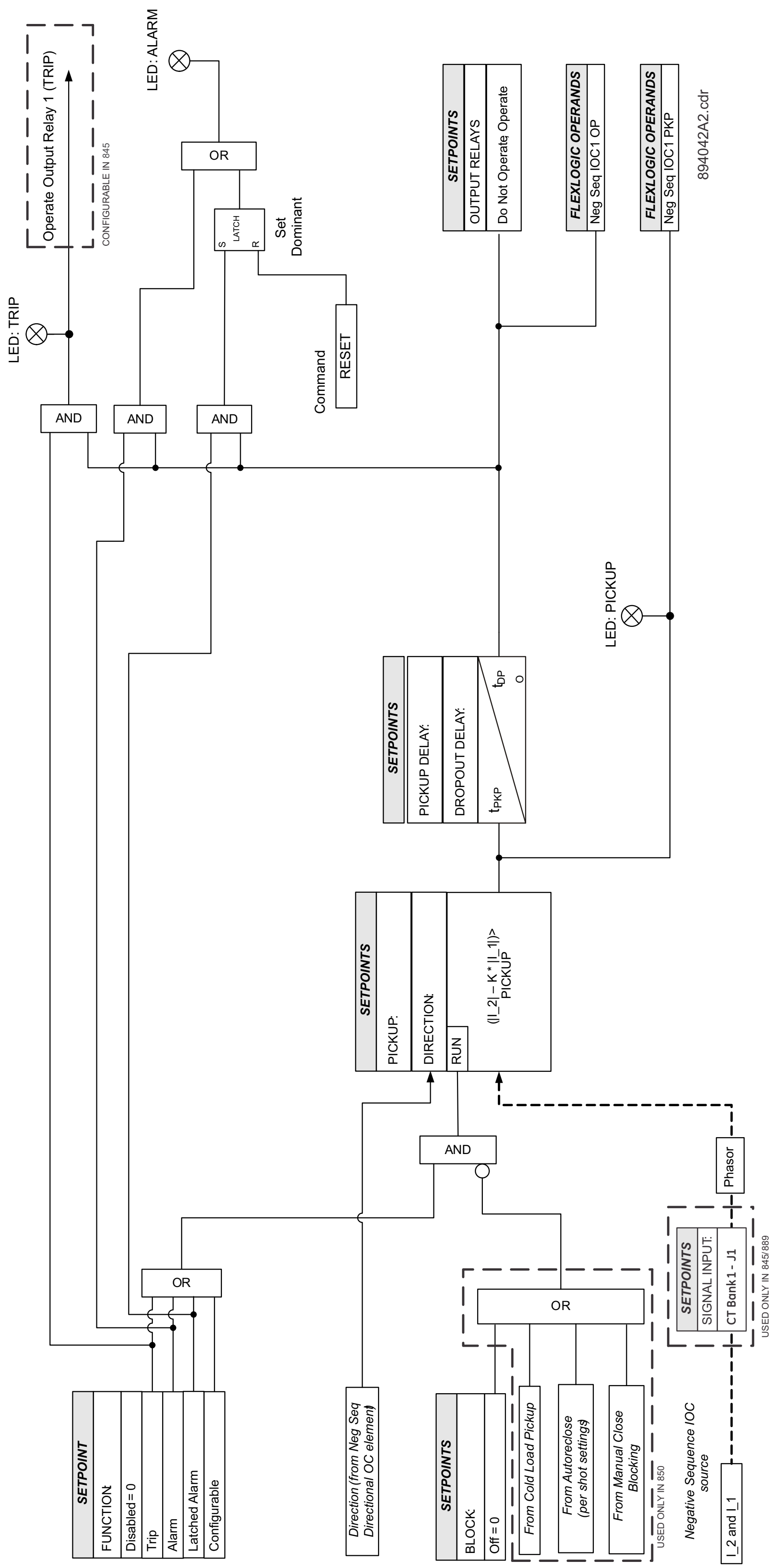
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

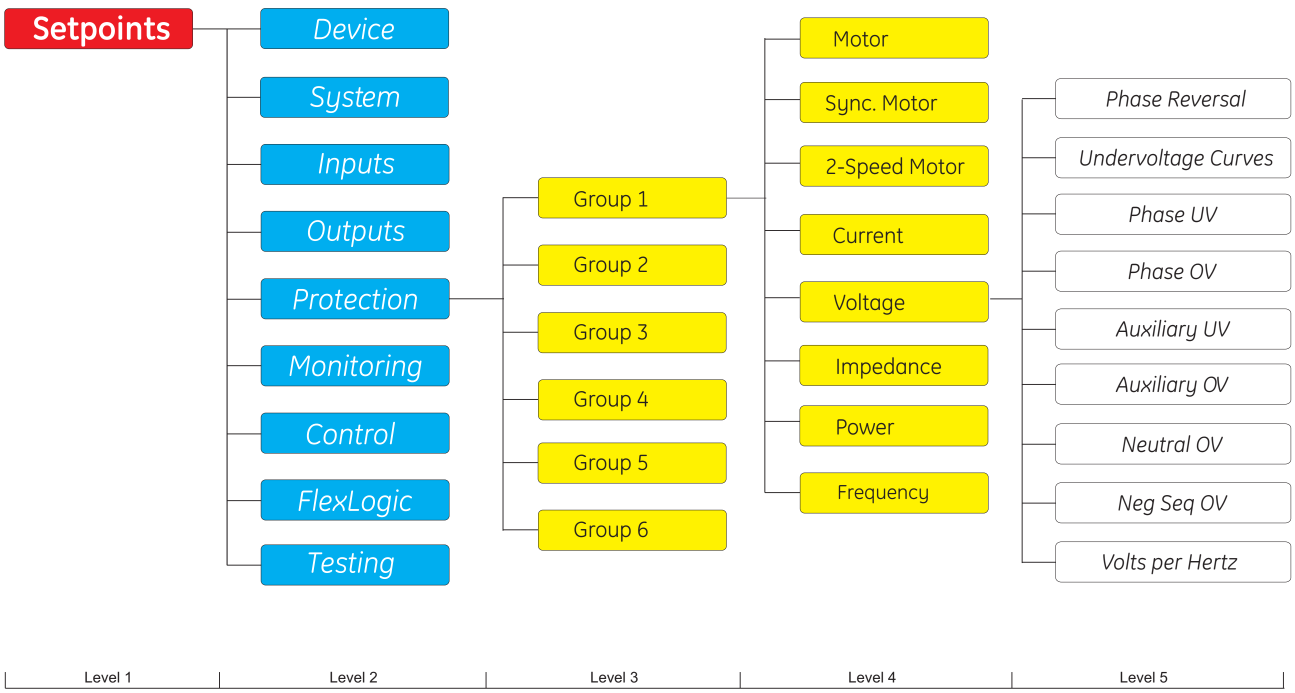
Range: Self-reset, Latched, Disabled
Default: Self-reset

Figure 6-55: Negative Sequence Instantaneous Overcurrent logic diagram



Voltage Elements

Figure 6-56: Voltage Elements Display Hierarchy



Phase Reversal (47)

The 869 can detect the phase rotation of the three phase voltages. When all three Phase-to-Phase Voltages (V_{ab}, V_{bc} and V_{ca}) are greater than 50% of VT, if the phase rotation of the three phase voltages is not the same as the Phase Rotation or Reverse Phase Rotation (under **Setpoints > System > Power System**), and there is no fuse failure, either an alarm or a trip will occur within the programmed Pickup Delay time.

Upon detection of the phase reversal, this element will also issue a Phase Rev Inhibit operand to inhibit starting of a motor.

This element will be blocked automatically by the relay for three cycles when voltage phase rotation dynamically switches from forward to reverse or reverse to forward. Dynamic switching of the phase rotation (ABC<->ACB) can be achieved using the 869 feature Reverse Phase Rotation - VT Bnks. More details can be found in section **Setpoints > System > Power System**.

NOTE: VT is the secondary voltage programmed under Setpoints > System > Voltage Sensing > Phase VT Secondary.

NOTE: In 2 Speed motor application, when 2-Speed Motor Protection is Enabled and Speed2 Motor Switch is On, the setpoint Speed2 Phase Rotation (under **Setpoints > System > Motor System > Setup**) is used by the Phase Reversal element.

Path: Setpoints > Protection > Group 1(6) > Voltage > Phase Reversal

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

This setting enables the Phase Reversal functionality.

PICKUP DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s
Default: 1.00 s

This setting specifies the pickup delay of the element.

DROPOUT DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s
Default: 1.00 s

This setting defines the reset delay of the element.

BLOCK

Range: Any FlexLogic Operand
Default: Off

The Phase Reversal can be blocked by any asserted FlexLogic operand.

OUTPUT RELAY X

For details see Common Setpoints.

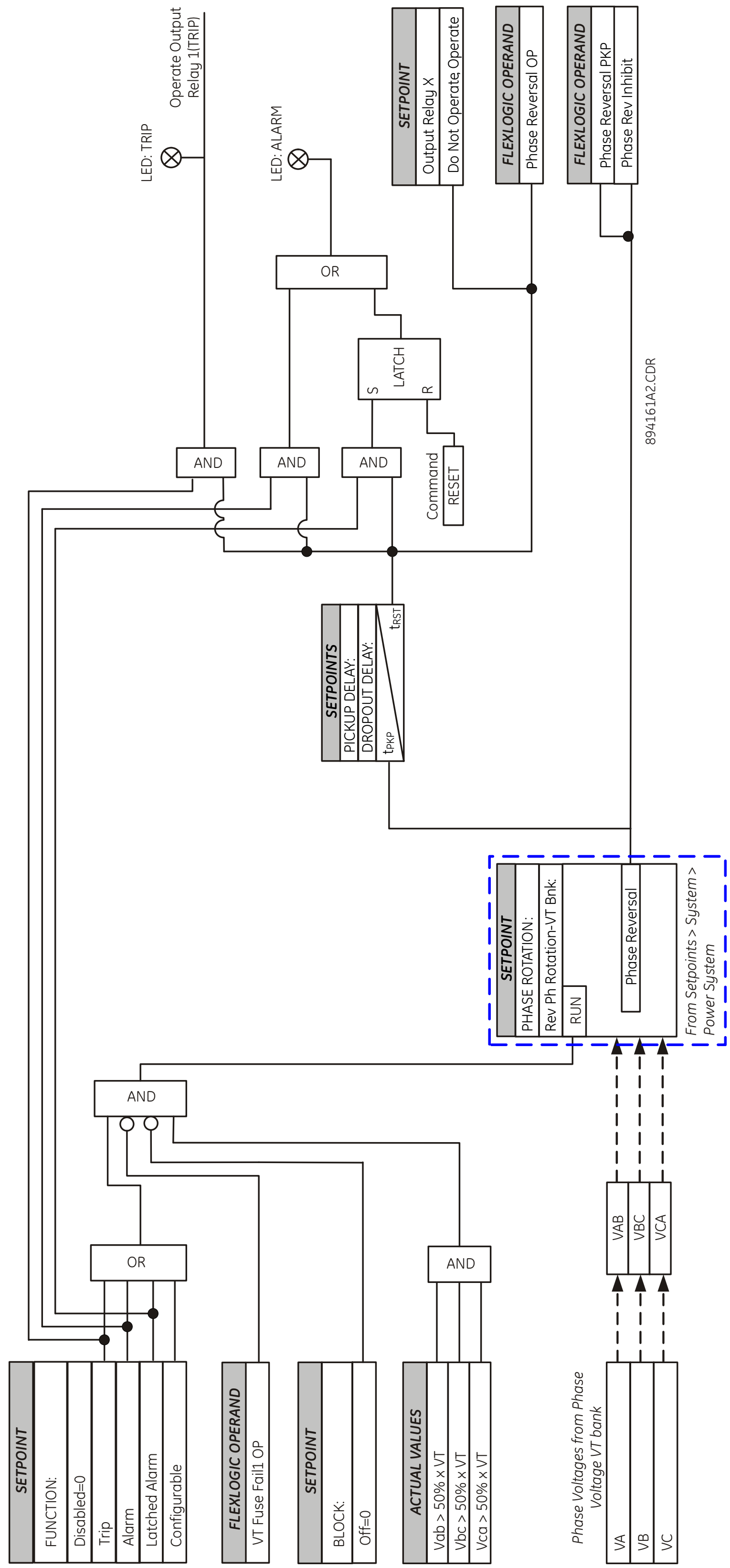
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Self-Reset, Latched, Disabled
Default: Self-Reset

Figure 6-57: Phase Reversal logic diagram



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

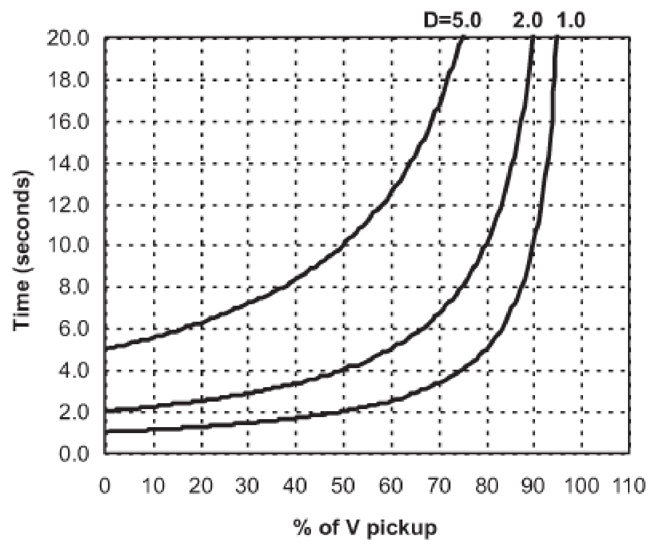
V_{pkp} = Undervoltage Pickup Level

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 6-58: 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 869 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 inUndervoltage 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.

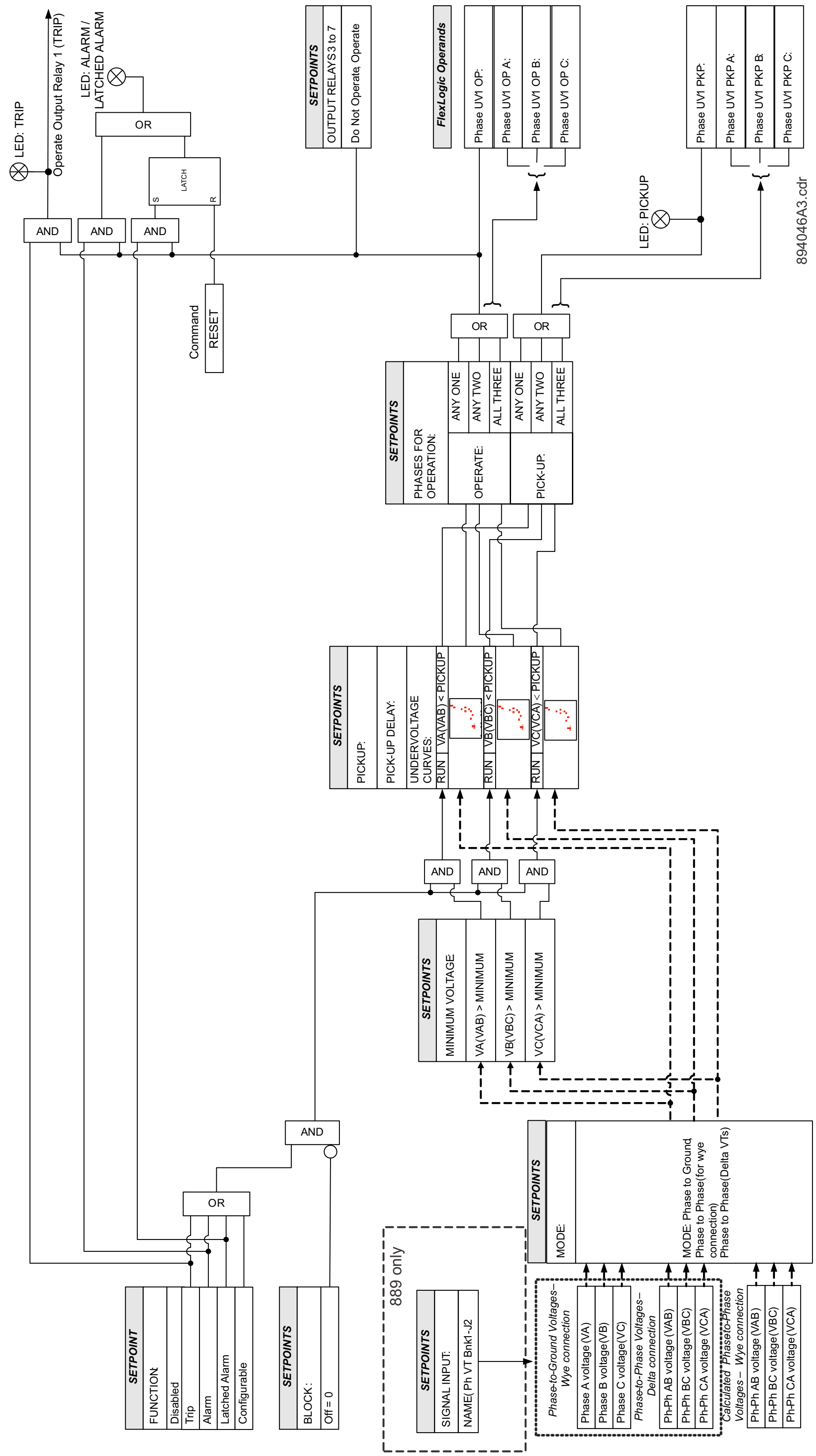
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Self-reset

Figure 6-59: Phase Undervoltage Protection logic diagram



Phase Overvoltage Protection (59P)

The 869 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.

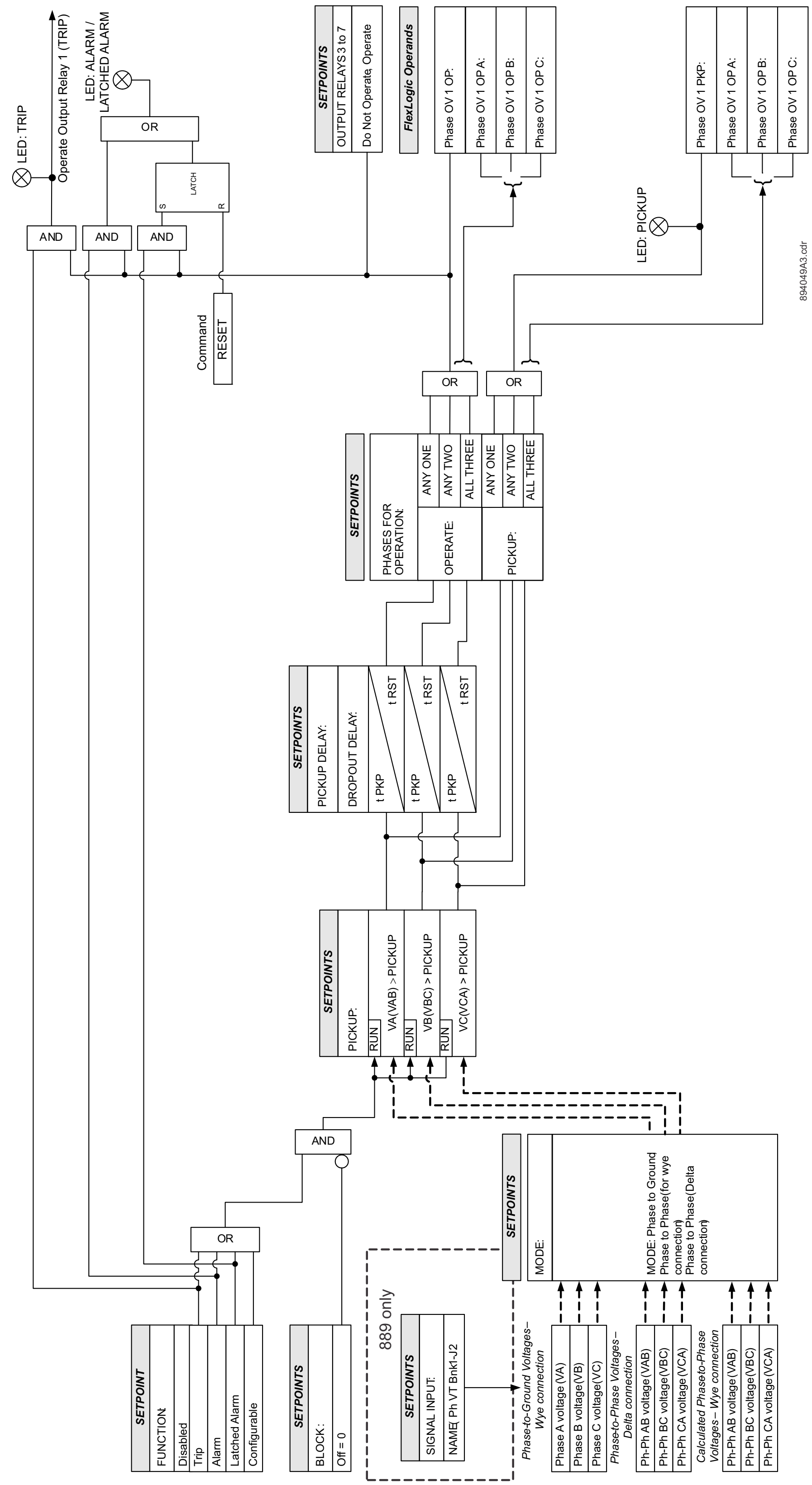
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Self-reset

Figure 6-60: Phase Overvoltage logic diagram



Auxiliary Undervoltage (27X)

The 869 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.

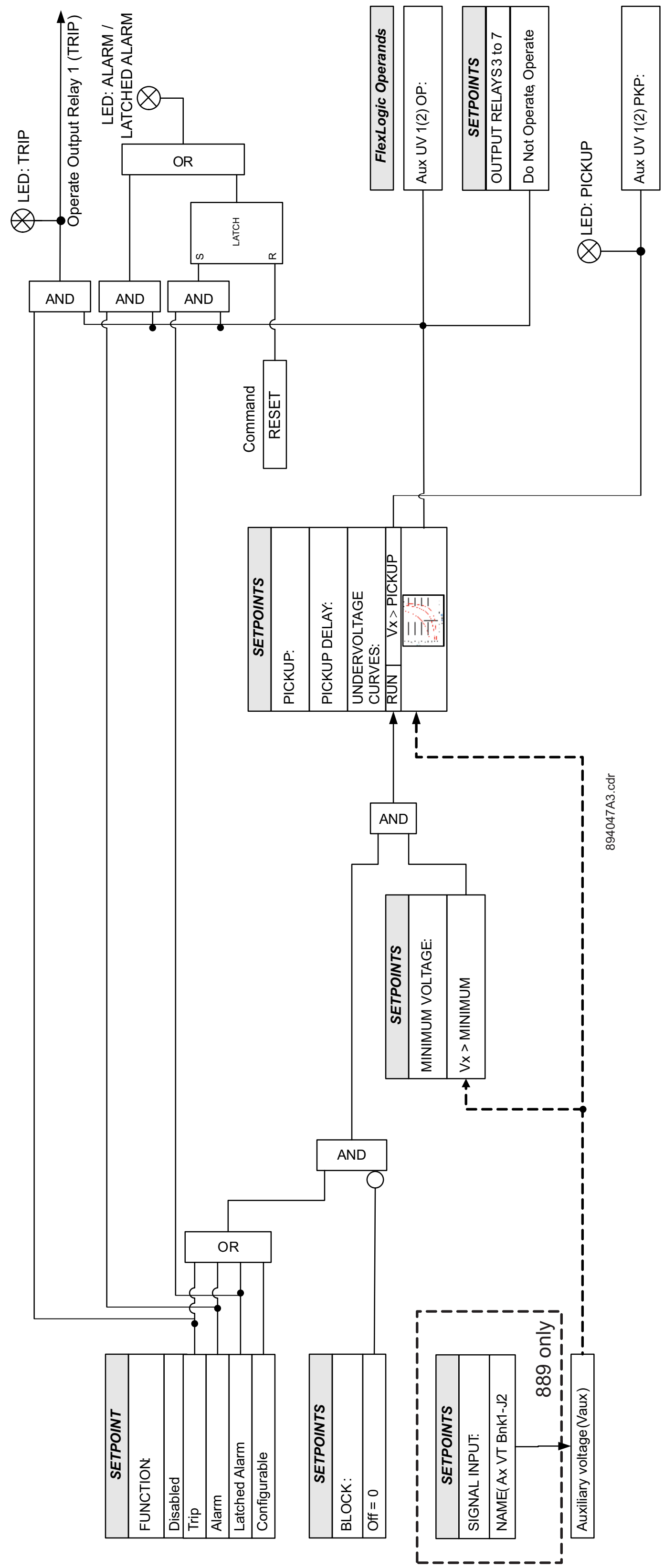
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Self-reset

Figure 6-61: Auxiliary Undervoltage Protection logic diagram



Auxiliary Overvoltage Protection (59X)

The 869 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

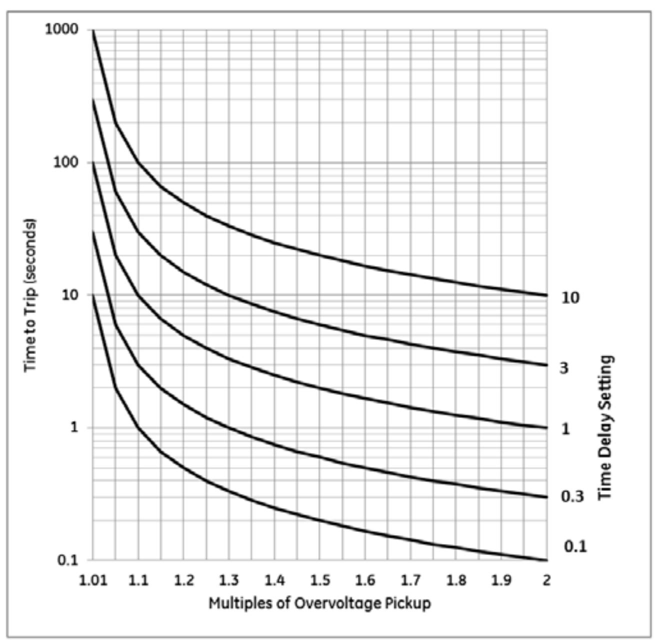
D = Overvoltage Pickup Delay setpoint

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 6-62: 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.

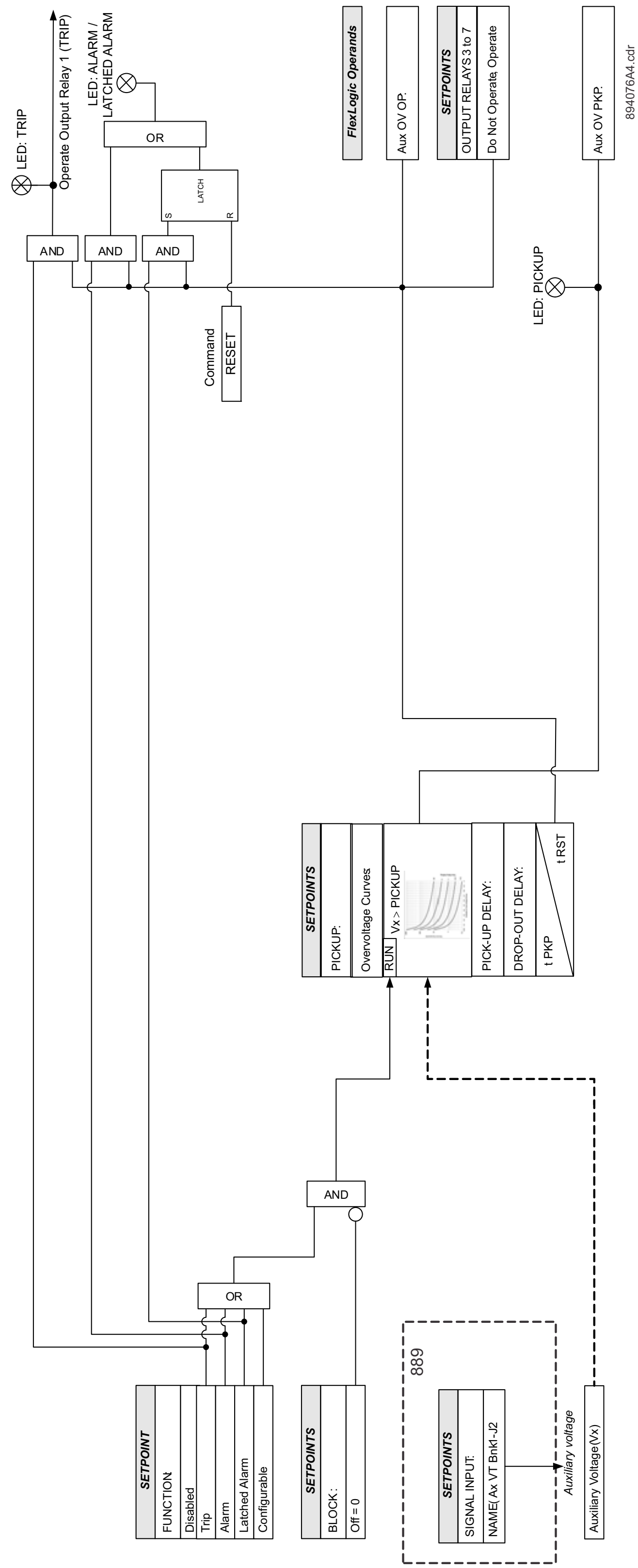
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Self-reset

Figure 6-63: Auxiliary Overvoltage Protection logic diagram



Neutral Overvoltage Protection (59N)

The 869 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.

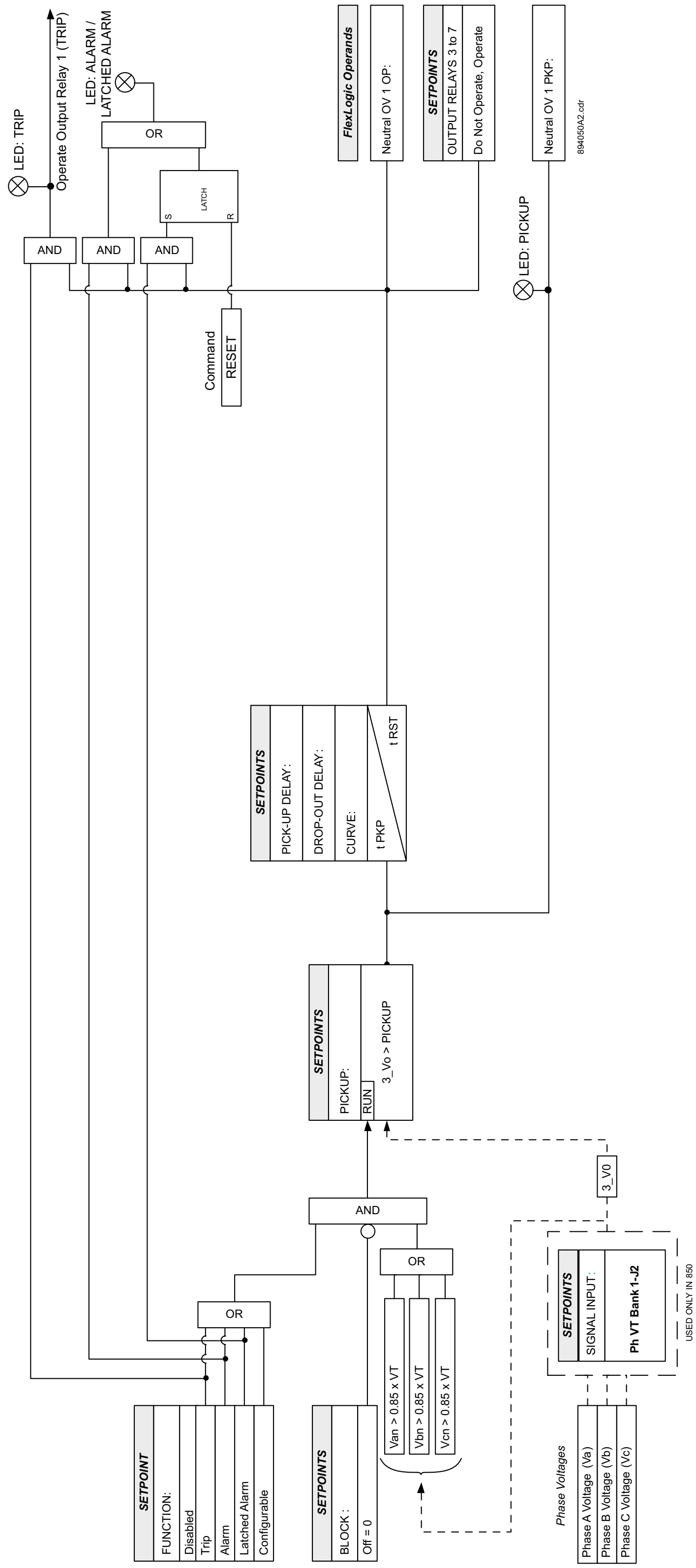
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Self-reset

Figure 6-64: Neutral Overvoltage Protection logic diagram



Negative Sequence Overvoltage Protection (59_2)

The 869 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.

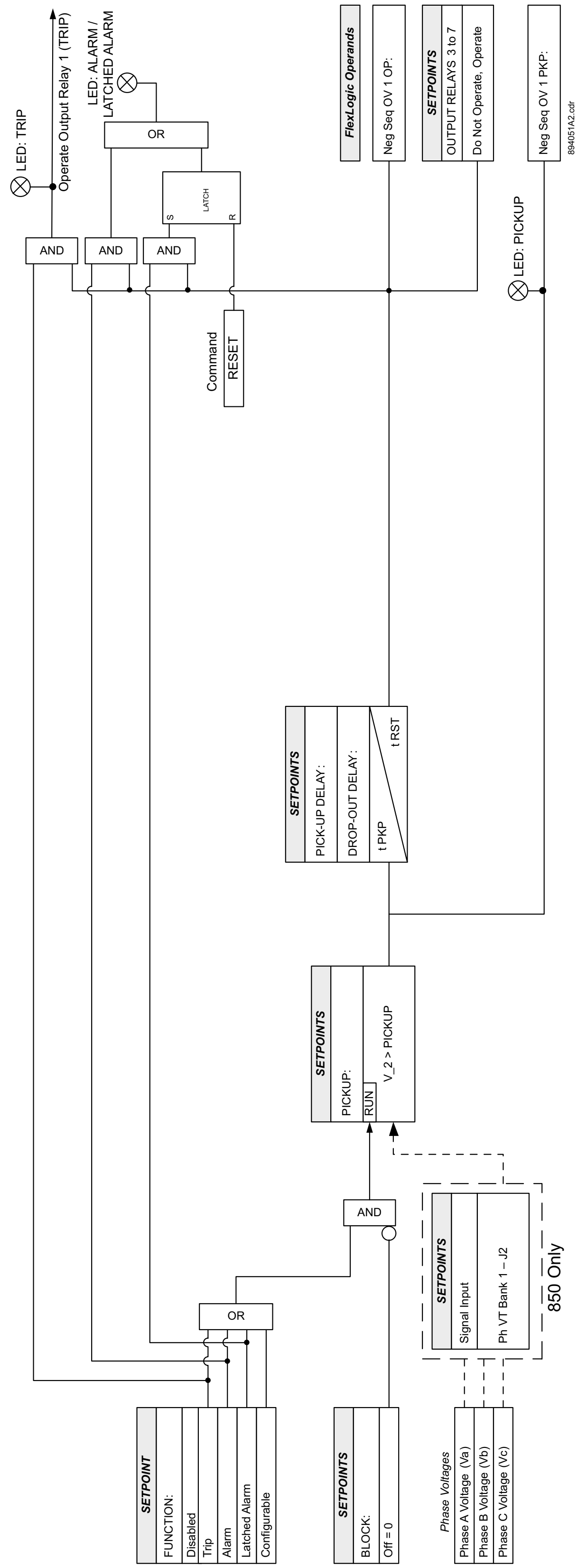
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Self-reset

Figure 6-65: 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**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable

Default: Disabled

This setting enables the Volts per Hertz functionality.

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)

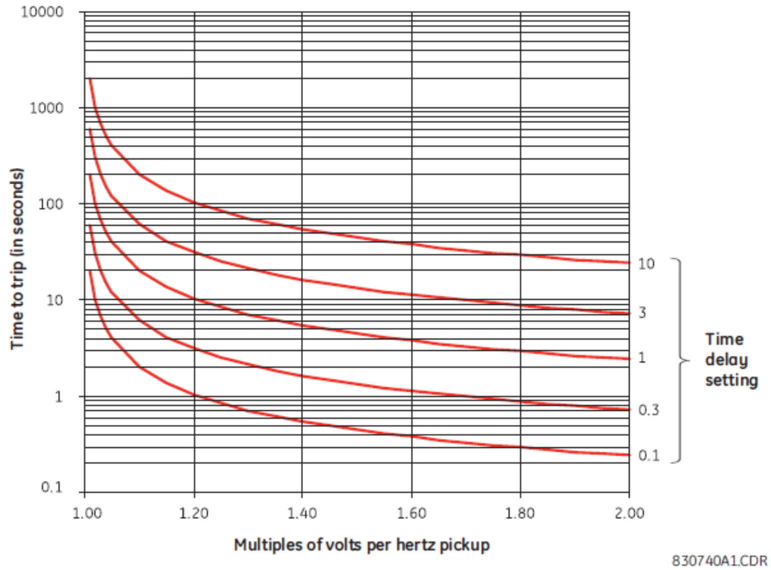
V = fundamental RMS value of voltage (pu)

F = frequency of voltage signal (pu)

Pickup = volts-per-hertz pickup setpoint (pu)

The volts/hertz inverse A curves are shown below.

Figure 6-66: 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:

$$T = \frac{TDM}{\left[\left(\frac{V}{F}\right)\Big/ Pickup\right] - 1} \quad when \ \frac{V}{F} > Pickup$$

where: T = Operating Time

TDM = Time Delay Multiplier (delay in seconds)

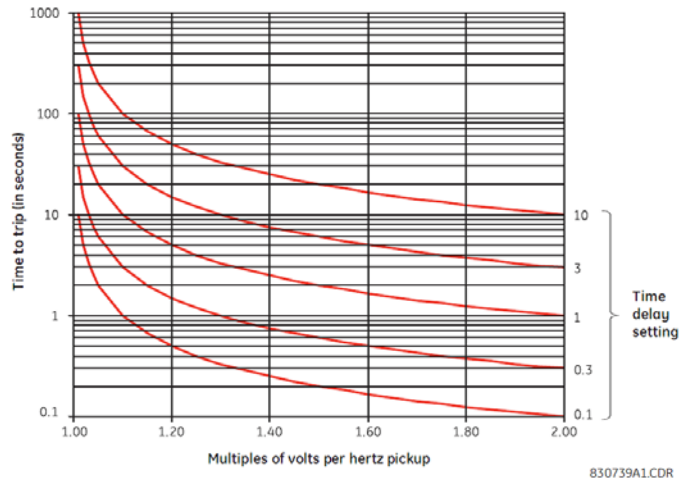
V = fundamental RMS value of voltage (pu)

F = frequency of voltage signal (pu)

Pickup = volts-per-hertz pickup setpoint (pu)

The Volts/Hertz inverse B curves are shown below.

Figure 6-67: 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:

$$T = \frac{TDM}{\left[\left(\frac{V}{F}\right)\Big/ Pickup\right]^{1/2} - 1} \quad when \ \frac{V}{F} > Pickup$$

where: T = Operating Time

TDM = Time Delay Multiplier (delay in seconds)

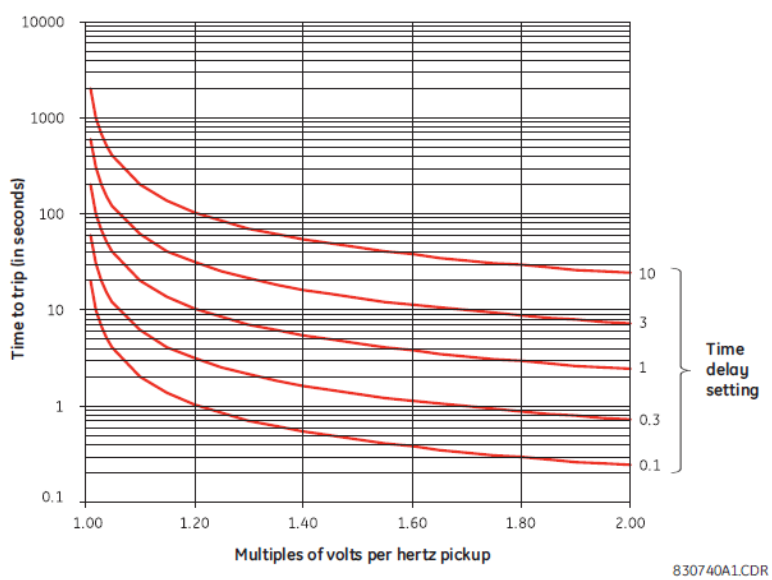
V = fundamental RMS value of voltage (pu)

F = frequency of voltage signal (pu)

Pickup = volts-per-hertz pickup setpoint (pu)

The Volts/Hertz Inverse C curves are shown below.

Figure 6-68: 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

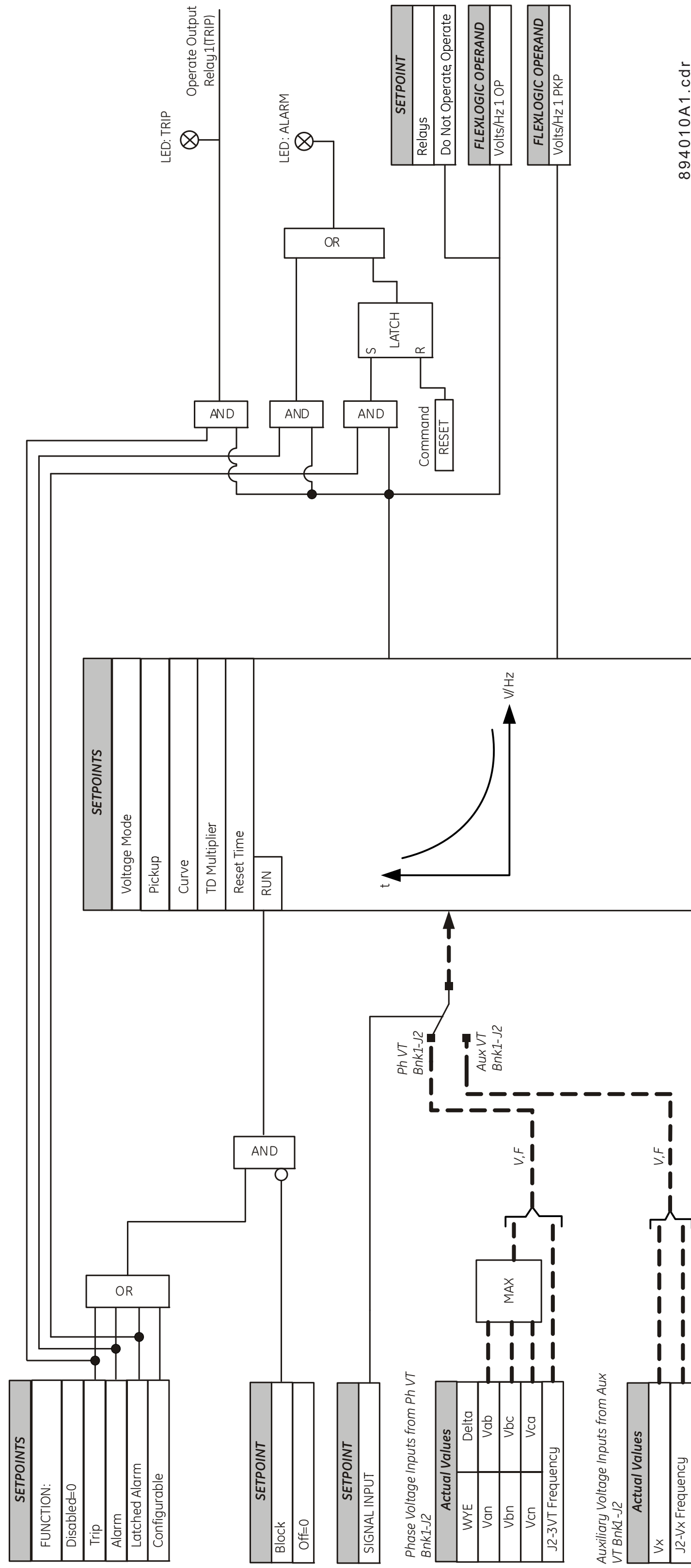
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched

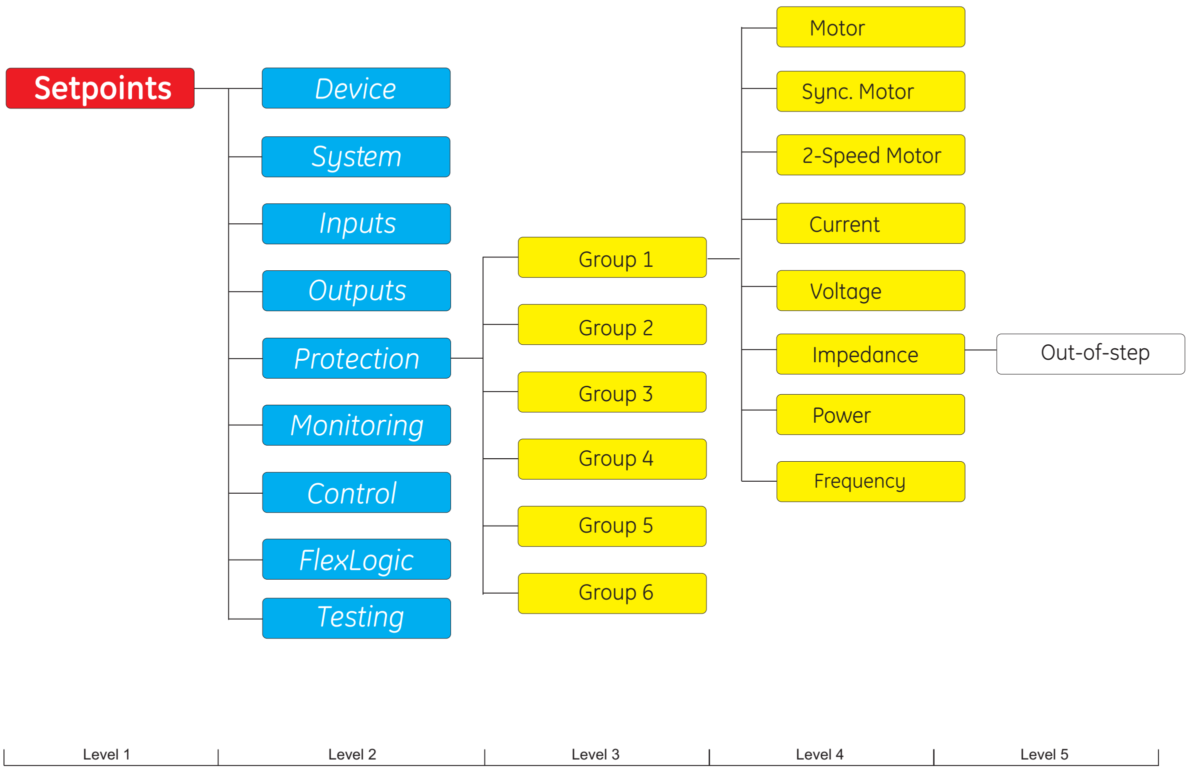
Default: Self-reset

Figure 6-69: Volts per Hertz logic diagram



Impedance Elements

Figure 6-70: Impedance Elements Display Hierarchy

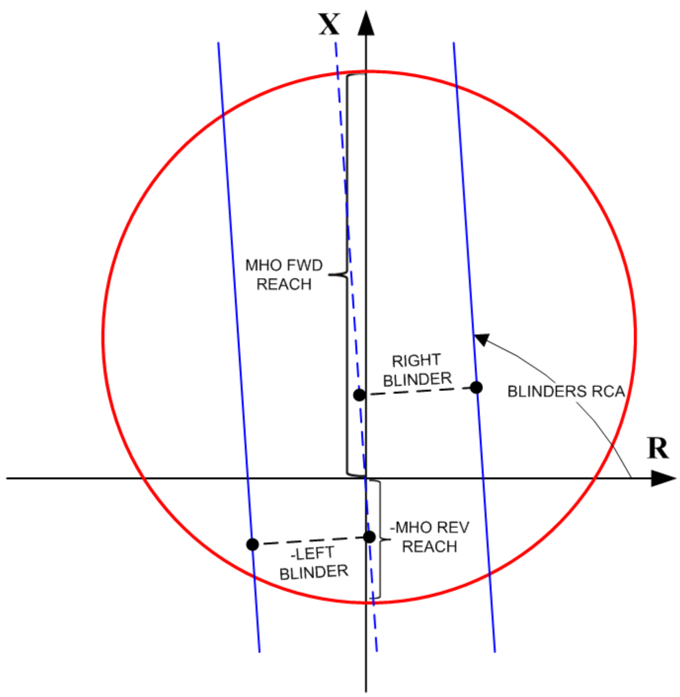


Out-of-step (78)

The Out-of-step element provides an out-of-step (loss-of-synchronism or pole slip) tripping function for motors. The element measures the positive-sequence apparent impedance, and traces its locus with respect to a single blinder operating characteristic with an offset mho supervisory. The purpose of the supervisory mho is to permit tripping for swings that pass through the motor and a limited portion of the system, but to prevent operation on stable swings that pass through both blinders and outside the mho characteristic.

The out-of-step tripping feature operates as follows: The trip sequence identifies unstable power swings by determining whether the impedance locus enters one blinder, spends a finite time between the left and right blinder characteristics, and then exits the opposite blinder. The out-of-step trip process is supervised by a mho characteristic. If the locus enters the left blinder, right blinder and mho characteristic (indicated by the AND operation of OOS LFT BLD PKP and OOS RGT BLD PKP FlexLogic operands) for an interval longer than PICKUP DELAY, the timing out signal (OOS TIMER PKP FlexLogic operand) is established. After the PICKUP DELAY timer times out, latch 1 is set as long as the impedance stays within the mho characteristic. If afterwards, at any time (given the impedance stays between the two blinders characteristic), the locus exits from the opposite blinder, latch 2 is set as long as the impedance stays inside the mho characteristic. The element is now ready to trip. If the "BLINDER EXIT" trip mode is selected, the OOS OP operand is set immediately and sealed-in for the interval set by the SEAL-IN DELAY. If the "MHO EXIT" trip mode is selected, the element waits until the impedance locus leaves the mho characteristic, and then the OOS OP operand is set and sealed-in.

The element is set to use the single blinder characteristic with a supervisory mho as illustrated below.



The FlexLogic output operands for the out-of-step element are described as follows:

- The OOS Lft Bld PKP, OOS Rgt Bld PKP, and OOS Timer PKP FlexLogic operands are auxiliary operands that can be used to facilitate testing and special applications.
- The OOS OP FlexLogic operand can be used to trip the circuit breaker to isolate the loss-of-synchronism motor.

Follow these steps for a typical setting procedure of the out-of-step element:

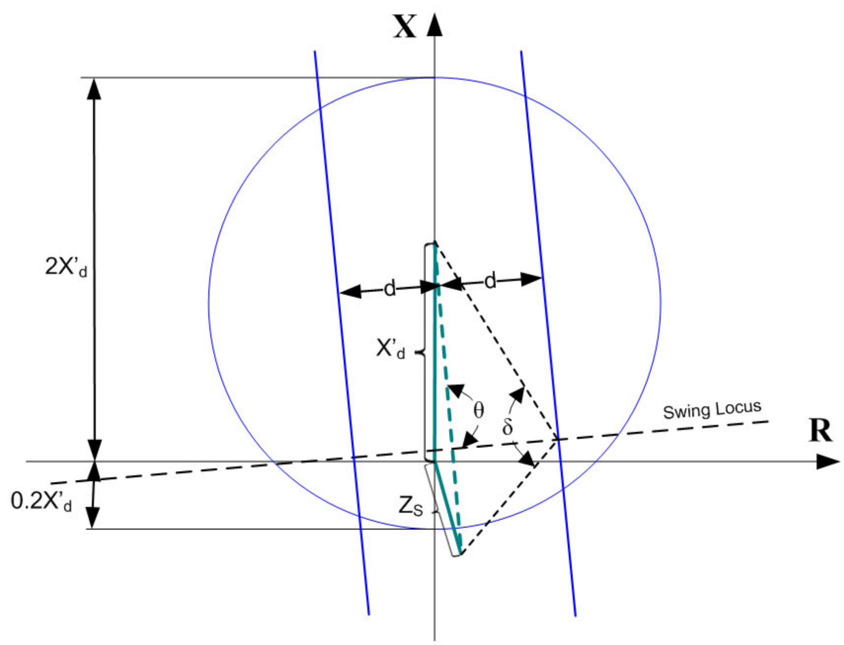
1. Carry out detailed transient stability studies for the overall system.

2. Determine the values of the motor transient reactance (X'_d), and system impedance (Z_S). The total impedance is given by $Z_{total} = Z_S + j * X'_d$
3. Set MHO REVERSE REACH for 0.05 to 0.15 times the motor transient reactance. Set MHO FORWARD REACH to twice the motor transient reactance in the motor direction.
4. Set BLINDERS RCA to the angle of Z_{total}, θ.
5. Using the results of transient stability analysis, find the critical angle δ_c between the motor and the system, beyond which the system begins to become unstable. If a stability study is not available, this angle is typically set at 120°. Then, 10 degrees are normally added in order to increase relay operation security, $\delta = \delta_c + 10$.
6. Determine the blinder distance, d, from the following equation:

$$d = \frac{|Z_{total}|}{2} \tan(90 - \frac{\delta}{2})$$

7. Set RIGHT BLINDER and LEFT BLINDER to *d*.
8. Using the results of the transient stability analysis, find the PICKUP DELAY, which is shorter than the time required for the impedance locus to travel between the left and right blinders during the fastest expected out-of-step.
9. Validate the settings with the transient stability study cases.

Figure 6-71: A Typical Out-of-step Setting



Path: **Setpoints > Protection > Group 1(6) > Impedance > Out of Step**

FUNCTION

Range: Disabled, Trip, ALarm, Latched Alarm, Configurable
Default: Disabled

SIGNAL INPUT

Range: Positive Impedance 1, Positive Impedance 2

Default: Positive Impedance 1

This setting provides the selection for the positive sequence impedance which is calculated by terminal side or neutral side CT. Positive sequence impedance 1 is calculated using 3-phase J1 currents and 3-phase J2 voltages. Positive sequence impedance 2 is calculated using 3-phase K1 currents and 3-phase J2 voltages.

MHO FORWARD REACH

Range: 0.10 to 500.00 ohms in steps of 0.01 ohms

Default: 2.00 ohms

This setting specifies the forward reach of the mho characteristic. The reach impedance is entered in secondary ohms. The reach impedance angle is fixed to 90 degrees.

MHO REVERSE REACH

Range: 0.10 to 500.00 ohms in steps of 0.01 ohms

Default: 2.00 ohms

This setting specifies the reverse reach of the mho characteristic. The reach impedance is entered in secondary ohms. The reach impedance angle is fixed to -90 degrees.

RIGHT BLINDER

Range: 0.10 to 500.00 ohms in steps of 0.01 ohms

Default: 2.00 ohms

This setting defines the right blinder position of the blinder characteristic along with the resistive axis of the impedance plane, expressed ins secondary ohms. The angular position of the blinder is adjustable with the use of the BLINDERS RCA setting.

LEFT BLINDER

Range: 0.10 to 500.00 ohms in steps of 0.01 ohms

Default: 2.00 ohms

This setting defines the left blinder position of the blinder characteristic along with the resistive axis of the impedance plane, expressed ins secondary ohms. The angular position of the blinder is adjustable with the use of the BLINDERS RCA setting.

BLINDERS RCA

Range: 40 to 90° in steps of 1°

Default: 90°

This setting defines the angular position of the left and right blinders.

PICKUP DELAY

Range: 0.000 to 1.000 s in steps of 0.001 s

Default: 0.100 s

This setting should be set to detect the fastest expected unstable power swing and produce out-of-step tripping in a secure manner. This timer defines the interval that the impedance locus must spend between the left and right blinders to establish the out-of-step tripping signal. This time delay must be set shorter than the time required for the impedance locus to travel between the left and right blinders during the fastest expected out-of-step. Setting the delay too long can reduce dependability.

TRIP MODE

Range: Blinder Exit, MHO Exit

Default: MHO Exit

Selecting "Blinder Exit" results in an instantaneous trip after the last step in the out-of-step tripping sequence is completed (the impedance locus leaves the opposite blinder). The Blinder Exit trip mode stresses the circuit breakers as the currents at that moment are high (the electromotive forces of the two equivalent systems are close to 180° apart).

Selecting "MHO Exit" results in a trip at the moment when the impedance locus leaves the mho characteristic. The MHO Exit trip mode relaxes the operating conditions for the breakers as the currents at that moment are low, preventing the breakers from a maximum recovery voltage during interruption. The selection should be made considering the capability of the breakers in the system.

POS SEQ CURR SUPERVISION

Range: 0.05 to 10.00 x CT in steps of 0.01 x CT

Default: 1.00 x CT

A common overcurrent pickup level supervises the left and right blinder characteristics. The supervision responds to the positive sequence current.

SEAL-IN DELAY

Range: 0.000 to 1.000 s in steps of 0.001 s

Default: 0.100 s

The out-of-step trip FlexLogic operand (OOS OP) is sealed-in for the specified period of time. The sealing-in is crucial to the MHO EXIT trip mode, as the original trip signal is a very short pulse occurring when the impedance locus leaves the mho characteristic after the out-of-step sequence is completed.

BLOCK

Range: Off, Any FlexLogic operand

Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

EVENTS

Range: Enabled, Disabled

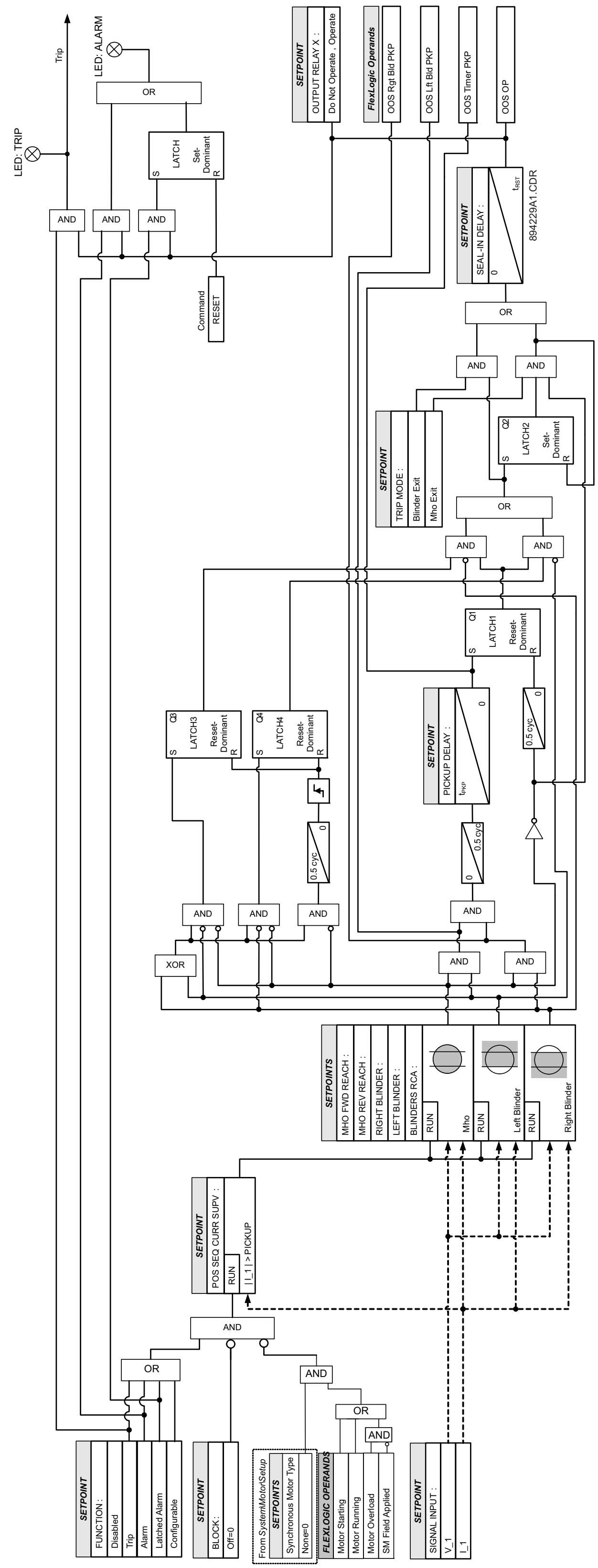
Default: Enabled

TARGETS

Range: Self-reset, Latched, Disabled

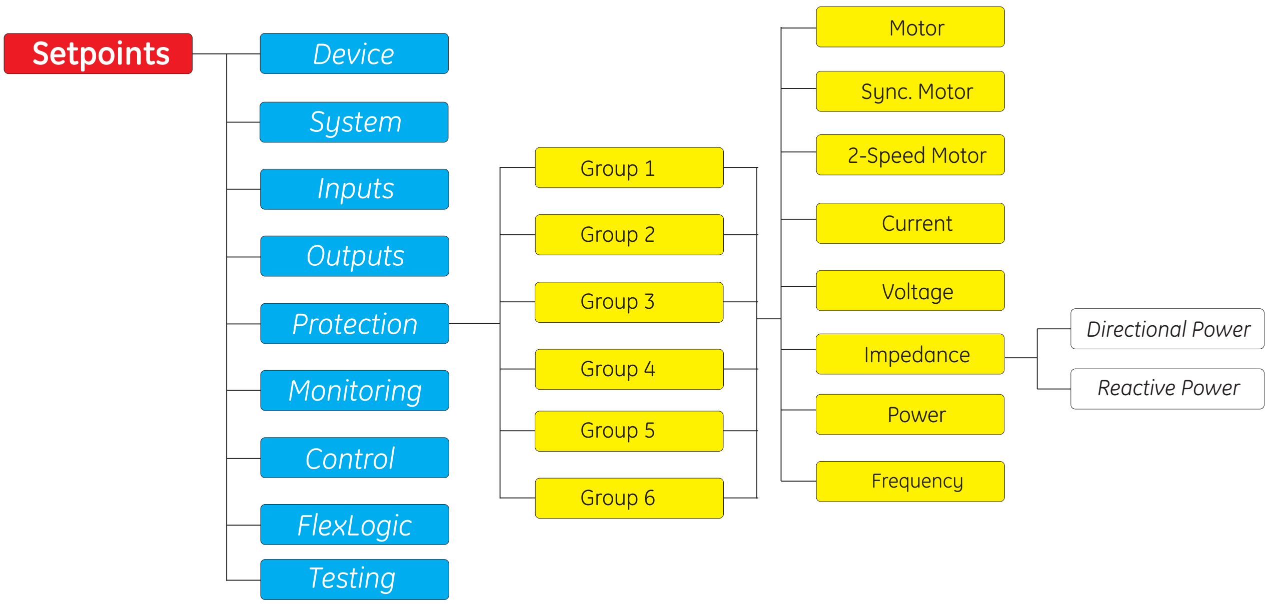
Default: Latched

Figure 6-72: Out-of-step Protection Logic Diagram



Power Elements

Figure 6-73: Power Elements Display Hierarchy



Directional Power (32)

The 869 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:

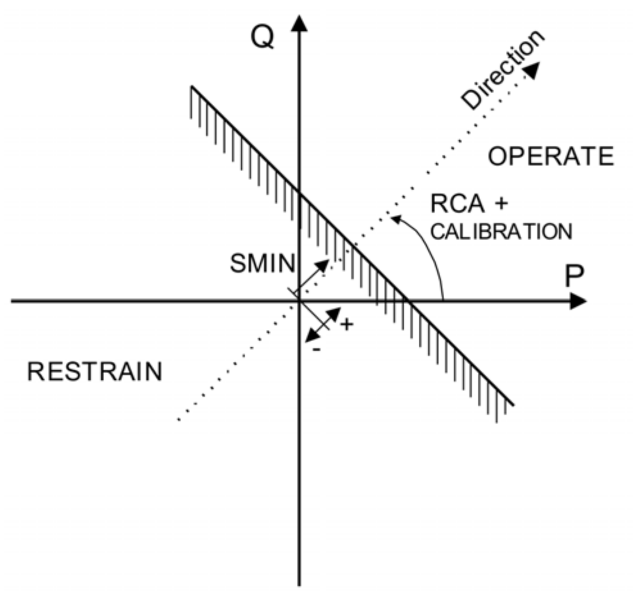
P and Q are active and reactive powers as measured per the metering convention

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.

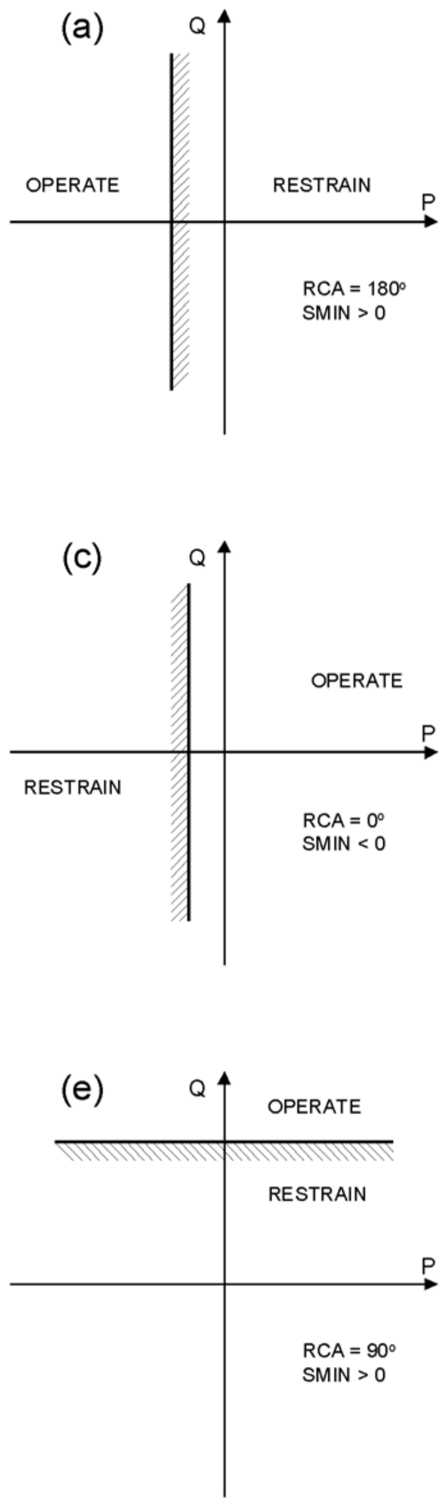
The element has two independent (as to the Pickup and Delay settings) stages for Alarm and Trip, and they can be set separately to provide mixed power protection.

Figure 6-74: 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 6-75: 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 x $VT_{Secondary\ (phase\text{-}neutral)} \times VT_{Ratio} \times CT_{Primary}$ (Wye-connected VT), or
Rated Power = $(3)^{1/2} \times VT_{Secondary\ (phase\text{-}phase)} \times VT_{Ratio} \times CT_{Primary}$ (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

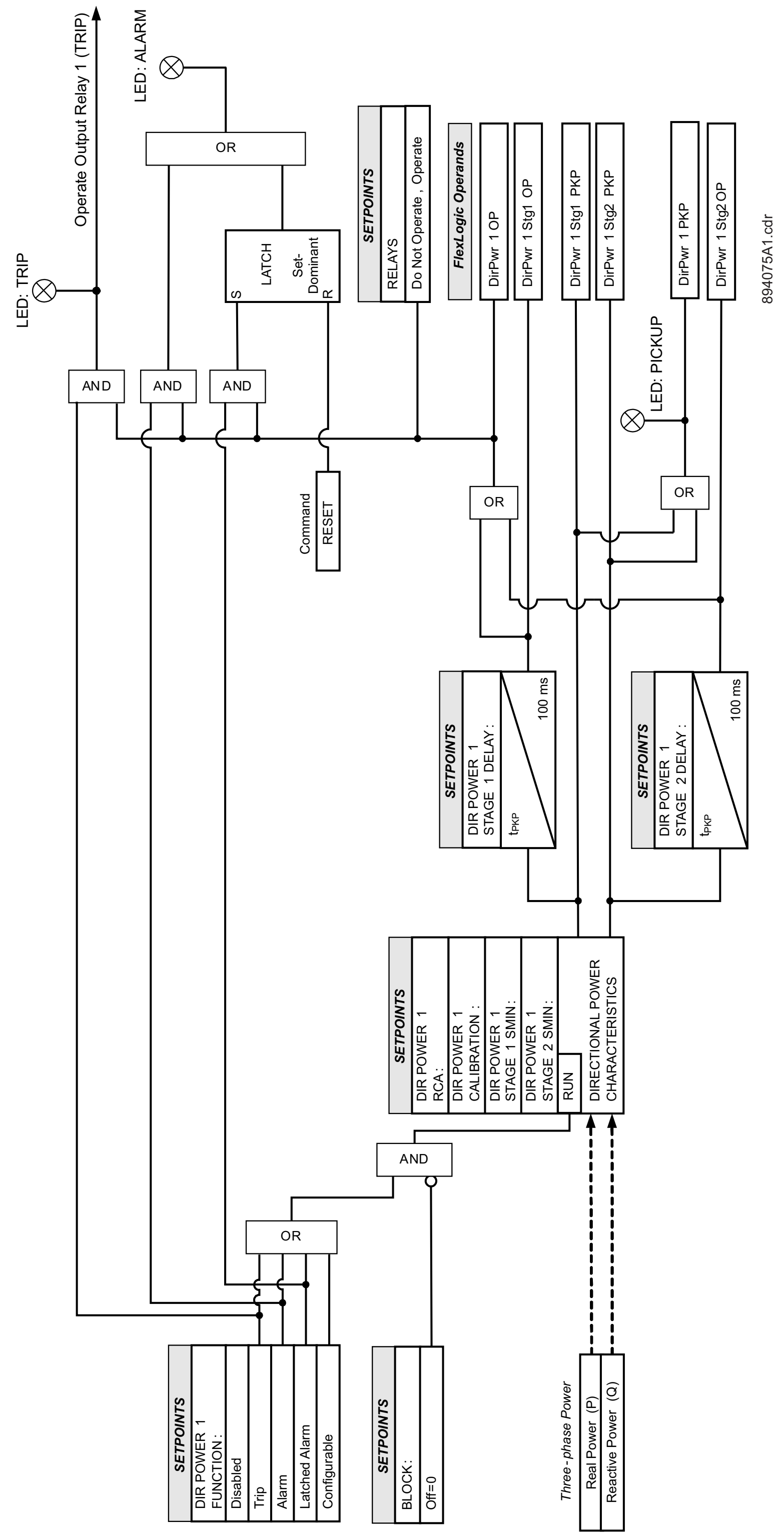
Default: Enabled

TARGETS

Range: Self-reset, Latched, Disabled

Default: Self-reset

Figure 6-76: Directional Power logic diagram



Reactive Power (40Q)

In a synchronous motor application, the reactive power element can be used to detect excitation system malfunction, e.g. under excitation, loss of excitation, etc. Once the 3-phase total reactive power exceeds the positive or negative level, for the specified delay, a trip or alarm occurs indicating a positive or negative kvar condition. VTFF detection can be used to block this function.

Path: **Setpoints > Protection > Group 1 > Power > Reactive Power**

TRIP FUNCTION

Range: Disabled, Trip, Configurable

Default: Disabled

This setting enables the Reactive Power Trip functionality.

POSITIVE VAR TRIP PICKUP

Range: 1 to 25000 kvar in steps of 1

Default: 25 kvar

This setting specifies a pickup threshold for the positive var trip function.

NEGATIVE VAR TRIP PICKUP

Range: 1 to 25000 kvar in steps 1

Default: 25 kvar

This setting specifies a pickup threshold for the negative var trip function.

POSITIVE VAR TRIP DELAY

Range: 0.00 to 600.00 s in steps of 0.01 s

Default: 10.00 s

This setting specifies a time delay for the positive var trip function. Once the 3-phase total reactive power exceeds the positive level for the duration of the Positive var Trip Delay time, a trip will occur indicating a positive var condition.

NEGATIVE VAR TRIP DELAY

Range: 0.00 to 600.00 s in steps of 0.01 s

Default: 1.00 s

This setting specifies a time delay for the negative var trip function.

TRIP RELAY X

For details see Common Setpoints.

ALARM FUNCTION

Range: Disabled, Alarm, Latched Alarm

Default: Disabled

This setting enables the Reactive Power alarm functionality.

POSITIVE VAR ALARM PICKUP

Range: 1 to 25000 kvar in steps of 1

Default: 10 kvar

This setting is typically set at a level less than the Positive var Trip Pickup for the alarm function.

NEGATIVE VAR ALARM PICKUP

Range: 1 to 25000 kvar in steps of 1

Default: 10 kvar

This setting specifies a pickup threshold for the negative var alarm function.

POSITIVE VAR ALARM DELAY

Range: 0.00 to 600.00 s in steps of 0.01 s
Default: 10.00 s

This setting specifies a time delay for the positive var alarm function.

NEGATIVE VAR ALARM DELAY

Range: 0.00 to 600.00 s in steps of 0.01 s
Default: 1.00 s

This setting specifies a time delay for the negative var alarm function.

ALARM RELAY X

For details see Common Setpoints.

BLOCK FROM ONLINE

Range: 0.00 to 600.00 s in steps of 0.01 s
Default: 0.50 s

In a synchronous motor application, it may be desirable not to trip or alarm on reactive power until the speed of the machine is near the synchronous speed or the field has been applied. Therefore, this feature can be blocked upon the initiation of a motor start for a period of time specified by this setting. From that point forward, the reactive power trip and alarm elements are active. A value of zero for the block time indicates that the reactive power protection is active as soon as motor start is detected.

NOTICE

The setpoint BLOCK FROM ONLINE is hidden when the order code includes Phase Currents - Slot K option C5/D5 and the setpoint SYNCHRONOUS MOTOR TYPE (under **Path**: **Setpoints > System > Motor Setup**) is programmed as Brushless or Brush-type. In this case, the Reactive Power element activates when the motor is synchronized (field applied) and therefore the motor state becomes SM Running or Overload=1 with field applied.

The setpoint BLOCK FROM ONLINE is visible when the order code does not include Phase Currents - Slot K option C5/D5 or when the setpoint SYNCHRONOUS MOTOR TYPE (under **Path**: **Setpoints > System > Motor Setup**) is programmed as None. In this case the Reactive Power element runs after the BLOCK FROM ONLINE timer expires.

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

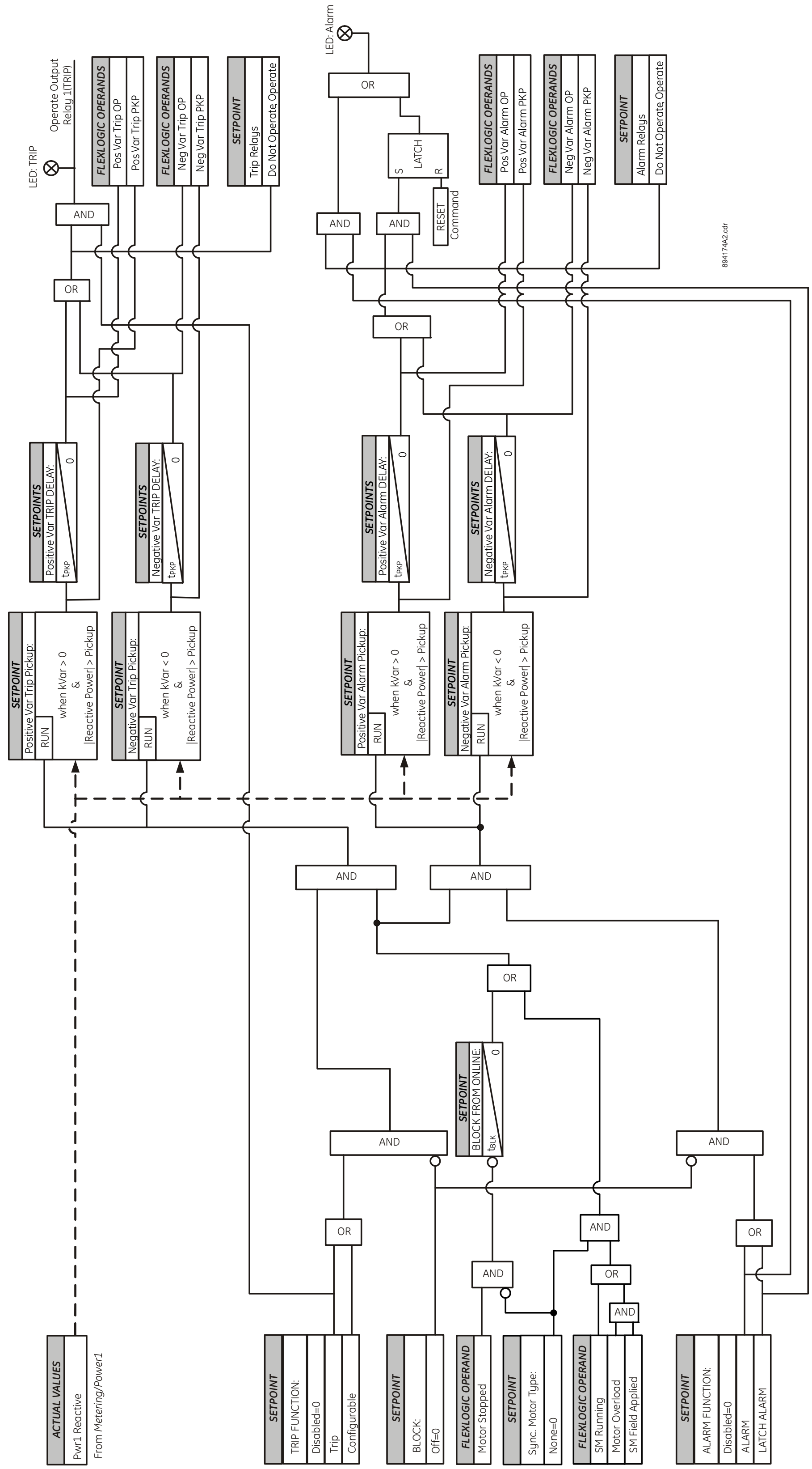
EVENTS

Range: Disabled, Enabled
Default: Disabled

TARGETS

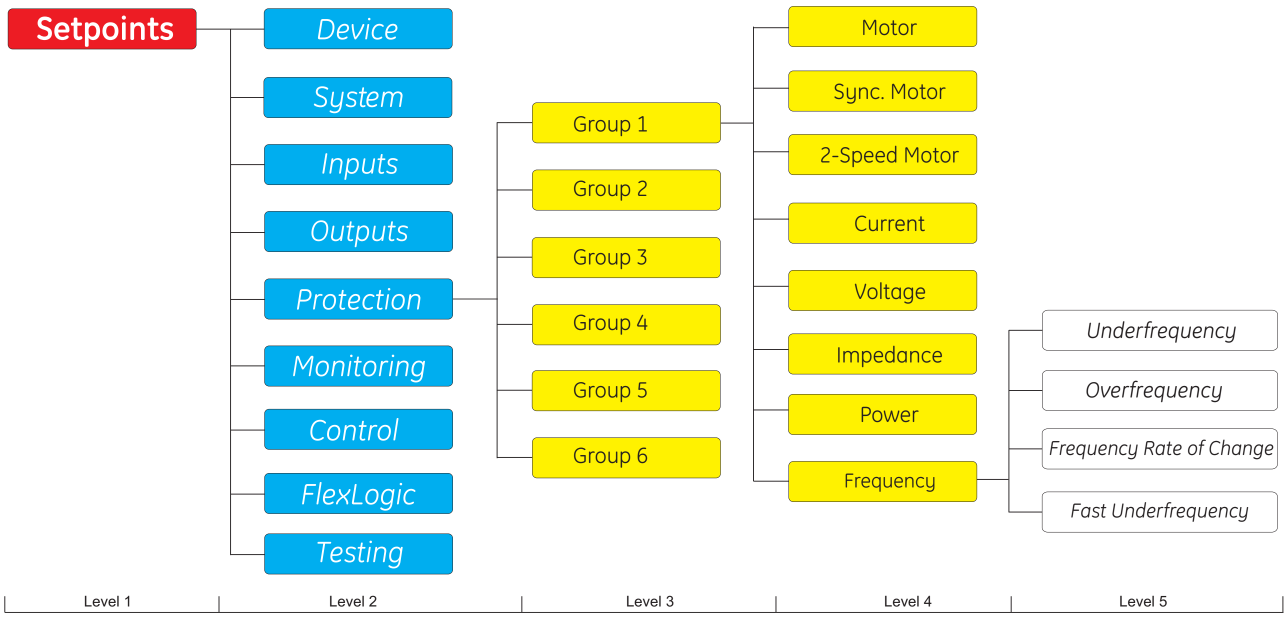
Range: Disabled, Self-reset, Latched
Default: Self-reset

Figure 6-77: Reactive Power Logic Diagram



Frequency Elements

Figure 6-78: Frequency Elements Display Hierarchy



Underfrequency (81U)

The 869 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 869 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.

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

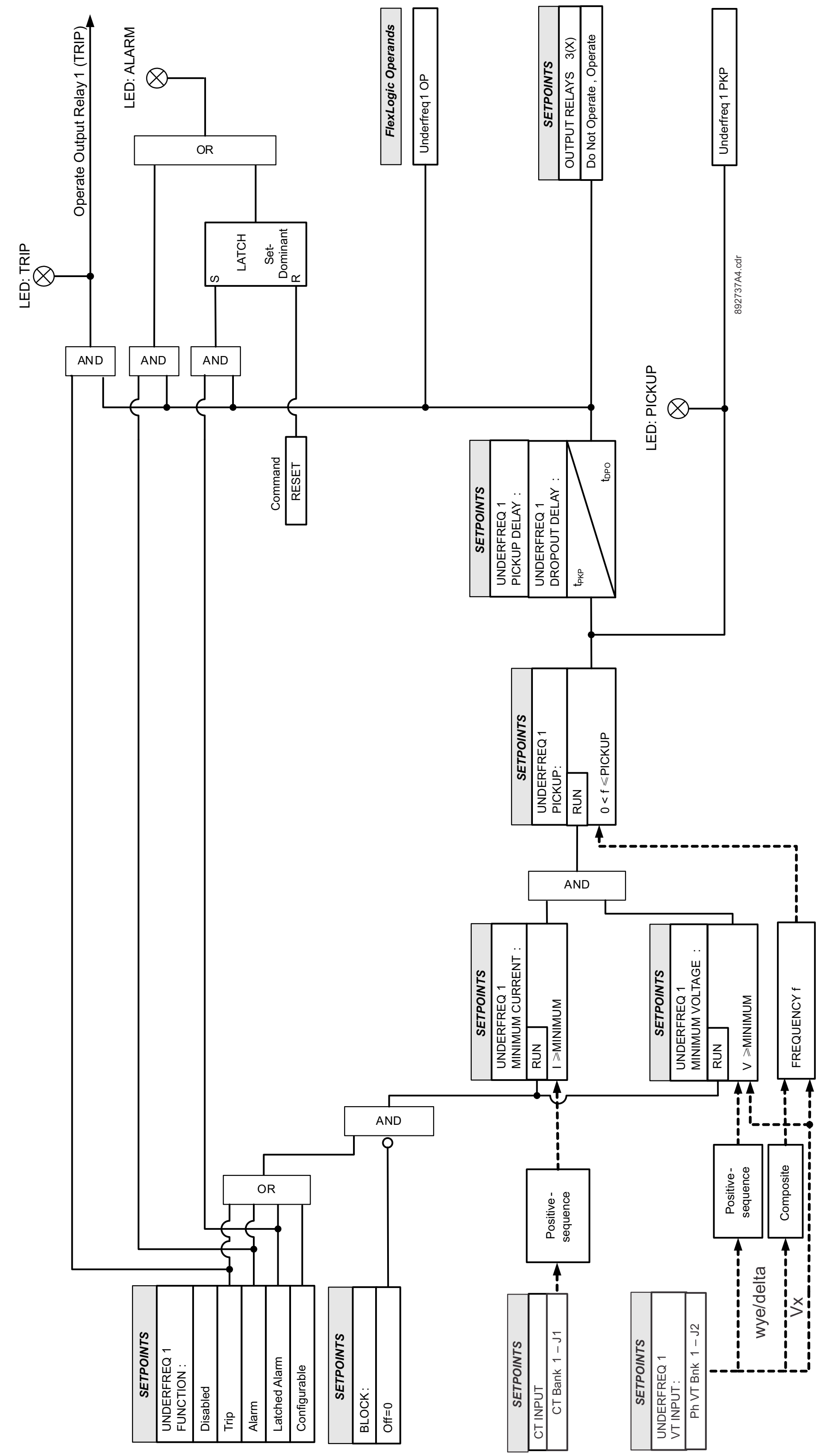
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched

Default: Self-reset

Figure 6-79: Underfrequency Protection logic diagram



Overfrequency (81O)

The 869 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.

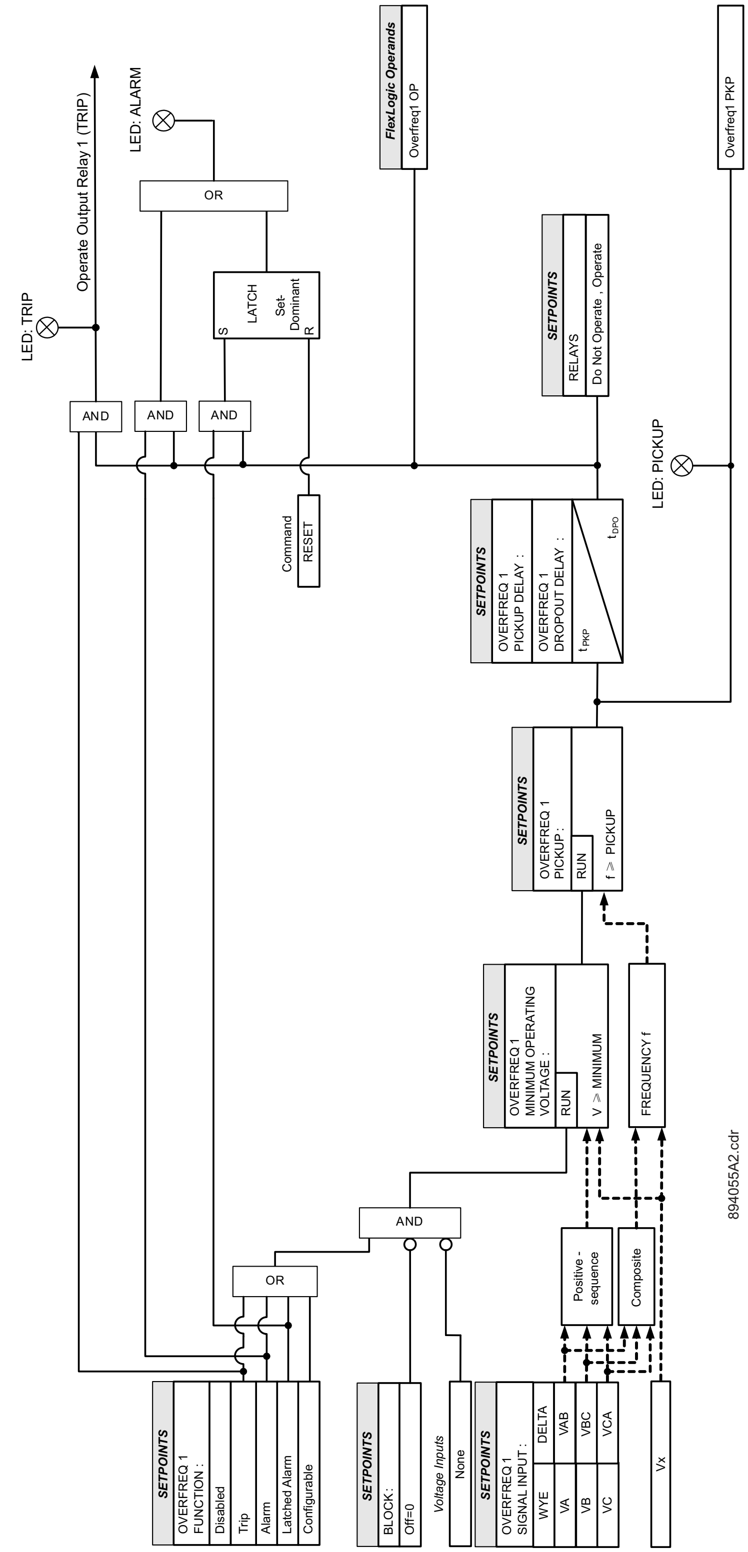
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Self-reset

Figure 6-80: 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.

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.

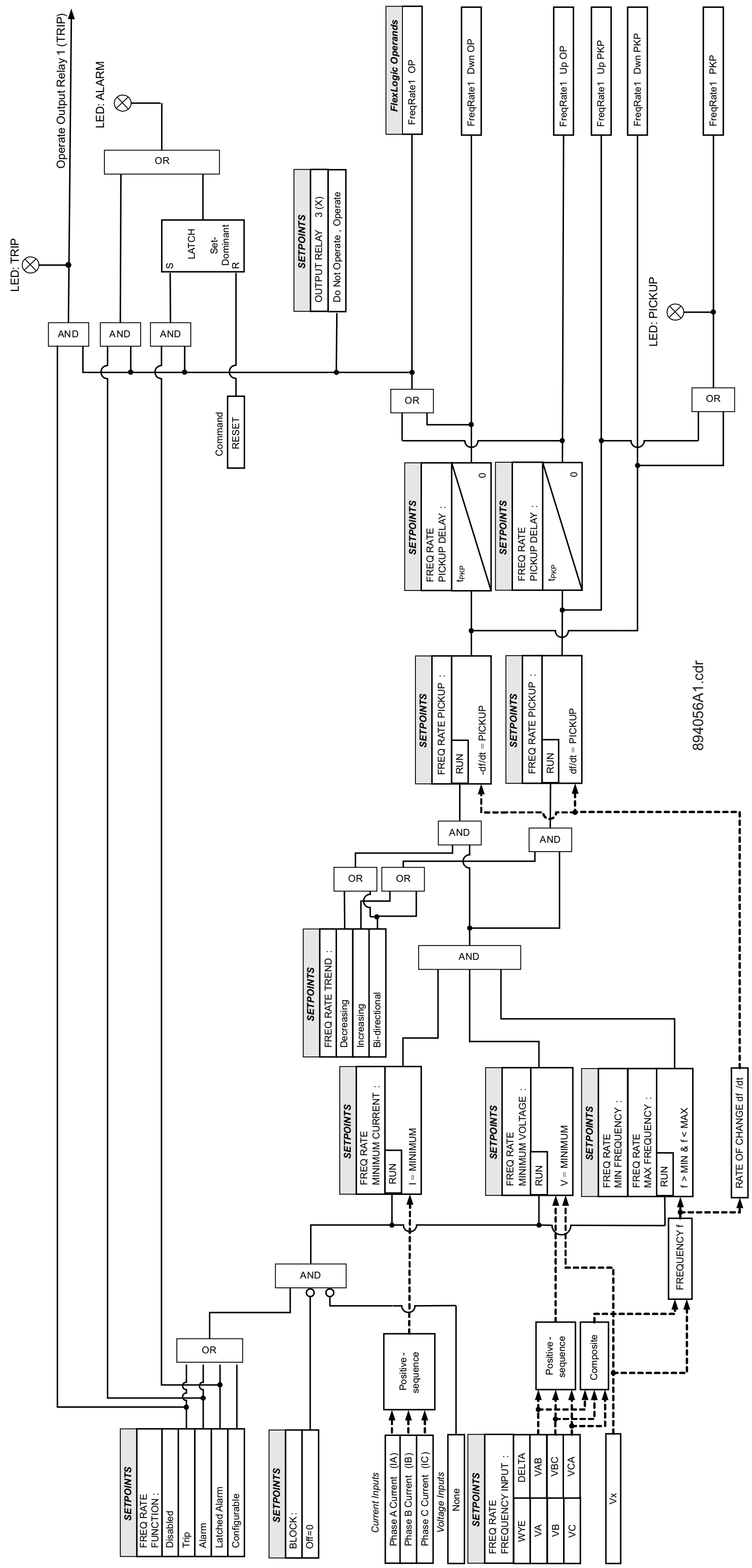
TARGETS

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 6-81: Frequency Rate-of-Change Protection logic diagram



Fast Underfrequency

Frequency variations originate from unbalance conditions between generation and load. The main reasons for these conditions are given:

- Inadequate load forecast or deficient generation capacity programming.
- Busbars, generator group or interconnection feeders trip.
- System splits into islands.

When the frequency variation is small, the unbalance condition is corrected by the generator regulator. In the case of big frequency variations, the regulator is not able to correct itself, and the frequency value decreases which the danger of losing generation capacity.

If this underfrequency condition is not corrected a general blackout may occur.

In case of a shortage of generation capacity, the only possible way of recovering the stability of the system is through a selective load shedding scheme. The load disconnection is done when the frequency goes down below certain thresholds, in order to provide adequate reaction time for the generators to recover via their speed regulators.

It is important to point out that when the frequency decreases quickly, relay operation based on the detection of the underfrequency condition may not be enough to recover stability. In this case the load shedding scheme must also take into account the rate of change of frequency. This is done by calculating the frequency derivative over time. Loads are "shed" based not only on an absolute (static) underfrequency threshold, but also on the dynamic rate of change of frequency.

The Fast Underfrequency element is mainly used in medium voltage and distribution substations as a selective load shedding scheme. By doing so, frequency recovers stability and potentially dangerous situations that might affect generators in other parts of the electrical system are avoided.

The Fast Underfrequency element measures frequency by detecting the consecutive voltage zero crossings and measuring the time between them. The measured frequency has a range between 20 to 70 Hz. The out-of-range measurement will be classified as invalid, which will not affect the behavior of the SET and RESET counters. The fast frequency is the average value of the measured frequency in a short window. Compared to the regular metered voltage frequency value, the fast frequency has the faster response but lesser accuracy.

Path: **Setpoints > Protection > Group 1(6) > Frequency > Fast Underfrequency > Common Setup**

FREQUENCY INPUT

Range: dependant upon the order code
Default: Ph VT Bnk1-J2

This setting provides the selections for the frequency signal source.

MINIMUM VOLTAGE

Range: 0.10 to 1.10 x VT in steps of 0.01 x VT
Default: 0.40 x VT

The setting sets the minimum voltage for all Fast Underfrequency elements operation specified per times VT. The setpoint prevents incorrect operation if the voltage decreases below the threshold.

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.

SEMICYCLES SET

Range: 1 to 20 in steps of 1
Default: 3

This setting specifies a SET counter prior to picking up. When the frequency is detected to be below the setting (and the rate of change is below the setting as well if in the DF/DT Type), the element starts counting for however many consecutive half-periods (semi cycles) it continues below the setting. If the SET counter is reached, the pickup signal of the element is activated and the element starts the delay timer set independently for each element. However, the invalid frequency measurement will not affect the SET counter.

SEMICYCLES RESET

Range: 0 to 4 in steps of 1
Default: 0

If the frequency transiently restores and pickup conditions are not satisfied, the element freezes the SET counter to pick up and starts counting the number of semi cycles to reset the element. If the count of semi cycles to reset reaches the value set in the setting SEMICYCLES RESET, then the element is reset. On the other hand, if the pickup conditions are satisfied before reset, the element will continue the count of semi cycles to set from where it was left. The invalid frequency measurement will not affect the SET counter.

The SEMICYCLES SET and SEMICYCLES RESET settings are common for the eight Fast Underfrequency elements.

Path: **Setpoints > Protection > Group 1(6) > Frequency > Fast Underfrequency > Fast Underfreq1(X)**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Configurable
Default: Disabled

TYPE

Range: UF Only, UF and df/dt
Default: UF Only

This setting specifies the input to the element. The UF ONLY type uses only the frequency value. The UF and DF/DT type considers both frequency and rate of change of frequency (df/dt) as the input.

UNDERFREQENCY PICKUP

Range: 20.00 to 65.00 Hz in steps of 0.01 Hz
Default: 59.00 Hz

This setpoint sets the Underfrequency Pickup level.

RATE OF CHANGE PICKUP

Range: -10.00 to -0.10 Hz/sec in steps of 0.01 Hz/sec
Default: -0.75 Hz/sec

This setpoint sets the Rate of Change Pickup level.

PICKUP DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 1.000 s

RESET 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.

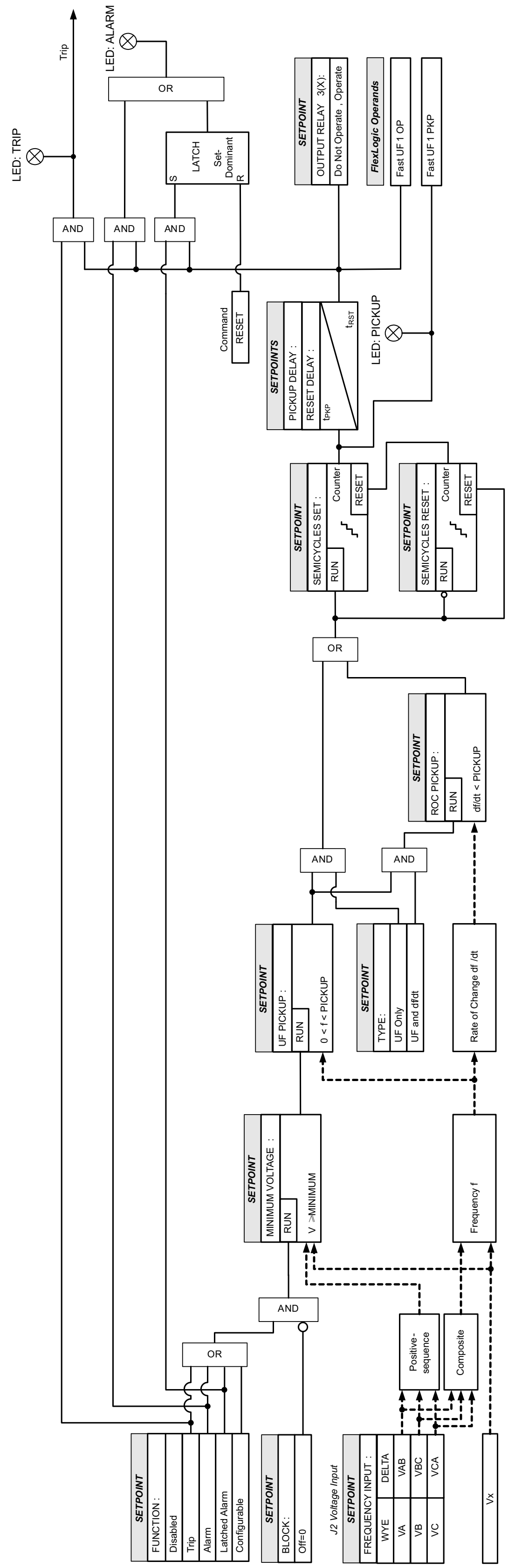
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Self-reset, Latched, Disabled
Default: Self-reset

Figure 6-82: Fast Underfrequency logic diagram

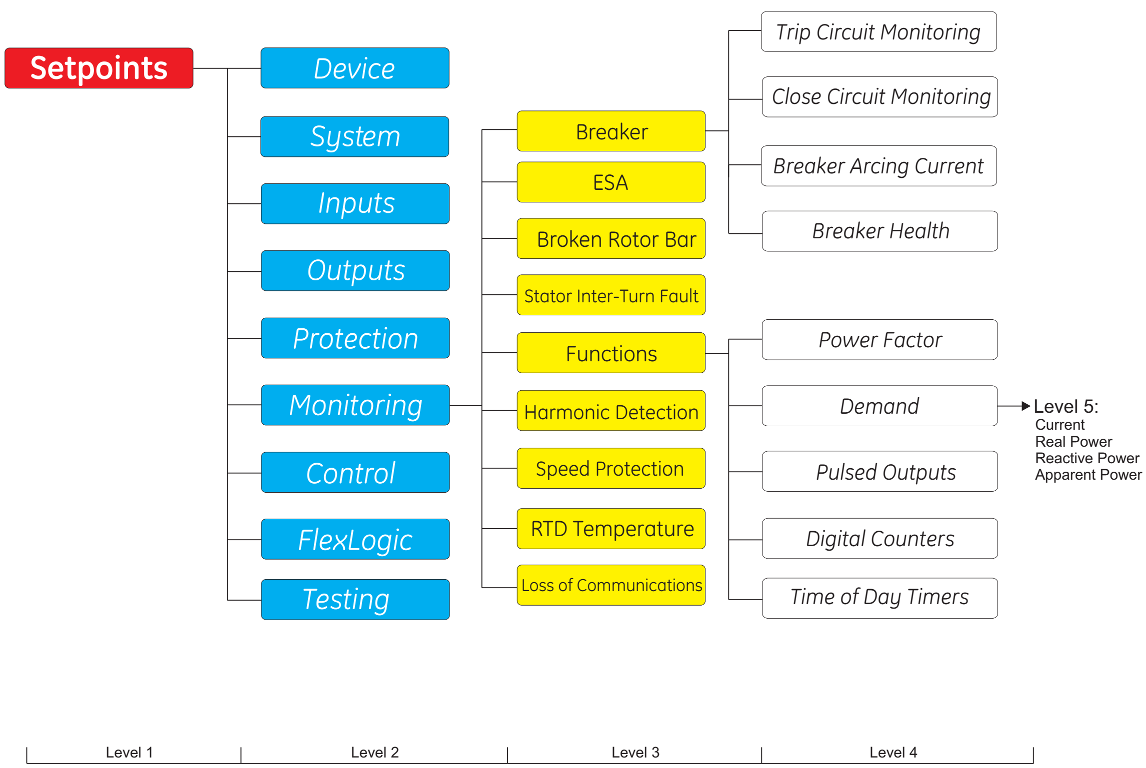


GE
Grid Solutions

869 Motor Protection System

Chapter 7: Monitoring

Figure 7-1: Monitoring Display Hierarchy



Breaker

Trip and Close Circuit Monitoring

The 869 relay provides Trip and Close Circuit Monitoring elements.

The first and second Form A relay outputs on slot “F” 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 terminals “FA_1 COM” and “FA_1 OPT/V” for the Trip coil monitoring, or/and “FA_2 COM” and “FA_2 OPT/V” for the Close coil monitoring.

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 7-2: Trip Coil Circuit without Monitoring

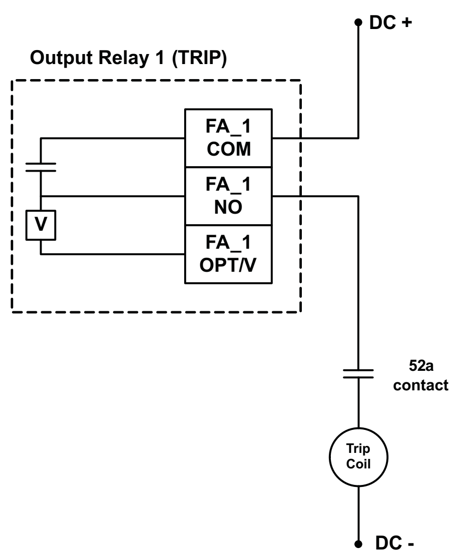


Figure 7-3: Close Coil Circuit without Monitoring

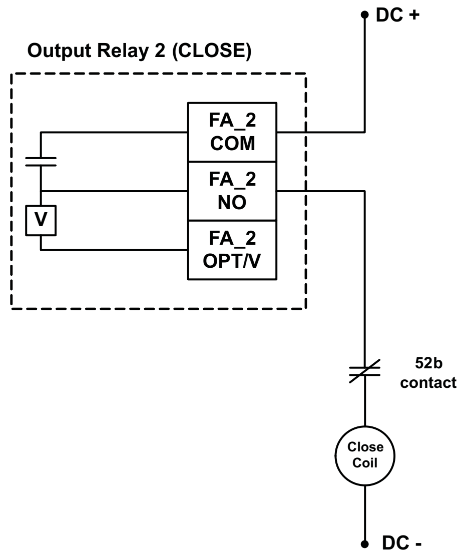


Figure 7-4: Trip Coil Circuit with Monitoring

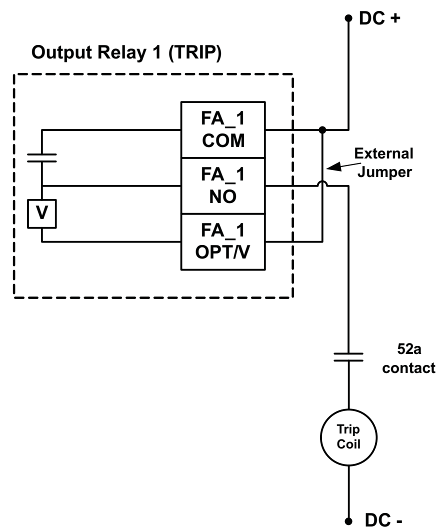
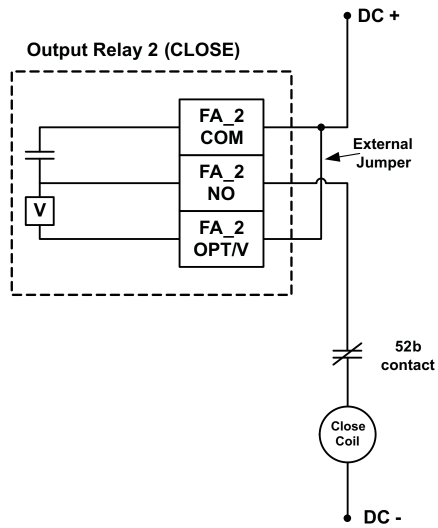


Figure 7-5: Close Coil Circuit with Monitoring



NOTICE

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).

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 7-6: Trip and Close Coil Circuit with Continuous Monitoring

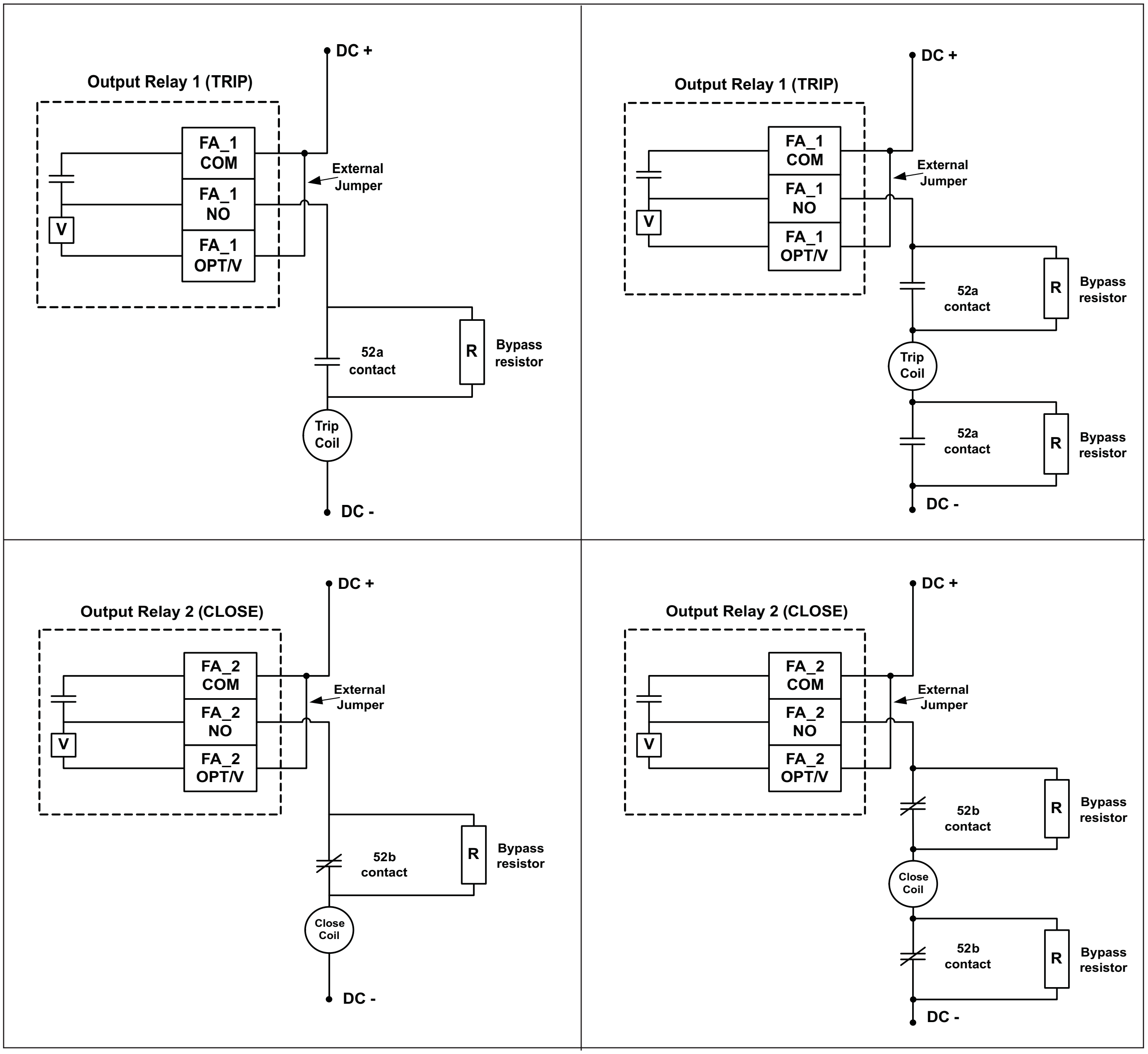


Table 7-1: Value of Resistor "R"

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.

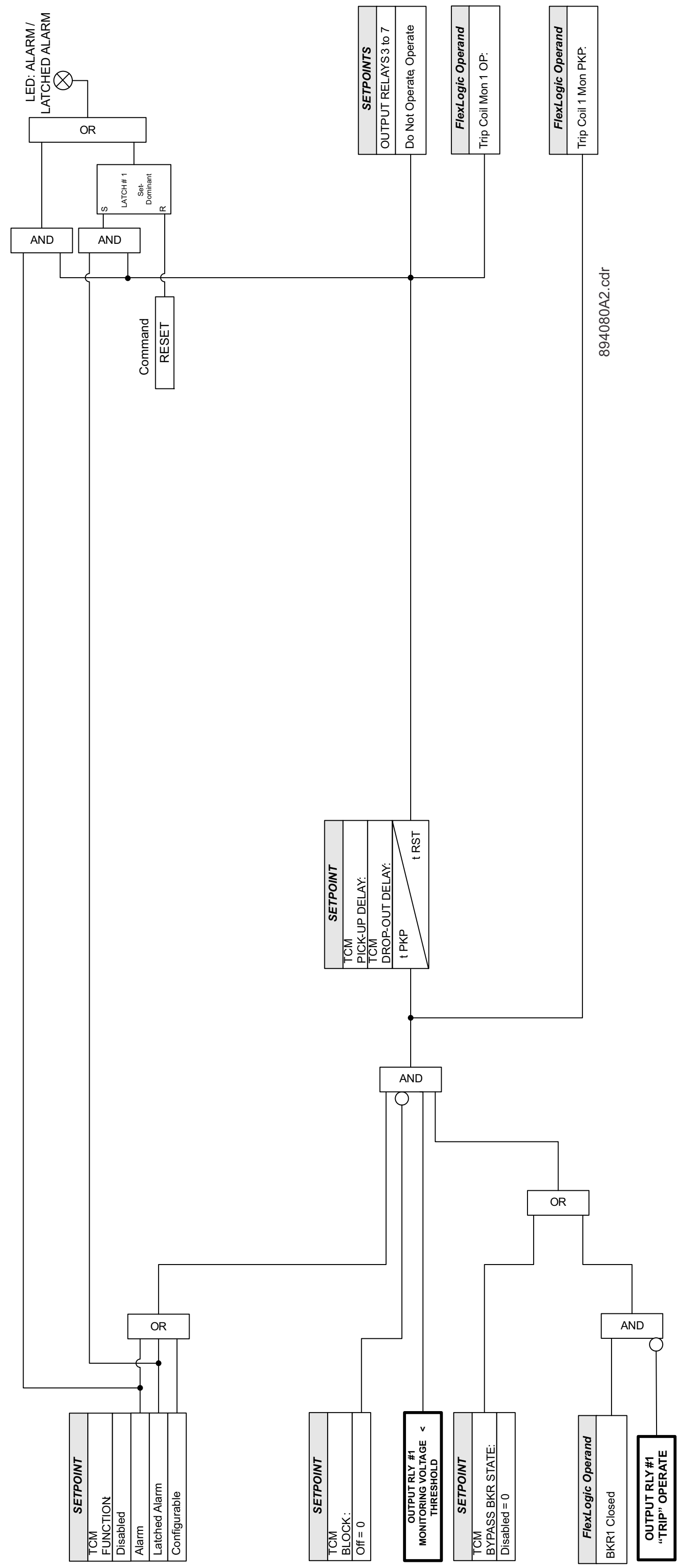
EVENTS:

Range: Disabled, Enabled
Default: Enabled

TARGETS:

Default: Self-reset
Range: Disabled, Self-reset, Latched

Figure 7-7: Trip Circuit Monitoring Diagram



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

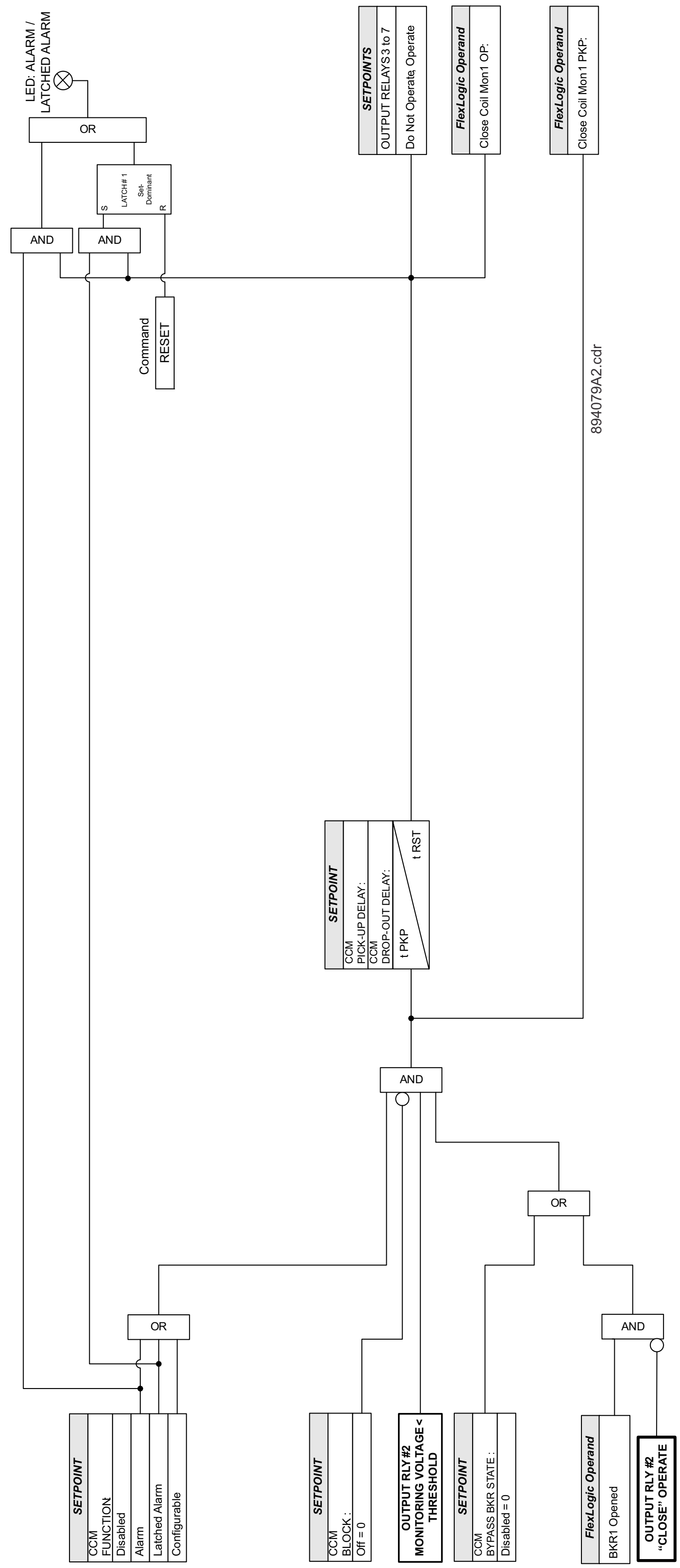
EVENTS:

Range: Disabled, Enabled
Default: Enabled

TARGETS:

Range: Disabled, Self-reset, Latched
Default: Self-reset

Figure 7-8: Close Circuit Monitoring Diagram

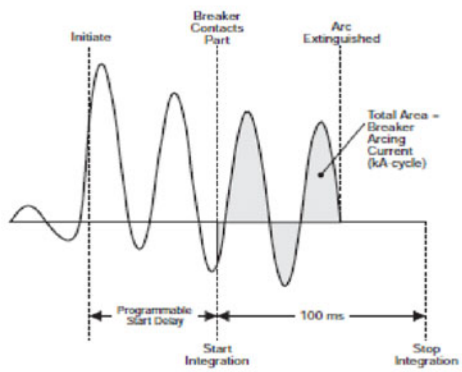


Breaker Arcing Current

The 869 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 7-9: Breaker Arcing Current Measurement



Path: Setpoints > Monitoring > Breaker > BKR 1 Monitor > BKR 1 Arcing Current

FUNCTION

Range: Disabled, Alarm, Latched Alarm, Configurable
Default: Disabled

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.

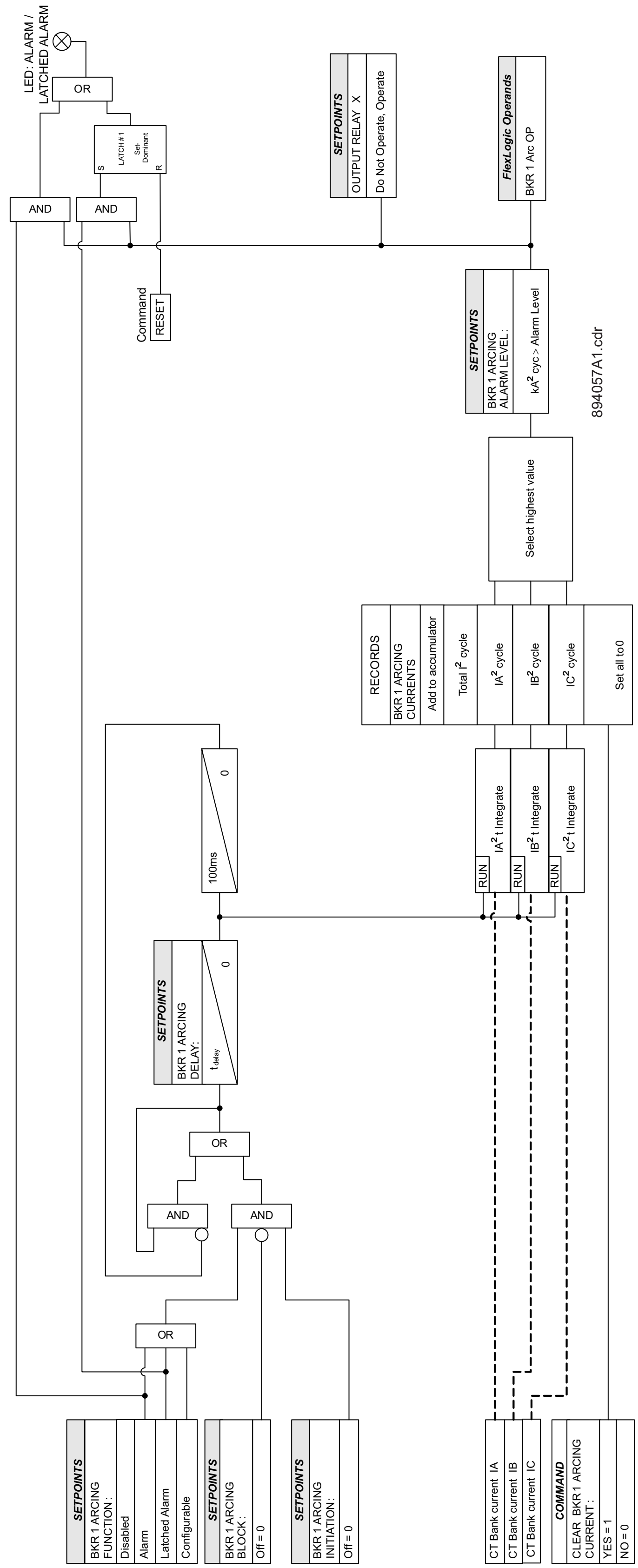
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Self-reset, Latched, Disabled
Default: Self-reset

Figure 7-10: Breaker Arcing Current logic diagram



Breaker Health

The 869 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.

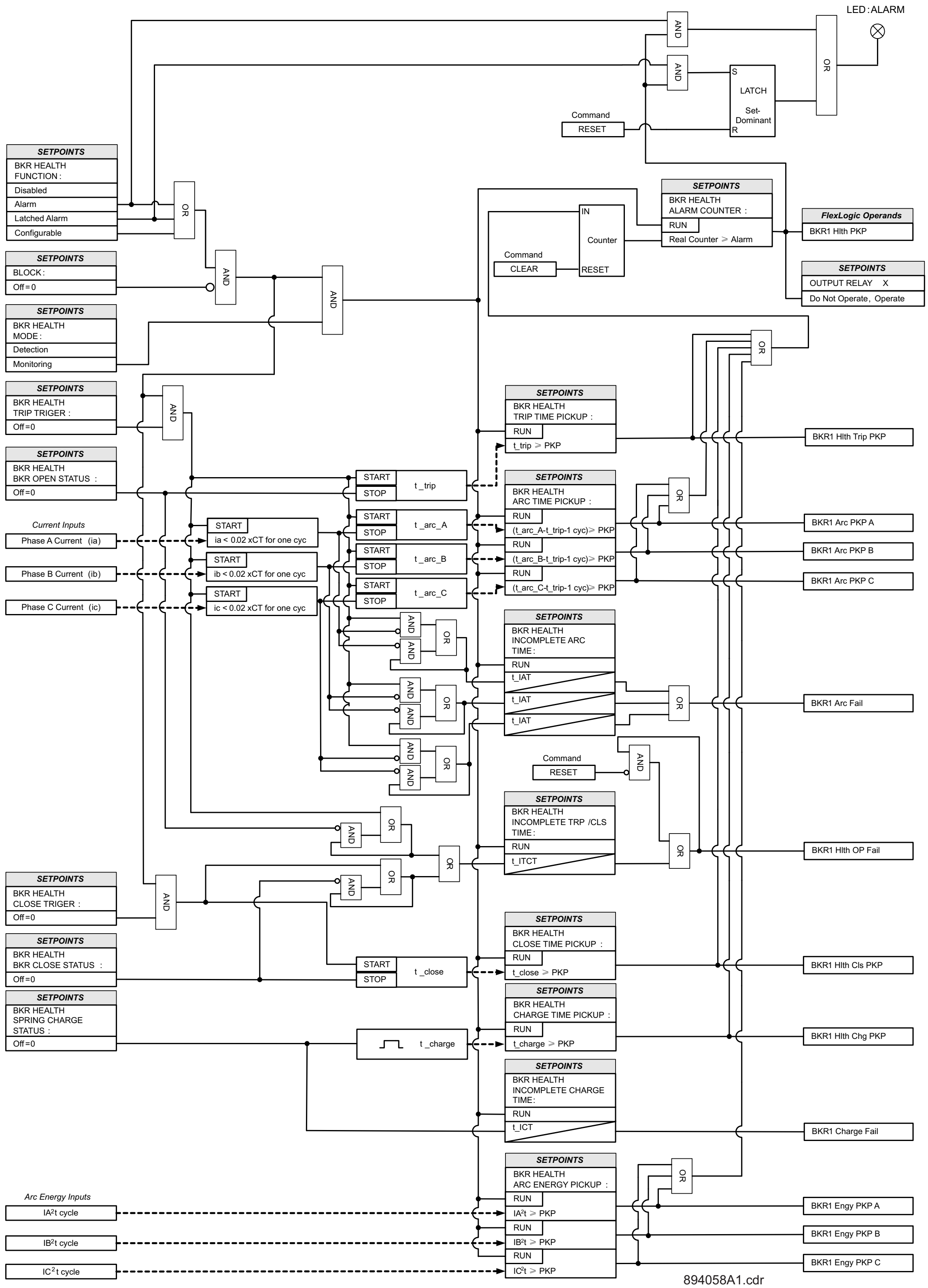
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Self-reset

Figure 7-11: Breaker Health and Operation logic diagram



Broken Rotor Bar

Under healthy rotor conditions, there will be only the slip frequency ($s*f_S$) current in the rotor. A broken rotor bar creates an asymmetry in the rotor circuit which in turn creates a negative rotating magnetic field at slip frequency ($-s*f_S$) in the rotor. This negative slip frequency component in the rotor creates $f_S*(1-2*s)$ component in the stator. This causes electromagnetic torque and speed oscillation at twice the slip frequency. This results infs*(1+2*s) and other harmonics in stator current at fs*(1+2*k*s), where k is an integer and s is the slip. A defect in a rotor bar of an induction motor causes modulation of the stator current. The impact of broken rotor bars on the stator current can be determined by analyzing in the frequency domain. This approach to detecting rotor bar failures is called Motor Current Signature Analysis (MCSA).

There are two methods of detecting Broken Rotor Bar component implemented in 869 relay:

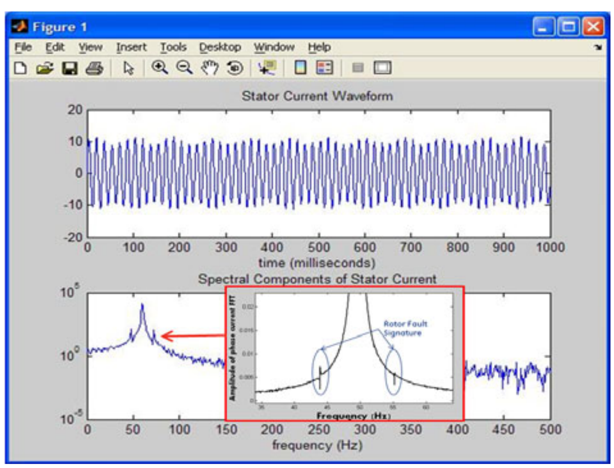
1. Power Based Coherent Demodulation: This technique uses multiplication of voltage and current samples thereby shifting the fundamental to DC and fault frequency to lower closer to DC value, to detect the broken rotor bar component. This method is running when voltage is available and is meeting MOTOR VOLTAGE SUPERVISION setting check.
2. Conventional current based FFT method: In case voltage is not available or the voltage magnitude is lower than the MOTOR VOLTAGE SUPERVISION setting value, the algorithm switches to analyzing the frequency spectrum from current samples only, to detect the broken rotor bar component.

The spectral components due to broken rotor bars can be expressed as: $f_b = (1 \pm 2s)f_1$. The lower component is due to broken bars, and the upper one is due to a related speed oscillation. Since the broken rotor bar disturbances are of an “impulse nature” (not a pure sine wave), the broken rotor bar spectral components can be expressed more accurately as: $f_S = (1 \pm 2k*s)*f_1$, where k = 1,2, 3...

The amplitude of harmonic spectral components due to rotor bar defects, where k >= 2, is dependant on the geometry of the fault. Their amplitude is significantly lower than the “main” sidebar component and they can be ignored in this analysis.

Below figure shows the frequency spectrum of a Motor with Broken Rotor Bar:

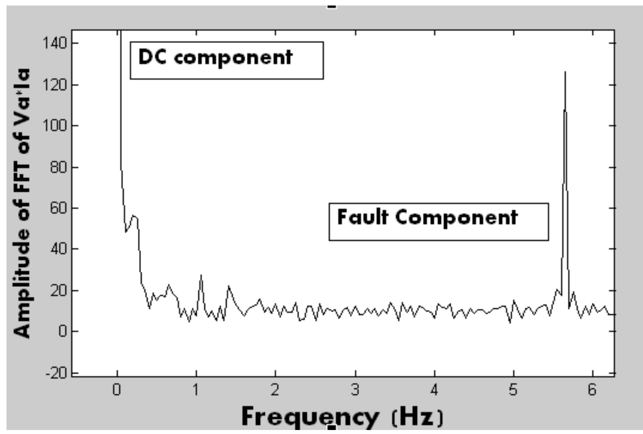
Figure 7-12: EFT of Stator Current of Induction Machine with Rotor Bar Fault



The figure above shows that the envelope of the stator current waveform is heavily modulated with the broken rotor frequency present at nearly ±12 Hz with respect to the fundamental frequency.

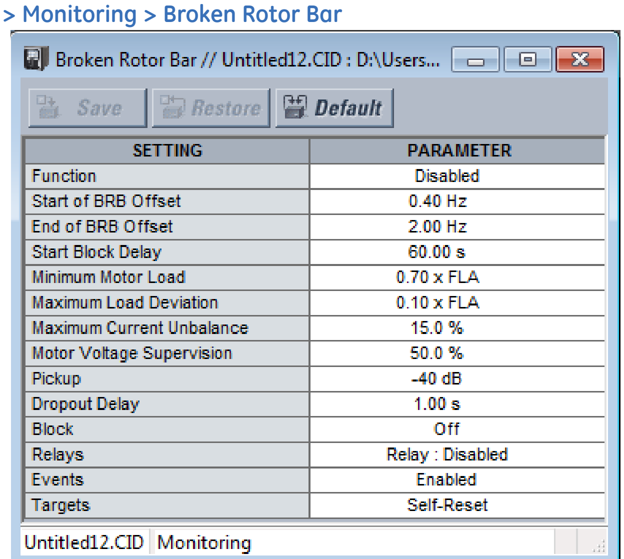
Patented Power Based Coherent Demodulation method is based on the multiplication of the current signal with any supply of fundamental frequency signal. The supply frequency signal is readily available in the voltage signal. Hence, for coherent demodulation, the current signal is multiplied by the corresponding phase or line voltage signal V_a*I_a. This approach allows to increase the contrast between fault signature by shifting fault characteristic frequency closer to the DC in the whole spectrum.

The FFT of the resultant multiplied signal is shown in the following figure. Comparison of the two figures shows a clear contrast between fault signature and fundamental frequency in coherent demodulated signal compared to only current FFT method signal.



NOTICE This element is not applicable to synchronous motor applications.

Path: Setpoints > Monitoring > Broken Rotor Bar



Broken Rotor Bar // Untitled12.CID : D:\Users...

Save Restore Default

SETTING	PARAMETER
Function	Disabled
Start of BRB Offset	0.40 Hz
End of BRB Offset	2.00 Hz
Start Block Delay	60.00 s
Minimum Motor Load	0.70 x FLA
Maximum Load Deviation	0.10 x FLA
Maximum Current Unbalance	15.0 %
Motor Voltage Supervision	50.0 %
Pickup	-40 dB
Dropout Delay	1.00 s
Block	Off
Relays	Relay : Disabled
Events	Enabled
Targets	Self-Reset

Untitled12.CID Monitoring

FUNCTION

Range: Disabled, Alarm, Latched Alarm, Configurable

Default: Disabled

The selection of **Alarm, Latched Alarm** or **Configurable** setting enables the Broken Rotor Bar function. When the **Alarm** function is selected and the Broken Rotor Bar operates, the LED "ALARM" flashes, and self-resets, when the operating conditions are cleared.When the **Latched Alarm** function is selected, and the Broken Rotor Bar operates, the LED "ALARM" flashes during the Broken Rotor Bar operating condition, and is steady lit after the conditions are cleared. The LED "ALARM" is cleared by issuing the reset command.When the **Configurable** function is selected, the ALARM LED does not turn on automatically. They need to be configured using their own menus and flexlogic operands.

START OF BRB OFFSET

Range: -12.00 to 11.99 Hz in steps of 0.01 Hz
Default: 0.40 Hz

This setting defines the beginning of the frequency range where the spectral component due to a rotor bar failure, is searched.

The setting must be set to a value equal to:
fstart_offset = 2*s* f1 – max(0.3, min(2*s* f1 – 0.4, 1.0))

where:

f1 = system frequency
s = the motor slip at full load
max = returns the largest of its arguments
min = returns the smallest of its arguments.

For example, if the full load slip is 0.01, set this setting to: 2*0.01*60 – 0.8 = 0.40 Hz, for a 60 Hz power system.

END OF BRB OFFSET

Range: -12.00 to 11.99 Hz in steps of 0.01 Hz
Default: 2.00 Hz

This setting defines the end of the frequency range where the spectral component due to a rotor bar failure, is searched.

This setting must be set to a value equal to:

fend_offset = 2*s* f1 + max(0.3, min(2*s* f1 – 0.4, 1.0))

where:
f1 = system frequency
s = the motor slip at full load
max = returns the largest of its arguments
min = returns the smallest of its arguments.

For example, if the full load slip is 0.01, set this setting to: 2*0.01*60 + 0.8 = 2.00 Hz, for a 60 Hz power system.

START BLOCK DELAY

Range: 0.00 to 600.00 s in steps of 0.01 s
Default: 60.00 s

This setting specifies the time for which the broken rotor bar detection algorithm is blocked after the motor status has changed from “Stopped” to “Running”. This ensures that the broken rotor bar element is active only when the motor is running.

MINIMUM MOTOR LOAD

Range: 0.50 to 1.00 x FLA in steps of 0.01 x FLA
Default: 0.70 x FLA

This setting is used to block the data acquisition of the Broken Rotor Bar detection function, as long as the motor load is below this setting. The Broken Rotor Bar detection algorithm cannot accurately determine the BRB spectral component when a motor is lightly loaded.

MAXIMUM LOAD DEVIATION

Range: 0.00 to 1.00 x FLA in steps of 0.01 x FLA

Default: 0.10 x FLA

This setting is used to block the data acquisition of the Broken Rotor Bar detection function, as long as the standard deviation of the motor load is above this setting. The Broken Rotor Bar detection algorithm cannot accurately determine the BRB spectral component when the motor load varies.

MAXIMUM CURRENT UNBALANCE

Range: 0.0 to 100.0% in steps of 0.1%

Default: 15.0%

This setting is used to block the data acquisition of the Broken Rotor Bar detection function, as long as the current unbalance is above this setting. The Broken Rotor Bar detection algorithm cannot accurately determine the BRB spectral component in a current unbalance situation.

MOTOR VOLTAGE SUPERVISION

Default: 50.0%

Range: 0.0 to 100.0% in steps of 0.1%

This setting is used to switch the detection technique from a Power based Coherent demodulation to a Current based FFT detection method in case the minimum of the three phase-to-phase voltages falls below the setting configured. This voltage is expressed as a percentage of the **Setpoints > System > Motor > Motor Nameplate Voltage** setting. This setting is hidden for non-voltage order code devices.

PICKUP

Default: -40 dB

Range: -60 to -12 dB in steps of -1dB

This setting specifies a pickup threshold for this element. The pickup threshold is usually be set to a level between –54 dB (likely a cracked rotor bar) and –50 dB (likely a broken rotor bar).

PICKUP DELAY

Range: 5 to 600 min in steps of 5 min

Default: 10 min

This setting is used to set the pickup time delay used to delay the pickup of the detection of the Broken Rotor Bar condition.

DROPOUT DELAY

Range: 0.00 to 600.00 s in steps of 0.01 s

Default: 0.00 min

This setting is used to set the dropout time delay used to delay the dropout of the detection of the Broken Rotor Bar condition.

BLOCK

Range: Off, Any FlexLogic operand

Default: Off

The Broken Rotor Bar is blocked when the selected operand is asserted.

OUTPUT RELAY X

For details see Common Setpoints.

EVENTS:

Range: Enabled, Disabled

Default: Enabled

The selection of the **Enabled** setting enables the events of Broken Rotor Bar function.

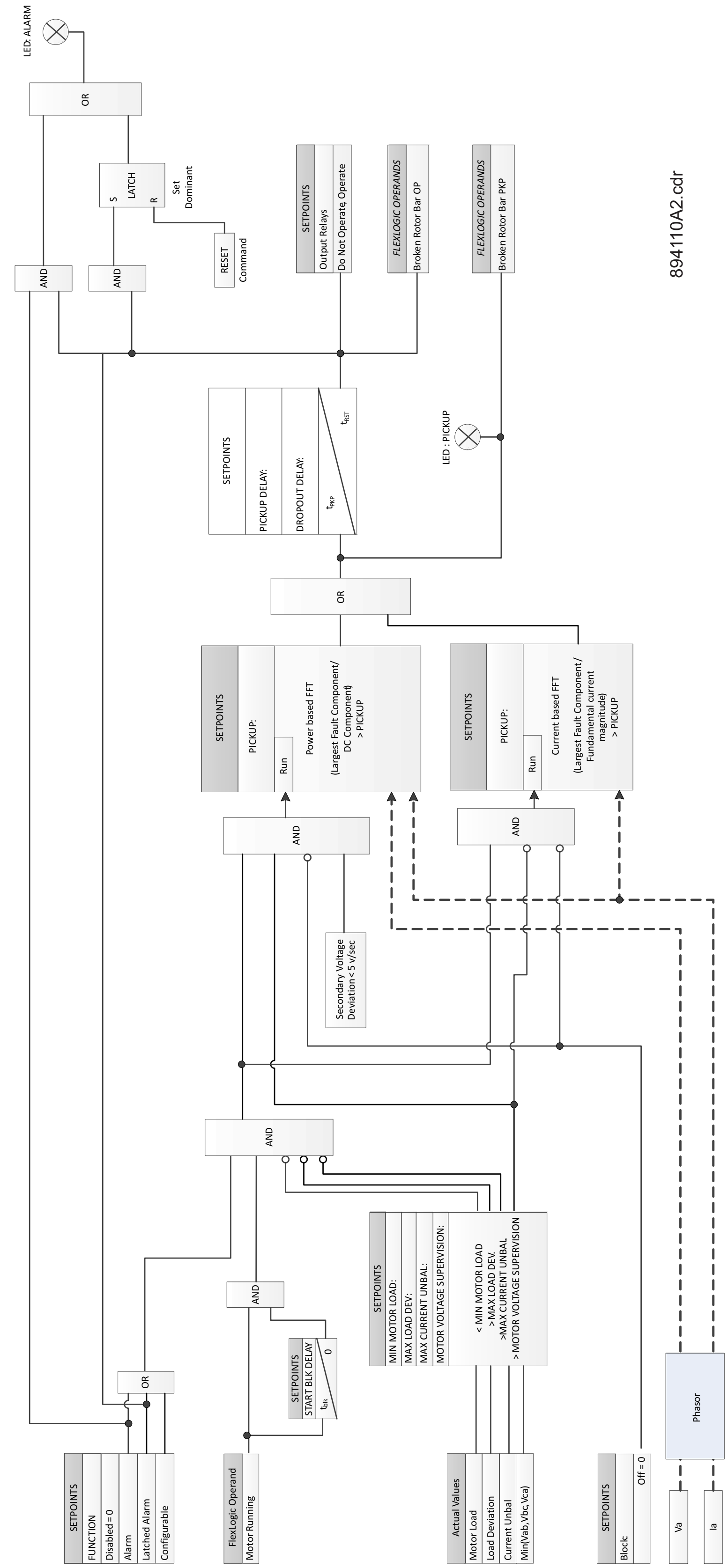
TARGETS:

Range: Self-reset, Latched, Disabled

Default: Self-reset

The selection of **Self-reset** or **Latched** settings enables the targets of the Broken Rotor Bar function.

Figure 7-13: Broken Rotor Bar Logic Diagram



Electrical Signature Analysis (ESA)

Rotating machines are a critical component of many industrial processes and are frequently integrated in commercially available equipment and industrial processes. The condition of a rotating machine can be effectively monitored using a non-intrusive method called Electrical Signature Analysis (ESA). The concept is to treat the electric machine as an implicit transducer built into machine-driven equipment; the current behavior can then be used to show various operating conditions of the machine as well as the load it is driving.

Proven ESA algorithms are implemented in the 8 Series to detect various failure modes in a rotating machine and its assembly. Some of the proven ESA applications are described as follows. Traditionally, machine condition can be supervised by measuring quantities such as noise, vibration and temperature. The implementation of these measuring systems is expensive and proves only to be economical in the case of large motors or critical applications. A solution to this problem is to use quantities that are already measured in a drive system e.g. the machine stator current, often required for command purposes. ESA is the technique used to analyze and monitor the trend of dynamic energized systems.

Specifically, ESA is the monitoring of stator current or voltage (more precisely supply current) of the machine. A single stator current or voltage monitoring system is commonly used (monitoring only one of the three phases of the machine supply). Machine stator windings are used as a transducer in ESA, picking the signals (induced currents and voltages) from the rotor (but also revealing information about the state of the stator). Various electrical and mechanical fault conditions present in the machine further modulate machine current and/or voltage signal and contribute to additional sideband harmonics. Faults in machine components produce corresponding anomalies in the magnetic field and change the mutual and self-inductance of then machine and this appears in the supply current and/or voltage spectrum as sidebands around line (supply, grid) frequency. Based on fault signatures motor faults can be identified and their severity can be accessed.

NOTE

The technology discussed in this manual has been patented (filed) with following disclosure numbers.

- GE 73745/316350: System, method and procedure for Industrial motor electrical signature analysis.
- US 15/489, 228: An autonomous procedure for electrical signature analysis based machine M&D.

The following high-level procedure describes how a motor is diagnosed:

1. ESA is part of existing Multilin 869 Protection Relay product. Hence ESA captures current signal from the same CT sensing mechanism available in 869 relay. No additional sensing or wiring mechanism is required to install or use ESA (M&D) with the 869 relay.
2. Stator phase A current measured by the J1 slot is used for the purpose of motor current signature analysis.
3. Before doing analysis, a data quality check is performed to verify if the power quality condition is good. Voltage, frequency, THD and current unbalance levels are checked to be within satisfactory limits. Signature analysis is performed only if the data quality check passes and an event is generated if the check fails.
4. Once the data quality check has passed, FFT is applied on J1 phase A current samples to convert time domain data into frequency domain and obtain current magnitudes at various frequency ranges of interest.

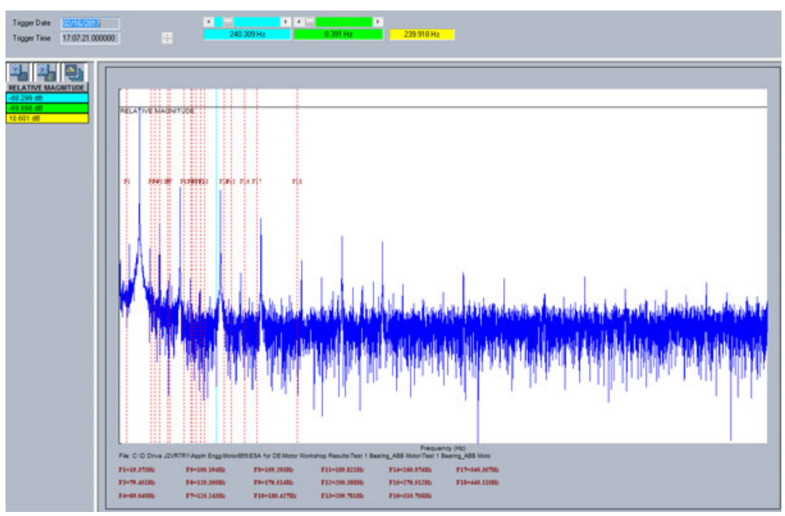
5. For each fault or anomaly, fault frequencies are computed based on supply frequency, speed, harmonic factor, slip etc. depending on the fault type.
6. Normalized dB magnitudes are computed at fault frequencies (based on formulae) as the ratio of magnitude at fault frequency and magnitude at fundamental frequency i.e. Magnitude in dB = 20 * Log10 (X1/Xf), where 'X1' is magnitude at fault frequency 'f1' and 'Xf' is magnitude at fundamental frequency 'fs'.
7. Peak magnitude in dB is computed as the highest magnitude observed at all fault frequencies and Energy in dB is computed as the ratio of an area within a +/- 0.5Hz vicinity at a frequency corresponding to peak magnitude and at fundamental frequency.
   Energy in dB = 20 * Log10 (E1/Ef), where 'E1' is the area within the vicinity at a fault frequency 'f1' and 'Ef' is the area within a vicinity at a fundamental frequency 'fs'.
8. During baseline mode, the dBs are computed as per steps 6 and 7 which are then averaged over the entire configured period and then stored as averaged normalized dB with respect to each load bin of the motor. A load bin is defined as the load interval of 10% within the 0% to 120% range of motor load operation, a total of 12 load bins.

NOTE

The relay enters baseline mode at any instant of time if the baseline data for a load bin is not available.

9. During monitoring mode, the dBs are computed at every interval as per steps 6 and 7. These dB levels and corresponding frequencies can be analyzed using an FFT spectrum analyzer, as shown in the next figure, Path: Motor M&D\ Records\ ESA Record. This spectrum tool works like the comtrade viewer available for viewing transient records (Path: Records\ Transients\ Transient Records) with the red, black and dark pink lines indicating fault frequencies of bearing, mechanical and stator faults and their corresponding values.

Figure 7-14: Relative Magnitude (dB) vs. Frequency (Hz)

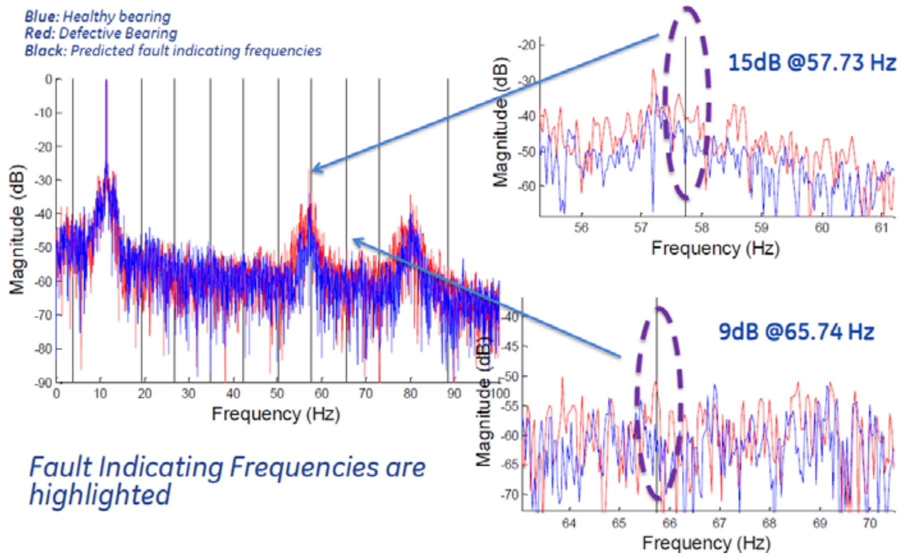


NOTE

To support event based monitoring, an additional FFT file is captured and saved from the Motor M&D\ Records\ ESA Record (Last PKP). This can be used to analyze the dB event conditions.

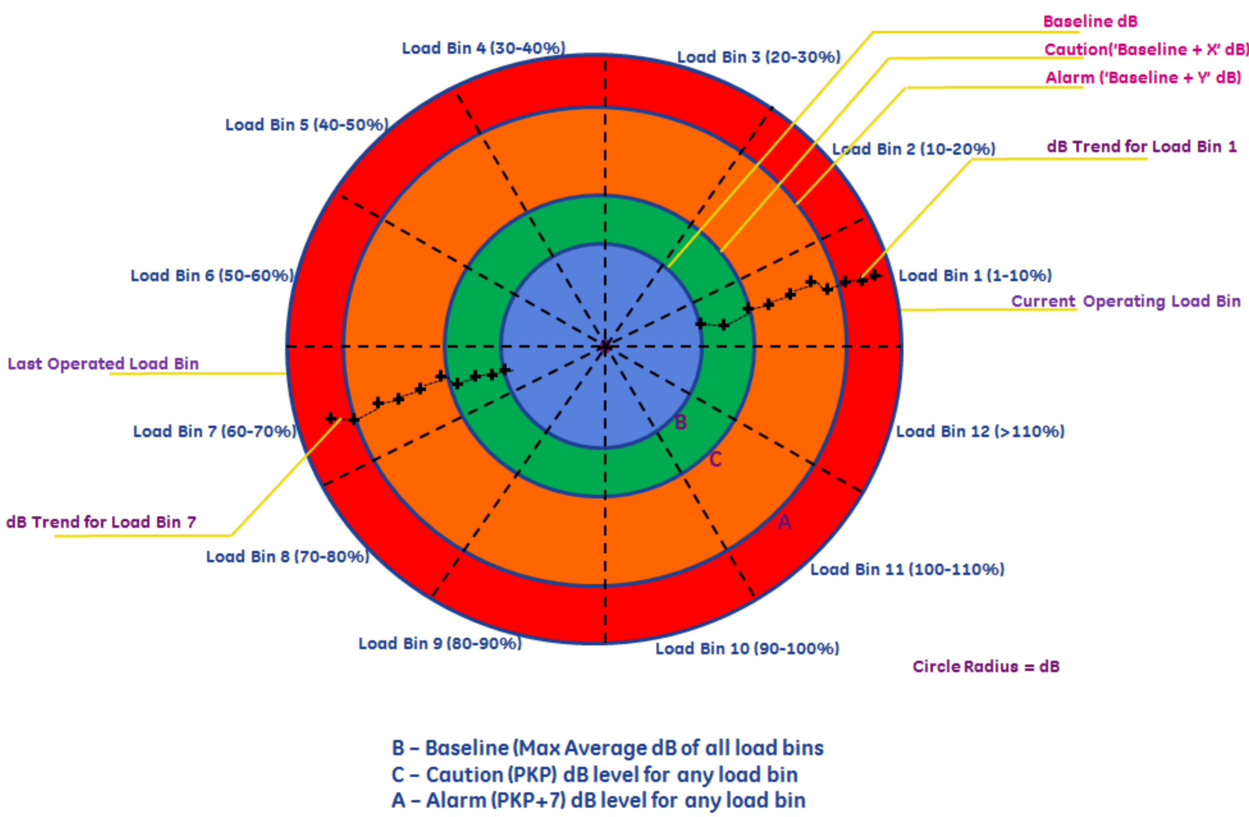
10. Based on dBs computed in steps 8 and 9, the change in Peak magnitude and Energy dBs are computed as the maximum difference in dB levels observed during baseline and monitoring modes at any of the fault frequencies. The following example is indicative of how a change in dB is computed at various fault frequencies.

Figure 7-15: Fault indicating frequencies are highlighted



11. If the change in dB of peak and energy magnitude is greater than the pick up levels configured in the ESA set points, then a corresponding fault element is triggered after the configured delay only if the level is sustained.
12. The dBs can be visualized in the form of a circle under the path Motor M&D\ESA Circle to determine the motor status (normal, caution or alarm) as represented in the following figure.

Figure 7-16: Motor status represented in circular format



- A circle is drawn with 3 dBs taken into consideration – baseline dB corresponding to 'k' value where maximum change in dB is observed, PKP level 1 dB setting and PKP level 2 dB setting as the radius of circles corresponding to the baseline, caution and alarm zones.
- The entire circle is divided into 12 equal sections covering 30 degrees of circumference corresponding to each load bin. Load bin 1 starts at 0 degrees and ends with load bin 12 at the 360 degree point in the anti-clockwise direction.
- The latest or last computed maximum change in dB at a specific 'k' is represented as a 'dot' in the current operating load bin and as a trend in future releases with respect to time in cases where historical data is available. The dB data represented in circle format will correspond to the maximum change in dB from baseline dB at a specific 'k' value in the formula (k = 1,2,3) related to the fault.

NOTE

In cases where the baseline mode is disabled or the baseline data is not available, the user can configure bearing, mechanical and stator function elements to operate based on peak magnitude (and energy) dBs. In such cases PKP 1 and PKP 2 settings are configured to correspond to the magnitude level (i.e. an example of 75 dB and 65 dB for PKP 1 and PKP 2 settings). However, in this case the circle will not plot any data

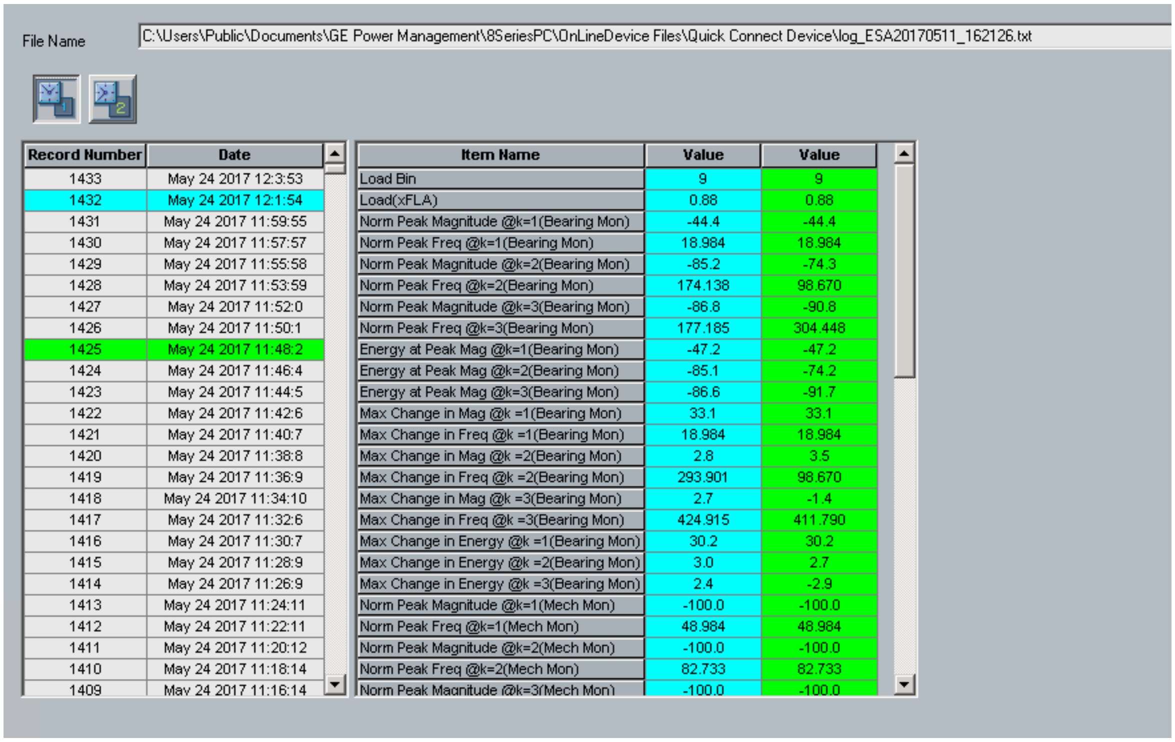
13. Motor M&D data is stored as a short-term historical log with a maximum of 4800 records with data logged at every 15 minute interval and during every intermediate PKP when the motor is in monitoring mode.
    - The file is stored in the local PC folder where EnerVista is installed @ C:\Users\Public\Documents\GE Power Management\8SeriesPC\OnLineDevice Files\(Device Name in EnerVista). The filename format is: log_ESA(Date_timestamp).txt, example: log_ESA20170511_162126.txt

NOTE

The file can also be converted to .csv format

- The file can be fetched and viewed by using EnerVista software in LDR (Learned Data Record) format under the section Motor M&D\Records\Historical log as shown in the next screenshot. Details of learned data record view can be found in section Records\Motor Learned Data (of the 869 instruction manual).
- Additionally, the file can be converted to .xlsx or .xls format and opened using Microsoft excel for analysis purposes or the trending of any parameter(s). T properly align data as rows/columns in the excel format, open the file and delete cell A1 and select shift cells left.

Figure 7-17: Viewing Motor M&D data file in EnerVista



Record Number	Date
1433	May 24 2017 12:3:53
1432	May 24 2017 12:1:54
1431	May 24 2017 11:59:55
1430	May 24 2017 11:57:57
1429	May 24 2017 11:55:58
1428	May 24 2017 11:53:59
1427	May 24 2017 11:52:0
1426	May 24 2017 11:50:1
1425	May 24 2017 11:48:2
1424	May 24 2017 11:46:4
1423	May 24 2017 11:44:5
1422	May 24 2017 11:42:6
1421	May 24 2017 11:40:7
1420	May 24 2017 11:38:8
1419	May 24 2017 11:36:9
1418	May 24 2017 11:34:10
1417	May 24 2017 11:32:6
1416	May 24 2017 11:30:7
1415	May 24 2017 11:28:9
1414	May 24 2017 11:26:9
1413	May 24 2017 11:24:11
1412	May 24 2017 11:22:11
1411	May 24 2017 11:20:12
1410	May 24 2017 11:18:14
1409	May 24 2017 11:16:14

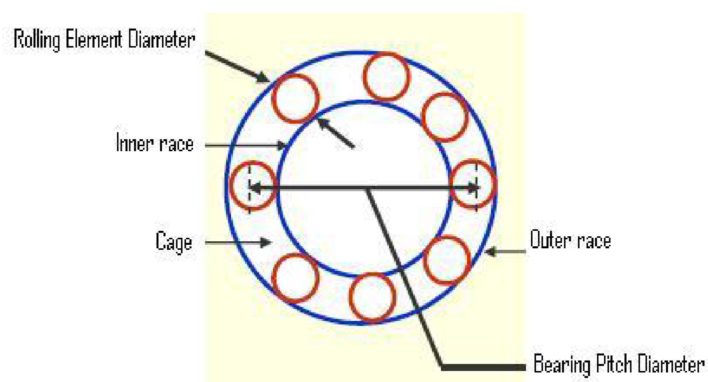
Item Name	Value	Value
Load Bin	9	9
Load(xFLA)	0.88	0.88
Norm Peak Magnitude @k=1(Bearing Mon)	-44.4	-44.4
Norm Peak Freq @k=1(Bearing Mon)	18.984	18.984
Norm Peak Magnitude @k=2(Bearing Mon)	-85.2	-74.3
Norm Peak Freq @k=2(Bearing Mon)	174.138	98.670
Norm Peak Magnitude @k=3(Bearing Mon)	-86.8	-90.8
Norm Peak Freq @k=3(Bearing Mon)	177.185	304.448
Energy at Peak Mag @k=1(Bearing Mon)	-47.2	-47.2
Energy at Peak Mag @k=2(Bearing Mon)	-85.1	-74.2
Energy at Peak Mag @k=3(Bearing Mon)	-86.6	-91.7
Max Change in Mag @k =1(Bearing Mon)	33.1	33.1
Max Change in Freq @k =1(Bearing Mon)	18.984	18.984
Max Change in Mag @k =2(Bearing Mon)	2.8	3.5
Max Change in Freq @k =2(Bearing Mon)	293.901	98.670
Max Change in Mag @k =3(Bearing Mon)	2.7	-1.4
Max Change in Freq @k =3(Bearing Mon)	424.915	411.790
Max Change in Energy @k =1(Bearing Mon)	30.2	30.2
Max Change in Energy @k =2(Bearing Mon)	3.0	2.7
Max Change in Energy @k =3(Bearing Mon)	2.4	-2.9
Norm Peak Magnitude @k=1(Mech Mon)	-100.0	-100.0
Norm Peak Freq @k=1(Mech Mon)	48.984	48.984
Norm Peak Magnitude @k=2(Mech Mon)	-100.0	-100.0
Norm Peak Freq @k=2(Mech Mon)	82.733	82.733
Norm Peak Magnitude @k=3(Mech Mon)	-100.0	-100.0

ESA application for Rolling Element Bearing Fault Detection

The faults occurring in motor bearings are generally due to the excessive load, rise of temperature inside the bearing, use of bad lubricant and so on. The bearing consists mainly of the outer race and inner race ways, the balls and cage; this assures equal distance between the balls. The different faults that may occur in a bearing can be indicated as a single parameter based on any affected component as shown in the next figure.

- Outer raceway defect
- Inner raceway defect
- Ball defect

Figure 7-18: Ball bearing details



The Bearing Flt element uses FFT computation on the current signal to detect bearing failure on an electrical machine. The operating condition can be defined as: Computing vibration frequency related to bearing damage using this equation.

Eq. 1

$$f_{vib} = \begin{cases} \frac{N_b}{2}\frac{\omega_r}{60}(1+\frac{D_b}{D_c}) & \text{(inner race)} \\ \frac{N_b}{2}\frac{\omega_r}{60}(1-\frac{D_b}{D_c}) & \text{(outer race)} \\ \frac{D_c}{D_b}\frac{\omega_r}{60}(1-\frac{D_b^{\,2}}{D_c^{\,2}}) & \text{(ball damage)} \end{cases}$$

where

- N_b is no. of rolling elements (see setpoint No of Rolling Elements for more details)
- D_c is cage diameter (see setpoint Cage Diameter for more details)
- D_b is rolling ball diameter (see setpoint Rolling Element Ball Diameter for more details)

Compute stator current frequency related to bearing damage using the following equation.

Eq. 2

$$f_{bearing} = f_{supply} \pm k * f_{vib}$$

where

- k is any integer: 1,2,3
- f_{supply} is actual supply frequency (when Frequency Tracking is Enabled), otherwise Nominal Frequency (programmed under System > Power System) is taken as supply frequency.

Identifying peak magnitudes or energy in dB at the stator current frequencies and calculating change in dB magnitude for baseline (healthy mode) peak magnitudes or energy at the corresponding stator current frequencies in dB for each load bin is given by the equations *Change in Energy dB* and *Change in Peak Magnitude dB*.

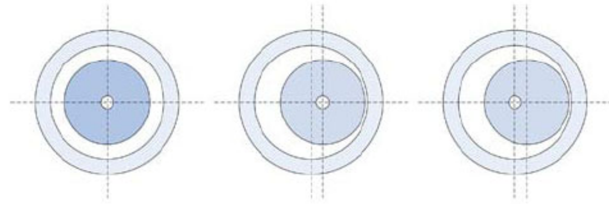
Change in Energy dB = Energy dB (Latest) – Energy dB (Baseline) **Eq. 3**

Change in Peak Magnitude dB = Peak magnitude dB (Latest) – Peak magnitude dB (Baseline) **Eq. 4**

ESA Application for Mechanical [Foundation Looseness, Eccentricity and Shaft Misalignment (FEM)] Fault Detection

Although mechanical faults like Foundation looseness, Eccentricity and Misalignment (FEM) are different fault conditions in a rotating machine, they can be identified at the same set of stator current frequencies related to eccentricity damage. Air-gap eccentricity represents a condition when air gap distance between the rotor and the stator is not uniform. Two types of abnormal air-gap eccentricity exist: static and dynamic. In the case of static eccentricity the position of a minimal radial air gap is fixed, while in the case of dynamic eccentricity the position of the minimal air gap follows the turning of the rotor. Normal (concentric) state, static and dynamic eccentricities are illustrated in the following figure. As the rotor bars recede or approach the stator magnetic fields, they cause a change to the current in the stator. In the case of static eccentricity, sideband components appear at frequencies.

Figure 7-19: Eccentricity details



The Mechanical fault detection application uses ESA computation on the current signal to detect misalignment, eccentricity and foundation-looseness failure cases of the machine. The operating condition can be defined as:

Computing the ESA frequencies related to the mechanical defects (shaft misalignment, load unbalance, loose foundation, dynamic/static eccentricity). The ESA frequencies are calculated using the following equation.

Eq. 5

$$f_{misalignment} = f[1 \pm \frac{2k(1-s)}{P}]$$

where

- k is any integer: 1,2,3
- s is actual motor slip computed based on rated slip and actual input power
- P is number of poles programmed under System\Motor\Setup
- f_{supply} is actual supply frequency (when Frequency Tracking is Enabled), otherwise Nominal Frequency (programmed under System > Power System) is taken as supply frequency.

Identify the peak magnitudes (or energy in dB at the stator current frequencies) and calculate the maximum change in dB at baseline (healthy mode) peak magnitudes (or energy at the corresponding stator current frequencies). This is performed w.r.t. the current load bin of the operation as given by the following *Change in Energy dB* and *Change in Peak Magnitude dB* equations:

Change in Energy dB = Energy dB (Latest) – Energy dB (Baseline) **Eq. 6**

Change in Peak Magnitude dB = Peak magnitude dB (Latest) – Peak magnitude dB (Baseline) **Eq. 7**

ESA Application for Stator Fault Detection

Stator faults cause damage to insulation, laminations, frames and winding due to various electro-mechanical and thermal stresses.

Reason/Effect:

- Failure of insulation leading to turn-turn, phase-phase, coil-coil, phase to ground etc. faults
- Rotor striking the stator due to misalignment or shaft deflection, bearing failure causing stator laminations to puncture the coil insulation leading to coil to ground fault
- Transients in supply voltage due to power system faults, VFDs, operation of breakers leading to turn-turn or turn-ground fault
- Thermal stress due to overcurrent flowing due to sustained overload or fault, higher ambient temperature, obstructed ventilation, unbalanced supply voltage etc. increases winding temperature and reduces insulation life.
- Environment stress based on ambient temperature

The 869 relay detects stator faults using ESA based on fault frequencies computed as:

- CF ± Supply frequency sidebands and
- CF ± Supply frequency ± Rotational frequency sidebands

where,

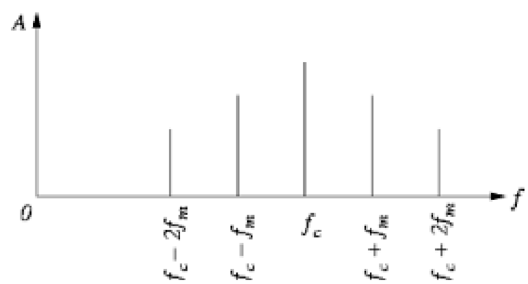
CF = Center Frequency = Rotational frequency (rps) * Number of stator slots

Rotational frequency = Running speed in rpm/60

Sideband represents the upper and lower frequency region for the stated frequency at the center.

For example, in figure 2a 'fc' represents the center frequency and 'fc+fm' or 'fc-fm' represents sidebands of 'fc'.

Figure 7-20: Center frequency with sidebands



The algorithm for detection of Bearing, Mechanical and Stator fault consists of two sections named the Baseline mode and Operation mode.

Baseline Mode

This mode runs once during the commissioning/installation for a given setup of CTs, PTs and machine rating, for a default 48 hours (baseline period - configurable) of motor operational time. All dB computations (highest normalized peak magnitude and energy at peak magnitude) with baseline data are computed and captured for each load bin. During the baseline period, dB computations are averaged continuously for each load bin and stored as averaged normalized dBs. Thereafter the device enters into this mode whenever there is a need to capture baseline data for a particular load bin or if the baseline data is not captured for that particular bin during the initial 48 hours period (default) after installation, and enters back to operational or monitoring mode instantly once baseline data is captured and stored. FFT is run on baseline data samples to capture peak magnitude or energy for each possible harmonic factor (k = 1,2,3) related to bearing, mechanical and stator faults and the averaged values are stored in an internal file for each load bin. Both data quality check and ESA accuracy checks are performed prior to recording data. Baseline data is considered the data of a healthy motor. Users can clear baseline data using the 'Clear ESA baseline data' command and capture data again by enabling baseline mode and configuring the baseline period.

Monitoring mode

During monitoring mode ESA algorithms for bearing, mechanical and stator faults are computed every 1 minute based on current (Ia) samples. FFT is run on these current (Ia) samples to capture the peak magnitude or energy for each possible harmonic factor (k = 1,2,3) related to bearing, mechanical and stator faults, and stored in an internal file for each load bin. Computed ESA dB magnitudes at all fault frequencies after each interval are compared with baseline magnitudes to extract the maximum change in dB. Both data quality checks and ESA accuracy checks are performed prior to recording data. Users can clear operational data using the 'Clear ESA operational data' command.

System > Motor > Setup

ESA computation uses some of the existing settings already available in 869. The following are the settings (shown with their path location) that must be configured.

- **Number of Poles**
  this setting from **System > Motor > Setup** is used to compute synchronous speed. (Mandatory)
- **Motor Rated Horse Power and Motor Rated Efficiency**
  these settings from section **System > Motor > Setup** are used to compute rated input power that in turn is used for speed estimation. (Mandatory)
- **Nominal frequency**
  this setting from section **Platform > Frequency 1-J (or 2-K)** is used to compute frequency variation in the case of data quality check. (Mandatory)
- **Frequency tracking**
  this setting from section **Settings > Power System** if enabled is used to compute source frequency more accurately. Enabling this setting is recommended. (Optional)
- **Rated speed**
  this setting from section Path: **Monitoring > Speed** is used for speed estimation. (Mandatory)

Path: **Setpoints > Monitoring > ESA**

NOTE

Some of the existing settings in 869 as mentioned in the preceding list will be re-used for ESA computation hence it is necessary to configure them. Since ESA is dependent on speed and frequency, it is mandatory to configure the rated speed. In addition, frequency tracking must be enabled for accurate ESA results.

MOTOR MANUFACTURER

Range: n/a

Default: None

Configure the name of the motor manufacturer as a character string using the information taken from the motor nameplate data.

FUNCTION - BEARING

Range: Disabled, Enabled

Default: Disabled

When the Enabled function is selected, the element checks for the Bearing (Eccentricity) Fault status as programmed.

FUNCTION - MECHANICAL (MECH)

Range: Disabled, Enabled

Default: Disabled

When the Enabled function is selected, the element checks for the mechanical (FEM) Fault status as programmed.

FUNCTION - STATOR

Range: Disabled, Enabled

Default: Disabled

When the Enabled function is selected, the element checks for the stator Fault status as programmed.

Data Quality Check

Range: Disabled, Enabled

Default: Enabled

When this setpoint is Enabled, FFT computation on current samples is only performed when data quality checks are passed. If input phase A current fails any of the following data quality checks, the ESA element asserts a FlexLogic operand and generates the event 'Data Quality Check Fail'.

– Frequency measured shall be within +/- 5% limits of nominal frequency.
– Voltage measured shall be within +/- 10 % limits of nominal voltage (voltage order code).
– THD (total harmonic distortion) of phase current computed shall be less than 5% of nominal frequency.
– ROCOF (rate of change of frequency) computed shall be less than 5% of nominal frequency.
– Current unbalance in system computed shall be less than 10% of the FLA.

BASELINE PERIOD

Range: 1 to 240 hours in steps of 1hr

Default: 48 hours

Baseline period indicates the duration of time (motor running hours) that the relay stays in this period to capture baseline data, during installation or commissioning, for extracting baseline (healthy) dB magnitudes.

BASELINE MODE

Range: Disabled, Enabled

Default: Disabled

Baseline mode is disabled by default. During installation/commissioning baseline mode must be enabled along with having a set baseline period. The 869 will capture baseline data for the specified time period then go back to operational mode automatically. If necessary, the user can clear the baseline data and restart data capture by enabling baseline mode and setting or changing the baseline period.

NUMBER OF ROLLING ELEMENTS

Range: 1 to 1000 in steps of 1

Default: 1

Number of rolling elements (ball or cylindrical) must be configured using the motor bearing specification information provided by manufacturer.

CAGE DIAMETER

Range: 0.001 to 1000.000 inches in steps of 0.001

Default: 0.500 inch

Cage diameter needs to be configured using the motor bearing specification information provided by the manufacturer. See 'Dc' in the following figure: Ball bearing cross-sectional view for reference.

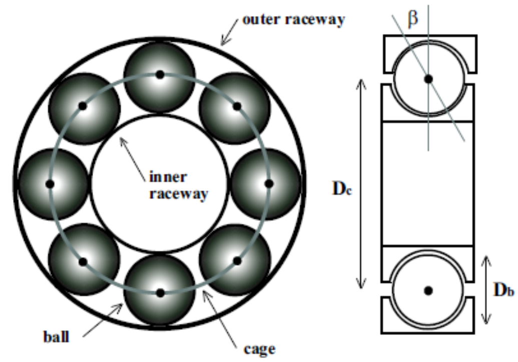
ROLLING ELEMENT BALL DIAMETER

Range: 0.001 to 1000.000 inches in steps of 0.001

Default: 0.100 inch

Rolling element ball diameter needs to be configured using the motor bearing specification information provided by the manufacturer. See 'Db' in the following figure: Ball bearing cross-sectional view for reference.

Figure 7-21: Ball bearing cross-sectional view



NO. OF STATOR SLOTS

Range: 1 to 500 in steps of 1

Default: 0

Configure the number of stator slots based on the motor design. This information is available from the manufacturer or found in the motor technical manuals.

BEARING FAULT PKP STAGE 1(2)

Range: 1 to 100 dB in steps of 1 dB

Default: 45 dB (55 dB)

Configure the minimum dB level above the baseline dB level (for any load bin) at which the bearing fault operand level 1 (level 2) picks up. This setting is applicable to both peak magnitude and energy at peak magnitude.

ESA operates and generates an event when change in dB, ΔdB value is greater than the pickup level in dB and is sustained for the pickup delay time for the specific load bin. Change in dB, ΔdB is computed from actual dB level minus baseline dB.

Example 1 - when Baseline Mode is Enabled

Pickup level(dBpkp) is set at 25dB

Baseline dB (dBbaseline) computed by Baseline Mode = -80dB

Actual dB level required to operate = dBbasline + dBpkp =-80dB + 25dB = -55dB

ESA operates when actual dB is equal to or greater than -55dB

Example 2 - when Baseline Mode is not Enabled

Pickup level(dBpkp) is set at 45dB

Baseline dB (dBbaseline) is fixed = -100 dB.

Actual dB level required to operate ESA = (dBbasline) + dBpkp = -100dB + 45 = -55dB

ESA operates when actual dB is equal to or greater than -55dB

Therefore, for the same threshold, i.e. -55dB, with baseline mode disabled, the pickup level should be higher as it is compared with -100dB, as compared to baseline enabled. The pickup level can be adjusted to get threshold around -55dB to -45dB for Caution, and -45dB to -35dB for Alarm purposes.

BEARING FAULT PKP DELAY 1(2)

Range: 5 to 60 min in steps of 5 min

Default: 10 min (15 min)

Configure the delay in minutes after which the bearing fault operand pickup level 1 (level 2) will operate if the level sustains.

MECH FAULT PKP STAGE 1(2)

Range: 1 to 100 dB in steps of 1 dB
Default: 45 dB (55 dB)

Configure the minimum dB level above the baseline dB level (for any load bin) at which the bearing fault operand level 1 (level 2) picks up. This setting is applicable to both peak magnitude and energy at peak magnitude.

MECH FAULT PKP DELAY 1(2)

Range: 5 to 60 min in steps of 5 min
Default: 10 min (15 min)

Configure the delay in minutes after which the bearing fault operand pickup level 1 (level 2) will operate if the level sustains.

STATOR FAULT PKP STAGE 1(2)

Range: 1 to 100 dB in steps of 1 dB
Default: 45 dB (55 dB)

Configure the minimum dB level above the baseline dB level (for any load bin) at which the bearing fault operand level 1 (level 2) picks up. This setting is applicable to both peak magnitude and energy at peak magnitude.

STATOR FAULT PKP DELAY 1(2)

Range: 5 to 60 min in steps of 5 min
Default: 10 min (15 min)

Configure the delay in minutes after which the bearing fault operand pickup level 1 (level 2) will operate if the level sustains.

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

The ESA element is blocked, when the selected operand is asserted.

OUTPUT RELAY X

For details see Common Setpoints.

EVENTS

Range: Enabled, Disabled
Default: Enabled

The selection of the **Enabled** setting enables the events of the Stator Inter-Turn fault function.

TARGETS

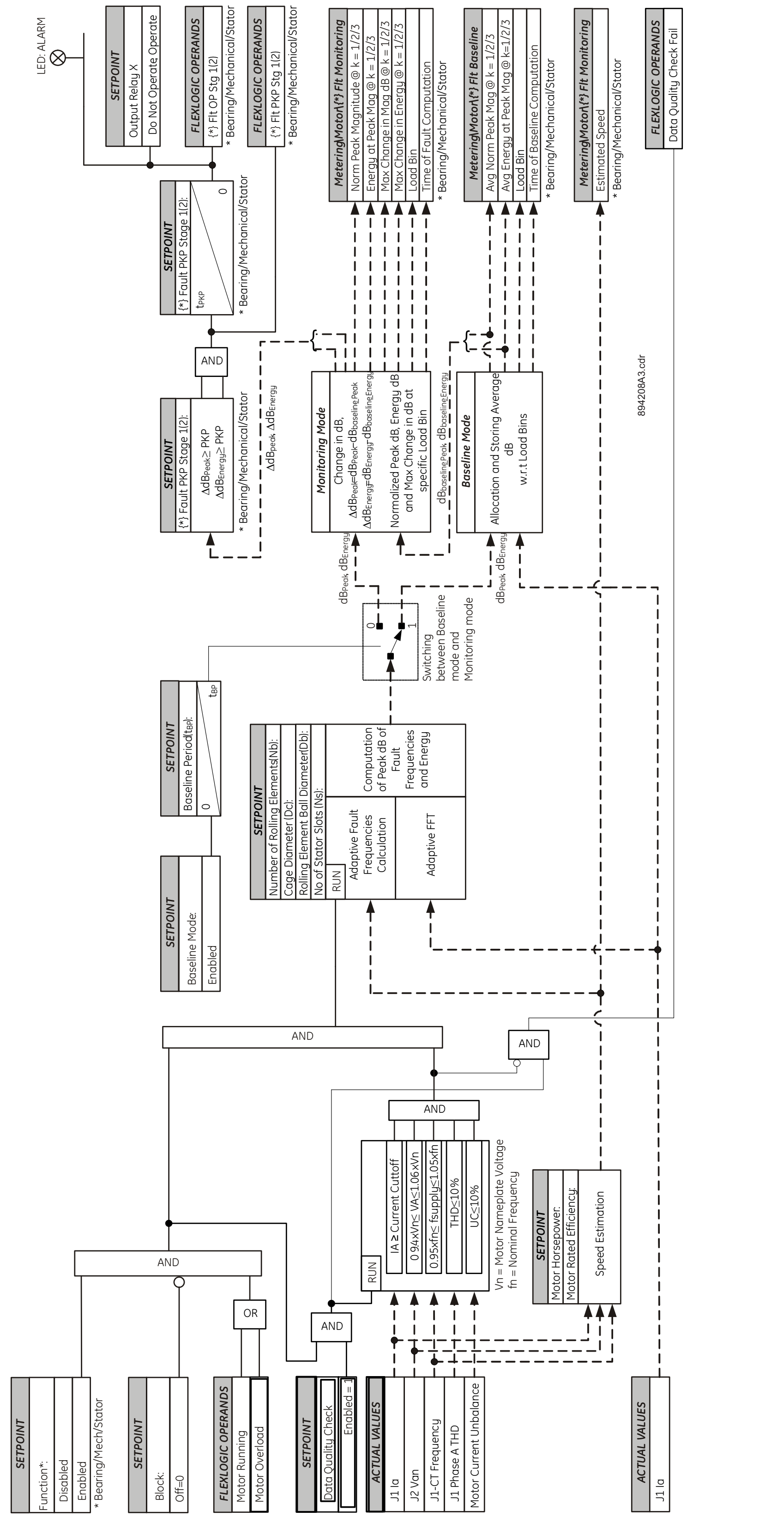
Range: Self-reset, Latched, Disabled
Default: Latched

The selection of the **Self-reset** or **Latched** setting enables the targets of the Stator Inter-Turn fault function.

NOTE

In cases where baseline mode is disabled or baseline data is not available, the PKP related settings of bearing, mechanical and stator for dB levels should correspond to peak magnitude and not change in dB magnitude (Example: a default of 75dB for Flt PKP Stg 1 and 65dB for Flt PKP Stg 2).

Figure 7-22: Bearing/ MECH/ Stator Logic diagram



Stator Inter-turn Fault

When the insulation of the stator windings deteriorates due to age and other factors, this creates an inter-turn fault. This type of fault is local and can happen either on the same phase or different phases. An inter-turn fault causes heating at the local level, but the heat rapidly propagates, causing the fault to extend to other areas of the stator winding. If an inter-turn fault can be detected in time, it provides warning of upcoming major damage to the system.

The stator inter-turn fault element uses sequence components to detect stator turn failure of the induction machine.

The operating condition can be defined as:

$$OP = \frac{Z_{np}}{Z_{pp}} - Z_{UBbase}$$

Where:

Z_{pp} = positive sequence impedance

Z_{np} = cross-coupled negative-to-positive sequence impedance

Z_{UBbase} = learned unbalance base impedance

Z_{np}/Z_{pp} can be calculated from V1, V2, I2 and Z_{nn} as follows:

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} Z_{pp} & Z_{pn} \\ Z_{np} & Z_{nn} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

$$\Rightarrow \frac{Z_{np}}{Z_{pp}} = \frac{V_2 - Z_{nn} I_2}{V_1}$$

Where:

V1 = positive sequence voltage calculated from the motor terminal voltages

V2 = negative sequence voltage calculated from the motor terminal voltages

I1 = positive sequence current calculated from the motor terminal currents

I2 = negative sequence current calculated from the motor terminal currents

Z_{nn} = negative sequence impedance

For an ideal symmetrical machine $Z_{pn} = Z_{np} = 0$ i.e., it is a decoupled positive and negative sequence component circuit for the induction machine. However, in practice the situation is not ideal and due to inherent asymmetry in the machine the Z_{pn} and Z_{np} values are small non-zero quantities. When a turn fault occurs, the asymmetry in the system is further aggravated which results in these cross-coupling terms increasing. The normalized cross-coupled impedance, or ratio of Z_{np} to Z_{pp} as defined by the above equation, is the key operating signal that can effectively detect a stator inter-turn fault.

The inherent asymmetries in the machine at the time of commissioning and without a stator inter-turn fault present are represented as:

$Z_{UBbase} = (Z_{np} / Z_{pp})_{\text{at 0 inter-turn fault}}$

The setpoint “Neg Seq Impedance” (Z_{nn}) required for the implementation of the above can be set manually if “Neg Seq Imp Autoset” is set toManual. This value can be calculated from the machine equivalent circuit parameters (i.e. winding inductance and resistance). It can also be measured by deliberately applying the unbalance condition during commissioning.

When “Neg Seq Imp Autoset” is set to Auto, the internal algorithm calculates this value from the motor nameplate information (kWatts, rated voltage and number of poles) using the Heuristic method.

With the known value of Z_{nn} and the phasor value for each current and voltage, all parameters of equation (1) are known and hence the operating signal can be calculated.

The algorithm for detection of the stator inter-turn fault is comprised of two phases:

- Learning Phase – this runs only once during commissioning for the given CTs, PTs and machine rating. This phase is used to calculate the unbalance impedance Z_{UBbase} of the machine that is used by the monitoring phase. The setpoint “Learn Turn Fault Data” can be used to initiate the learning phase of the algorithm. Once set to Yes from front panel, the monitoring algorithm pauses and the learning algorithm runs to acquire a new set of Z_{UBbase} values. The monitoring phase is disabled until Z_{UBbase} is calculated; once the new average of Z_{UBbase} is calculated, the monitoring phase is automatically reactivated.
- Monitoring Phase – Once the learning phase is complete and the new average of Z_{UBbase} is available, the monitoring phase runs, checking for the operating signal, and alarms whenever it exceeds Pickup Stage 1 and Pickup Stage 2.

Both the learning and monitoring phase algorithms calculate the average of Z_{UBbase} over a window size of 100 ms.

Path: **Setpoints > Monitoring > Stator Inter-turn Fault**

FUNCTION

Range: Disabled, Alarm, Latched Alarm, Configurable

Default: Disabled

This setting enables the Stator Inter-turn Fault function.

NEG SEQ IMP AUTOSET

Range: Manual, Auto

Default: Auto

As a convenient alternative to manually determining the negative sequence impedance (Z_{nn}), the relay can automatically calculate the setting Neg Seq Impedance from the nameplate information (Horse Power, Poles and Rated Voltage).

- When NEG SEQ IMP AUTOSET is changed from Auto to Manual, the learning phase is automatically initiated to calculate the new Z_{UBbase}.
- When NEG SEQ IMP AUTOSET is already set to Manual and the Z_{nn} value is changed, the learning phase is automatically initiated to calculate the new Z_{UBbase}.
- When NEG SEQ IMP AUTOSET is changed from Manual to Auto, a new Z_{nn} value is calculated based on the nameplate information (Horse Power, Poles and Rated Voltage) and the learning phase is automatically initiated to calculate the new Z_{UBbase}.
- When NEG SEQ IMP AUTOSET is set to Auto and any of the nameplate information (Horse Power, Poles and Rated Voltage) is changed, a new Z_{nn} value is calculated and the learning phase is automatically initiated to calculate the new Z_{UBbase}.

NEG SEQ IMPEDANCE:

Range: 0.10 to 100.00 Ω in steps of 0.01 Ω

Default: 10.00 Ω

This setting is only visible when Neg Seq Imp Autoset is set to Manual. This setting defines the negative sequence impedance Z_{nn} calculated by the user.

PICKUP STAGE 1:

Range: 0.001 to 10.000 in steps of 0.001

Default: 0.100

This setting specifies a first pickup threshold of the ratio between Z_{np} and Z_{pp} averaged over 100 msec.

PICKUP DELAY STAGE 1:

Range: 0.00 to 600.00 s in steps of 0.01 s

Default: 0.00

This setting provides the selection for the Pickup 1 time delay used to delay the operation of the protection.

PICKUP STAGE 2:

Range: 0.001 to 10.000 in steps of 0.001

Default: 0.600

This setting specifies a second pickup threshold of ratio between Z_{np} and Z_{pp} averaged over T_{avg} time.

PICKUP DELAY STAGE 2:

Range: 0.00 to 600.00 s in steps of 0.01 s

Default: 0.00

This setting provides the selection for the Pickup 2 times delay used to delay the operation of the protection.

DROPOUT DELAY:

Range: 0.00 to 600.00 s in steps of 0.01 s

Default: 0.00

This setting provides the selection for the dropout time delay used to delay the dropout of the detection of the Stator Inter-turn Fault condition.

LEARN TURN FAULT DATA:

Default: No

Range: Yes, No

Selecting Yes causes the monitoring algorithm to pause and run the learning phase algorithm. Once the learning phase algorithm has finished running, LEARN TURN FAULT DATA is automatically set to No.

NOTE

- During the learning phase, the monitoring phase algorithm is blocked.
- When a new Z_{nn} value is calculated (in Auto mode) or manually entered (in Manual mode), LEARN TURN FAULT DATA is automatically changed to “Yes” in order to calculate the new Z_{UBbase}

BLOCK:

Range: Off, Any FlexLogic operands

Default: Off

The Stator Inter-turn fault element will be blocked, when the selected operand is asserted.

OUTPUT RELAY X:

For details see Common Setpoints.

EVENTS:

Range: Enabled, Disabled

Default: Enabled

The selection of the Enabled setting enables the events of the Stator Inter-turn fault function.

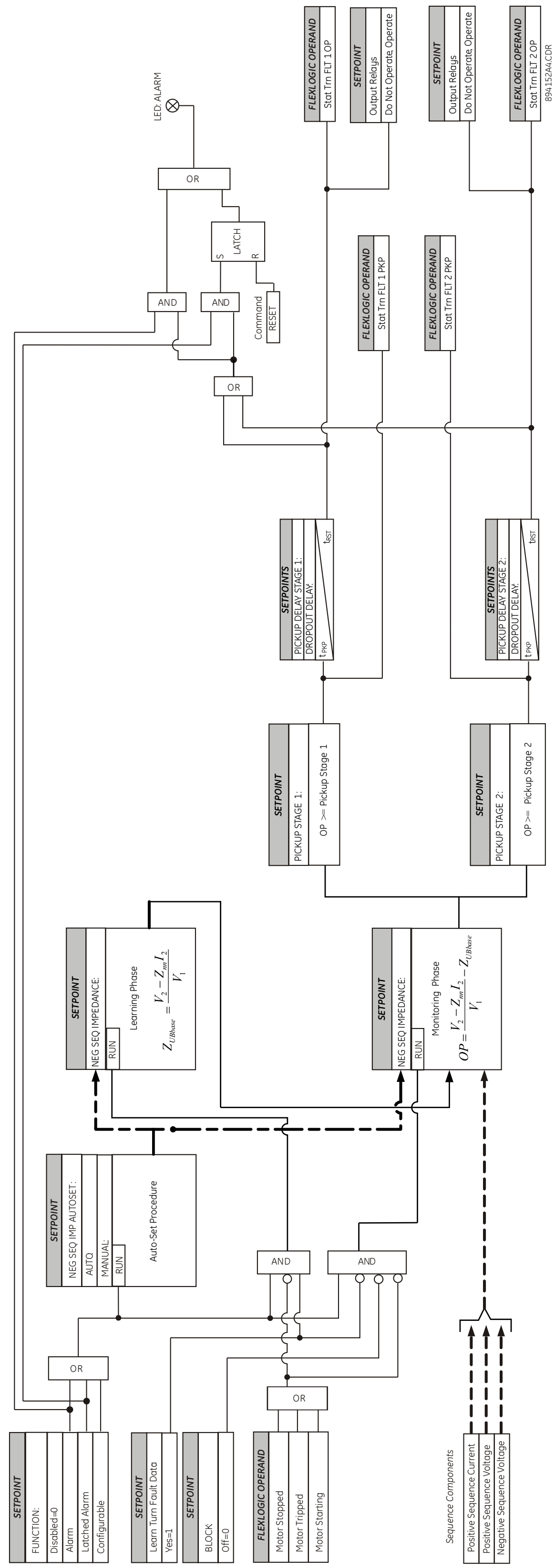
TARGETS:

Range: Self-reset, Latched, Disabled

Default: Latched

The selection of the Self-reset or Latched settings enables the targets of Stator Inter-turn fault function.

Figure 7-23: Stator Inter-Turn Fault Protection logic diagram



Functions

Power Factor

The 869 is applied on a synchronous machine, it is desirable not to trip or alarm on power factor until the field has been applied. Therefore, this feature can be blocked until the machine comes up to speed and the field is applied. From that point forward, the power factor trip and alarm elements will be active. Once the power factor is less than either the Lead or Lag level, for the specified delay, a trip or alarm will occur indicating a Lead or Lag condition. The power factor alarm can be used to detect loss of excitation and out of step.

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

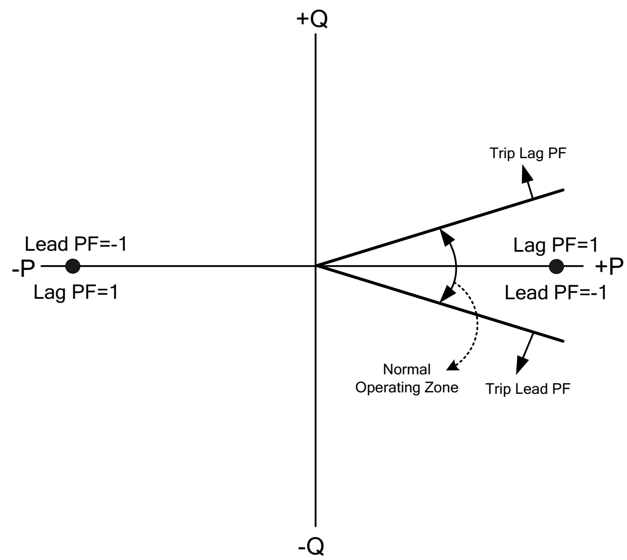
For delta-connected VTs, the Power Factor feature is inhibited from operating unless all three voltages are above the selected voltage threshold and one or more currents are above the selected current threshold. Power Factor element delay timers are only allowed to time when the voltage threshold is exceeded on all phases and current threshold is exceeded on one phase. In the same way, when a Power Factor condition starts the Power Factor delay timer, if all three phase voltages fall below the threshold and one phase current threshold falls below the timer has timed-out, the element resets without operating. A loss of voltage during any state returns both Power Factor elements to the Reset state.

For wye-connected VTs, the power factor value is calculated from the valid phase(s) for which voltage and current are above the user selected thresholds. Power Factor element delay timers are only allowed to time when the supervision conditions are met. 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 is re-calculated based on the still valid phase(s). If the element is continuously asserted with the new power factor value, the timer would continue timing, otherwise, the element resets without operating.

The minimum operating voltage and current are set as a threshold below which the element is reset.

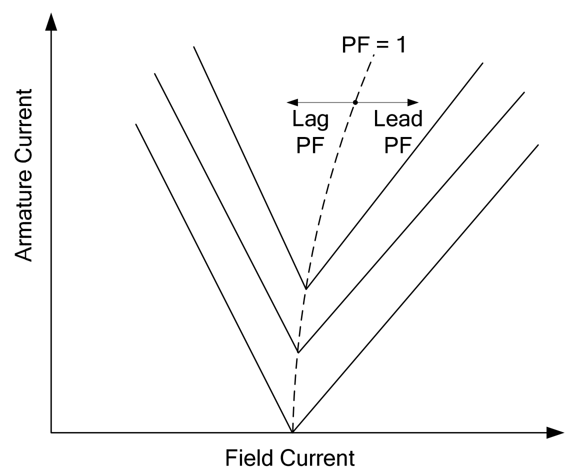
The following figure illustrates the conventions established for use in the 869 relay, where the negative value means the lead power factor, and the positive value means the lag power factor. For details on the convention used for measuring power, see Chapter 6: Metering/ Power.

Figure 7-24: Power Factor Conventions



In a synchronous machine, this type of machine can operate in lagging (under excitation), leading (over excitation) or unity power factor conditions depending on the applied field current. As shown in below figure, V-curves are normally provided by the machine manufacturer to determine the relationship between the filed current and power factor.

Figure 7-25: Synchronous Machine Simplified V-Curve Example



In synchronous motor applications, in case of a lagging power factor, two modes of power factor protection are available. They are as follows:

Resync Mode

When the setpoint PF Mode is set to Resync, this feature initiates an attempt to automatically resynchronize the motor (instead of direct Tripping when the motor goes into a pull-out condition). When the power factor lags below the configurable setpoint TRIP LAG LEVEL, the operand SM Resync Init Cmd is asserted. This feature allows the motor to continue running with field removed for the set Resync Check Delay time, and if resynchronization does not occur within this time, the Trip relay can then be operated to stop the motor.

Energizing the output relay configured to open the field switching device and/or auto-loading is recommended, using the FlexLogic operand SM Resync Init Cmd in order to remove the motor-field excitation and disconnect the load. Note that operand SM Resync Init Cmd, when set to high, remains latched until the motor is successfully synchronized (i.e. operand 'SM Running' =1 and PF Trip Lag condition becomes false) or the motor resynchronization fails (operand 'SM Resync Failed' = 1) or the motor is stopped or tripped.

Ride-thru mode

If the alternate "ride-thru" mode is selected, the field is not removed immediately as in the Resync mode. Instead, if the power factor dips below the configured threshold of setpoint TRIP LAG LEVEL and persists for the set TRIP PICKUP DELAY time, the TRIP relay operates and the motor stops.

Path: **Setpoints > Monitoring > Functions > Power Factor**

TRIP FUNCTION

Range: Disabled, Trip, Configurable

Default: Disabled

This setting enables the Power Factor Trip functionality.

PF MODE

Default: Ride-thru

Range: Resync, Ride-thru

NOTE

Note: This setpoint is only applicable to synchronous motor applications with proper order code selection.

Ride-through Mode: This mode allows the motor to 'ride through' power factor dips with duration less than the TRIP PICKUP DELAY.

Resync Mode: Upon measuring a power factor below the TRIP LAG LEVEL setpoint, the 869 may de-energize the field switching device and Auto-loading relays and attempt to resynchronize the motor. The motor continues to run with the field removed for the programmed Resync Check Delay, and if resynchronization does not occur within this time a trip occurs, operating the trip relay and stopping the motor.

Notes:

- PF Mode only activates when the 869 measures lagging PF below the setpoint Trip Lag Level. PF Mode is not applicable when the motor is running with leading PF.
- This setting is hidden when setpoint Sync. Motor Type (under **Setpoints > System > Motor > Setup**) is set to None.
- This setting is hidden unless order code option C5/D5 is selected for 'Phase Currents-Slot K Bank 1/2'.

TRIP LEAD LEVEL

Range: 0.05 to 1.00 in steps of 0.01

Default: 1.00 Lag

This setting specifies the Power Factor Lead Trip level.

NOTE

Enter 1.00 to turn off the Trip Lead Level. The HMI also shows it is "OFF".

TRIP LAG LEVEL

Range: 0.05 to 1.00 in steps of 0.01

Default: 1.00

This setting specifies the Power Factor Lag Trip level.

NOTE

When the Trip Lag Level is set to 1.00, the pickup level turns it off.

TRIP PICKUP DELAY

Range: 0.00 to 600.00 s in steps of 0.01 s
Default: 1.00 s

The setting specifies a time delay for the trip function.

TRIP DROPOUT DELAY

Range: 0.00 to 600.00 s in steps of 0.01 s
Default: 1.00 s

The setting specifies a dropout time delay for the trip function.

TRIP OUTPUT RELAY X

For details see Common Setpoints.

ALARM FUNCTION

Range: Disabled, Alarm, Latch Alarm
Default: Disabled

This setting enables the Power Factor Alarm functionality.

ALARM LEAD LEVEL

Range: 0.05 to 1.00 in steps of 0.01
Default: 1.00

This setting specifies the Power Factor Lead Alarm level.

NOTE

Enter 1.00 to turn off the Alarm Lead Level. The HMI shows “OFF”.

ALARM LAG LEVEL

Range: 0.05 to 1.00 in steps of 0.01
Default: 1.00

This setting specifies the Power Factor Lag alarm level.

NOTE

Enter 1.00 to turn off the Alarm Lag Level. The HMI shows OFF”.

ALARM PICKUP DELAY

Range: 0.00 to 600.00 s in steps of 0.01 s
Default: 1.00 s

The setting specifies a time delay for the alarm function.

ALARM DROPOUT DELAY

Range: 0.00 to 600.00 s in steps of 0.01 s
Default: 1.00 s

The setting specifies a dropout time delay for the alarm function.

ALARM OUTPUT RELAY X

For details see Common Setpoints.

START BLOCK DELAY

Range: 0.00 to 600.00 s in steps of 0.01 s

Default: 1.00 s

The Power Factor element can be blocked until the machine comes up to speed and the field is applied. The element is blocked upon initiation of a motor Starting status for a period of time defined by this setting.

This setting is not applicable to synchronous motor applications. The PF element remains blocked until the motor start sequence is completed.

MINIMUM VOLTAGE

Range: 0.00 to 1.25 x VT in steps of 0.01 x VT

Default: 0.30 x VT

This setting sets the minimum voltage for the Power Factor element operation specified times VT.

MINIMUM CURRENT

Range: 0.00 to 10.00 x CT in steps of 0.01 x CT

Default: 0.20 x CT

This setting sets the minimum current for the Power Factor element operation specified times CT.

MINIMUM CURRENT

Range: 0.00 to 10.00 x CT in steps of 0.01 x CT

Default: 0.20 x CT

This setting sets the minimum current for the Power Factor element operation specified times CT.

RESYNC INITIATE

Range: Off, any FlexLogic Operand

Default: Off

In addition to the power factor initiating motor Resync functionality, this setpoint allows a specified input (e.g. Reactive Power, Out-of-step, loss of excitation) to initiate the Resync function for resynchronization of the synchronous motor. When the assigned input is active, the SM Resync Init Cmd is asserted and the TRIP PICKUP DELAY timer starts. If the motor fails to resynchronize within the TRIP PICKUP DELAY time, the PF Trip operates.

If more than one input is required to initiate the restoration function, the FlexLogic builder must be used to build the required logic.

NOTE

This setting is hidden unless setpoint PF Mode is selected as Resync Mode and order code option C5/D5 is selected from 'Phase Currents-Slot K Bank 1/2'.

RESYNC CHECK DELAY

Range: 0.00 to 600.00 s in steps of 0.01 s

Default: 2.00 s

This timer is only applicable to power factor Resync Mode for synchronous motor applications. Upon initiation of the auto-resynchronization command, the motor continues running with the field removed for the RESYNC CHECK DELAY time, and if resynchronization does not occur within this time, the Trip relay can be operated to stop the motor.

BLOCK

Range: Off, Any FlexLogic operand

Default: Off

The element is blocked when the selected operand is asserted.

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

Figure 7-26: Power Factor logic diagram

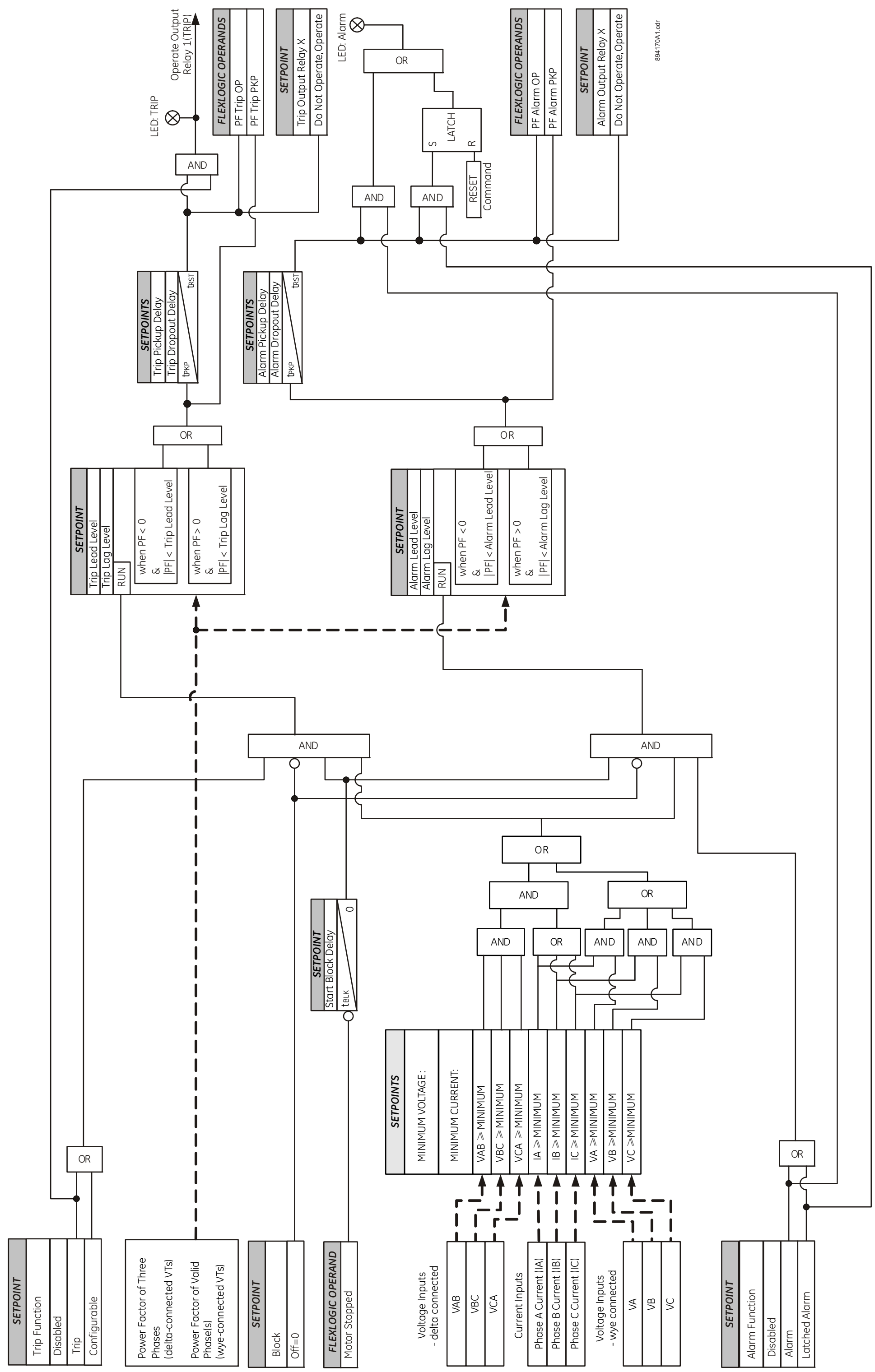
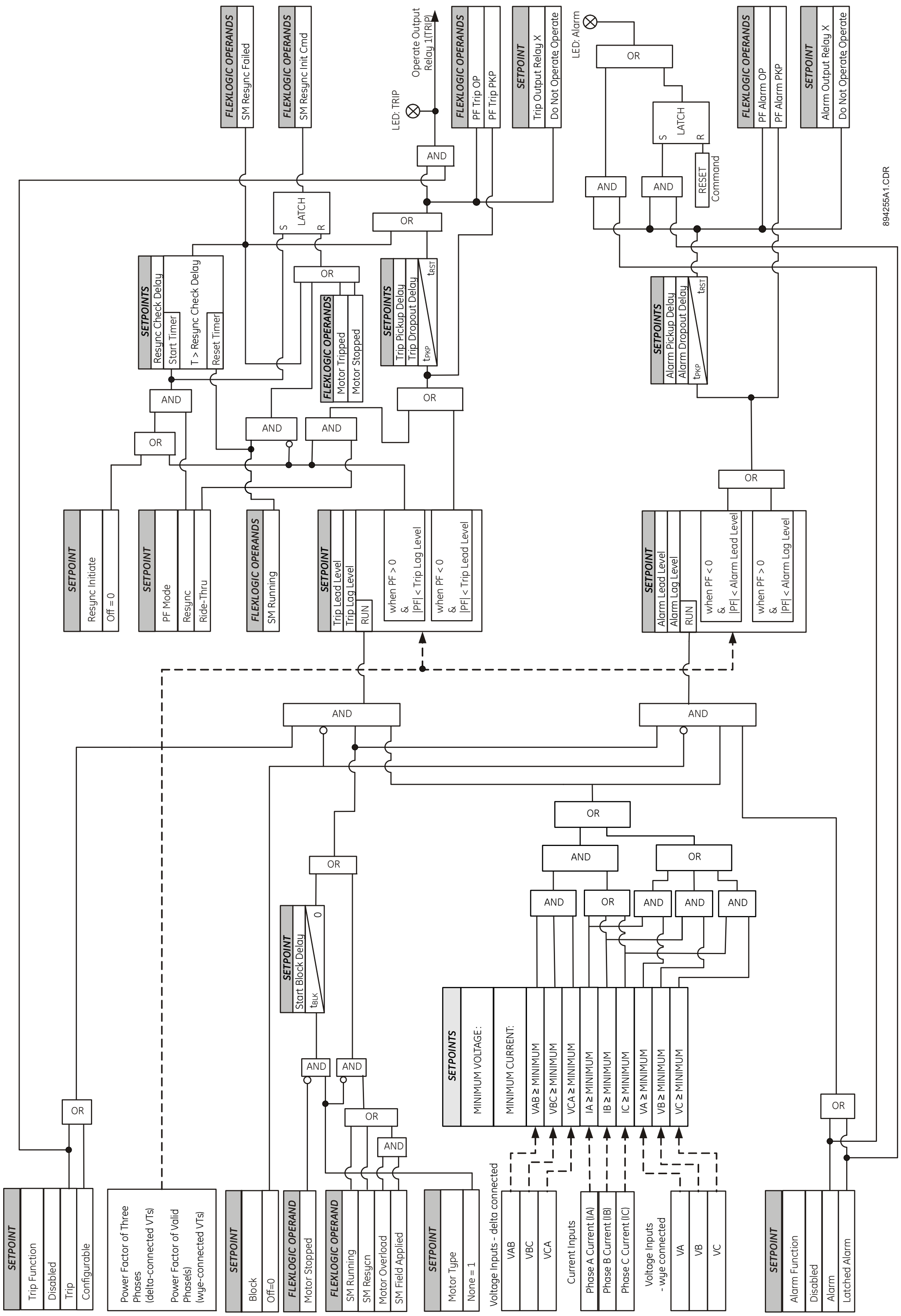


Figure 7-27: Synchronous Motor Power Factor logic diagram



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.

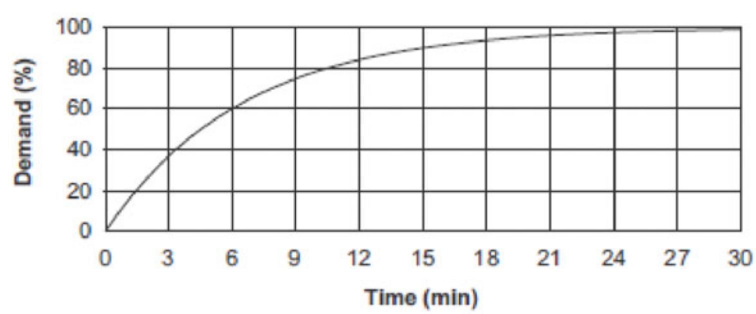
NOTICE

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 7-28: 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.

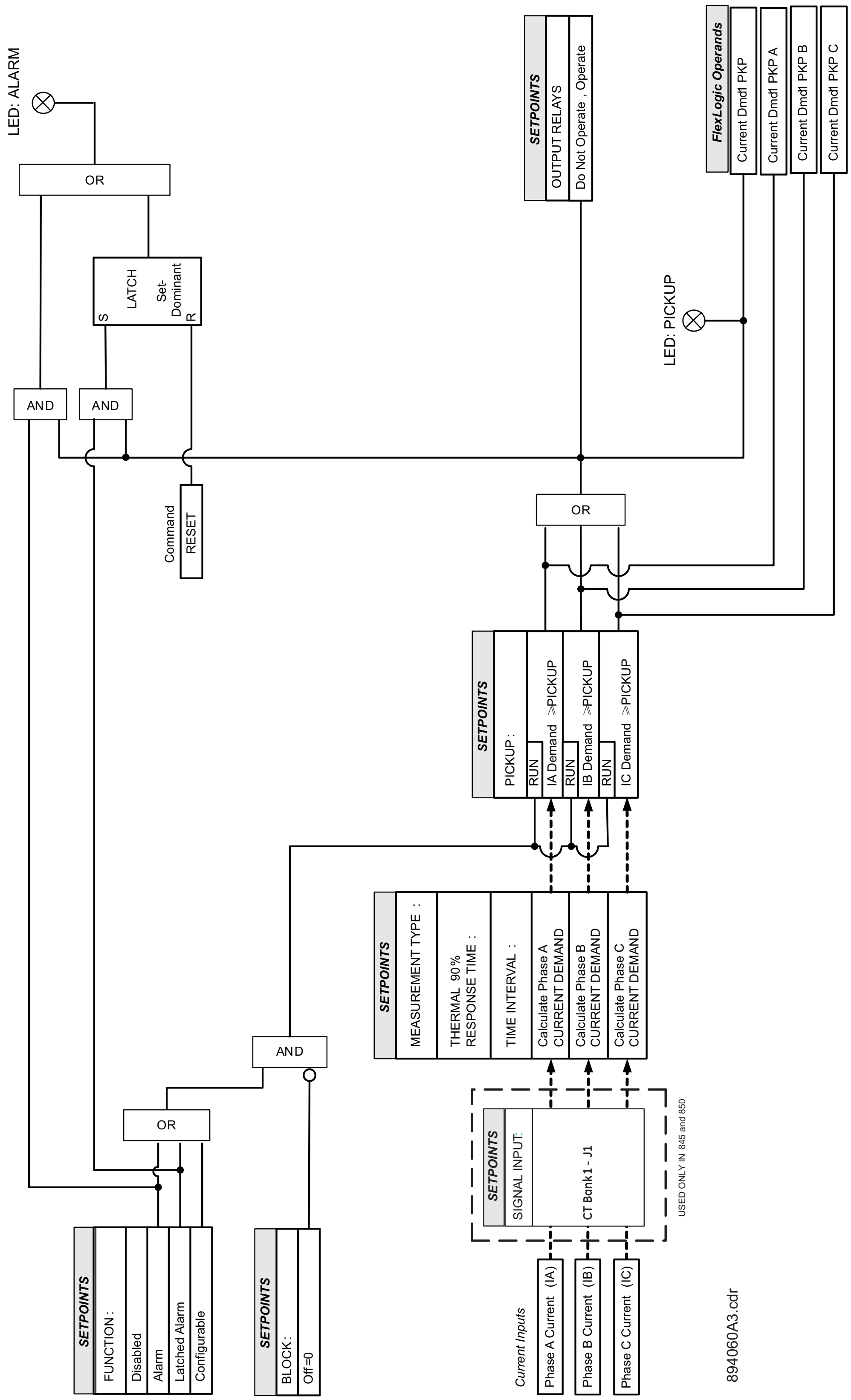
EVENTS

Range: Enabled, Disabled
Default: Disabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Disabled

Figure 7-29: 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.

An application example is the monitoring of the minimum and maximum demand values per shift. A shift can be defined by the breaker status operand (open or closed) or operand derived from the Time of Day Timer element.

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

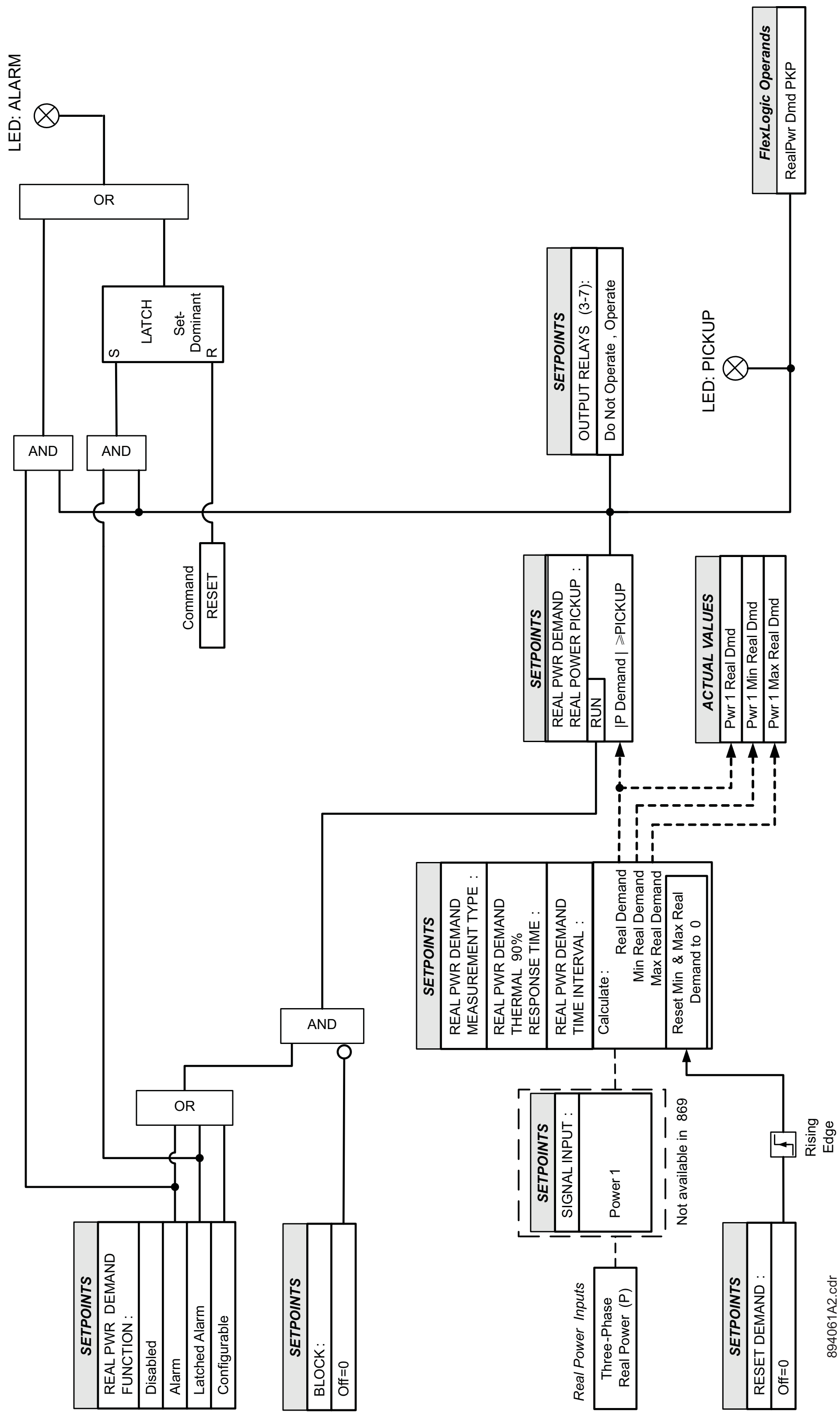
For details see Common Setpoints.

EVENTS

Range: Enabled, Disabled
Default: Disabled

TARGETS
Range: Disabled, Self-reset, Latched
Default: Disabled

Figure 7-30: 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.

An application example is monitoring the accumulated demand per the shift. A shift can be defined by the breaker status operand (open or closed) or operand derived from the Time of Day Timer element.

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.

An application example is the monitoring of the minimum and maximum reactive demand per shift. A shift can be defined by the breaker status operand (open or closed) or operand derived from the Time of Day Timer element.

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.

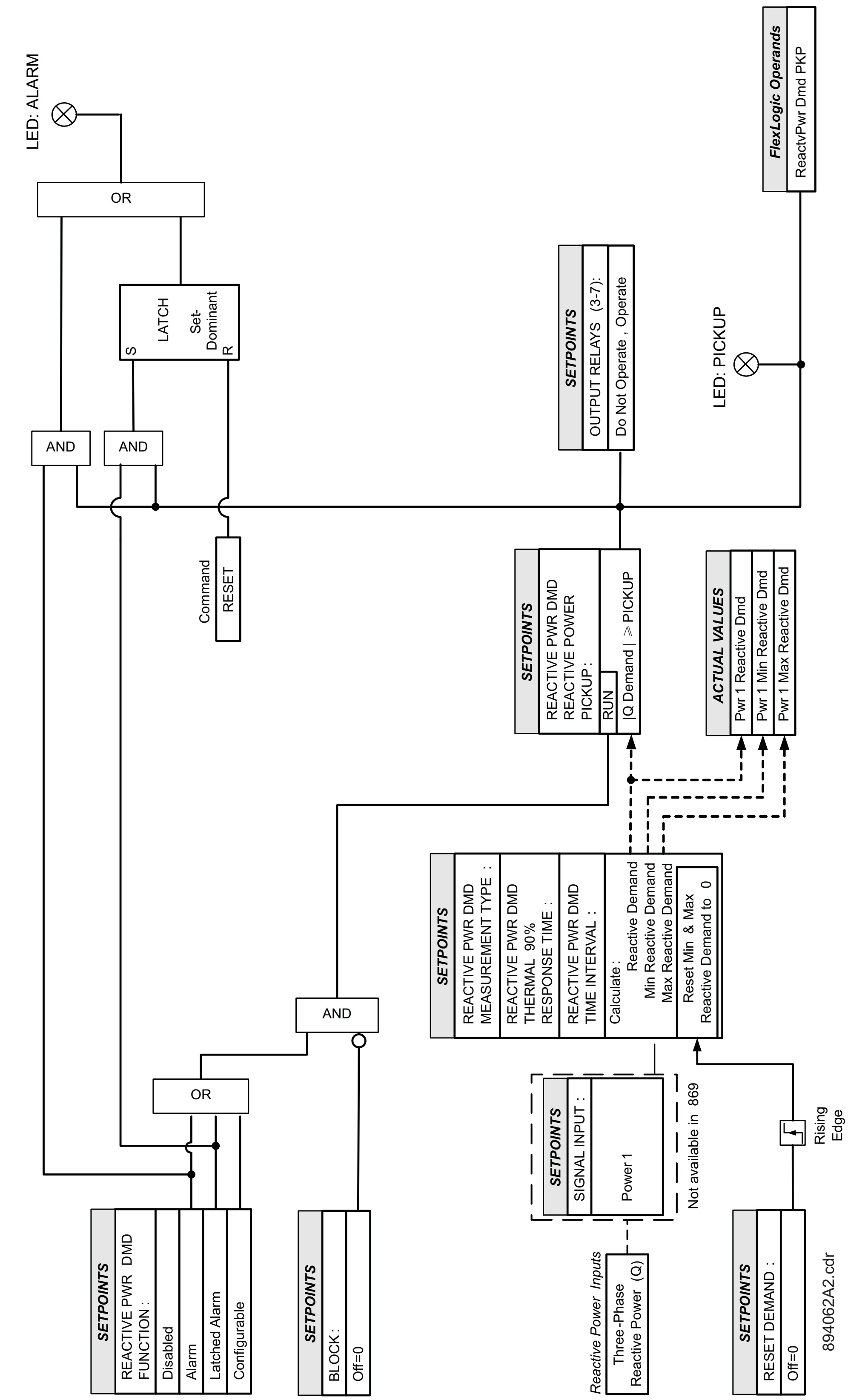
EVENTS

Range: Enabled, Disabled
Default: Disabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Disabled

Figure 7-31: 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.

An application example is the monitoring of the minimum and maximum apparent power demand per shift. A shift can be defined by the breaker status operand (open or closed) or operand derived from the Time of Day Timer element.

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

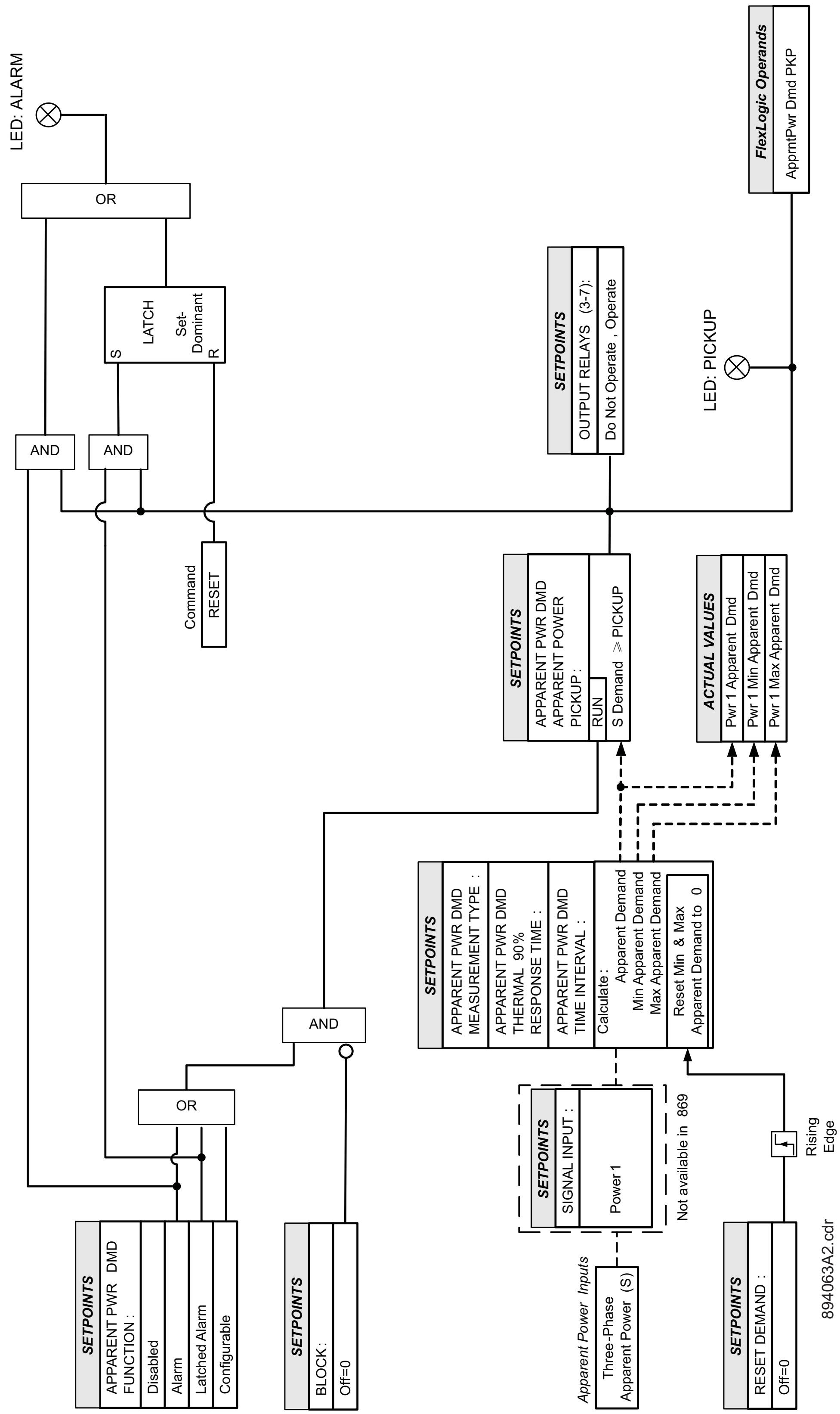
Range: Enabled, Disabled
Default: Disabled

TARGETS

Range: Disabled, Self-reset, Latched

Default: Disabled

Figure 7-32: Apparent Power Demand logic diagram



Pulsed Outputs

The 869 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 869 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.

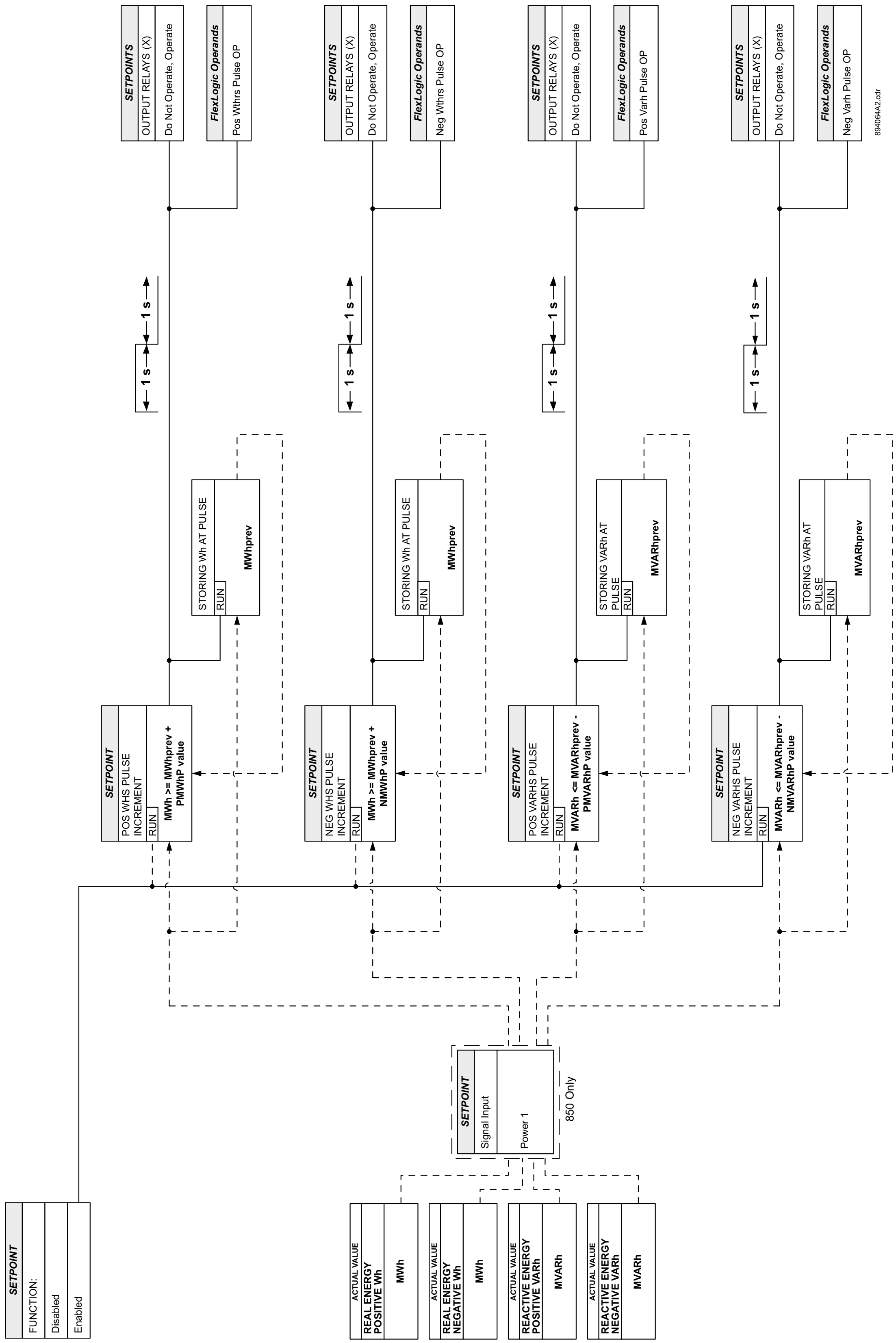
EVENTS

Range: Disabled, Enabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Self-Reset

Figure 7-33: Pulsed Outputs logic diagram



Digital Counters

The 869 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.

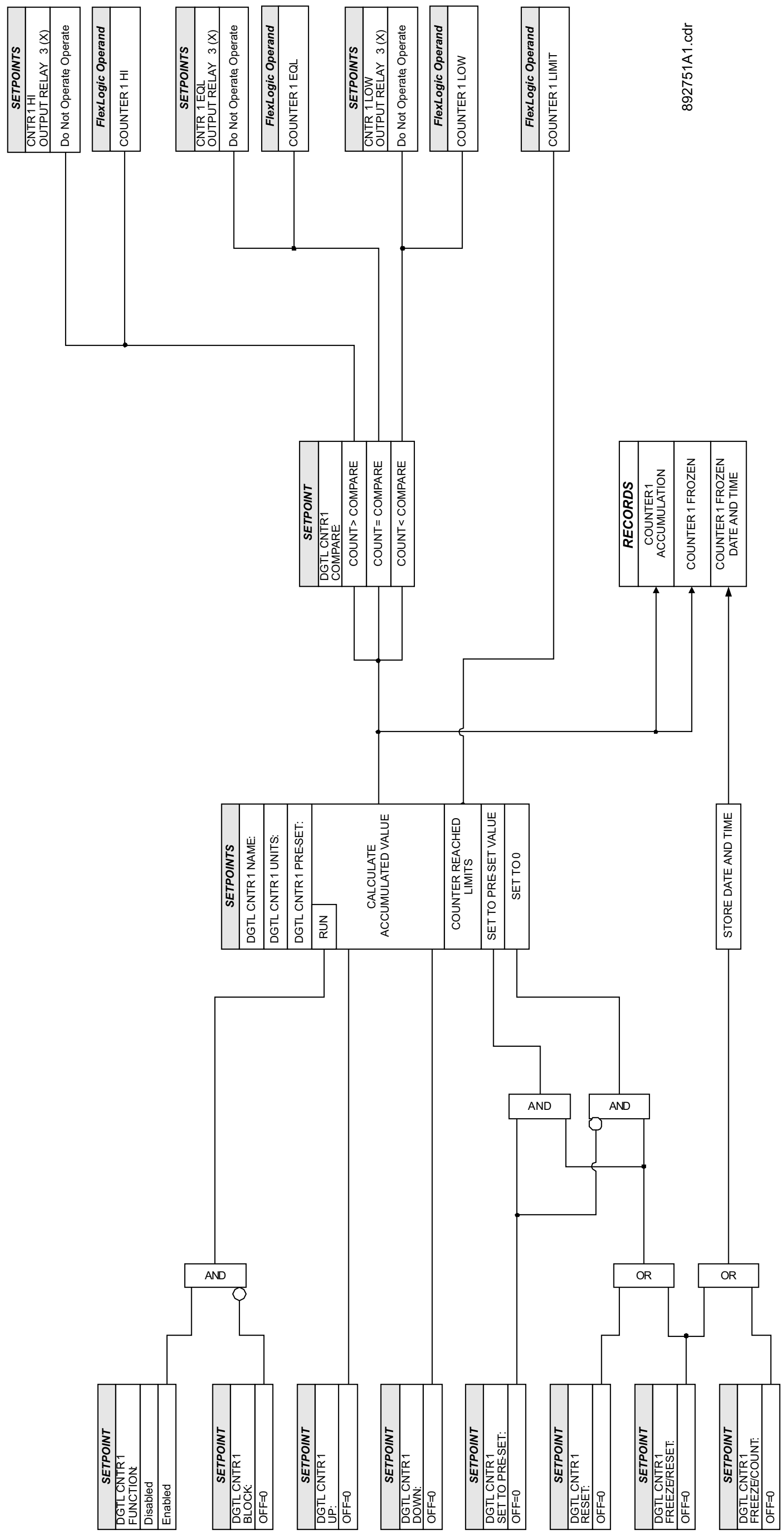
EVENTS

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".

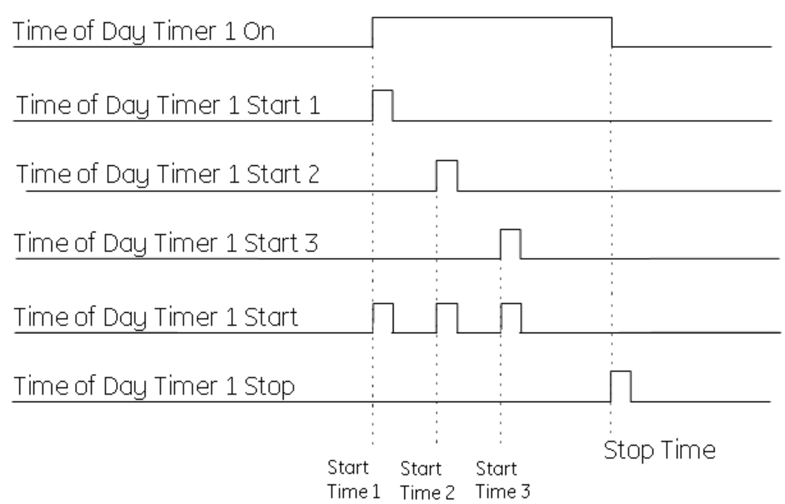
Figure 7-34: Digital Counter logic diagram



Time of Day Timer

The Time of Day Timer function provides the user with the ability to program control actions based on real time. There are two identical Time of Day Timers, numbered 1 and 2, each with an independent start and stop time setting. Each timer is on when the relay real-time clock/calendar value is later than the timer Start Time 1, and earlier than the timer Stop Time. FlexLogic Operand Time of Day 1 On follows the state of the timers. In addition, 1.0 second pulses are generated on FlexLogic Operands Time of Day 1 Start to Time of Day 3 Start and Time of Day 1 Stop when the timers turn on and off respectively, as shown in the following figure.

Figure 7-35: Five operands per timer allow flexible close/open/maintain control



If the relay is connected to an external clock that follows daylight time changes, care should be taken that the changes do not result in undesired operation. The timers wrap around 24h.

Path: **Setpoints > Monitoring > Functions > Time of Day Timers > Time of Day Timer 1(X)**

FUNCTION

Range: Disabled, Enabled
Default: Disabled

START TIME 1

Range: 00:00 to 23:59 in steps of 1 min
Default: 00:00

This setting is used to set the relay clock/calendar value at which the timer turns on. When the relay clock/calendar is equal to the value set here, FlexLogic operands Time of Day 1(2) ON and Time of Day 1(2) Start 1 are asserted.

START TIME 2

Range: 00:00 to 23:59 in steps of 1 min
Default: 00:00

This setting is used to set the relay clock/calendar value at which the timer turns on. When the relay clock/calendar is equal to the value set here, FlexLogic operand Time of Day 1(2) Start 2 is asserted.

START TIME 3

Range: 00:00 to 23:59 in steps of 1 min

Default: 00:00

This setting is used to set the relay clock/calendar value at which the timer turns on. When the relay clock/calendar is equal to the value set here, FlexLogic operand Time of Day 1(2) Start 3 is asserted.

STOP TIME

Range: 00:00 to 23:59 in steps of 1 min

Default: 00:00

This setting is used to set the relay clock/calendar value at which the timer turns off. When the relay clock/calendar is equal to the value set here, FlexLogic operand Time of Day 1(2) Stop is asserted.

BLOCK

Range: Off, Any FlexLogic operand

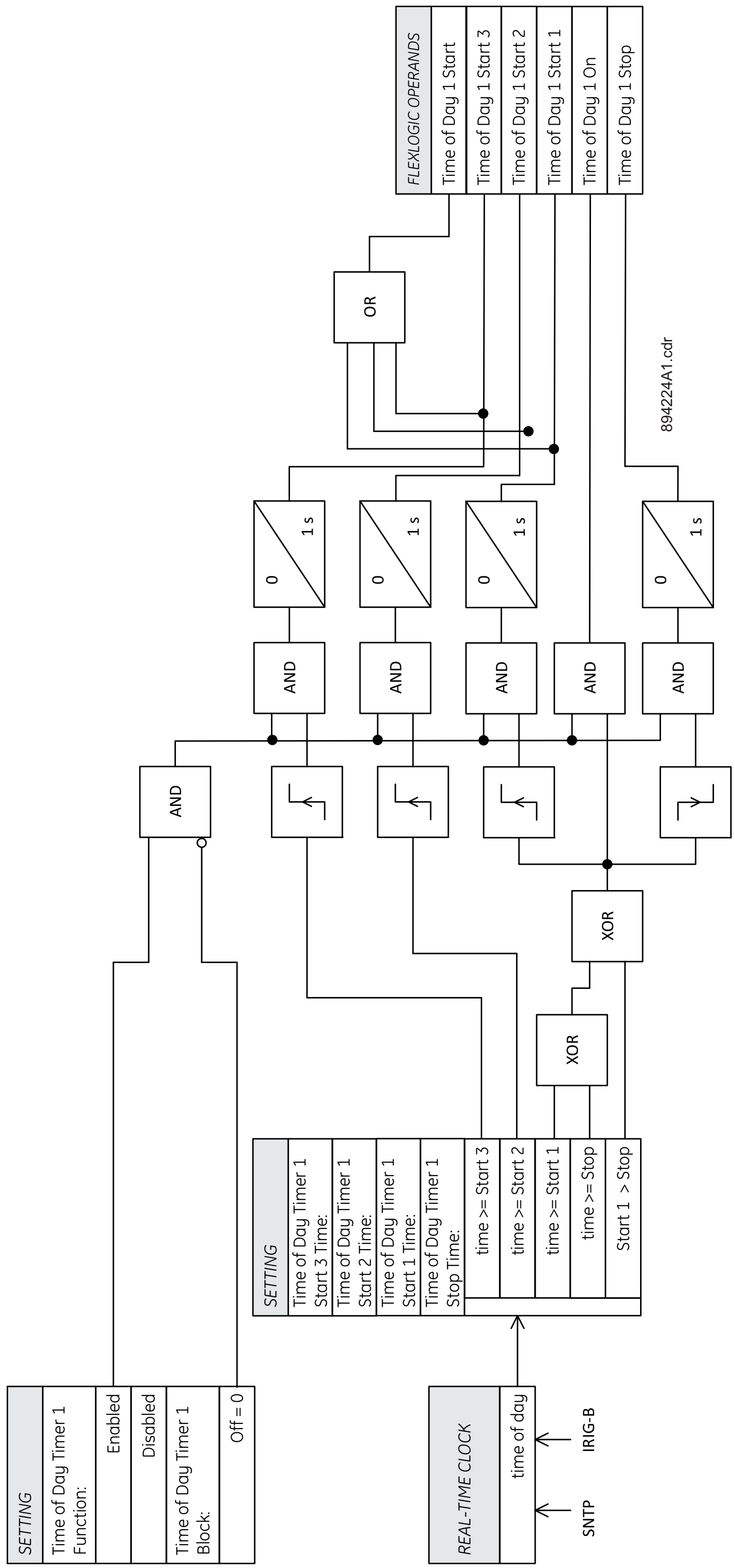
Default: Off

EVENTS

Range: Disabled, Enabled

Default: Enabled

Figure 7-36: Time of Day Timer logic diagram



Harmonic Detection

The Harmonic detection 1(6) element monitors the selected 2^{nd} to 5^{th} 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.

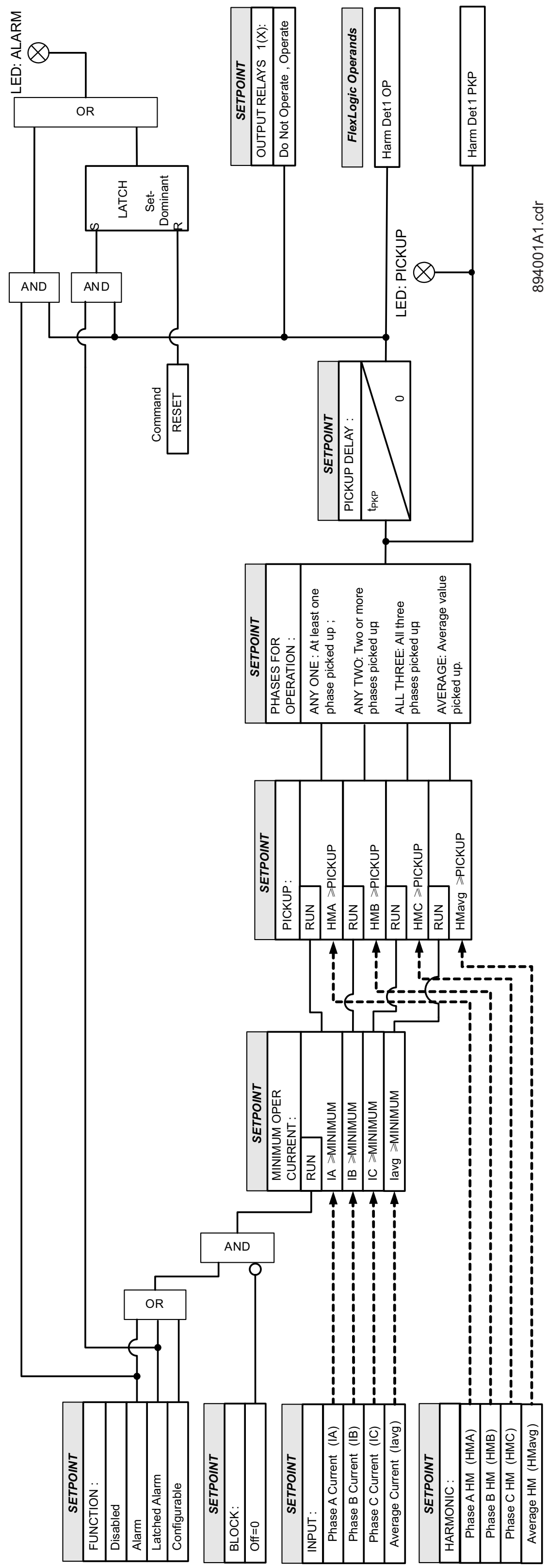
EVENTS

Range: Disabled, Enabled
Default: Enabled

TARGETS

Range: Self-reset, Latched, Disabled
Default: Latched

Figure 7-37: Harmonic Detection logic diagram



Power Quality/Voltage Disturbance

The Voltage disturbance function includes both Voltage Swell and Voltage Sag.

Voltage Sag, as described in IEEE 1159-2009 : IEEE Recommended Practice for Monitoring Electric Power Quality, is a fall in RMS voltage between 0.1 pu and 0.9 pu for durations from 0.5 cycles to 1 min. The condition ends when the level increases to at least 10% of the nominal voltage above the SAG LEVEL setting. When the voltage on any phase drops below this level a voltage sag condition occurs. Voltage sags are usually associated with system faults but can also be caused by switching heavy loads or starting large motors. Short duration voltage sag may cause process disruptions

Voltage Swell, as described in IEEE 1159-2009, Voltage swell is an increase in RMS voltage above 1.1 pu for durations from 0.5 cycle to 1 min. To end a Swell condition the level must decrease to 10% of the nominal voltage bellow the SWELL LEVEL setting. Voltage swells are usually associated with system fault conditions, but they are much less common than voltage sags. An SLG fault on the system can cause a swell to occur, resulting in a temporary voltage rise on the healthy phases. Swells can also be caused by switching off a large load, load shedding, or switching on a large capacitor bank. Voltage swell may cause failure of the components depending upon the magnitude and frequency of occurrence.

The following reference table represents the different categories of Voltage Sag/Swell conditions based on duration and pickup level.

Short duration root-mean-square (RMS)	Duration	Level
Instantaneous		
Sag	0.5 - 30 cycles	0.1 - 0.9 pu
Swell	0.5 - 30 cycles	1.1 - 1.8 pu
Momentary		
Sag	30 cycles - 3 s	0.1 - 0.9 pu
Swell	30 cycles - 3 s	1.1 - 1.4 pu
Interruption	0.5 cycles - 3 s	< 0.1 pu
Temporary		
Sag	>3 s - 1 min	0.1 - 0.9 pu
Swell	>3 s - 1 min	1.1 - 1.2 pu
Interruption	>3 s - 1 min	< 0.1 pu

Path: **Setpoints > Monitoring > Power Quality > Voltage Disturbance1(X)**

FUNCTION

Range: Disabled, Alarm, Latched Alarm, Configurable

Default: Disabled

MODE

Range: Phase to Ground, Phase to Phase

Default: Phase to Ground

This setting provides selection of Phase to ground and Phase to phase voltages for a Wye VT connection (phase to phase for delta connected VT connection).

NOTE

Only "Phase to Phase" mode shall be selected when Delta is programmed for Phase VT connection under System/Voltage Sensing.

VOLT SWELL PICKUP

Range: 0.02 to 3.00 x VT in steps of 0.01 x VT
Default: 1.20 x VT

This setting defines the voltage swell pickup level for phase (A, B, C), and is usually set to a level 1.1 to 1.8 times the VT / nominal voltage.

VOLT SWELL DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s
Default: 5.000 s

This setting specifies an operation time delay for the voltage swell function. Short duration (less than 1 min) or long duration (more than 1 min) swell overvoltage conditions can be differentiated by setting this delay appropriately.

MIN VOLT SUPV

Range: 0.02 to 3.00 x VT in steps of 0.01 x VT
Default: 1.20 x VT

This setting defines the minimum feeder voltage level required to identify the voltage sag condition. This will help to discriminate the voltage sag condition from the feeder down condition.

VOLT SAG PICKUP

Range: 0.02 to 3.00 x VT in steps of 0.01 x VT
Default: 1.20 x VT

This setting defines the voltage sag pickup level, and it is usually set to a level between 0.1 to 0.9 times the VT / nominal voltage.

NOTE

This setting must be higher then value set under Min Volt Supv.

VOLT SAG DELAY

Range: 0.02 to 3.00 x VT in steps of 0.01 x VT
Default: 1.20 x VT

This setting specifies an operation time delay for the voltage sag function. Short duration (less than 1 min) or long duration (more than 1 min) sag undervoltage conditions can be differentiated by setting this delay appropriately.

VOLT SAG ALARM RESET

Range: 0.02 to 3.00 x VT in steps of 0.01 x VT
Default: 1.20 x VT

This setting specifies duration for the Volt Sag operation alarm. After this alarm reset time, the sag operation alarm is reset until the next sag event. This setting avoids an undesired continuous alarm in case the upstream power source is turned off.

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

OUTPUT RELAY X

For details see Common Setpoints.

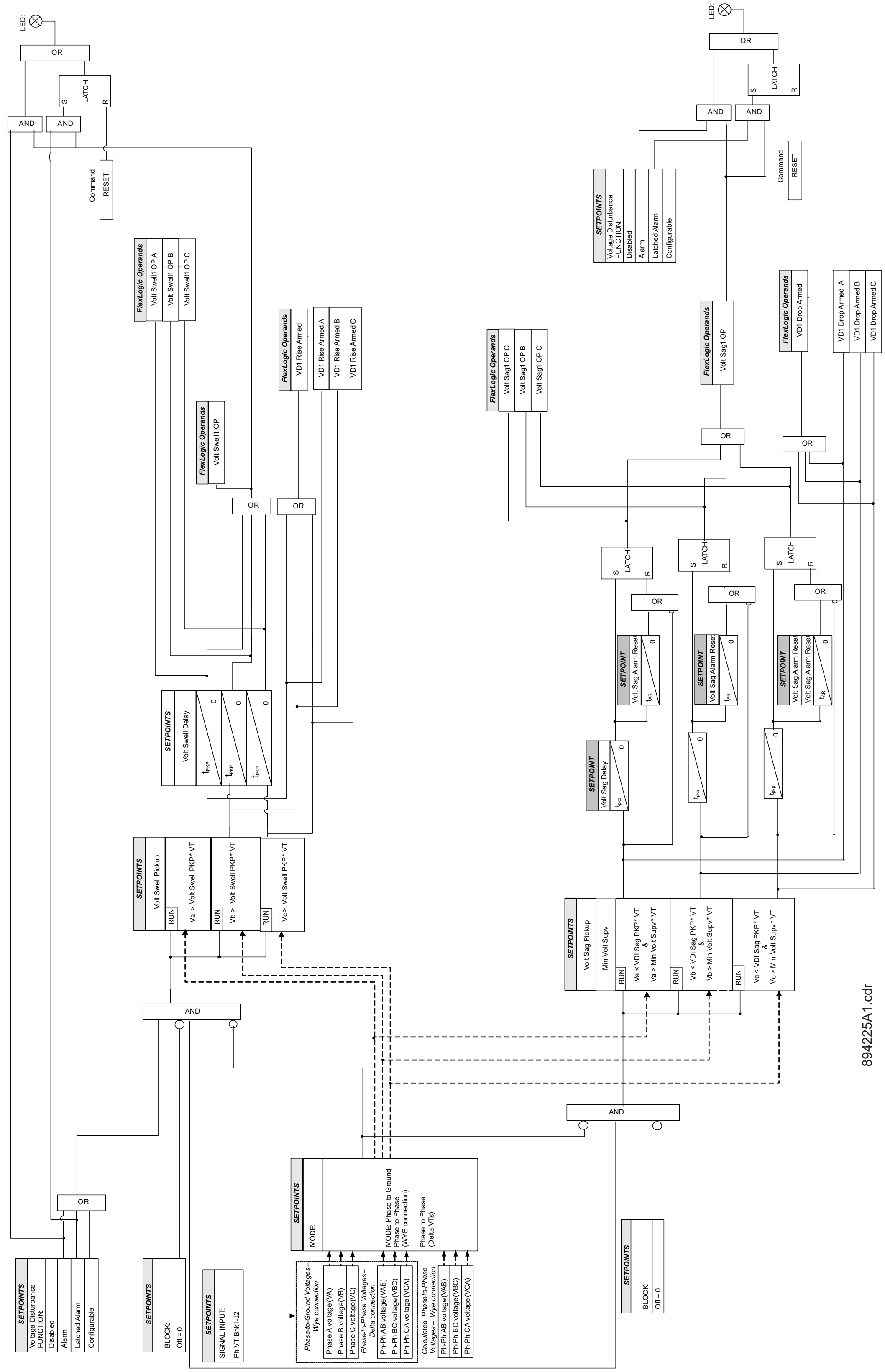
EVENTS

Range: Disabled, Enabled
Default: Enabled

TARGETS

Range: Self-reset, Latched, Disabled
Default: Self-reset

Figure 7-38: Voltage Disturbance 1 logic diagram



Speed

The 869 is capable of measuring the motor speed. Any of the input contacts can be used to read the pulses from the input source. The source of the pulses can be an inductive proximity probe or Hall Effect gear tooth sensor. The speed algorithm calculates the number of pulses in the window length (WL) and converts it into an RPM value. A minimum pulse width of 10% of a revolution is required to detect a pulse from the pulse source.

The following equation is used to calculate the speed based on the detection of the number of pulses 'N' during window length WL.

$$RPM = \frac{N}{PPR} \cdot \frac{60}{WL} \cdot f$$

Where:
N – number of pulses during time defined by the setpoint Cal. Window
PPR – pulses per revolution defined by setpoint PULSES PER REV (PPR)
f – system frequency defined under Setpoints\System\Power System
WL – calculated window length in cycles is defined as

WL = (60 x f) / (PPR x 50)

This element has two modes of speed: under speed and over speed which is defined by the setpoint Direction.

In the under speed mode, a trip and alarm is configured so that the machine must be at a certain speed within a set period of time from starting. The trip and alarm features are configured so that the specified speed (Trip Pickup or Alarm Pickup) must be reached in the specified time (Trip delay or Alarm Delay) otherwise the element operates. Initially, the time delay begins when the machine starts rotating and resets when the desired speed is reached. Once the machine is running with the rated speed and then that speed drops below the set threshold, the time delay restarts and the designated output contact will operate if the machine fails to reach the set speed in the allotted time.

In the over speed mode, the tachometer trip and alarm features are configured so that if the specified speed (Trip Pickup or Alarm Pickup) is exceeded for the specified time (Trip delay or Alarm Delay), the element operates. Initially, the time delay begins when the machine speed exceeds the pickup value resets when the speed drops below the pickup.

Path: **Setpoints > Monitoring > Speed**

TRIP FUNCTION

Range: Disabled, Trip, Configurable
Default: Disabled

This setting enables the Speed protection Trip functionality.

INPUT

Range: Off, Any Digital Input
Default: Off

Any of the digital input contacts can be used to read the pulses from the input source. For example, an inductive proximity probe or Hall Effect gear tooth sensor may be used to sense the key on the motor. The probe can be powered by the +24 V from the input switch power supply. The NPN transistor output can be sent to one of the digital inputs.

NOTE

The voltage threshold must be set to 17 V for the inputs to be recognized using the internal +24 V.

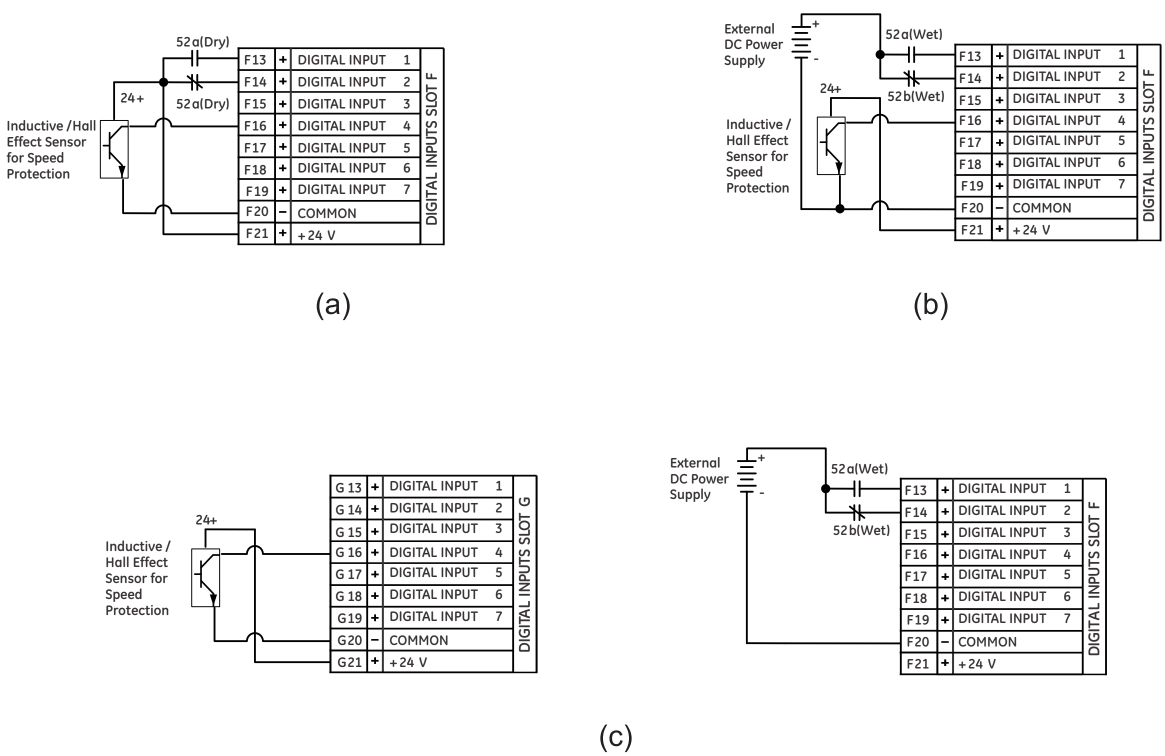
The following figure illustrates three wiring examples: (a), (b) and (c) of a speed probe connected to the input terminals. For illustration purposes, the breaker status inputs are shown along with the speed probe input.

Example (a)An internal +24 V supply is used to power both the speed probe connected to CI # 4 and the breaker status signals (DRY type) connected to CI # 1 and CI # 2 of the same Slot F.

Example (b)An internal +24 V supply is used to power the speed probe connected to CI # 4 while an external DC power supply is used by the breaker status signals (WET type) connected to CI # 1 and CI # 2. In this example, since both speed probe and breaker status signals are connected to Slot F, the voltage threshold must be set to 17 V.

Example (c) Separate input slots are used for the speed probe input signals and the breaker status. An internal +24 V supply is used to power the speed probe connected to CI # 4 of Slot G, the voltage threshold must be set to 17 V. WET Breaker status signals are connected to CI # 1 and CI # 2 of Slot F. The voltage threshold must be selected as per the criteria: 17 V for 24 V sources, 33 V for 48 V sources, 84 V for 110 to 125 V sources and 166 V for 250 V sources.

Figure 7-39: Wiring Examples of Speed Protection Input



NOTE

The maximum load current that can be delivered by the internal +24 V supply is 80 mA. When the internal +24 V supply is used to power the probe, the current limitations of the 24V supply must be considered.

RATED SPEED

Range: 100 to 7200 RPM in steps of 1

Default: 3600 RPM

RPM defines the rated speed of the motor.

NOTE

In a two speed motor application, when 2-Speed Motor Protection is “Enabled” and Speed2 Motor Switch is “On”, the setpoint Speed2 Rated Speed, programmed under System/Motor/Setup, is used by the Speed protection as the rated value.

PULSES PER REV

Range: 1 to 6 PPR in steps of 1 PPR

Default: 1 PPR

Number of pulses per revolution (PPR) is required to calculate the switching frequency of the input pulses. Switching frequency can be calculated as follows.

$$Switching\ frequency = \frac{PPR\ x\ RPM}{60}$$

Where:
PPR = pulses per revolution
RPM = rated speed

DIRECTION

Range: Underspeed, Overspeed

Default: Underspeed

This setting defines the mode for speed protection. When Direction is set to Underspeed, the Trip and/or Alarm function picks up when the measured motor speed is below the set pickup level. Likewise, when the Direction is set to Overspeed, the Trip and/or Alarm function picks up when the measured motor speed is above the programmed pickup level.

NOTE

When TRIP FUNCTION is set to 'Trip' and DIRECTION is set to Underspeed, the speed function requires a block signal configured under the setpoint BLOCK to reset the outputs. It is recommended to use the breaker/contactor open status operand (Brk1 Opened/ Contactor Opened) to indicate that the motor is stopped.

TRIP PICKUP

Range: 50 to 120% in steps of 1

Default: 75%

This setting specifies a pickup threshold for the trip function.

TRIP PICKUP DELAY

Range: 0.00 to 600.00 s in steps of 0.01 s

Default: 1.00 s

This setting specifies a pickup threshold for the trip function.

TRIP OUTPUT RELAY X

For details see Common Setpoints.

ALARM FUNCTION

Range: Disabled, Alarm, Latched Alarm

Default: Disabled

This setting enables the speed protection Alarm functionality

ALARM PICKUP

Range: 50 to 120% in steps of 1

Default: 80%

This setting specifies a pickup threshold for the Alarm function.

ALARM PICKUP DELAY

Range: 0.00 to 600.00 s steps of 0.01 s

Default: 1.00 s

This setting specifies a time delay for the Alarm function.

ALARM OUTPUT RELAY X

For details see Common Setpoints.

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

The Speed protection can be blocked by any asserted FlexLogic operand.

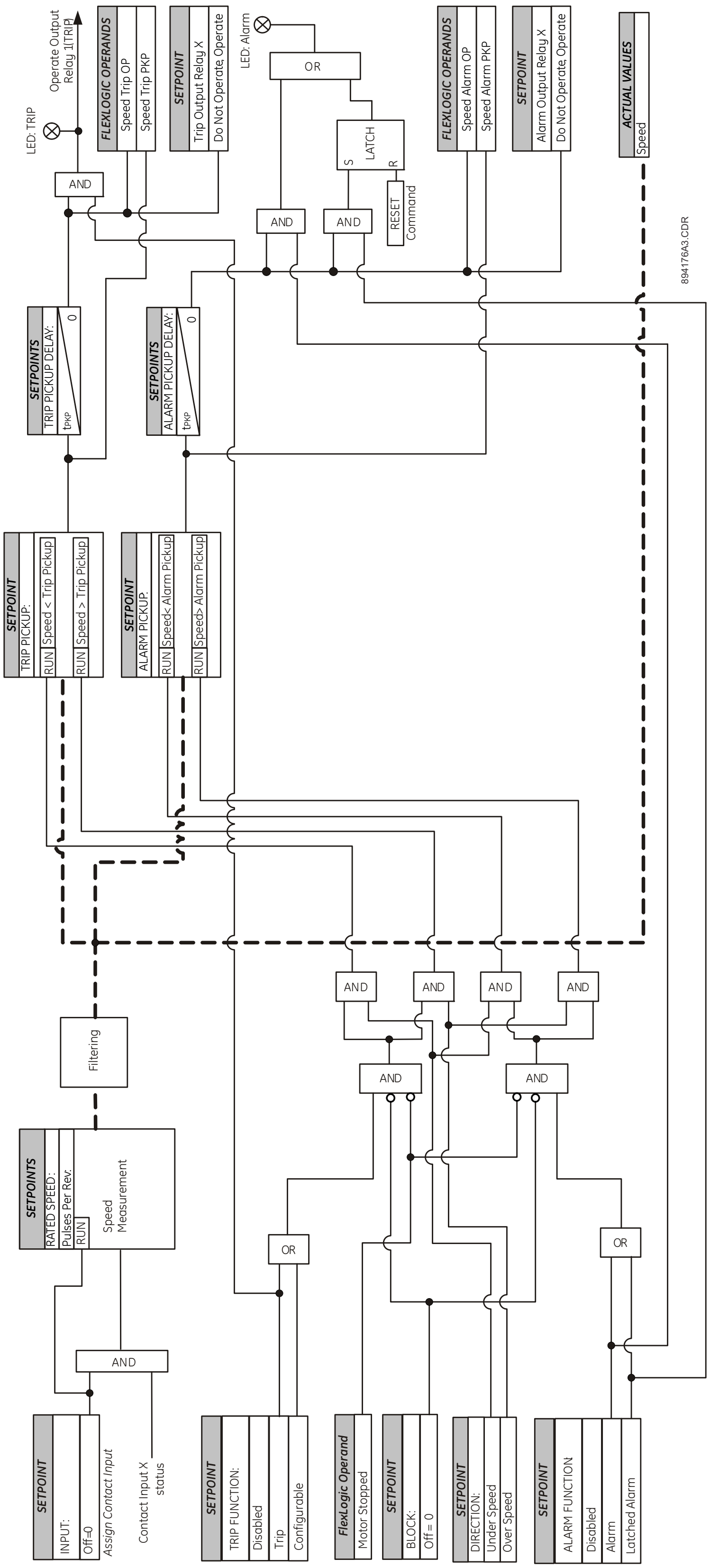
EVENTS

Range: Disabled, Enabled
Default: Enabled

TARGETS

Range: Disabled, Self-Reset, Latched
Default: Latched

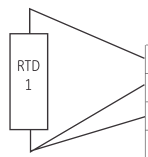
Figure 7-40: Speed Protection logic diagram



RTD Temperature

RTD Wiring Diagram

Figure 7-41: RTD Wiring diagram



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	

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 869 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, the 869 can be furnished with up to two optional RTD cards. Each card has six RTD input channels. Only slots “B” and “C” can accept RTD cards. When two RTD cards are used, then inputs on the card inserted into slot “B” are labelled 1 to 6 and inputs on the card inserted into slot “C” are labelled 7 to 12.

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 869 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 protection setpoints can be seen only if an LVIO card or one or two RTD modules are installed and validated. The RRTD protection setpoints can be seen only if the 869 has the RMIO module installed and validated.

The alarm temperature is normally set slightly above the normal running motor temperature.

The trip temperature is normally set at the insulation rating. Trip Voting has been added for extra security in the event of RTD malfunction. If enabled, a second RTD must also exceed the trip temperature of the RTD being checked before a trip will be issued. If the RTD is chosen to vote with itself, the voting feature is disabled. Each RTD may also be configured as being of application type None, Stator, Bearing, Ambient or Other. RTDs configured as Stator type are also used by the thermal model for determining the RTD Bias.

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.

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, 10 Ω Copper
Default: 100 Ω Platinum

Selects the type of the RTD used.

APPLICATION

Range: None, Stator, Bearing, Ambient, Other
Default: None

The setting allows each individual RTD to be assigned to a group application. This is useful for some applications, which require group measurement. The setting “None” means that the RTD operates individually and is not part of any RTD group. Common groups are provided for needs at rotating machines applications such as “Ambient” of “Bearing”.

VOTING

Range: Off, RTD 1, RTD 2....RTD 12
Default: Off

This setting selects the RTD that must also exceed this RTD’s Trip Temperature for a trip to occur. Selecting the same RTD to which the element is related to, has the same effect as selecting “Off”.

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

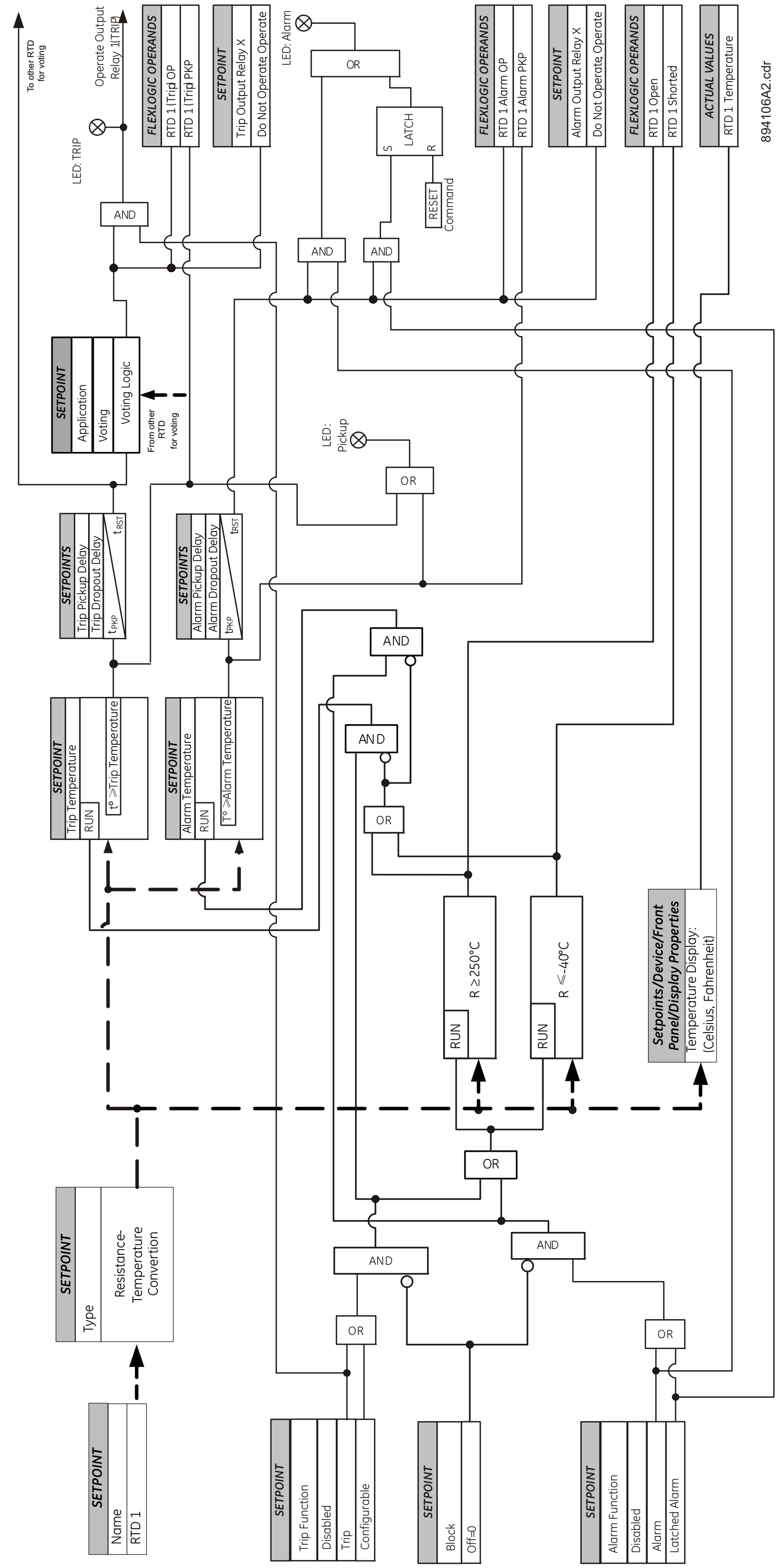
EVENTS

Range: Disabled, Enabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Latched

Figure 7-42: 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.

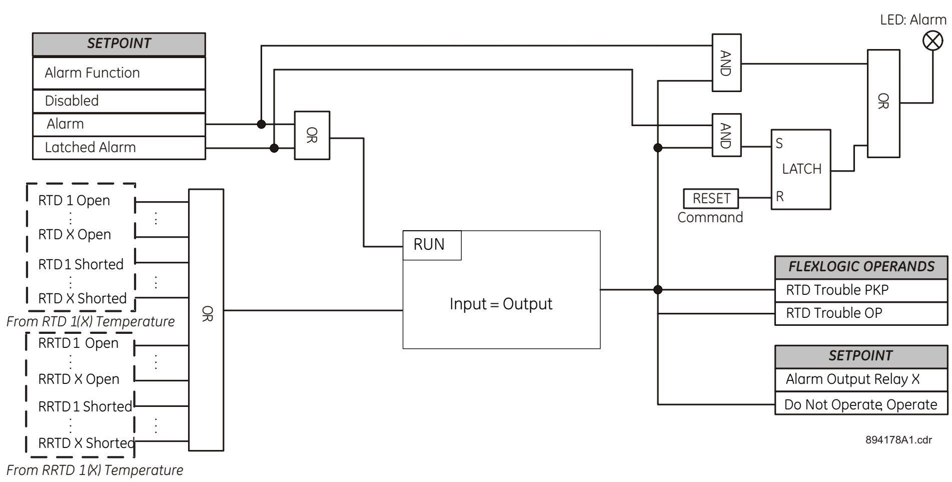
EVENTS

Range: Disabled, Enabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Latched

Figure 7-43: RTD Trouble logic diagram



Sync. Motor Field Overtemperature (26F)

869 relay provides two Field Overtemperature elements. The element responds to calculated field resistance, element operates when magnitude of the field resistance or temperature exceeds the Pickup level for the time specified by the Pickup Delay setting.

This element is applicable to both Brushless and Brush-type synchronous motors. Operation of the element blocks when motor is running in induction mode i.e. when motor state is Starting, Running or SM Resync.

This function emulates a resistance temperature detector (RTD) on the field windings. The resistance of an RTD is temperature dependent - it increases as the temperature increases. In this case, the RTD behavior is emulated by examining the field voltage and current. As the ratio of field voltage to field current increases, the field resistance increases, indicating an increase in temperature of the field windings.

The motor nameplate contains the motor's maximum temperature rise and field resistance. This information is used with the multiplier from the table below to determine the maximum field ohms, and therefore the maximum field winding temperature, at which the motor should be allowed to operate.

NOTE

This function requires a VDN Module (Voltage Divider Network Module) to connect exciter output (primary side) to relay input (secondary side) via the VDN Module.

Path: **Setpoints > Monitoring > SM Field Overtemperature**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm or Configurable

Default: Disabled

This setting enables SM Field Overtemperature functionality. When set to Trip, the protection element operates the Trip Relay (Output Relay 1) to open the main circuit breaker/contactor. To trip the field winding breaker/contactor, the FlexLogic operand 'FLD OverTemp[X] OP' must be used to operate the selected relay set under **Path: Setpoints > System > Breaker 2 (or Contactor 2)**.

PICKUP

Range: 0.10 to 500.00 ohms in steps of 0.01 ohms

Default: 5.00 ohms

This setting specifies the pickup threshold, and should be based on the primary side values of field current and voltage.

NOTE

This function requires VDN Module to hookup exciter output (primary side) to relay input (secondary side) via VDN Module.

Primary field resistance is calculated as:

$$\text{Field Ohms} = \frac{\text{Primary Field Voltage}}{\text{Primary Field Current}}$$

where:

Primary Field Voltage equals actual value 'SM Field VDC' and

Primary Field Current equals actual value 'SM Field Amps'

Setting guidelines:

The motor nameplate contains the motor's maximum temperature rise and field resistance. This information is used with the multiplier from the table below to determine the maximum field ohms, and therefore the maximum field winding temperature, at which the motor should be allowed to operate.

Table 7-3: Field Ohms Multiplier

Rise °C	Multiplier	Rise °C	Multiplier	Rise °C	Multiplier
0	1	40	1.15	110	1.42
5	1.02	50	1.19	120	1.46
10	1.04	60	1.23	130	1.5
15	1.06	70	1.27	140	1.54
20	1.08	80	1.31	150	1.57
25	1.1	90	1.35	160	1.6
30	1.12	100	1.39	170	1.64

Example:

A motor with a nameplate field resistance of 2 Ω at 25°C with insulated copper windings has a maximum temperature rise of 80°C. This corresponds to a field resistance of 1.31 times the resistance at 25°C. Thus, the Pickup setpoint is set to 1.31 x 2 Ω = 2.62 Ω.

PICKUP DELAY

Range: 0.00 to 600.00 s in steps of 0.01 s

Default: 10.00 s

This setting specifies a time delay for the SM Field Overtemperature function.

DROPOUT DELAY

Range: 0.00 to 600.00 s in steps of 0.01 s

Default: 0.00 s

MIN FIELD VOLTAGE

Range: 0.00 to 50.00 VDC in steps of 0.01 VDC

Default: 20.00 VDC

This setting specifies the minimum DC field voltage, in primary volts, for over temperature element operation. Operation of the element blocks if field DC voltage is below this level.

MIN FIELD CURRENT

Range: 0.02 to 0.30 x MFA in steps of 0.01 x MFA (where MFA is Max FLD Amps Primary)
Default: 0.02 x MFA

This setting specifies the minimum DC field current for over temperature element operation. Operation of the element blocks if field DC current is below this level.

he pickup level is defined as a multiple of MFA (maximum field current at primary of DCCT). MFA is defined by the setpoint 'Max FLD Amps Primary (MFA)' programmed under **Path: Setpoints > System > Current Sensing > SM FLD A-K2**. MFA corresponds to the maximum output value of the DCCT (direct current transformer) or current transducer.

OUTPUT RELAY X

For details see Common Setpoints.

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

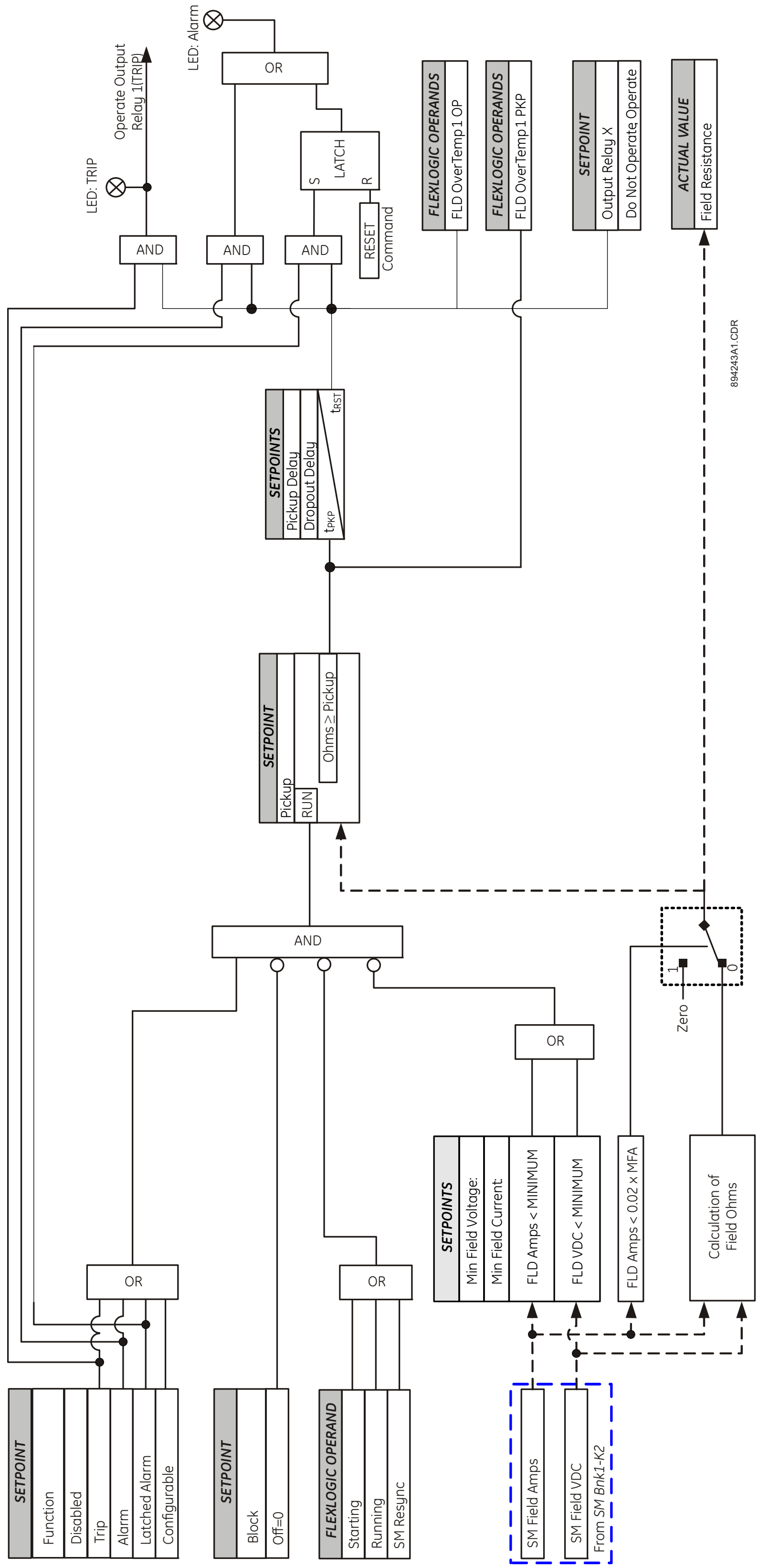
EVENTS

Range: Disabled, Enabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Latched

Figure 7-44: SM Field Overtemperature 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

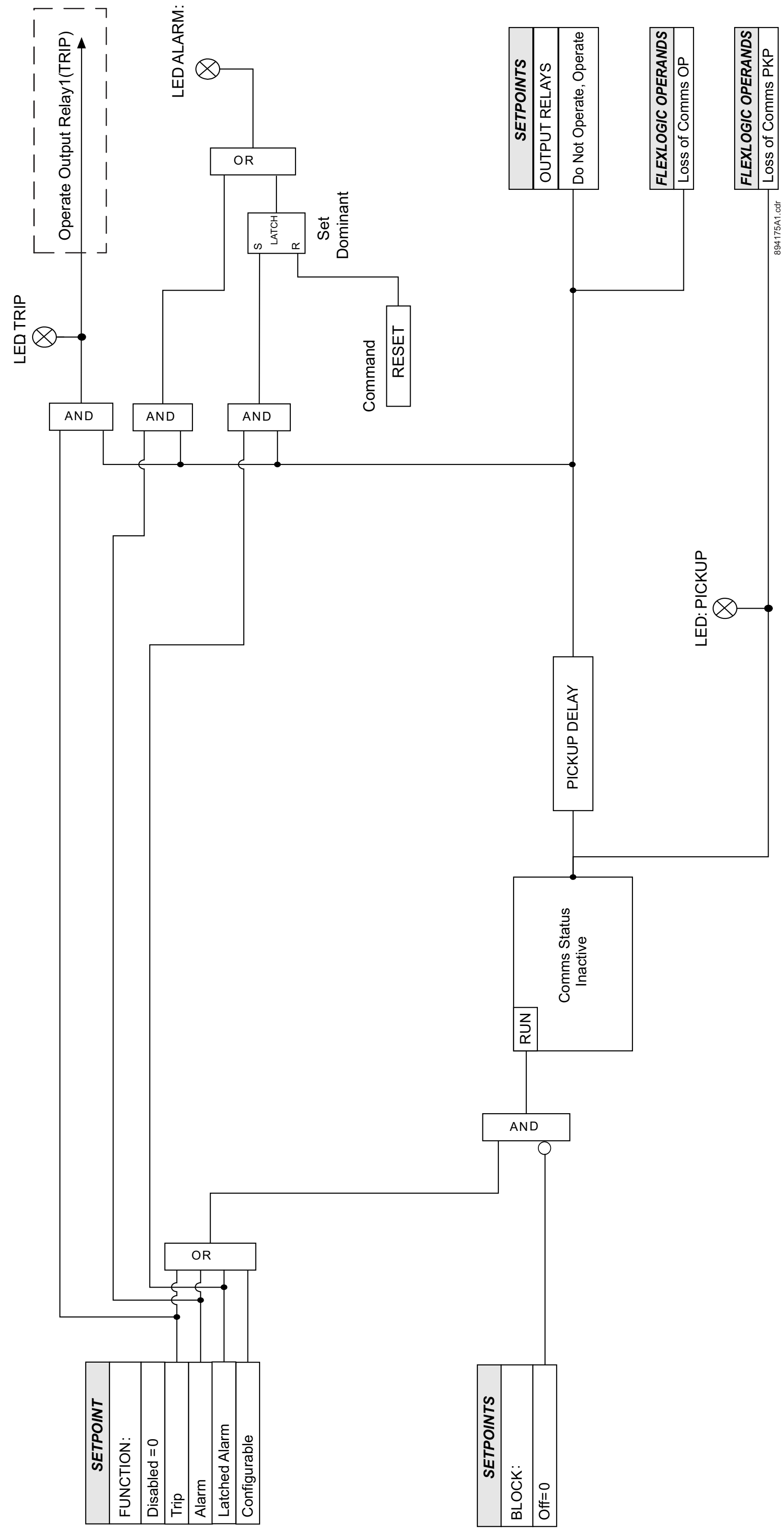
EVENTS

Range: Disabled, Enabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Latched

Figure 7-45: Loss of Communications logic diagram



GE
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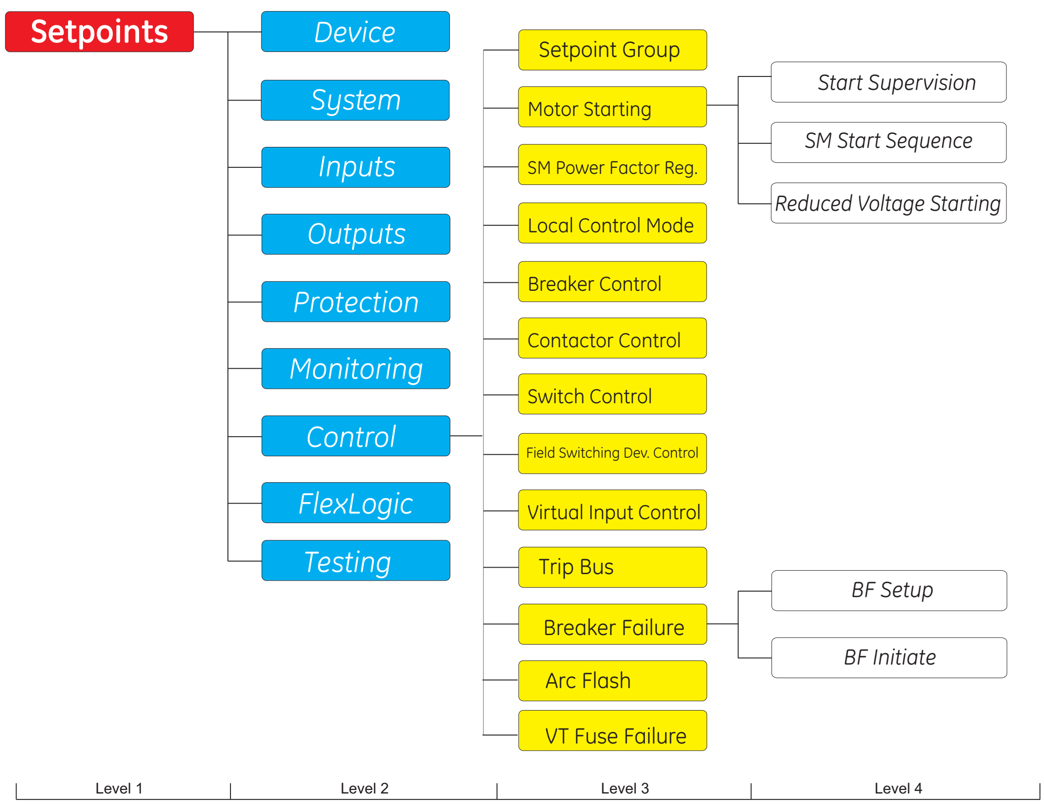
869 Motor Protection System

Chapter 8: Control

Figure 8-1: Control Display Hierarchy



Setpoint Group

The 869 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, sensitive 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)

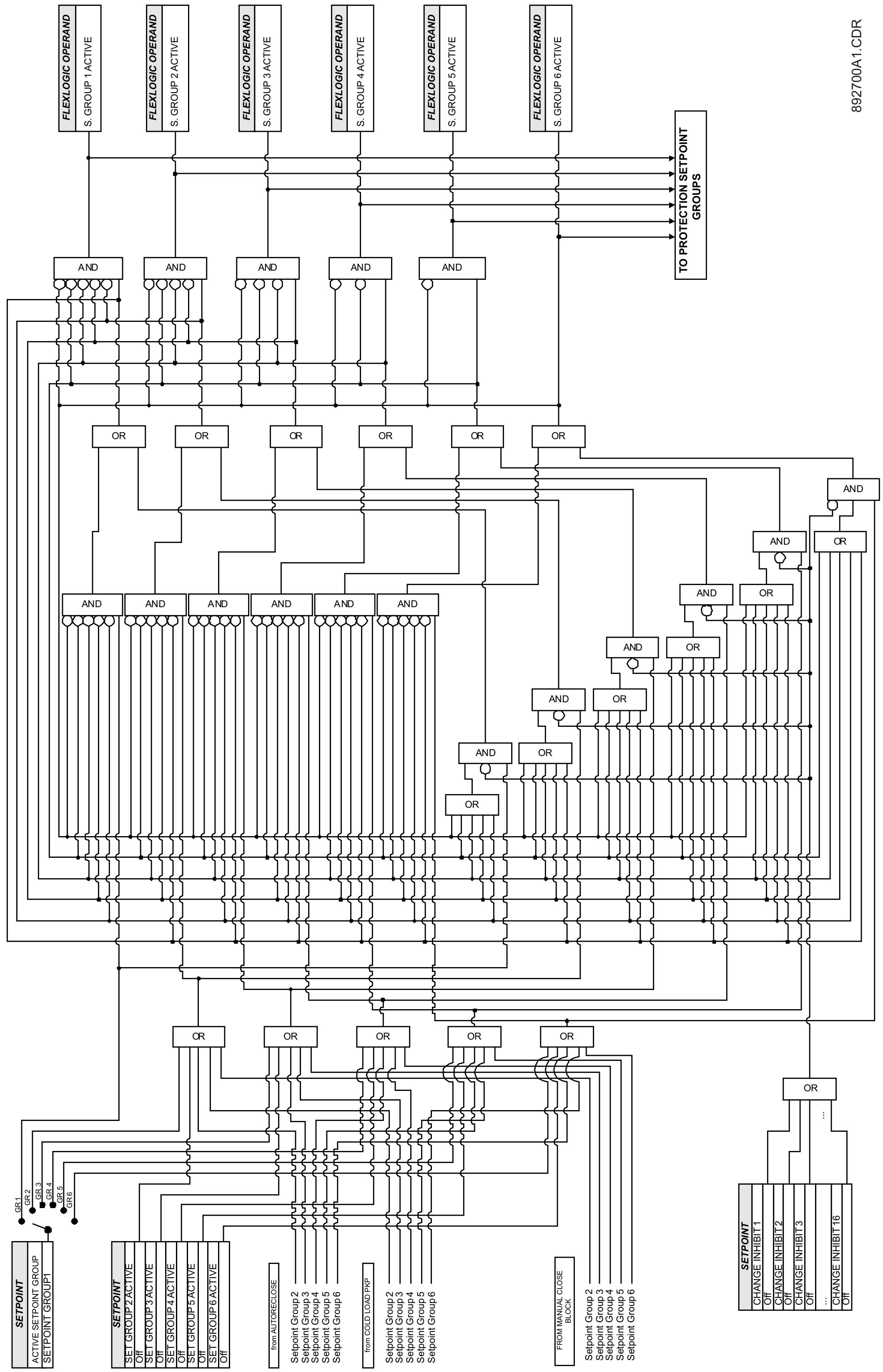
Range: Off, Any FlexLogic operand
Default: Off

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



Motor Starting

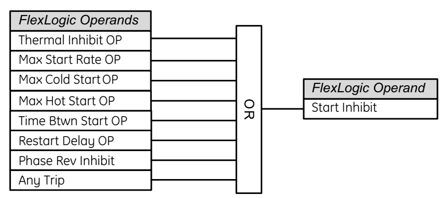
Start Supervision

Start Supervision consists of five elements that guard against excessive starting duty. All Start Supervision elements operate the FlexLogic operand Output Relay 3 (“Start Inhibit”). In addition to Start Supervision elements, the Start Inhibit operand relay also operates when the Phase Reversal element or Any Trip operates, as shown in the following figure: Start Inhibit FlexLogic operand. If the condition that has caused the trip is still present (e.g. hot RTD), the Start Inhibit operand relay will not reset until the condition is no longer present or the lockout time has expired. Auxiliary Output Relay, energized by the Start Inhibit operand, changes state only when the motor is stopped to accommodate control circuits that must be continuously energized, such as a contactor.

NOTE

The Start Inhibit operand is programmed as factory default to energize the auxiliary Output Relay 3, therefore, it is recommended to use the auxiliary Output Relay 3 to inhibit the closing of the motor switching device, as illustrated by the figure: Typical Wiring Diagram in chapter 2.

Figure 8-3: Start Inhibit FlexLogic operand



The five elements of Start Supervision are: Thermal Start Inhibit, Maximum Starting Rate, Maximum Cold/Hot Starting Rate, Time Between Starts, and Restart Delay.

Thermal Inhibit

This function is provided to inhibit starting of a motor if there is insufficient thermal capacity (TC) available for a successful start. The thermal capcity required for a successful start or the learned thermal capacity used at start (TC_L) is calculated even if the Thermal Start Inhibit element is disabled.

The information about learned thermal capacity is stored in a non-volatile memory and it is available after the power is removed from the 869 . The TC_L is the largest thermal capacity used value from a number (N) of most recent successful starts. "N" is set in **Setpoints > System > Motor > Setup > Number of Starts to Learn**. A successful motor start is one in which the motor reaches the Running state. See the Motor Status section of this manual for a description of Running state logic. When the start history is not available or "Clear Learned TCU" command (in Records > Clear Records) is executed, a value of 85% is used for the learned thermal capacity used until displaced by the largest of the "N" subsequent successful starts. This 85% default requires the thermal capacity used to decay to the 15% level before the start is allowed.

Starts are inhibited while the thermal capacity is greater than the adjusted thermal capacity (TC_{ADJ}) subtracted from 100%. TC_{ADJ} is equal to the learned thermal capacity used at start (learned start TCU or TC_L) increased by the margin (TC Used Margin). The formula is $TC_{ADJ} = TC_L + (\text{TC Used Margin} / 100\%) \times TC_L$.

For example, if the thermal capacity used for the last 5 starts is 24, 23, 27, 26 and 20% respectively, the learned starting capacity used at start is the Maximum of (24%, 23%, 27%, 26%, 20%) = 27%. If the set margin is 25%, the adjusted thermal capacity learned value (TC_{ADJ}) is calculated as 27% x (1+25%/100%) = 33.75%. A start inhibit is issued until the motor current TCU decays to 100% - 33.75 = 66.25%. For more details, please see the Thermal Start Inhibit logic diagram.

The Thermal Lockout Time calculation is based on the values of TCU, TC_{ADJ} and the Cool Time Constant Stopped (CTCS). The latter is set in **Setpoints > Protection > Group 1 > Motor > Thermal Model**. The formula is shown in on the Thermal Start Inhibit logic diagram:

If, for the example above, the Cool Time Constant Stopped = 30 Minutes and the motor TCU = 90%, the lockout time is: 30 x ln (90% / 66%) = 9.3 minutes

If the start history is not available, the inhibit time is: 30 x ln (90% / 15%) = 54 minutes

The 869 constantly displays the Thermal Lockout Time in **Status > Motor** menu even if the motor is neither stopped nor tripped.

If the Emergency Restart input is asserted during a Thermal Start lockout, the TCU is set to zero and the Thermal Trip OP is reset. This causes resetting of Thermal Lockout Time to zero and dropout of the Start Inhibit and Thermal Inhibit OP and allows a new start.

In the event of a real emergency, the Emergency Restart input operand must remain asserted at logic 1 until the emergency is over. The Thermal Inhibit OP and Start Inhibit operands will remain reset until the Emergency Restart Input is de-asserted. However, calculation of Thermal Lockout Time continues after resetting to zero regardless of the duration of the Emergency Restart input.

Path: Setpoints > Control > Motor Starting > Start Supervision > Thermal Inhibit

FUNCTION

Range: Disabled, Enabled

Default: Disabled

The element works as described at the beginning of this chapter if the Function is set to Enabled. If the Function is set to Disabled, the element is not functional unless the motor thermal capacity has reached 100% and the thermal model trip function is enabled. In that case, the Thermal Start Inhibit operates and the lockout time is approximately 190% of the Cool Time Constant Stopped. After the lockout time expires, the TCU will decay to 15% and a new start will be allowed.

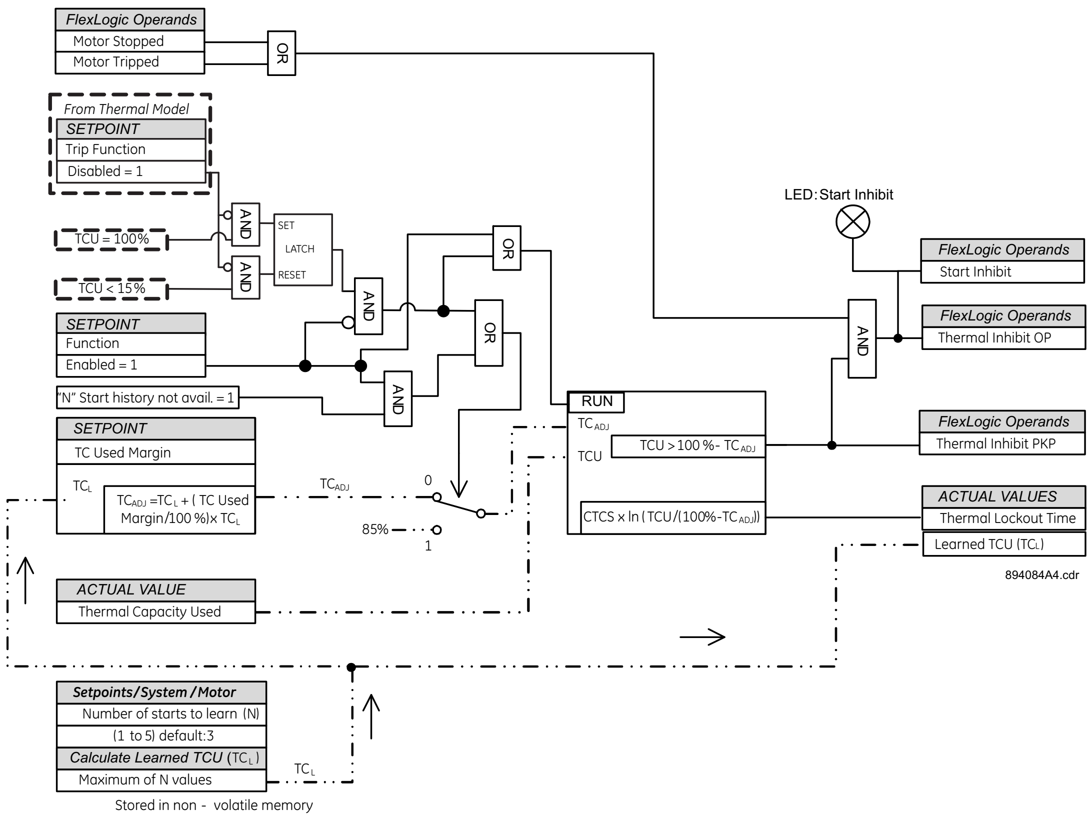
TC USED MARGIN

Range: 0 to 25% in steps of 1%

Default: 25%

Setpoint values in the range of 0 to 25% specify the margin to be included in the calculation of the adjusted Thermal Capacity Used at start value.

Figure 8-4: Thermal Start Inhibit logic diagram



Maximum Starting Rate

NOTE

It is recommended to use Maximum Cold/Hot Starting Rate element instead of the Maximum Starting Rate element when the allowable number of Cold and Hot starts is known.

The Maximum Starting Rate element defines the configurable number of start attempts allowed in a programmable time interval. After every new start, the number of starts within the past time Interval is compared to the number of starts allowed. When the maximum number of actual starts within the past Interval is reached, the FlexLogic operand Max Start Rate PKP is asserted. Once the motor stops, the comparison is performed again and if the two numbers are the same, the Start Inhibit operand is activated to block the motor start. If a block occurs, the lockout time is equal to the time elapsed since the 'oldest start' within the past Interval that occurred, subtracted from the time of the Interval. For more details, please refer to the figure: Maximum Starting Rate logic diagram. Even unsuccessful start attempts are logged as starts for this feature.

Example: If Max Number of Starts is programmed at "2" and the time Interval is programmed at 60 minutes.

- One start occurs at T = 0 minutes
- A second start occurs at T = 17 minutes
- The motor is stopped at T = 33 minutes
- A block occurs.
- The lockout time is 60 minutes – 33 minutes = 27 minutes.

If the Emergency Restart input is asserted while the motor is stopped or tripped during a Maximum Starting Rate lockout, the information about the oldest start inside the selected time Interval is erased. This causes a dropout of the Start Inhibit and allows a new start. If the motor starts while the Emergency Restart input is asserted, the new start is still recorded. It is important that the Emergency Restart is removed either shortly before or shortly after the motor is started.

NOTE

Consecutive assertion of multiple Emergency Restart inputs erases the equivalent number of the oldest motor starts. For example: when an Emergency Restart input is asserted twice consecutively, the two oldest starts will be erased and therefore allow two motor starts.

The information about motor starts and stops within the past Interval is stored in non-volatile memory and remains in the memory after the power is removed from the 869. When the power is restored, the Maximum Starting Rate element continues working normally using the information collected before the power loss if the real time clock worked properly during the power loss. However, when the relay power is restored, if the clock is not working properly or defaulted to the factory setting, LO time will remain unchanged and prevent the motor from starting until LO time becomes zero or the Emergency Restart is asserted.

Path: **Setpoints > Control > Motor Starting > Start Supervision > Maximum Starting Rate**

FUNCTION

Range: Disabled, Enabled
Default: Disabled

INTERVAL

Default: 60 min
Range: 1 to 300 min in steps of 1min

This setting specifies time interval for monitoring the maximum allowable rate of starting. Set it to 60 minutes for the classical starts-per-hour functionality.

MAX NUMBER OF STARTS

Range: 1 to 16 in steps of 1

Default: 3

The setting specifies the maximum allowable number of starts that can occur within the specified time Interval.

EVENTS

Range: Disabled, Enabled

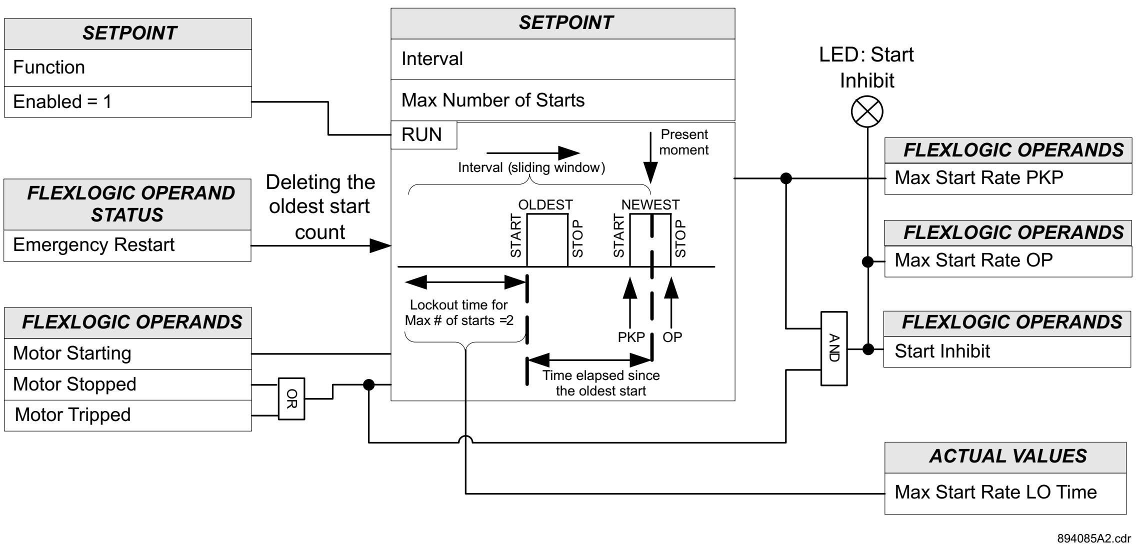
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched

Default: Latched

Figure 8-5: Maximum Starting Rate logic diagram



Maximum Hot/Cold Starting Rate

NOTE

It is recommended to use Maximum Starting Rate element instead of the Maximum Cold/ Hot Starting Rate element when the allowable number of Cold and Hot starts is not known .

This element defines the settable number of cold and hot start attempts allowed in a programmable time interval. On each start, the TCU level defined by the setpoint Cold/Hot TCU Level is used by this element to determine the start type: Hot or Cold.

The new start is declared as:

- A Hot Start if the actual TCU% is greater than or equal to the setpoint Cold/Hot TCU Level
- A Cold Start if the actual TCU% is less than the setpoint Cold/Hot TCU Level

At each new start, the number of starts (hot or cold) within the past time Interval is compared to the number of allowed starts (hot or cold).

When the maximum number of actual starts (hot or cold) within the past Interval is reached, the FlexLogic operand Max Hot Start PKP or Max Cold Start PKP is asserted.

Once the motor stops, the comparison is performed again and if the maximum number has indeed been reached, the Start Inhibit operand is activated to block the motor start. If a block occurs, the lockout time is equal to the time elapsed since the 'oldest start' within the past Interval that occurred, subtracted from the time of the Interval. For more details, please refer to the figure: Maximum Cold/Hot Starting Rate logic diagram. Note that unsuccessful start attempts are logged as starts for this feature.

Application Example 1 is illustrated by the figure that follows:

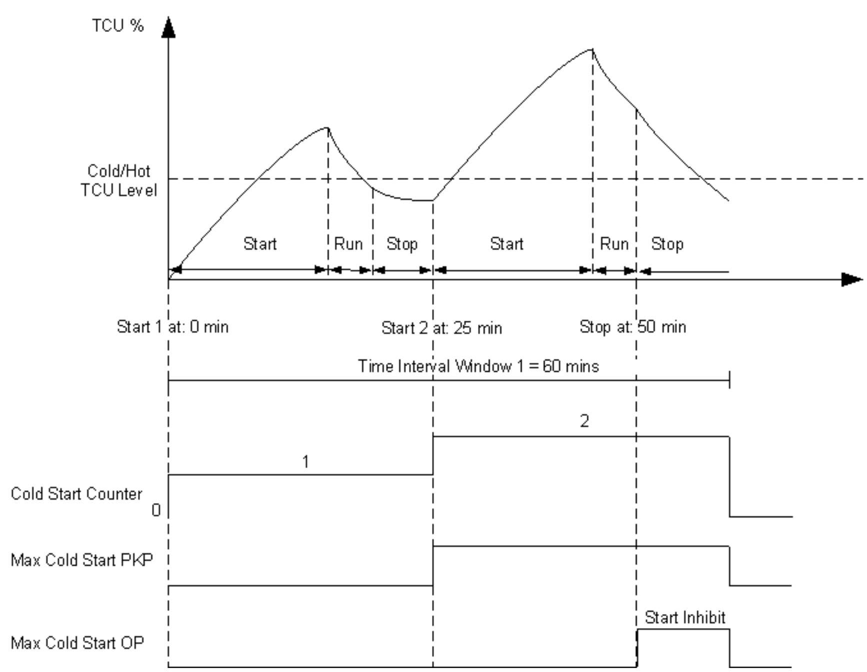
Setpoint **Max Number of Cold Starts** = 2

Setpoint **Max Number of Hot Starts** =2

Setpoint **Interval** = 60 mins

Setpoint **Cold/Hot TCU Level** = 25%

Figure 8-6: Application Example 1



- When the motor starts at time T = 0 minutes, and the TCU level lies below the set Cold/ Hot TCU Level, thus the element declares the first start as a Cold Start and increments the cold start counter to 1, while the hot start counter remains at zero.

- The second start occurs at time T = 25 minutes, and the TCU level lies below the set Cold/Hot TCU Level, thus the element declares the second start as a cold start and increments cold start counter to 2, while hot start counter remains at zero. After the second start, the element compares the number of cold starts and hot starts within past interval window with the set value of Max Number of Cold Starts and Max Number of Hot Starts, respectively. The element asserts the Max Cold Start PKP operand since the number of cold starts reaches the allowed number of cold starts attempts within past interval. When the motor stops at T = 50 minutes, the Flexlogic operands Max Cold Start OP and Start Inhibit are asserted. The motor remains inhibited from starting for 10mins (60 minutes - 50 minutes). Since the number of hot starts counter equals zero within the past time interval window, the Flexlogic operand Max Hot Start PKP/OP remains at zero.

Application Example 2 is illustrated by the figure that follows:

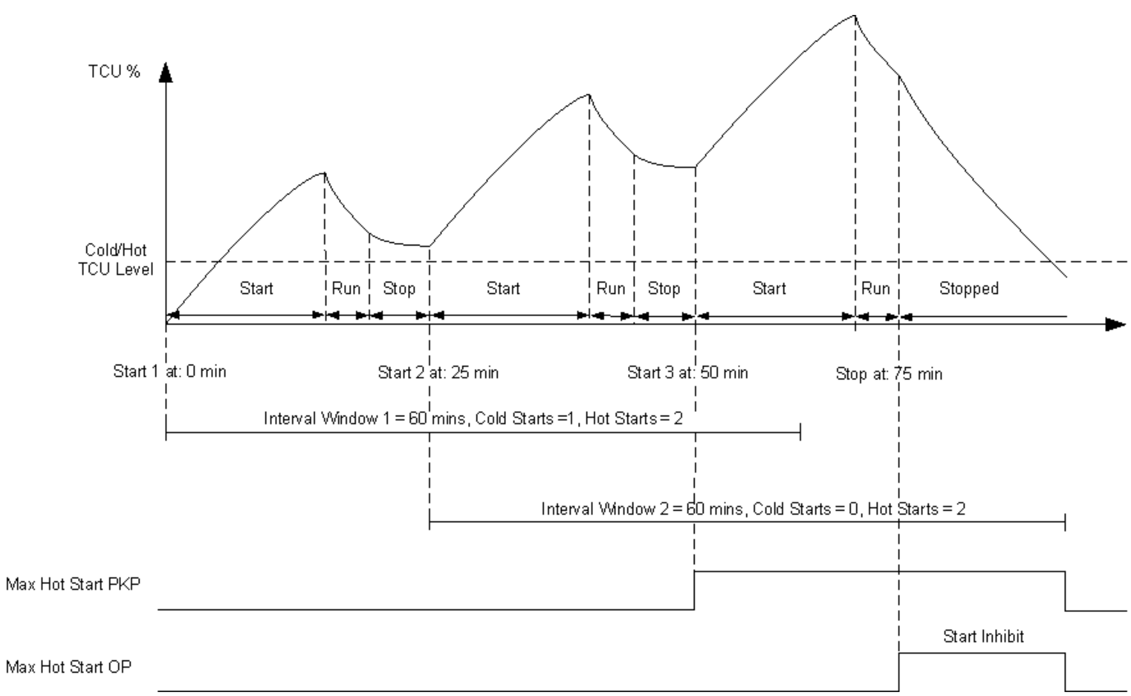
Setpoint **Max Number of Cold Starts** = 2

Setpoint **Max Number of Hot Starts** =2

Setpoint **Interval** = 60 mins

Setpoint **Cold/Hot TCU Level** = 25%

Figure 8-7: Application Example 2



- When the motor starts at time T = 0 minutes, the TCU level lies below the set Cold/Hot TCU Level, thus the element declares first start a cold start and increments the cold start counter to 1, while hot start counter remains at zero.
- The second start occurs at time T = 25 minutes, and the TCU level lies above the set Cold/Hot TCU Level. The element declares the second start a hot start and increments the hot start counter to 1, while the cold start counter remains at 1.
- After the second start, the element compares the number of cold starts and hot starts within past interval window with the corresponding programmed value of Max Number of Cold Starts and Max Number of Hot Starts, respectively. Within the past interval window, the number of cold starts remains below the allowed cold starts, so the Flexlogic operand Max Cld Srt Rate PKP remains zero. Similarly, within the past interval window, the number of hot starts remains below the allowed hot starts, so the Flexlogic operand Max Hot Start PKP remains zero.

- The third start occurs at T = 50 minutes, and the TCU level lies above the set Cold/Hot TCU Level, so the element declares third start a hot start and increments the hot start counter to 2, while the cold start counter remains at 1.
- After the third start, the element compares the number of cold starts and hot starts within past interval window with the corresponding programmed value of Max Number of Cold Starts and Max Number of Hot Starts, respectively. Within the past interval window, the number of cold starts remains below the allowed cold starts, so the Flexlogic operand Max Cold Start PKP remains zero. However, the number of hot starts reaches the allowed number of hot starts within the past interval window, and therefore the Flexlogic operand Max Hot Start PKP becomes high.
- When the motor stops at T = 75 minutes, Max Hot Start OP becomes high and blocks the motor from starting for the next 10mins (60 minutes - 50 minutes).
- Since the cold start counter equals 1 within the past time interval window, Max Cold Start PKP/OP remains de-asserted.

If the Emergency Restart input is asserted while the motor is stopped or tripped during a Max C/H Start Rate LO Time, the information about the oldest start inside the selected time Interval is erased. This causes a dropout of the Start Inhibit and allows a new start. If the motor starts while the Emergency Restart input is asserted, the new start is still recorded. It is important that the Emergency Restart is removed either shortly before or shortly after the motor is started.

NOTE

Consecutive assertion of multiple Emergency Restart inputs erases the equivalent number of the oldest motor starts. For example: when an Emergency Restart input is asserted twice consecutively, the two oldest starts will be erased and therefore allow two motor starts.

The information about motor hot and cold starts and stops within the past Interval is stored in non-volatile memory and remains in the memory after the power is removed from the 869. When the power is restored, the Maximum Hot/Cold Starting Rate element continues working normally using the information collected before the power loss if the real time clock worked properly during the power loss. However, when the relay power is restored, if the clock is not working properly or defaulted to the factory setting, LO time will remain unchanged and prevent the motor from starting until LO time becomes zero or the Emergency Restart is asserted.

Path: **Setpoints > Control > Motor Starting > Start Supervision > Maximum Cold/Hot Starting Rate**

FUNCTION

Range: Disabled, Enabled

Default: Disabled

INTERVAL

Default: 60 min

Range: 1 to 300 min in steps of 1min

This setting specifies time interval for monitoring the maximum allowable rate of starting. Set it to 60 minutes for the classical starts-per-hour functionality.

MAX NUMBER OF COLD STARTS

Range: 1 to 16 in steps of 1

Default: 3

The setting specifies the maximum allowable number of cold starts that can occur within the specified time Interval.

MAX NUMBER OF HOT STARTS

Range: 1 to 16 in steps of 1

Default: 2

The setting specifies the maximum allowable number of hot starts that can occur within the specified time Interval.

COLD/HOT TCU LEVEL

Range: 0 to 50% in steps of 1

Default: 30%

TCU level defined by this setpoint is used by the Maximum Starting Rate function to determine the next start type: Hot or Cold. The new start is declared as: Hot Start if the actual TCU% is greater than this setpoint; Cold Start if the actual TCU% is less than this setpoint.

Once this start inhibit function declares the start type, it will take the corresponding configurable number of starts (Max Number of Cold Starts or Max Number of Hot Starts) in order to compare with the actual number of starts within the past time Interval.

EVENTS

Range: Disabled, Enabled

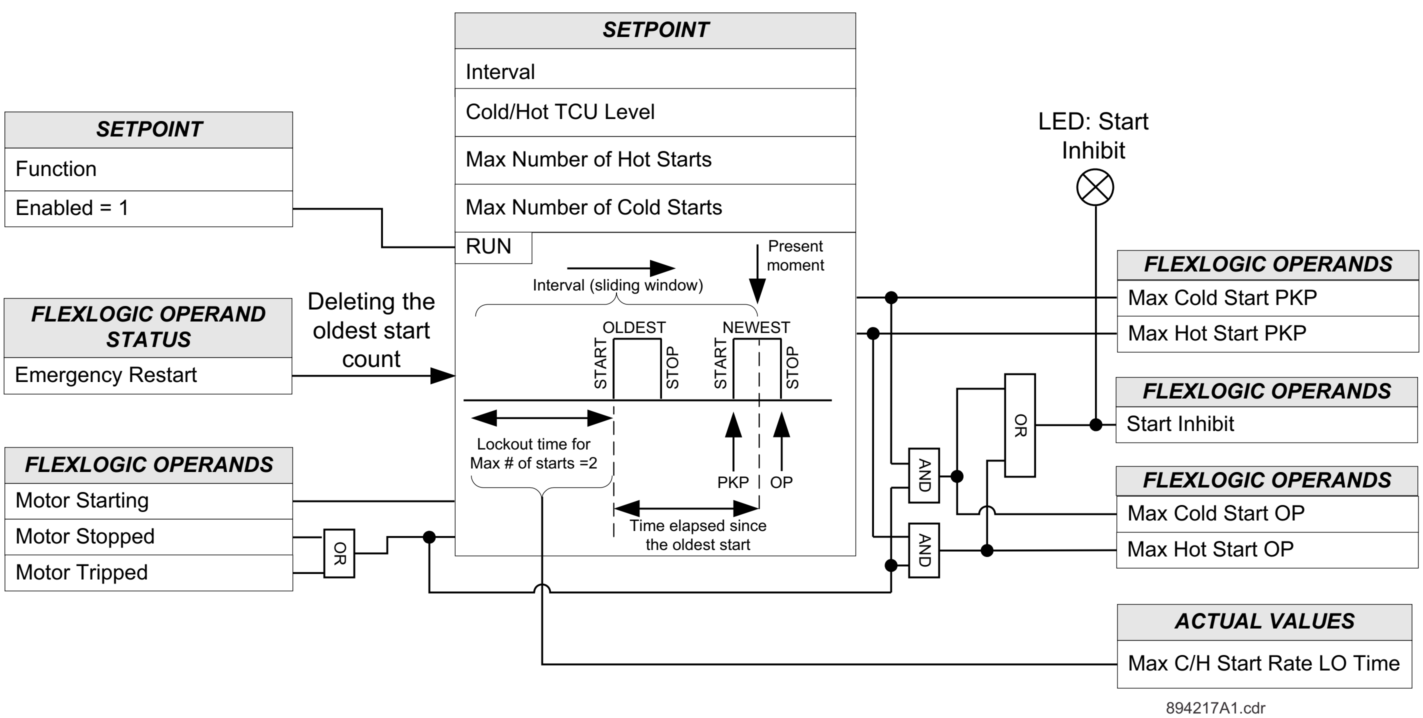
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched

Default: Latched

Figure 8-8: Maximum Hot/Cold Starting Rate logic diagram



Time Between Starts

The Time Between Starts function enforces a configurable minimum time duration between two successive start attempts. A time delay is initiated with every start attempt, and a new start is not allowed until the specified interval has lapsed. The timer feature is useful in enforcing the duty limits of starting resistors or starting autotransformers.

At the detection of the motor start, the Time Between Starts timer is loaded with the entered Minimum Time. Even unsuccessful start attempts are logged as starts for this feature. Once the motor is stopped, if the time elapsed since the most recent start is less than the Minimum Time setting, the Start Inhibit operand is activated to block the motor start. If a block occurs, the lockout time is equal to the time elapsed since the most recent start subtracted from the Minimum Time setting.

Example: If Minimum Time is programmed as 25 min.

- A start occurs at T = 0 minutes
- The motor is stopped at T = 12 minutes
- A block occurs. The lockout time is 25 minutes – 12 minutes = 13 minutes

If the Emergency Restart input is asserted while the motor is stopped or tripped during a Time Between Starts lockout, the Time Between Starts timer is reset. This causes a dropout of the Start Inhibit operand and allows a new start. If the motor starts while the Emergency Restart input is asserted, the lockout timer does not remain reset and starts running from the rising edge of the Motor Starting state. However, Start Inhibit and Time Btwn Start OP will remain reset until Emergency Restart Input is de-asserted.

The status of the Time Between Starts element (including the time) is stored into a non-volatile memory and remains in the memory after the power is removed from the 869. When the power is restored, the Time Between Starts element continues working normally using the information collected before the power loss if the real time clock worked properly during the power loss. However, when the relay power is restored and if the clock is not working properly or defaulted to the factory setting, LO time will remain unchanged and prevent the motor from starting until LO time becomes zero or the Emergency Restart is asserted.

Path: **Setpoints > Control > Motor Starting > Start Supervision > Time Between Starts**

Function

Range: Disabled, Enabled
Default: Disabled

Minimum Time

Range: 1 to 600 min in steps of 1 min
Default: 10 min

Sets time amount of time following a start before a start control is permitted to prevent restart attempts in quick succession (jogging).

Events

Range: Disabled, Enabled
Default: Enabled

Targets

Range: Disabled, Self-reset, Latched
Default: Latched

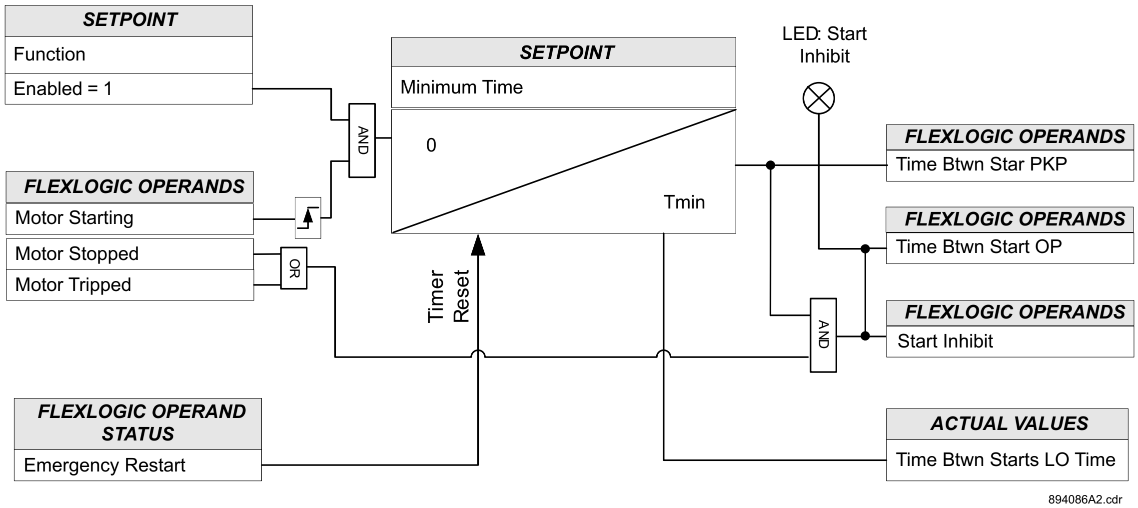


Figure 8-9: Time Between Starts logic diagram

Restart Delay

The Restart Delay feature is used to ensure that a certain amount of time passes between the time a motor is stopped and the restarting of that motor. This timer feature can be very useful for some process applications or motor considerations. If a motor is on a down-hole pump, after the motor stops, the liquid can fall back down the pipe and spin the rotor backwards. It is very undesirable to start the motor at this time.

The Restart Delay inhibit lockout will remain active (it may be used as a backspin timer) when the Emergency Restart input is asserted.

The status of the Restart Delay element (including the time) is stored into a non-volatile memory and remains in the memory after the power is removed from the 869. When the power is restored, the Restart Delay element continues working normally using the information collected before the power loss if the real time clock worked properly during the power loss.

Path: Setpoints > Control > Motor Starting > Start Supervision > Restart Delay

FUNCTION

Default: Disabled

Range: Disabled, Enabled

MINIMUM TIME

Range: 0 to 65000 s in steps of 1s

Default: 0 s

Sets the amount of time following stop before a start control is permitted.

EVENTS

Range: Disabled, Enabled

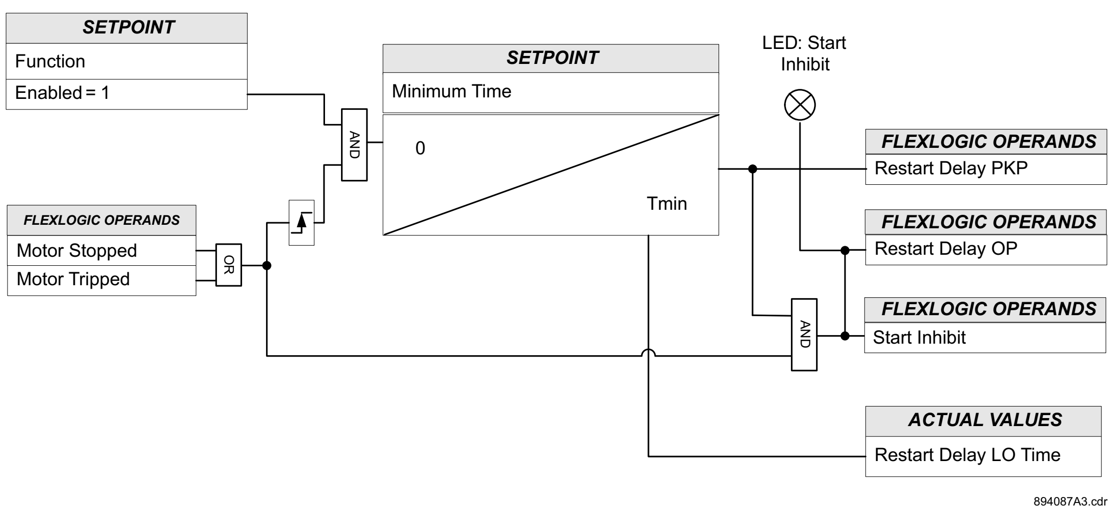
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched

Default: Latched

Figure 8-10: Restart Delay logic diagram



Sync. Motor Start Sequence Control (56)

When the motor accelerates to near synchronizing speed (about 95% of synchronous speed), DC current is introduced into the rotor field windings. This current creates constant polarity poles in the rotor, causing the motor to operate at synchronous speed as the rotor poles "lock" onto the rotating AC stator poles.

In Starting mode, the synchronous motor salient poles are not excited by their external DC source. Attempting to start the motor with DC applied to the field does not allow the motor to accelerate. In addition, there is a very large oscillating torque component at slip frequency, produced by field excitation, which could result in motor damage if full field current is applied during the entire starting sequence. Therefore, application of DC to the field is usually delayed until the motor reaches a speed where it can be pulled into synchronism without slip.

The 869 Start Sequence Control function provides:

- Control of applying a DC field to the rotor winding for both brush-type and brushless synchronous motors. The start sequence function is comprised of three field application control methodologies:
  - A slip-frequency-based method for brush-type motor applications.
  - A timer-based method for both brushless and brush-type motor applications.
  - A reluctance-torque based synchronization for brush-type motor applications.
- Incomplete start sequence protection to trip/alarm if the starting sequence is not completed in time.
- Load application relay functionality to enable loading the motor following the DC field application and unloading the motor following a trip and/or loss of synchronization (pole slipping).
- Motor start interlocking using the motor Starting state to initiate start sequence control. The 869 also initiates start sequence control when the motor goes into re-synchronization mode, by monitoring the motor state SM Resync (see Power Factor Resync mode for more details).

Starting a Brush-Type Synchronous Motor

The start sequence control function uses rotor speed and rotor angle to close the field switching device in order to apply the DC field to the rotor winding.

The rotor frequency is the most positive electrical parameter available for indicating speed, and can be sensed by detecting the frequency of the voltage across the shunt field discharge resistor (FDRS). Voltage across the FDRS is not actually the "induced field voltage," but it is the voltage which is essentially in a time-phase relation to the current through the resistor. That is, the current goes through zero at the same time as the voltage goes through zero.

The rotor angle at which stator winding current and induced field winding current go through zero indicates the point of maximum flux. Applying excitation at the point of zero induced current (favorable angle) takes advantage of motor capability in two ways:

1. It catches (traps) salient-pole flux at significant magnitude (provided there is a field discharge resistor of adequate value) and uses it for torque during a 180° acceleration period.
2. It catches the rotor in the correct angular position to be pulled forward into step.

The 869 detects the proper rotor speed and rotor angle from the field voltage measured across the shunt field discharge resistor (FDRS). The correct time to close the field switching device is determined by the 869 based on the percent synchronous slip setpoint and the rotor angle.

When both the rotor speed and the rotor angle conditions are met, the Start Sequence Control function delivers a signal to the output relay configured to close/open the field switching device in order to apply excitation to the motor field and to open the field discharge resistor loop.

For normal applications, when the field voltage across discharge resistor (VF) is higher than 30V RMS primary (prior to VDN), the 869 Start Sequence applies the field when following two conditions are met:

- Rotor Slip (RS) is less than or equal to target Sync Slip % (setpoint).

  RSF ≤ Sync Slip %

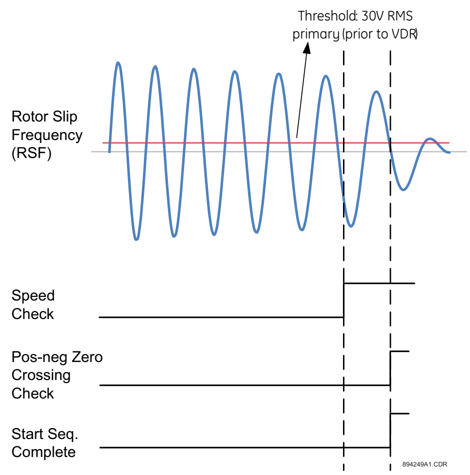
  where

  Sync Slip is the setpoint Sync Slip %

- Rotor angle obtained from the measured field voltage is crossing zero in negative direction, i.e. crossing zero from positive-to-negative.

The following diagram illustrates how the 869 automatically responds to normal synchronizing process.

Figure 8-11: Optional reluctance torque synchronizing (brush-type motor only)



A lightly loaded synchronous motor connected to a low inertial load may pull into synchronism before the rotor poles are externally magnetized. This is commonly known as reluctance torque synchronizing. This magnetization can result in sufficient torque to hold the salient poles in direct alignment with corresponding stator poles and run the motor at synchronous speed. However, when load is applied, the rotor begins to slip since the torque developed is only a fraction of the rated torque under separate excitation. Furthermore, the rotor is polarized by the stator flux under this condition and can therefore be polarized in any direct axis alignment; occurring each 180°. External excitation forces a pole-to-pole alignment in only one orientation of the direct axis

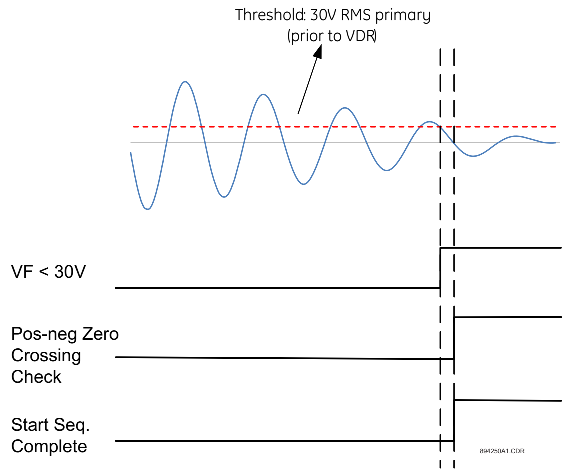
Should the rotor pull into synchronism 180° away from the normal running alignment, external excitation will build up rotor flux in opposition to the stator flux. As the external excitation builds up, correct alignment of the rotor to stator occurs by slipping one pole and the motor will then run in normal synchronism.

The Start Sequence Control must respond with proper application of excitation in the event the motor does synchronize on the reluctance torque. If, due to reluctance torque, the motor has pulled into synchronization and the RMS voltage across the discharge resistor drops lower then 30V RMS primary (impossible to detect zero crossing), the reluctance torque function checks the orientation of the reluctance-torque rotor magnetization.

- Correct orientation is declared when the input voltage drops to zero in the negative direction i.e. the rotor angle obtained from the measured field voltage is crossing zero in the negative direction, or crossing zero from positive-to-negative.
- 180° Disorientation is declared when input voltage drops to zero in the positive direction i.e. the rotor angle obtained from the measured field voltage is crossing zero in the positive direction, or crossing zero from negative-to-positive.

For correct orientation, the 869 start sequence applies the field as soon as the positive-to-negative zero crossing flag is high, as shown in the following figure.

Figure 8-12: Correct orientation Start Sequence Control applied field



For 180° disorientation, 869 Start Sequence applies the field after the PRS timer is elapsed to zero. PRS timer starts when rotor angle obtained from the measured field voltage is crossing zero in positive direction, as shown in the following figure.

Length of the PRS timer equals time of half-slip cycle.

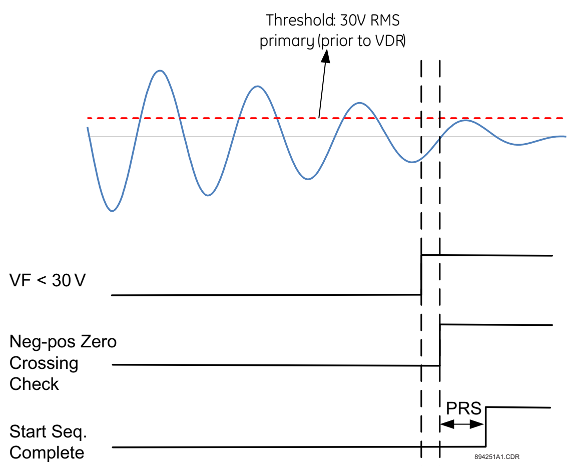
$$PRS\,Timer = \frac{1}{2} \times \frac{100}{Sync\,Slip\,\%} \times \frac{1}{f_n}$$

where

Sync Slip is the setpoint Sync Slip %

fn is the setpoint Nominal Frequency programmed under **Setpoints > System > Power System**.

Figure 8-13: Correct orientation Start Sequence Control applied field



NOTE

When the motor starts, RMS measurement of the input voltage across FDRS may take time to build up. In such cases the reluctance torque synchronizing feature may falsely initiate the field application command before the RMS voltage builds up past the 30V threshold. To prevent such operation, use of the 'Start Block Delay' timer is recommended to block element operation.

Starting a Brushless Synchronous Motor

To apply DC excitation to the rotor winding, the 869 Start Sequence Control operates an output relay to close the switching device after the configurable time delay set under FAR Delay. The timer starts at the rising edge of the Motor Starting state.

Path: **Setpoints > Control > Motor Starting > Reduced Voltage Start**

FUNCTION

Range: Disabled, FAR Close, Configurable

Default: Disabled

This setting enables the Start Sequence Control functionality.

FAR Close, when selected, bypasses the field switching device control logic (**Setpoints > Control > FLD SW Device Control**) and sends a close command directly to the auxiliary output relay programmed under Close Relay Select (path: **Setpoints > System > Breakers (Contactors) > SM Field Breaker (Contactor)**.

In order to not bypass the field switching device control logic, setpoint Function must be set as Configurable and operand FLD Sync Cmd must be selected under setpoint Close (**Setpoints > Control > FLD SW Device Control**) to initiate the auxiliary output relay closing.

MODE:

Default: Time

Range: Time, Slip Freq

NOTE

This setting is only applicable when Brush-type is set under **Setpoints > System > Motor > Setup > Sync. Motor Type**. When this is set to brushless synchronous motor, the start sequence control is hardcoded to Time mode.

In Time mode, start sequence control closes the field switching device to apply a DC excitation to the rotor winding after the time set by setpoint FAR Delay.

In Slip Freq. mode, start sequence control closes the field switching device to apply DC excitation to the rotor winding after the Rotor Slip reaches the level set by setpoint Sync Slip %.

In brush-type motor applications that are started rapidly via pony motors or by other mechanical means, it may not be possible to measure the rotor slip frequency from field AC voltage input. In such applications, use of the 'Time' Mode is recommended.

FAR DELAY

Default: 20.00 s

Range: 0.00 to 180.00 s in steps of 0.01 s

This setting specifies length of the time after which Start Sequence Control closes the field switching device to apply a DC excitation to the rotor winding of the synchronous motor. The timer starts counting down as soon as the main switching device is closed to supply power to the stator winding.

SYNC SLIP %

Range: 1.0 to 10.0% in steps of 0.1%

Default: 5.0%

This setting indicates the slip at which the Start Sequence Control closes the field switching device.

Example: To close the field switching device (apply the field) when the motor reaches 94.5% of synchronous speed, the SYNC SLIP setpoint is determined as follows:

100% speed - 94.5% speed = 5.5% sync slip

NOTE

This setting is only applicable to brush-type synchronous motors, and setpoint Mode must be set to Slip Freq in order to apply this setting. This setting is hidden when the setpoint **Setpoints > System > Motor > Setup > Sync. Motor Type** is set to 'None' or 'Brushless'.

REL TORQUE SYNC

Range: Disabled, Enabled

Default: Disabled

When enabled, this setpoint allows reluctance torque synchronizing control for brush-type motors only.

NOTE

This setting is only applicable to brush-type synchronous motors, and setpoint Mode must be set to Slip Freq in order to apply this setting. This setting is hidden when the setpoint **Setpoints > System > Motor > Setup > Sync. Motor Type** is set to 'None' or 'Brushless'.

START BLOCK DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s

Default: 1.00 s

This setting specifies the length of time to block the start sequence control function when the motor starts. An application of the start block delay may be to prevent the reluctance torque synchronizing feature to falsely apply DC field before RMS measurement of the voltage across discharge resistor builds up.

This timer is only applicable to brush-type synchronous motors when setpoint Mode is set to 'Slip Freq'. Otherwise, this setting is hidden.

OUTPUT RELAY X

Default: Do Not Operate

Range: Do Not Operate, Operate

Any assignable output relay can be selected as a Field Application Output Relay to close/open the field switching device.

For details see Common Setpoints.

INC SEQ FUNCTION

Range: Disabled, Trip, Alarm, Latch Alarm, Configurable

Default: Disabled

This setting enables the Incomplete Start Sequence functionality.

INC SEQ DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s

Default: 5.00 s

This setpoint configures the time during which the 869 must complete its starting sequence for the starting sequence to be deemed complete. If this time is exceeded, the SPM will trip and display an in-complete sequence condition.For brush-type motors, this time must be set to not less than the Load Application Delay setpoint. For brushless motors, this time must be set not less than the sum of the FAR Delay setpoint and the Load Application Delay setpoint.

NOTE

This setpoint only takes effect when Inc Seq Delay is set to Enabled.

INC SEQ OUTPUT RELAY

Default: Off

Range: Off, Operate

Any assignable output relay can be selected as a Field Application Output Relay to close/open field switching device.

For details see Common Setpoints.

LOAD APPLICATION RELAY

Default: Off

Range: Off, Operate

The setpoint Load Application Relay can be used to load the motor following the DC field application and to unload of the motor following a trip and/or loss of synchronization (pole slipping). Any assignable output relay can be selected as a Load Application Relay.When the motor is fully synchronized and ready to be loaded this relay picks up, the 'Load Applied' target message is issued, and 'Start Seq. Complete' is asserted for 2 seconds. This relay is controlled by the Load Application Delay setpoint.

NOTE

To avoid incorrect operation of the output relay selected under setpoint Load Application Relay, the selected output relay becomes hidden from the list of available relays for selection in the menu of all elements.

LOAD APPLICATION DELAY

Range: 0.00 to 180.00 s in steps of 0.01 s

Default: 2.00 s

This setting specifies the delay timer that begins with closing of FAR Close Relay and allows the synchronous motor to stabilize following the field application. This timer is not applicable if setpoint Load Application Relay is set to Off. Program this delay time to enable power factor protection, field overtemperature protection, field loss protection and Load Application Relay operation.

UNLOAD APPLICATION

Range: Off, Any FlexLogic operand

Default: Off

Any assignable FlexLogic operand can be used to reset the Load Application Output relay in order to unload the synchronous motor following a trip and/or loss of synchronization (pole slipping). If more than one input is required to reset the load application relay, the FlexLogic builder must be used to build the required logic. When this operand is high, the target massage 'Load Disconnected' is issued for 2 seconds.

This setpoint is not applicable if Load Application Relay is set to Off.

BLOCK

Range: Off, Any FlexLogic operand

Default: Off

EVENTS

Range: Disabled, Enabled

Default: Enabled

TARGETS

Range: Disabled, Self-Reset, Latched

Default: Latched

Figure 8-14: Start Sequence Control logic diagram (1 of 3)

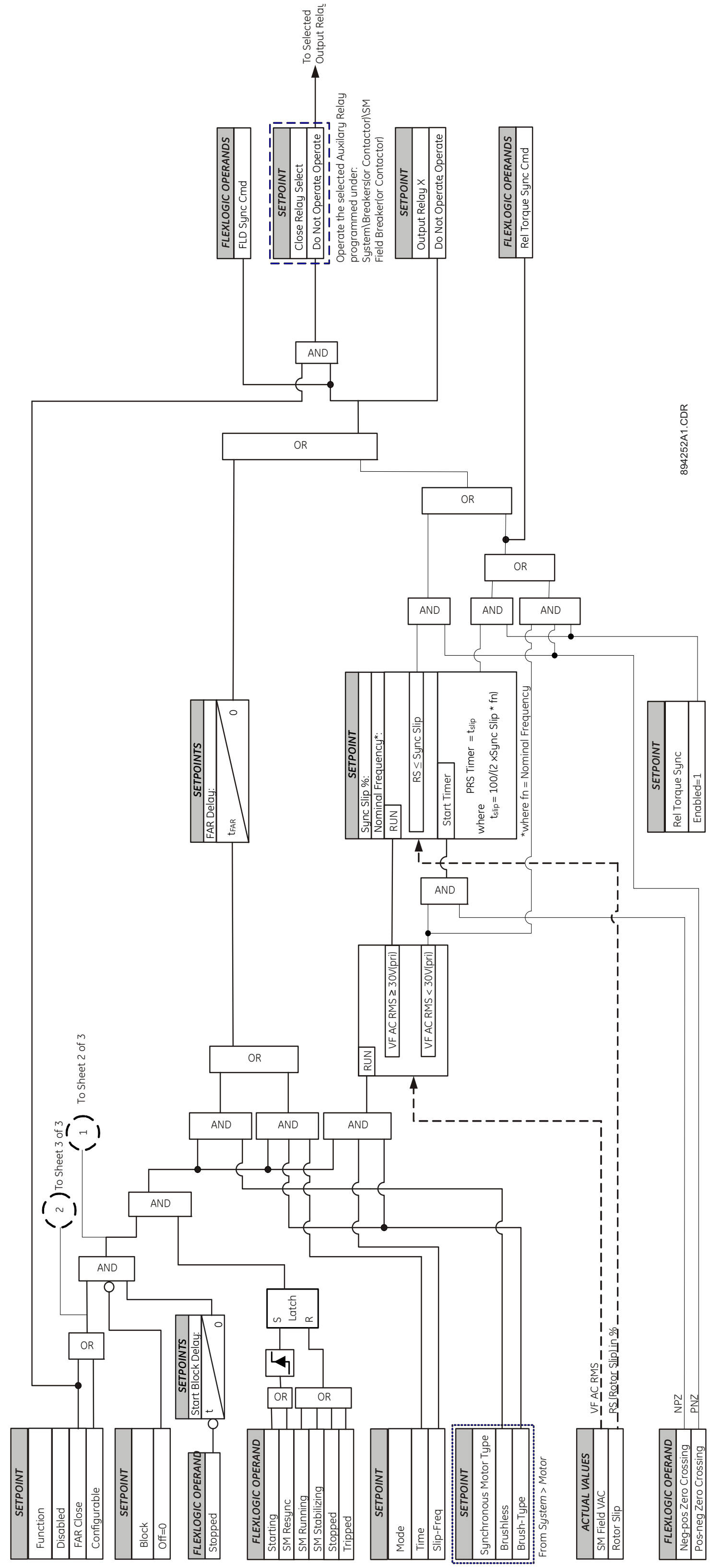


Figure 8-15: Start Sequence Control logic diagram (2 of 3)

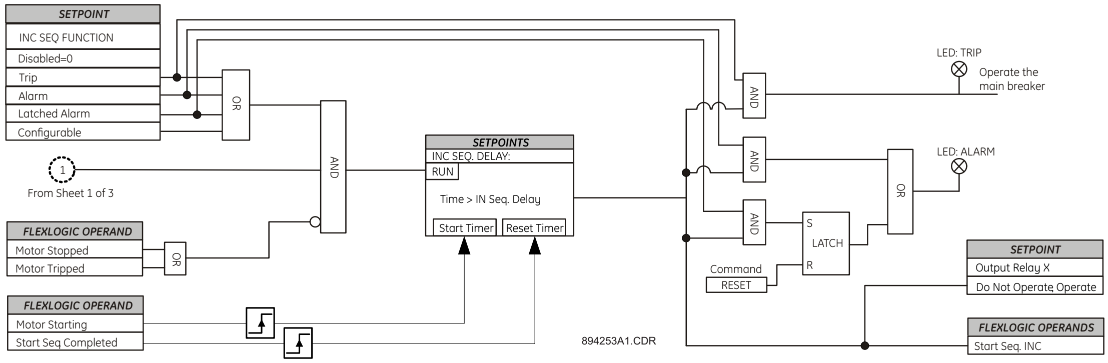
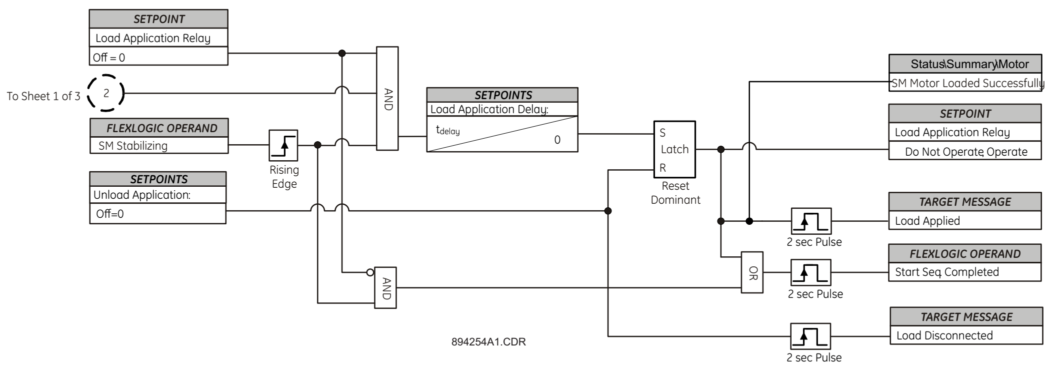


Figure 8-16: Start Sequence Control logic diagram (3 of 3)



Reduced Voltage Starting

The 869 can control the transition of a reduced voltage starter from reduced to full voltage. That transition may be based on "Current Only", "Current and Timer", or "Current or Timer" (whichever comes first). When the 869 detects a 'Motor Starting' condition the current will typically rise quickly to a value in excess of FLA (e.g., 5 × FLA). At this point, the Start Timer is initialized while the motor current is simultaneously monitored. When the transition from reduced to full voltage is initiated, the Reduced Volt Ctrl operand will be asserted for 1 second. The intention is to link this operand to the auxiliary output relay that can control reduced voltage start contactors. The feature can also assert a trip signal if the current or timer transitions do not occur as expected. This element is functional only if the external motor Start/Stop command is used. An example of the control wiring related to this element is depicted in the diagram, *Reduced Voltage Start Control Circuit*. A typical current – time diagram of a reduced voltage start sequence is shown in Figure 8-18:Reduced Voltage Start Current Characteristic.

Figure 8-17: Reduced Voltage Start Contactor Control Circuit

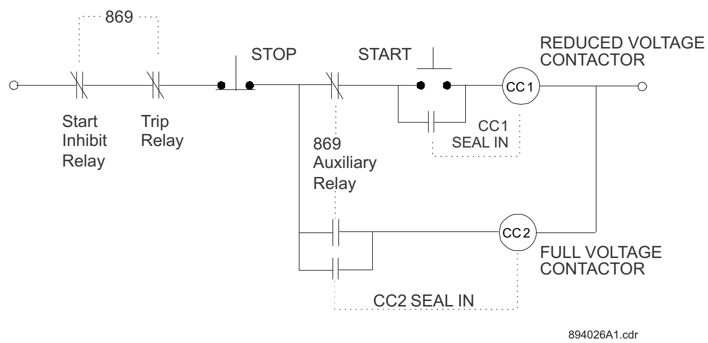
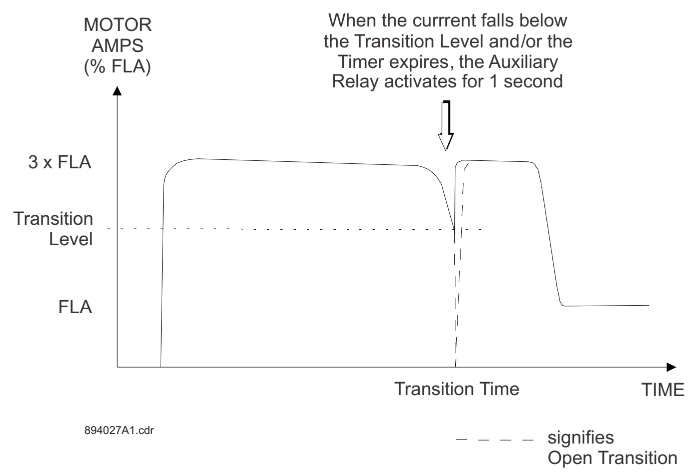


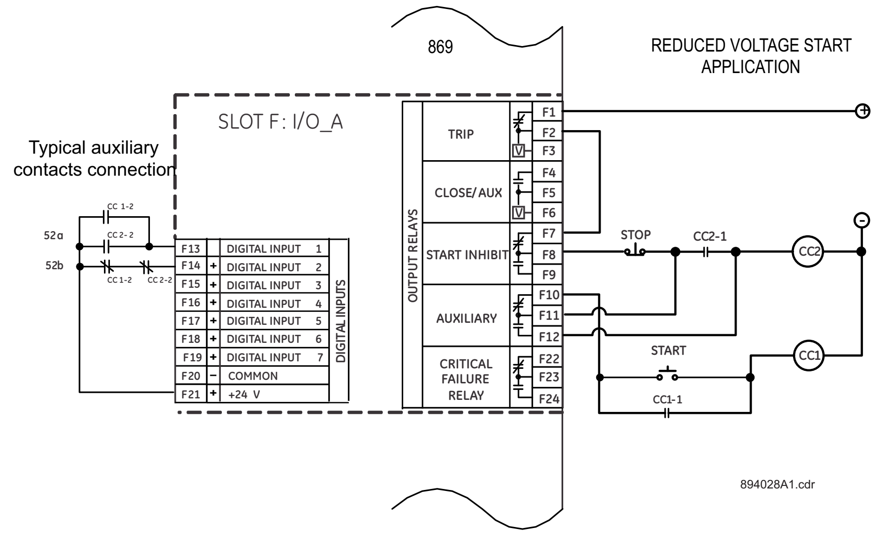
Figure 8-18: Reduced Voltage Start Current Characteristic



NOTE

If this feature is used, the Starter Status Switch input must be either from a common control contact or a parallel combination of Auxiliary '52a' contacts or a 1series combination of Auxiliary '52b' contacts from the reduced voltage contactor and the full voltage contactor as shown in the diagram, *Reduced Voltage Starting wiring example*.

Figure 8-19: Reduced Voltage Starting wiring example



Path: Setpoints > Control > Motor Starting > Reduced Voltage Start

FUNCTION

Range: Disabled, Trip, Configurable
Default: Disabled

CONTROL OUTPUT RELAY X

For details see Common Setpoints.

TRANSITION MODE

Range: Current Only, Current or Timer, Current and Timer
Default: Current Only

“Current Only”: When the motor load falls below the Start Current Level setting prior to the expiration of the Start Timer, a transition will be initiated by asserting the Reduced Volt Ctrl operand for a period of one second. Any contact output assigned to this operand will operate for this period of time. If the reduced voltage Start Timer expires prior to the motor load dropping below the Start Current Level setting, the Reduced Volt Ctrl operand does not change state and the Reduced Volt Fail operand is asserted.

“Current Or Timer”: When the motor load falls below the Start Current Level setting, or if the reduced voltage Start Timer expires, a transition will be initiated by asserting the Reduced Volt Ctrl operand for one second. Any contact output assigned to this control signal will operate for this period of time.

“Current And Timer”: A transition will be initiated by asserting the Reduced Volt Ctrl operand for one second when the reduced voltage Start Timer expires and the motor load has dropped below the Start Current Level setting prior to the expiration of the reduced voltage timer. If the reduced voltage timer expires prior to the motor load dropping below the Start Current Level setting, the Reduced Volt Ctrl operand does not change state and the Reduced Volt Fail operand is asserted.

START LEVEL CURRENT

Range: 0.25 to 3.00 x FLA in steps of 0.01
Default: 1.25 x FLA

Motor current has to drop below the value selected here to initialize the transition. This applies if “Current Only” or “Current or Timer” was selected.

START TIMER

Range: 1.0 to 600.0 s in steps of 0.1
Default: 10.0 s

BLOCK

Range: Off, Any FlexLogic operand
Default: Off

TRIP OUTPUT RELAY X

For details see Common Setpoints.

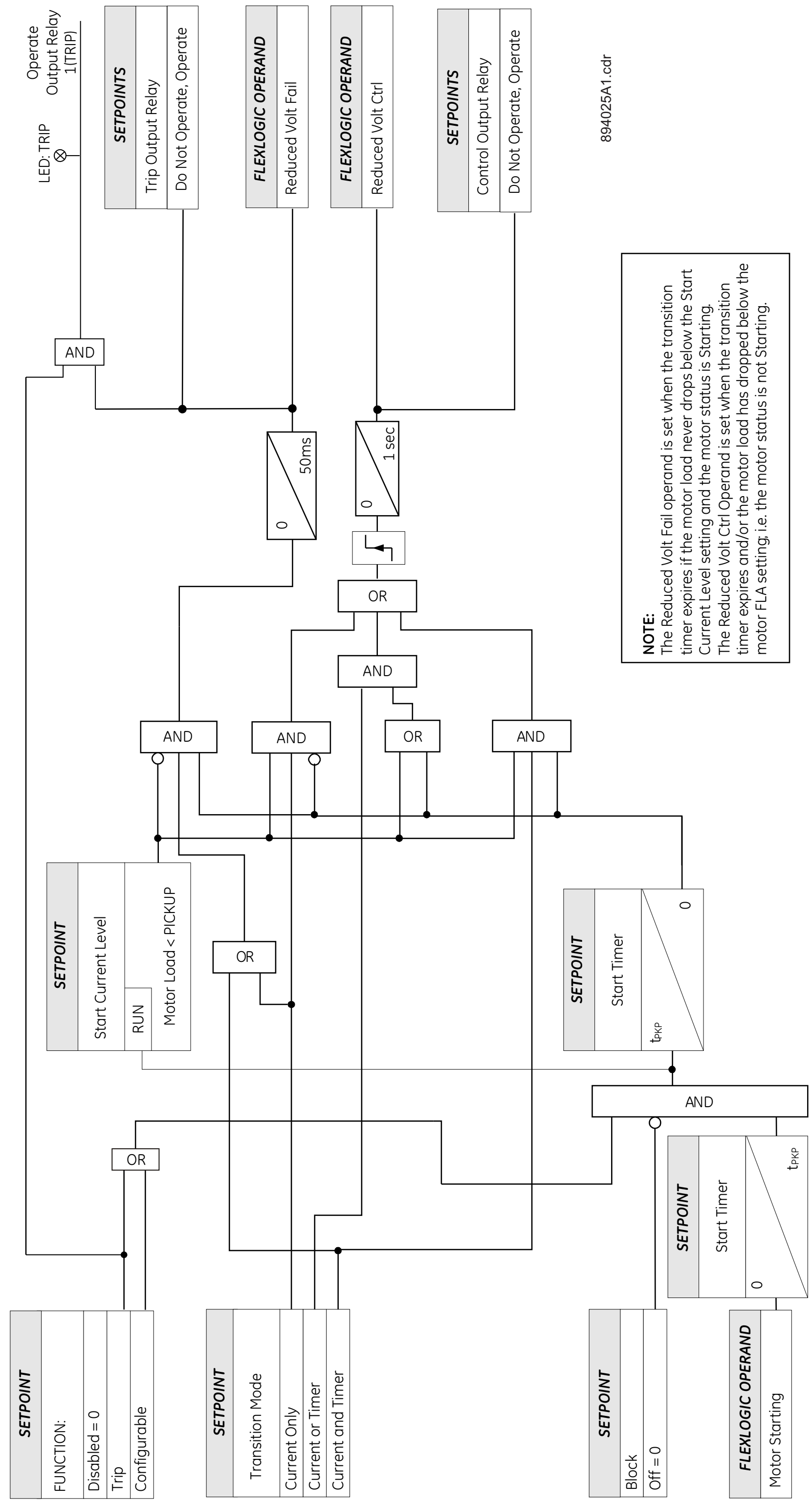
EVENTS

Range: Disabled, Enabled
Default: Enabled

TARGETS

Range: Disabled, Self-Reset, Latched
Default: Latched

Figure 8-20: Reduced Start logic diagram

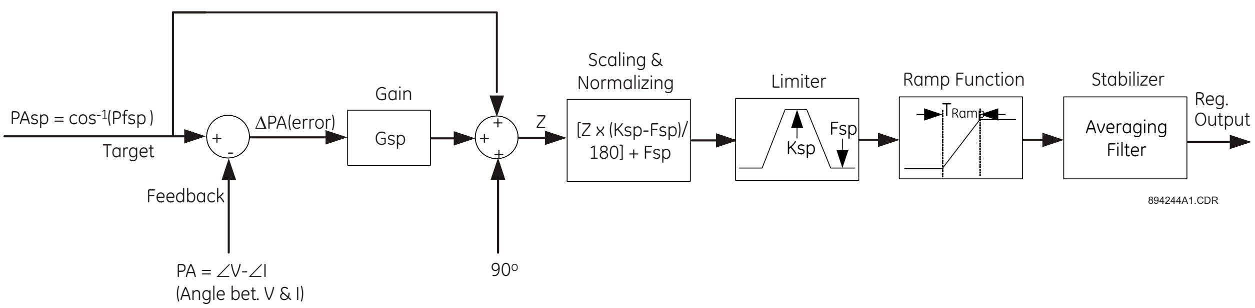


Sync. Motor Power Factor Regulation (90F)

Power Factor (PF) regulation is useful in applications where motors are subjected to high-level transient impact loads (such as chipper drives). The PF regulator senses the power factor dip occurring when the motor is loaded and signals the silicon-controlled rectifier (SCR) Exciter to respond with a boosted output. As a result, the pull-out torque of the synchronous motor is increased for the duration of the transient load. After the load subsides, the regulator senses an excessive leading power factor and signals the SCR to reduce its output. This automatic boosting of field current to avoid pull-out is called field forcing. The Power Factor regulator thus provides automatic boosting when field forcing is required and economical low field operation when the motor is idling.Another application of the power factor regulator is to control power factor swings resulting from various levels of loading so as not to cause fluctuations in the plant system voltage.

The 869 provides the control signal to the variable SCR exciter when PF regulation is required. See the following figure for a functional operation overview of this feature.

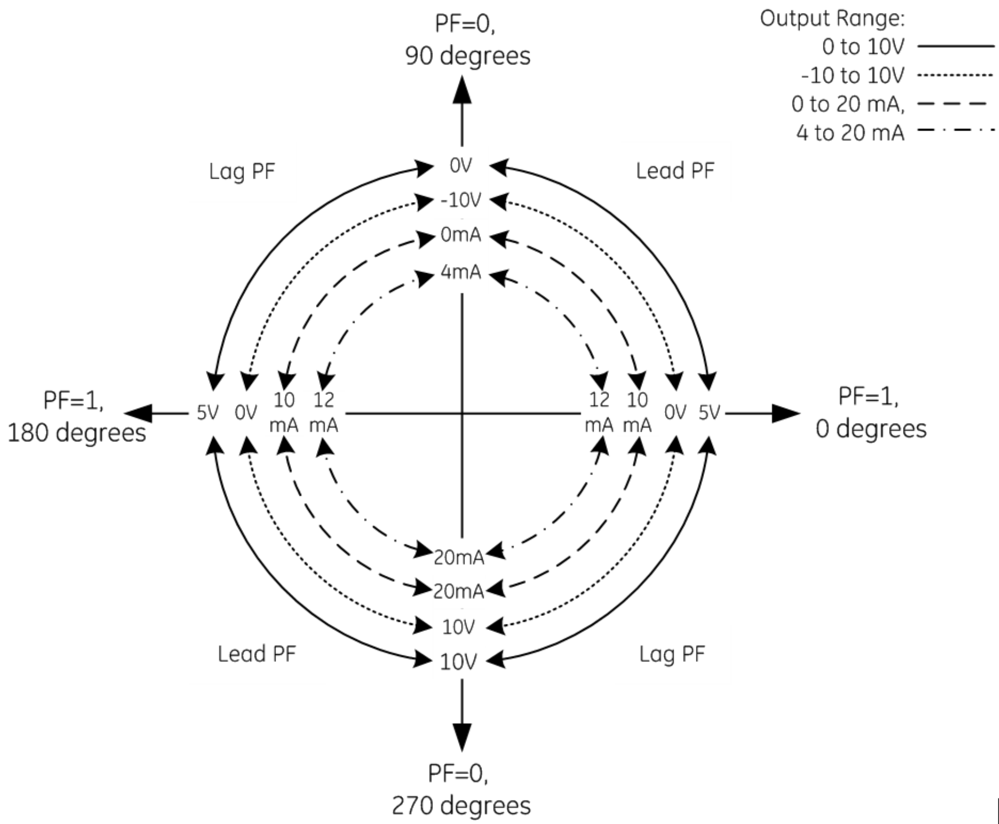
Figure 8-21: PF regulation and SCR exciter control layout



Gsp	setpoint 'Gain'	TRamp	setpoint 'Ramp Up Time'
Ksp	setpoint 'Max Output Limit'	PFsp	setpoint 'Regulator Target'
Fsp	setpoint 'Min Output Limit'	PA	Angle between Voltage and Current

The design of the PF regulation function generates control outputs of type VDC or DCmA, as defined by the maximum and minimum limits in setpoints 'Max Output Limit' and 'Min Output Limit', respectively. The control output range is configurable as a unipolar range type (0 to 20 mA, 4 to 20 mA, 0 to 10 V) or a bipolar range type (-10 to +10V).The following figures illustrates the Output generated by the PF Regulation control transfer function as a function of phase angle error (Target - Feedback).

Figure 8-22: PF Regulator output as a function of PF and Angle (angle I w.r.t angle V) for all configurable output ranges when setpoints Regulator Target and Gain are set to 1



Path: Setpoints > Control > SM PF Regulation

FUNCTION

Range: Disabled, Trip
Default: Disabled

OUTPUT RANGE

Range: 0 to 20 mA, 4 to 20 mA, 0 to 10 V, -10 to 10 V
Default: 0 to 10 V

This setting selects the PF Regulator Control output range.

REGULATOR TARGET

Range: -0.90 to 1.00 in steps of 0.01
(Lagging range -0.90,-0.91,...,-0.99,1.00 and Leading range 0.00,0.01, ...,0.99,1.00)
Default: 0.0

The 869 can provide a closed-loop PF Regulator with a very fast response. The regulator may be configured to regulate the motor power factor in a range from -0.9 (lagging) to 1.0 (unity) to 0.0 (leading) power factors. This setpoint determines the power factor at which the regulator operates. The regulator may be disabled in order to output the minimum value (see the Min Output Limit setpoint) by entering OFF (enter 1.11 numerically for an OFF setting). The OFF setting allows the operator to disable the regulator while setting up base-field amperes, and then return the regulator power factor to its normal setting for full functionality.

GAIN

Range: 0.00 to 100.00 in steps of 0.01

Default: 1.00

Properly adjusting this setpoint helps to achieve optimum regulator performance.

MAX OUTPUT LIMIT

Range: Populates based on OUTPUT RANGE selection

Default: 0.00 (e.g. 10.00 V when Output Range selected is 0 to 10 V)

This setpoint is the upper limit of the range of the control signal output. This value must match the input range of the separate variable excitation equipment.

NOTE

The MAX OUTPUT LIMIT value must be greater than or equal to the Min Output Limit setpoint.

MIN OUTPUT LIMIT

Range: Populates based on OUTPUT RANGE selection

Default: 0.00 (e.g. 0.00V when Output Range selected is 0 to 10V)

This value is the minimum limit for output control signal that is connected to the field-rectifier equipment. The value programmed here is the exact output from the 869. For example, if the minimum is programmed at 1.50V the 869 will output 1.50 volts minimum.

Certain conditions of operation require a floor so that the motor power factor will not become unstable if the field current is drastically reduced. When the floor overrides the regulator, the power factor moves in a more leading condition than the regulator setpoint. As the load and/or system force the motor power factor toward the lagging condition such that the power factor falls below the regulator setpoint, the regulator will once again take control and boost the field above the floor so that the power factor will not dip below the setpoint. The power factor regulator must be tuned during initial start-up. See section 6-6 for regulator tune up instructions.

NOTE

The MIN OUTPUT LIMIT value must be less than or equal to the Max Output Limit setpoint.

RAMP UP TIME

Range: 0 to 600 sec in steps of 1 sec

Default: 10 sec

This setting specifies the time taken to ramp up the control output from the set value for Min Output Limit to the set value for Max Output Limit.

STABILITY FILTER LENGTH

Range: 0 to 60 cycles in steps of 1 cycle

Default: 1 cycle

This value averages output for the programmed number of cycles using a running average technique in order to help compensate for instability. The unit 'cycle' represents the power cycle of nominal frequency specified under **Setpoints > System > Power System**.

MINIMUM VOLTAGE

Range: 0.00 to 1.25 x VT in steps of 0.01 x VT

Default: 0.30 x VT

This setting specifies the minimum voltage for Power Factor Regulation element operation specified per times VT.

MINIMUM CURRENT

Default: 0.20 x CT

Range: 0.00 to 10.00 x CT in steps of 0.01 x CT

This setting specifies the minimum current for Power Factor Regulation element operation specified per times CT.

REGULATOR TROUBLE

Default: OFF

Range: OFF, ON

When set to 'ON', this function checks for correct operation of the PF Regulator by monitoring the ' PA' quantity, which is the difference between actual phase angle (feedback) and desired phase angle (target). This function assert s the output operand PF Reg Trouble when the ' PA' quantity exceeds 1 degree for longer than the sum of the time delays set for Ramp Up Time and Stability Filter Length, plus 1 sec.

BLOCK

Range: Off, Any FlexLogic operand

Default: Off

EVENTS

Range: Disabled, Enabled

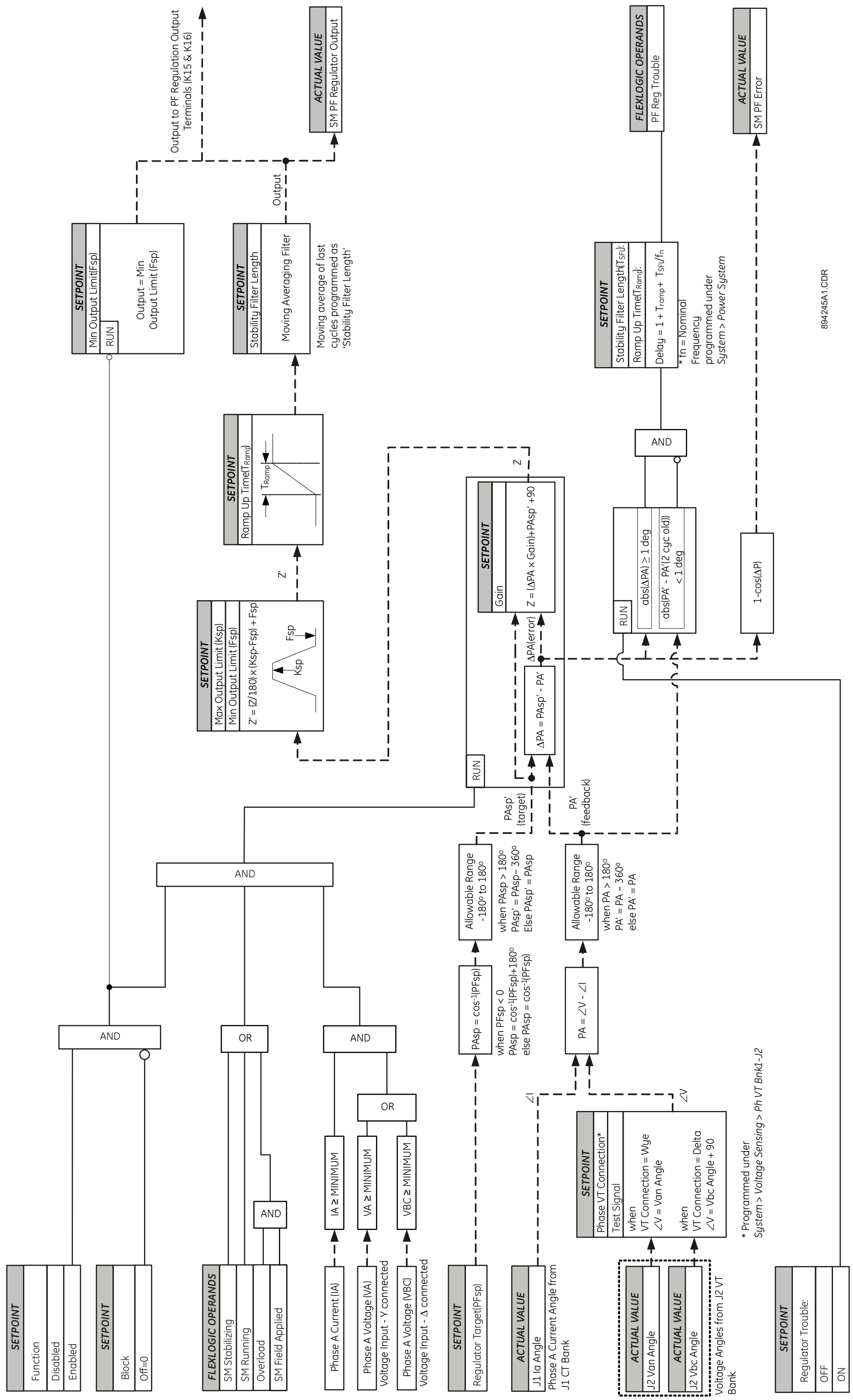
Default: Enabled

TARGETS

Range: Disabled, Self-Reset, Latched

Default: Self-Reset

Figure 8-23: Power Factor (PF) regulation logic diagram



Local Control Mode (breakers, contactor 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.

The same Local Control Mode applies if Contactor is selected as a switching device.

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 of the breaker control mode for the 869 with one breaker is **Remote** (Local Mode set to Off or the selected LOCAL MODE input de-asserted). In this mode, all programmed setpoints from the respective menus for Breaker Control and Switch Control (see the respective logic) are active. The same Remote Mode applies if Contactor is selected as a switching device. The default value for the 869 ordered with two breakers is **Local**.

Navigation

The 8 Series front panel provides navigation pushbuttons (PBs) which highlight the component (breaker, contactor or disconnect switch) from the single line diagram. As shown in Figure 8-24: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 (contactor), and then goes through all other components in sequence, until the last one (breaker or switch). Only the breakers (contactor) and switches included in the SLD from the display will be browsed (navigated).

Select Before Operate

Once the breaker (contactor) 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 8-24: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 (contactor) 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 (contactor) 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.

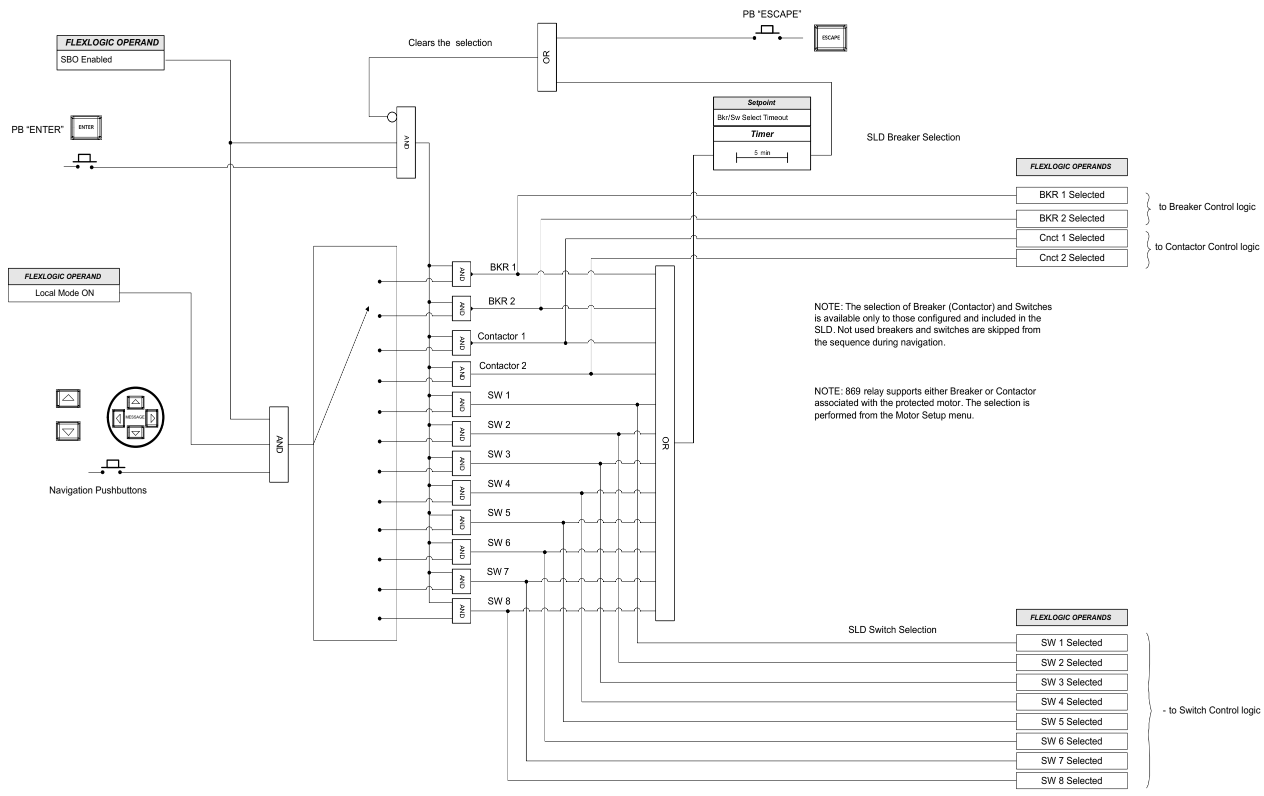
When the “Select Before Operate” setpoint is set to Enabled, the navigation, the breaker or switch selection, as well as the blocking, bypassing and tagging are operational when in Local mode. When switched to Remote mode, the remote blocking and bypassing will be operational as well.

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 (contactor) 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 (contactor) selection and operation is only active if the user has proper level security access.

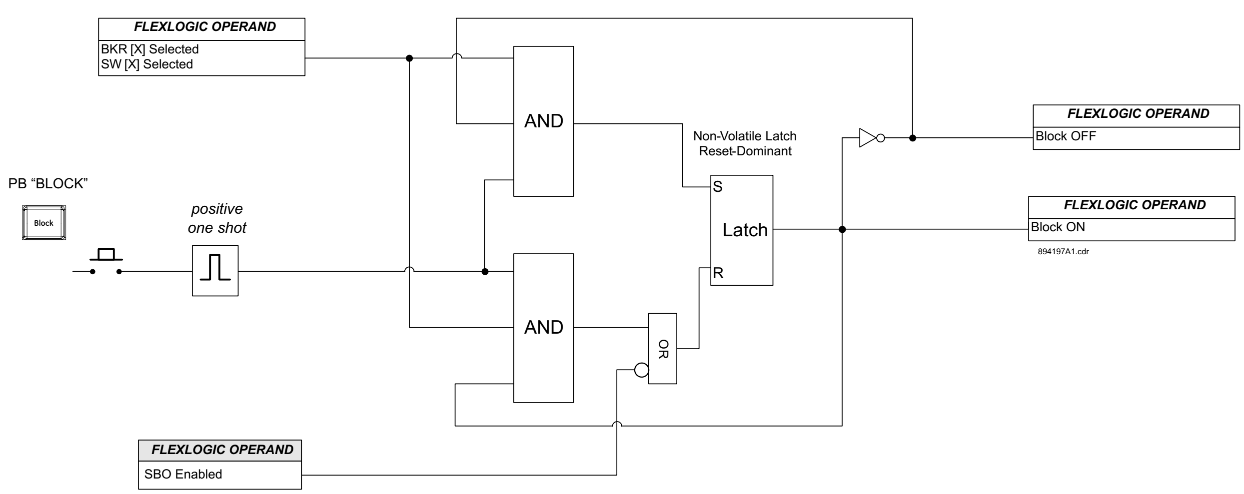
Figure 8-24: Navigation and SLD component selection



PB "Block" (Hardcoded SLD Pushbutton)

Blocking of a breaker (contactor) or switch can be used for simply inhibiting the close or open operation while in Local Mode. The selected breaker (contactor) 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 8-25: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

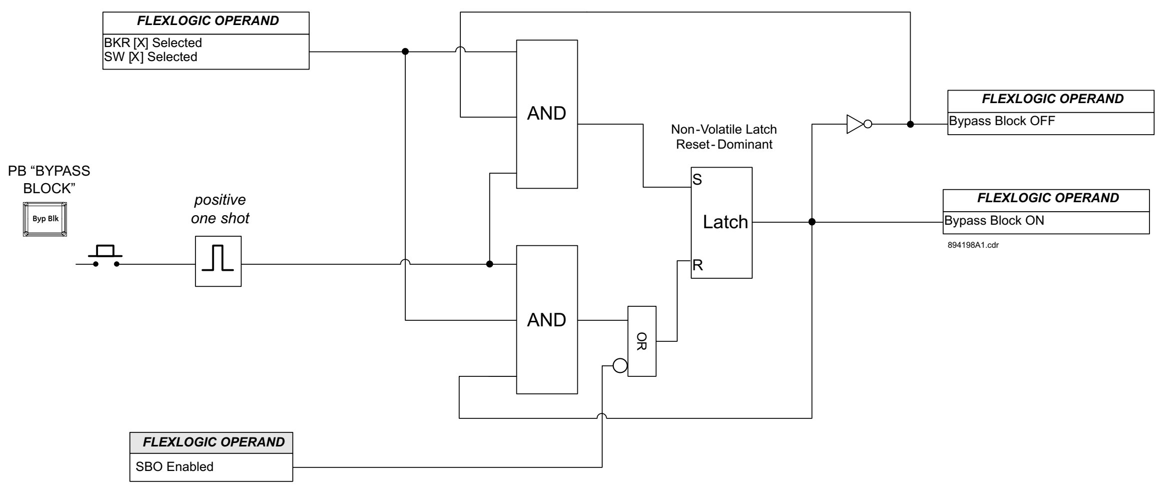
Figure 8-25: SLD Pushbutton "Block" logic diagram



PB “Bypass” (Hardcoded SLD Pushbutton)

Blocking of the command can be bypassed using the SLD pushbutton “Bypass” (see Figure 8-26: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 (contactor) or switch, a letter “By” appears next to the symbol in the SLD.

Figure 8-26: SLD Pushbutton “Bypass Block” logic diagram

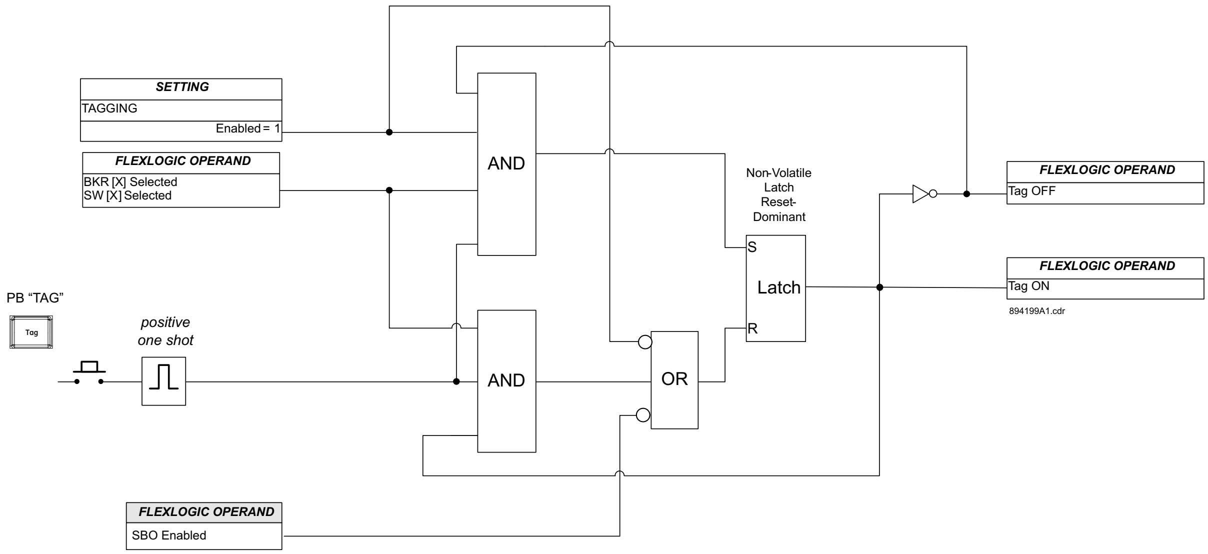


PB “Tag” (hardcoded SLD pushbutton)

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 breaker (contactor) or 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 (contactor) or switch respectively. The breaker (contactor) 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 8-27: Pushbutton "Tag" logic diagram



NOTICE

The pushbuttons, Tag, Block and Bypass Block are used for both breakers (contactor) 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 (contactor) 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 (contactor) 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 (contactor) and switches.

Figure 8-28: Local Control for breakers

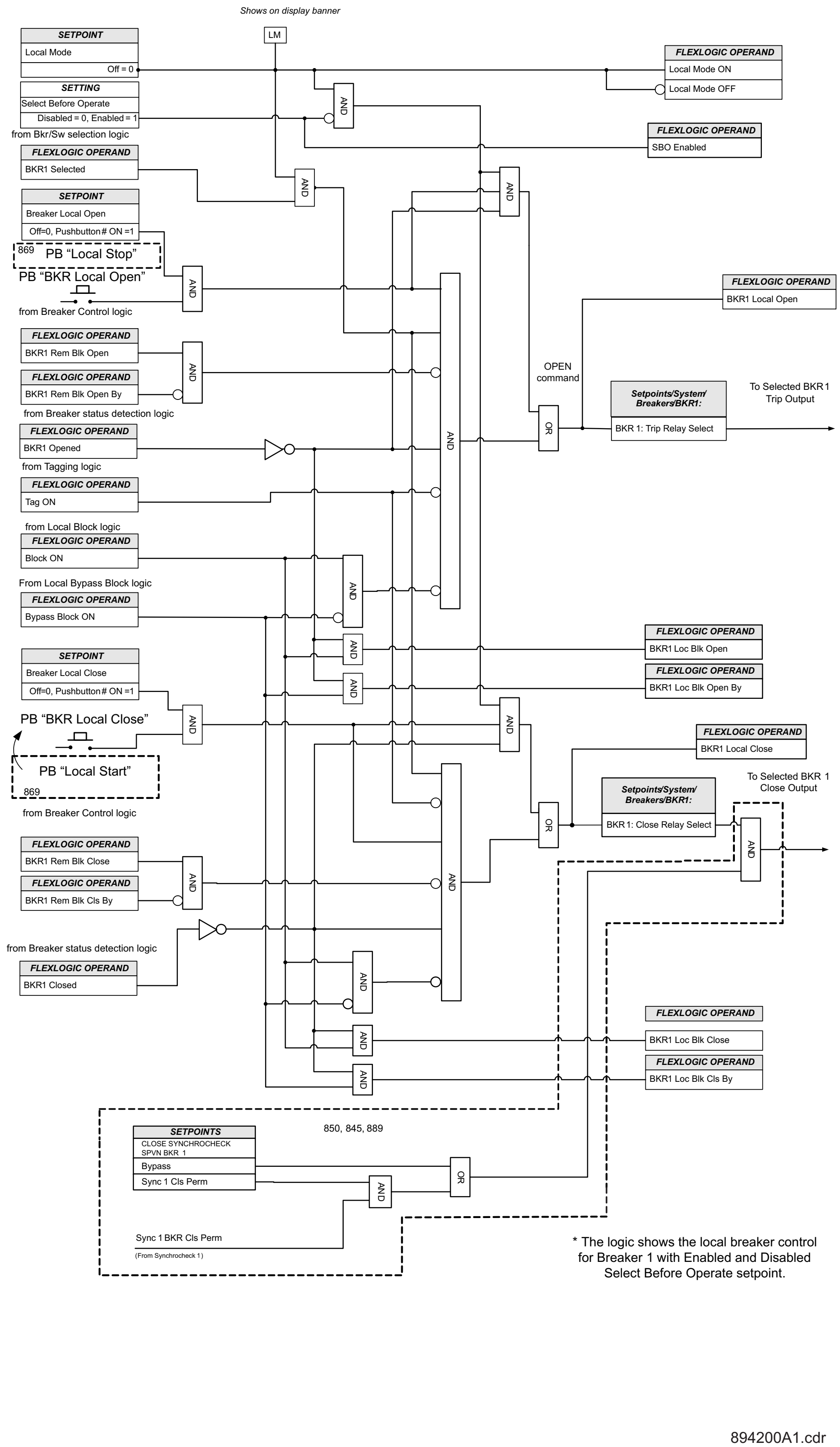
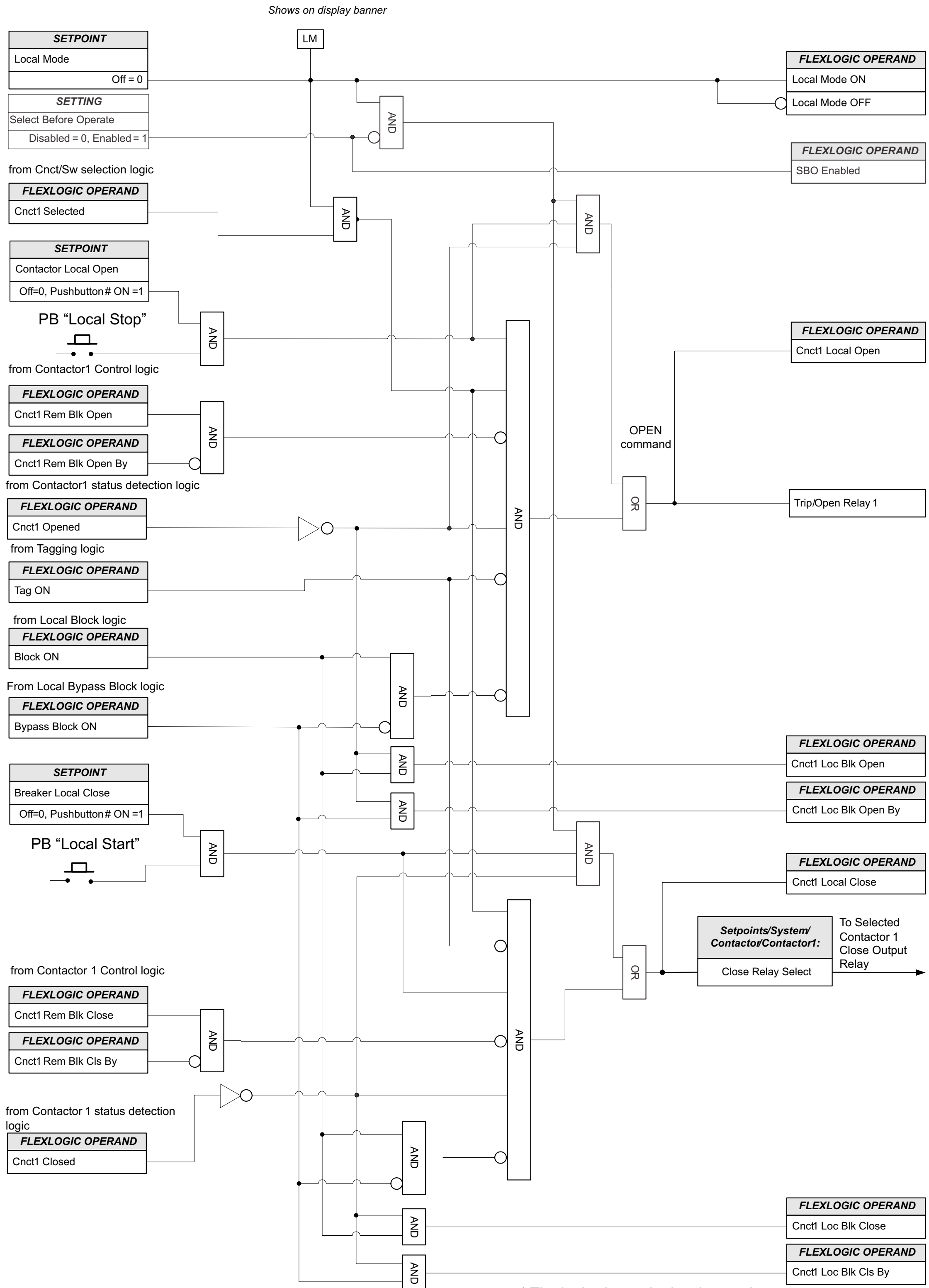
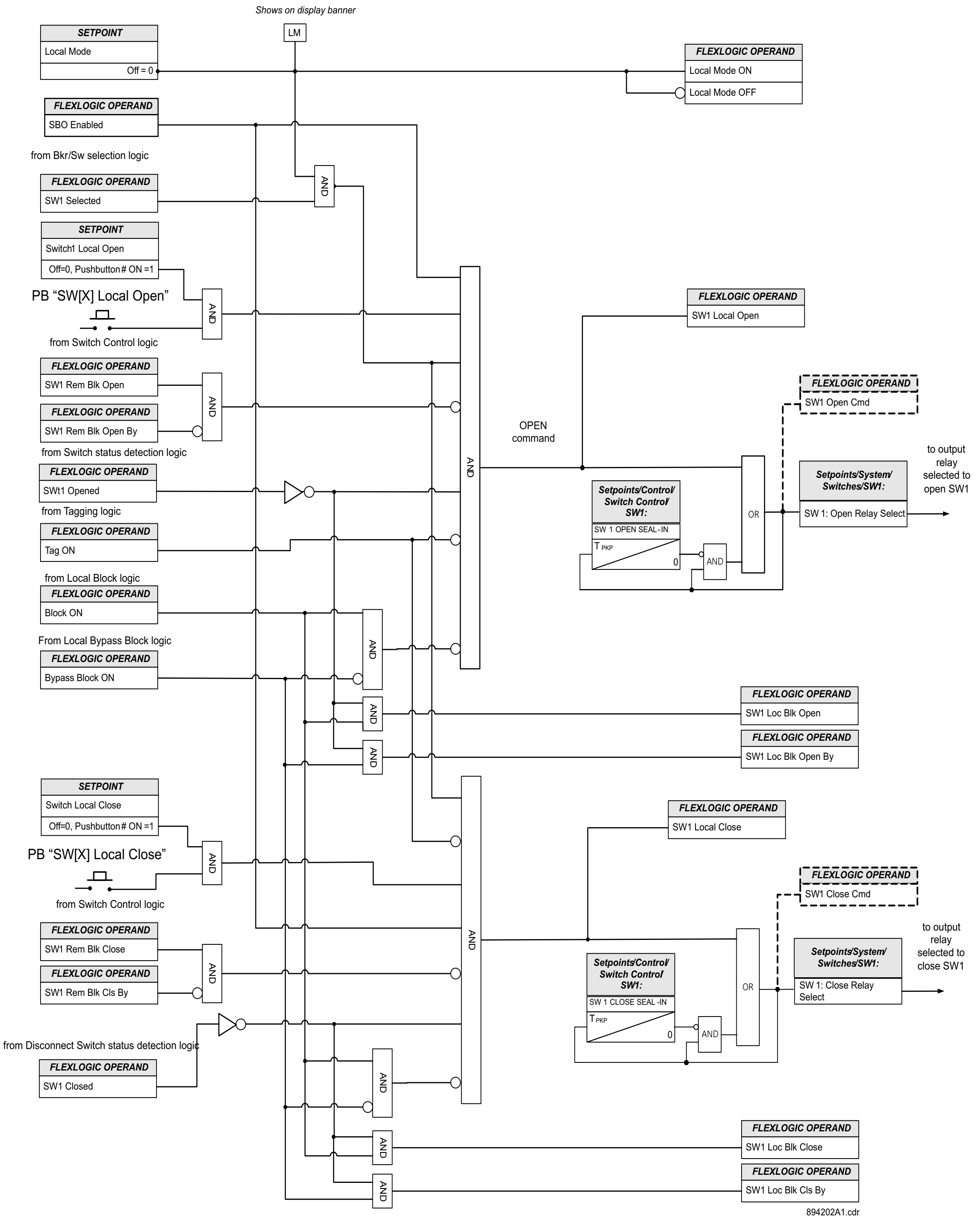


Figure 8-29: Local Control for Contactor



* The logic shows the local control for Contactor 1 with Enabled and Disabled Select Before Operate setpoint.

Figure 8-30: 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.

SELECT BEFORE OPERATE

Range: Disabled, Enabled

Default: Disabled

This setpoint is included in the Local Control Mode menu only if the 8 Series relay supports one breaker. This setpoint is omitted for relays supporting more than one breaker.

When the Select Before Operate (SBO) is set to Disabled, and Local Mode is set, the breaker control can be performed directly by pressing the corresponding front panel pushbuttons (or those mounted in close proximity to the relay). No component selection or additional confirmation is needed. The same applies when the breaker control is in Remote mode.

⚠CAUTION

When SBO is disabled, all local and remote flags such as blocking, bypassing, and tagging are reset.

Setting the SBO to Enabled enables the navigation and the selection of a component from the SLD, so that the pushbuttons Open or Close from the front panel (or those mounted in close proximity to the relay) can be used in Local Mode only after the component is selected. All flags such as blocking, bypassing and tagging can be initiated during this mode. Blocking and bypassing can also be initiated remotely, when in Remote Mode.

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 (CNCT)/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 (contactor) or a disconnect switch has been selected in the single line diagram.

BKR (CONTACTOR) LOCAL OPEN

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 (contactor) open command can be initiated by the selected faceplate pushbutton.

BKR (CONTACTOR) LOCAL CLOSE

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 (contactor) 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 1 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 2 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 (1)

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 control for the 869 relay depends on the selected Switching Device, i.e. either Breaker or Contactor. When Breaker is selected, the setpoints for contactor setup and contactor control are hidden on the relay, and when Contactor is selected, the setpoints for breaker are hidden. The selection of Switching Device, i.e. either Breaker or Contactor is available in the Motor Setup menu.

NOTICE

The 869 relay provides control of one breaker. 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.

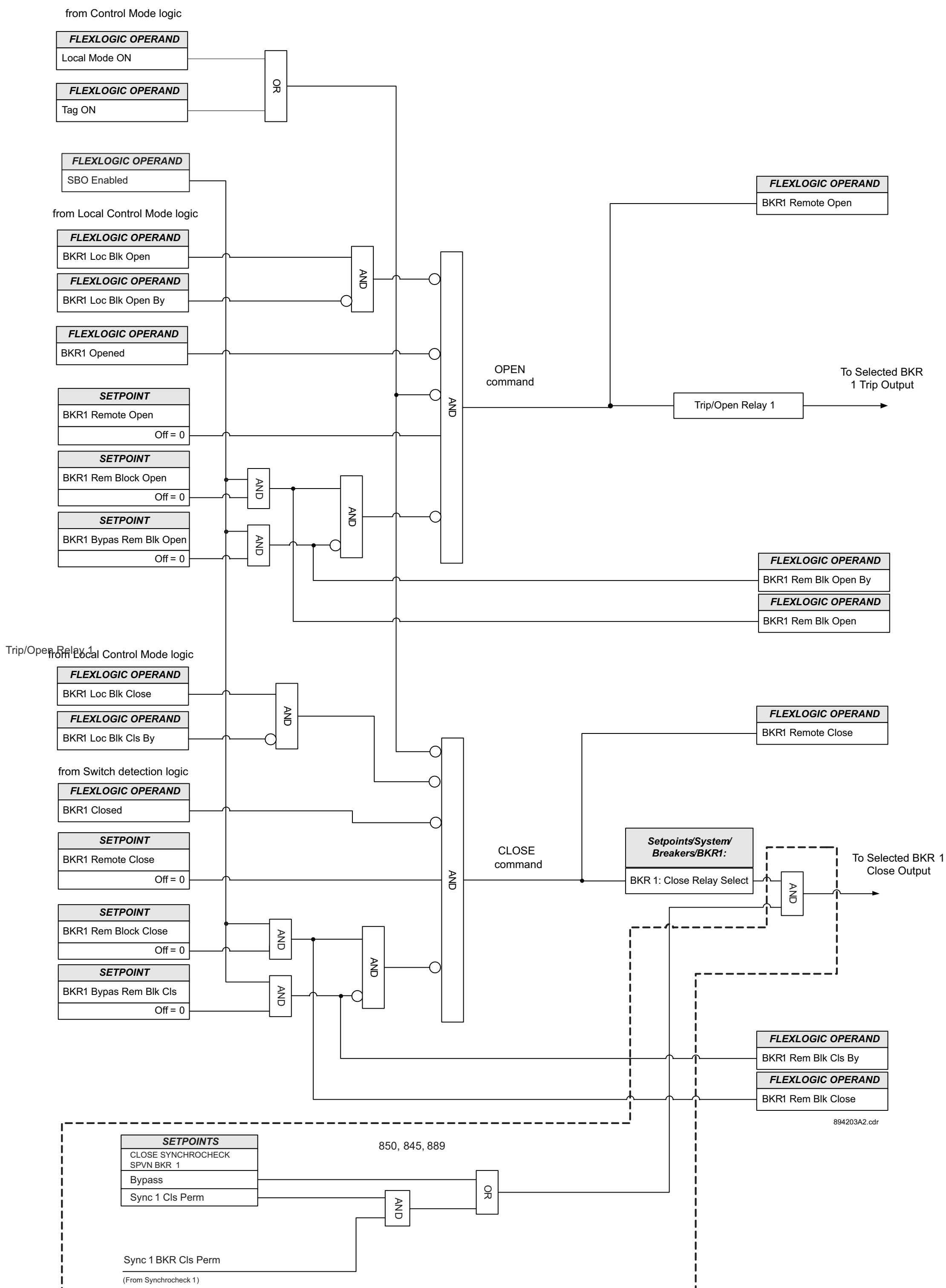
EVENTS

Range: Disabled, Enabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Self-reset

Figure 8-31: Breaker Control logic diagram



Contactor Control

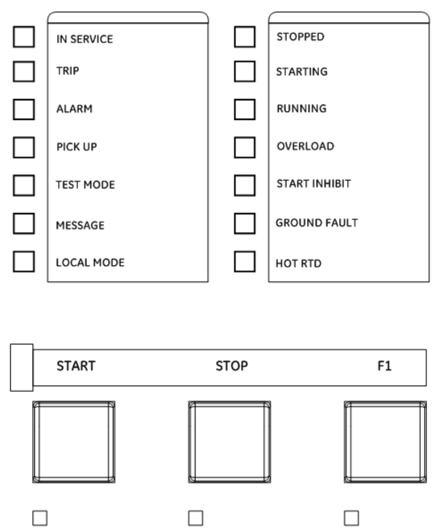
The selection for the Breaker or Contactor is available under the Motor Setup menu. The settings and logic for the Contactor Control described below only apply when the Contactor is selected, and the Control mode is set to Remote (Local Mode set to “Off”, or the selected LOCAL MODE operand de-asserted).

The selection for the Switching Device for either the Breaker or Contactor is available in the Motor Setup menu.

NOTE

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 the Local Control Mode menu is set to Disabled. The breaker remote open and close commands are still operational.

Figure 8-32: Switching Device Pushbuttons and Monitor LEDs



Path: Setpoints > Control > Contactor Control > Cnct1 Control

REMOTE OPEN

Range: Off, On, Any FlexLogic operand
Default: Off

This setpoint is active, when the Local Mode is inactive. The setting specifies the input that when asserted, initiates a “STOP” command. When the selected input is asserted, the output relay #1 is energized and stays energized until the input drops off, the breaker (or contactor) opens, and the selected Seal-in time expires. This setpoint provides flexibility to operate output relay #1 by selecting an operand from the list of FlexLogic operands, contact inputs, virtual inputs, or remote inputs. For example, the operand “Phase OV 1 OP” can be selected to activate output relay #1 according to the operate conditions configured under the Phase OV 1 menu.

REMOTE CLOSE

Range: Off, On, Any FlexLogic operand
Default: Off

This setpoint is active, when the Local Mode is inactive. This setting specifies the input that when asserted, initiates a START command. This setpoint provides flexibility to operate the designated output relay by selecting an operand from the list of FlexLogic operands, contact inputs, virtual inputs, or remote inputs.

NOTICE

The START command operates Output relay 2 if **Setpoint > System > Contactor > Contactor 1 > Close Relay Select** is set to “Relay 2”.

REMOTE BLOCK OPEN

Range: Off, Any FlexLogic operand
Default: Off

The assertion of the operand assigned to this setpoint prevents the contactor from opening (stopping the motor).

REMOTE BLOCK CLOSE

Range: Off, Any FlexLogic operand
Default: Off

The assertion of the operand assigned to this setpoint prevents the breaker from closing (starting the motor).

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 (stop motor) signal. The Open (Stop motor) command is permitted for the contactor.

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 open (stop motor) signal. The Open (Stop motor) command is permitted for the contactor.

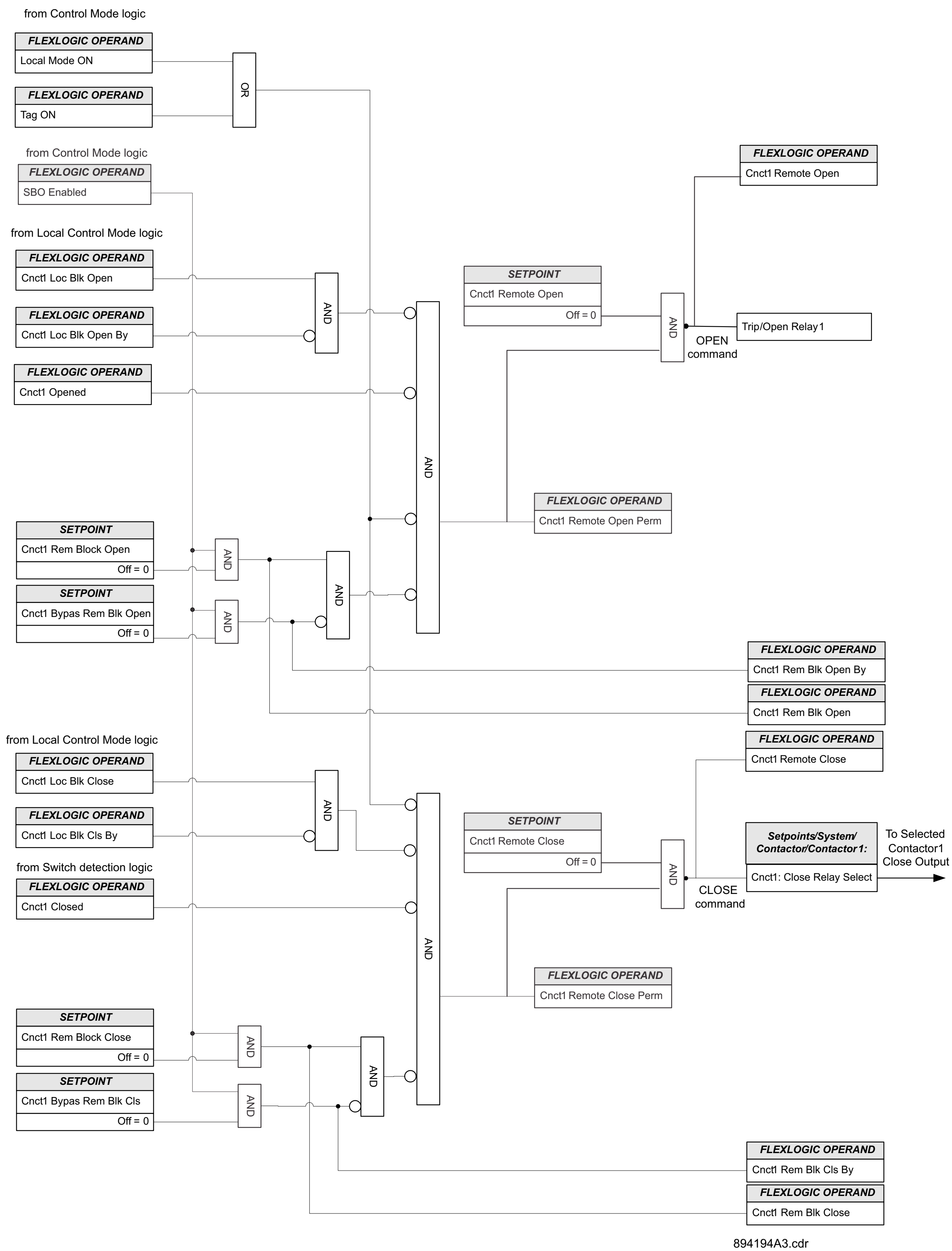
EVENTS

Range: Disabled, Enabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Self-reset

Figure 8-33: Contactor 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.

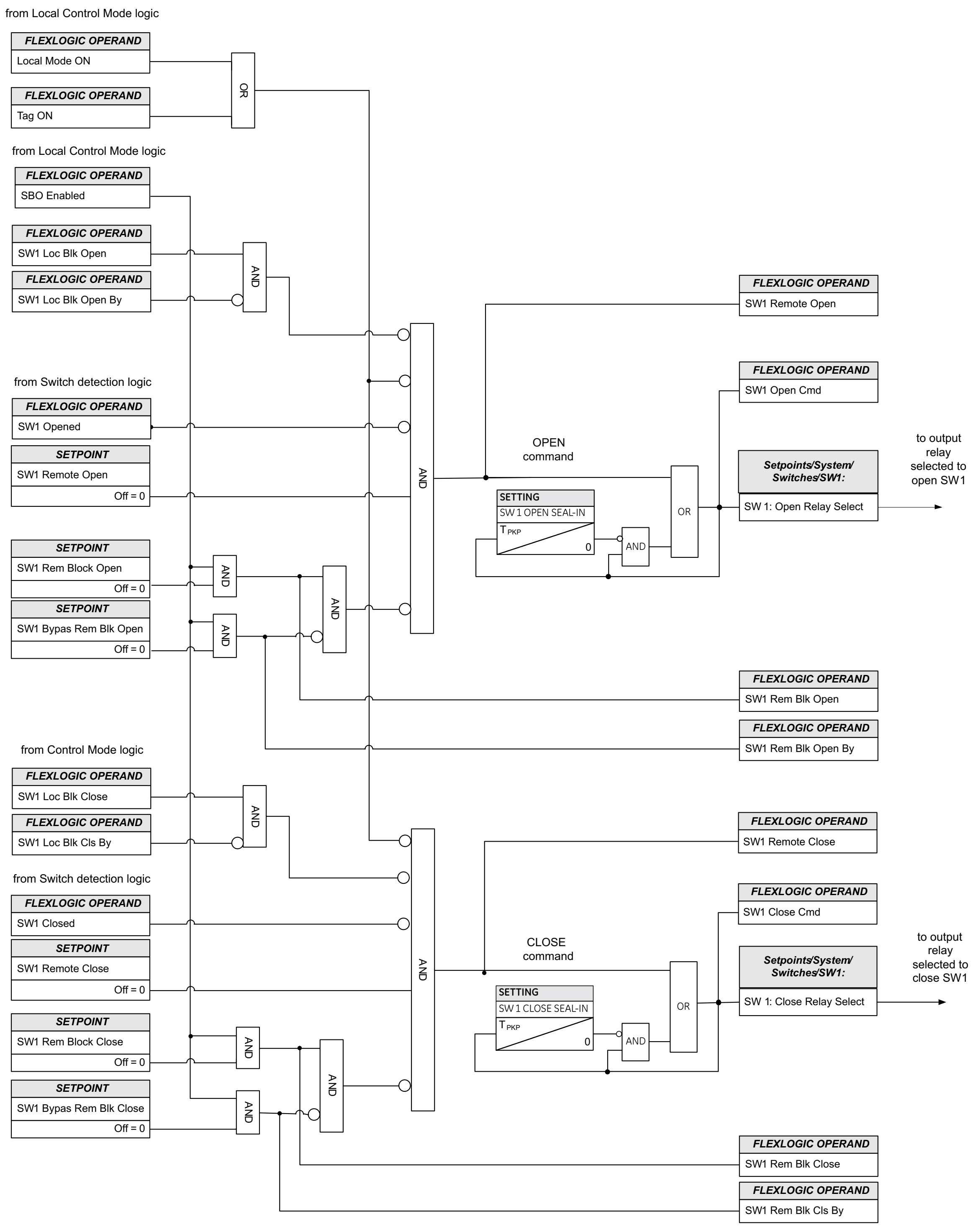
EVENTS

Range: Disabled, Enabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Self-reset

Figure 8-34: 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.

Field Switching Device Control

The 869 , with a synchronous motor order code selected, provides control and monitoring of DC Field switching devices types: breaker and contactor. The field switching device type is selected under **Setpoints > System > Motor > Setup > Switching Device Type**, and must match the actual switching device type used to control the DC Field in the specific synchronous motor application. The Switching Device Type selection affects execution of the field open and close commands, and monitoring of the device state targets and events.

The DC field is controlled (i.e. opened/closed) from any assigned and asserted FlexLogic operand; contact input, virtual input, virtual output, remote input, or via communications.

Path: **Setpoints > Control > FLD SW Device Control**

OPEN

Range: Off, Any FlexLogic operand

Default: Off

This setting specifies the input that, when asserted, initiates an "Open" command.

Upon assertion of the selected input, the selected trip output relay (configured under **Setpoints > System > Breaker (or Contactor)**) is energized and stays energized until the input drops off, the breaker/contactor opens, and the configured seal-in time expires.

CLOSE

Range: Off, Any FlexLogic operand

Default: Off

Upon assertion of the selected input, the selected close output relay (configured under **Setpoints > System > Breaker (or Contactor)**) is energized and stays energized until the input drops off, the breaker/contactor closes, and the selected seal-in time (set by Open Seal-in) expires.

In order to keep the close output relay energized, it is important to set Type to Latched in the auxiliary relay setup.

ANY TRIP INITIATE

Range: Off, On

Default: Off

When this setpoint is set to 'ON', the DC Field open command is initiated by any operated element Function selected as "Trip".

EVENTS

Range: Enabled, Disabled

Default: Enabled

TARGETS

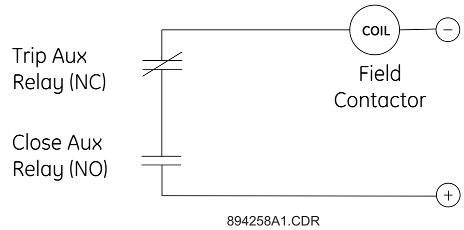
Range: Disabled, Self-reset, Latched

Default: Self-reset

Field Contactor Application Examples

The following application examples include relay configuration and suggested wiring in order to achieve correct Open/Close operation of the Contactor-type field switching device.

Example 1: Two auxiliary relays are selected under setpoints Trip Relay Select and Close Relay Select (**Setpoints > System > Contactors > SM Field Contactor**).

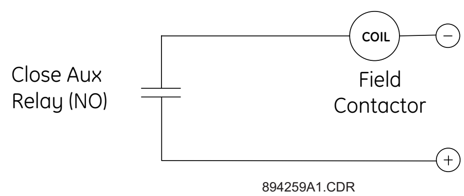


In order to keep the close relay energized, it is important to program Type as Latched in auxiliary relay setup.

To open/trip the field contactor, the normally closed (NC) field trip output relay must be operated to de-energize the contactor coil. If the NC type (Form-C) output relay is not available then the selected field trip output relay must be programmed for Failsafe operation mode (**Setpoints > Outputs > Output Relays**).

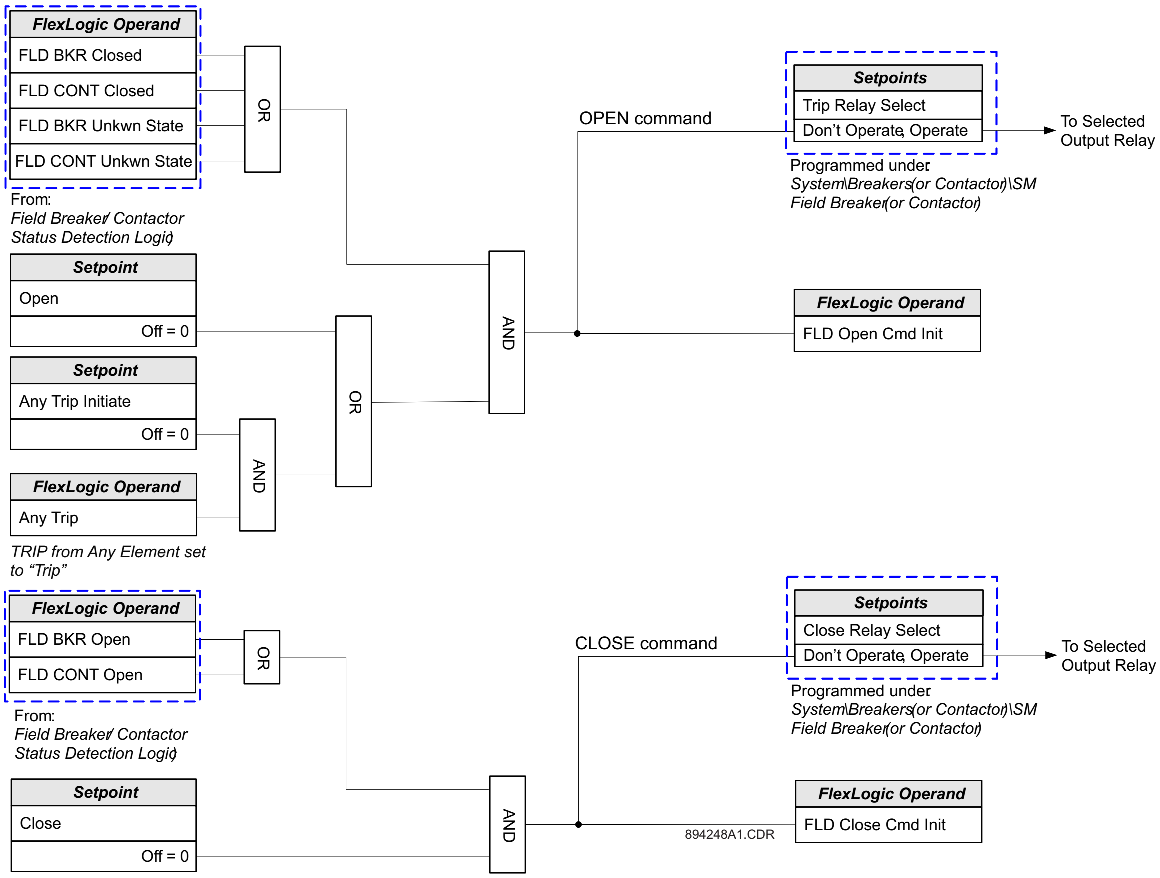
It is important to note that latched Close Aux Relay also requires a command to reset. The latched relay can be reset either from the front Reset pushbutton or an operand programmable under Reset Input 1(3) (see **Device > Resetting**).

Example 2: An auxiliary relay is selected as the field Close relay while Trip Relay Select = off.



In this case, to open/trip the field contactor, the latched Close Aux Relay must be reset either from the front Reset pushbutton or the programmable operand Reset Input 1(3) (see **Device > Resetting**).

Figure 8-35: Synchronous motor field breaker/contactor Control logic diagram



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 869 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**

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

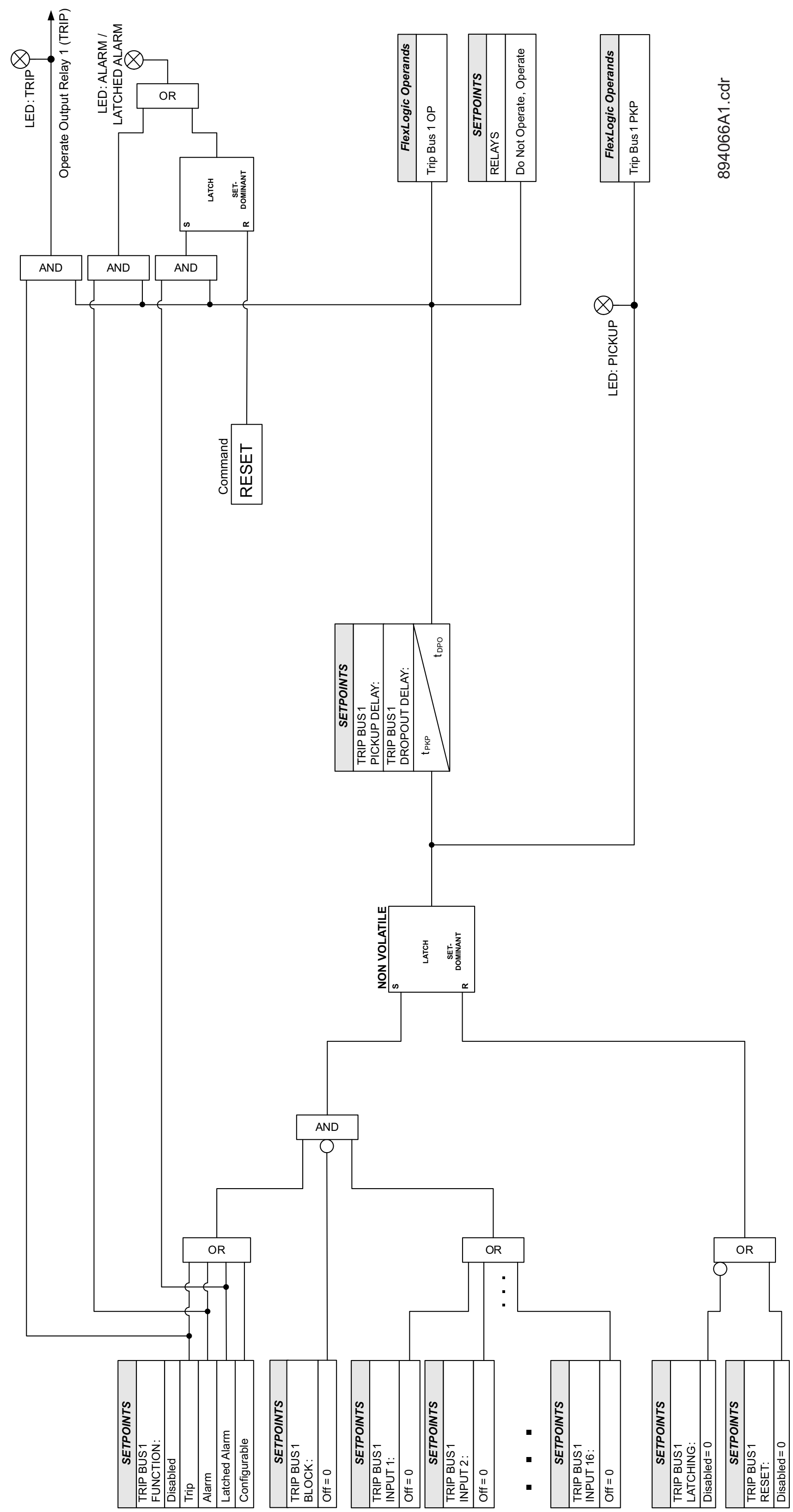
TARGETS

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 8-36: 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.

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 869 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

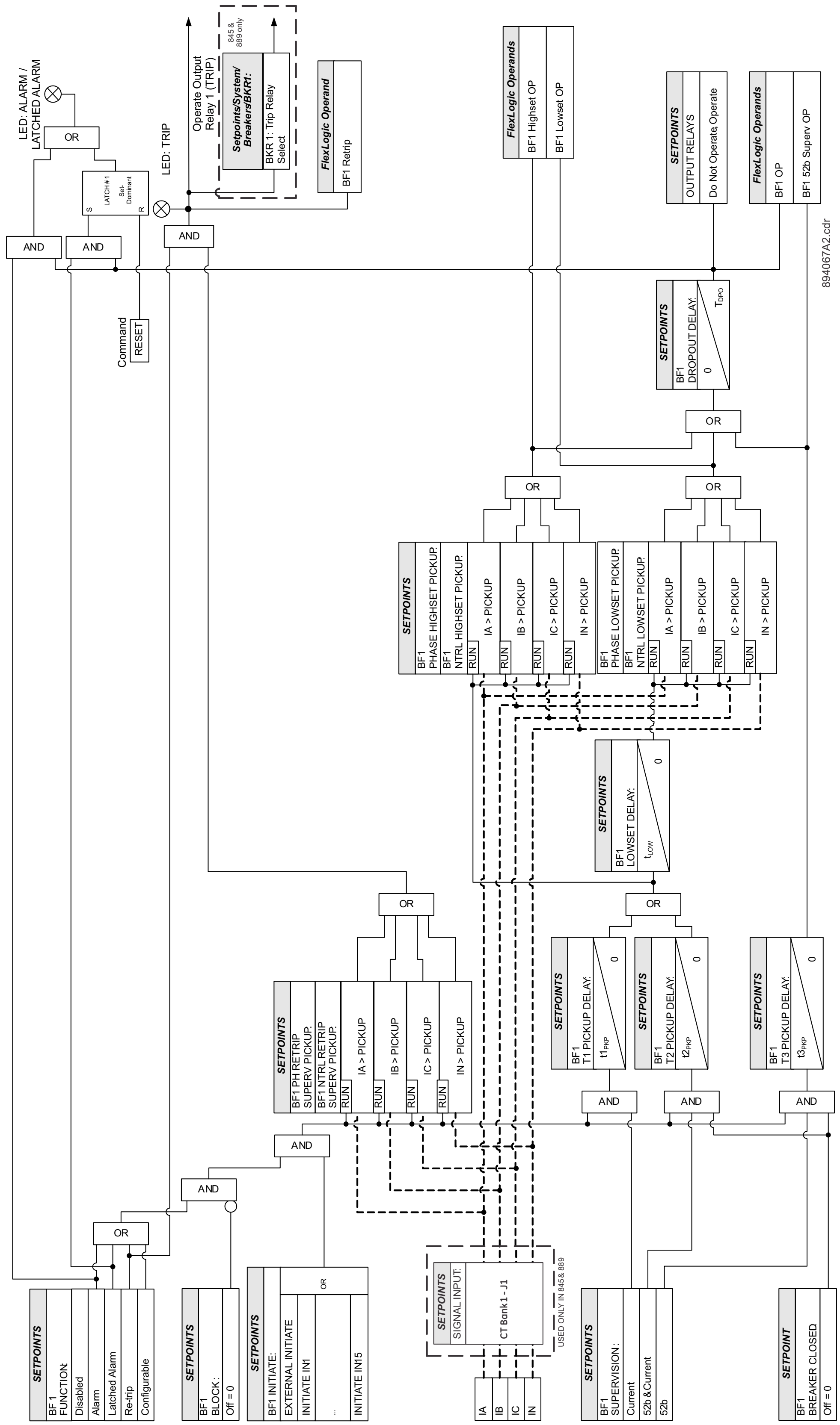
The setpoint selects the FlexLogic operand that initiates the Breaker Failure scheme; typically the trip signals from internal protection functions.

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 8-37: 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

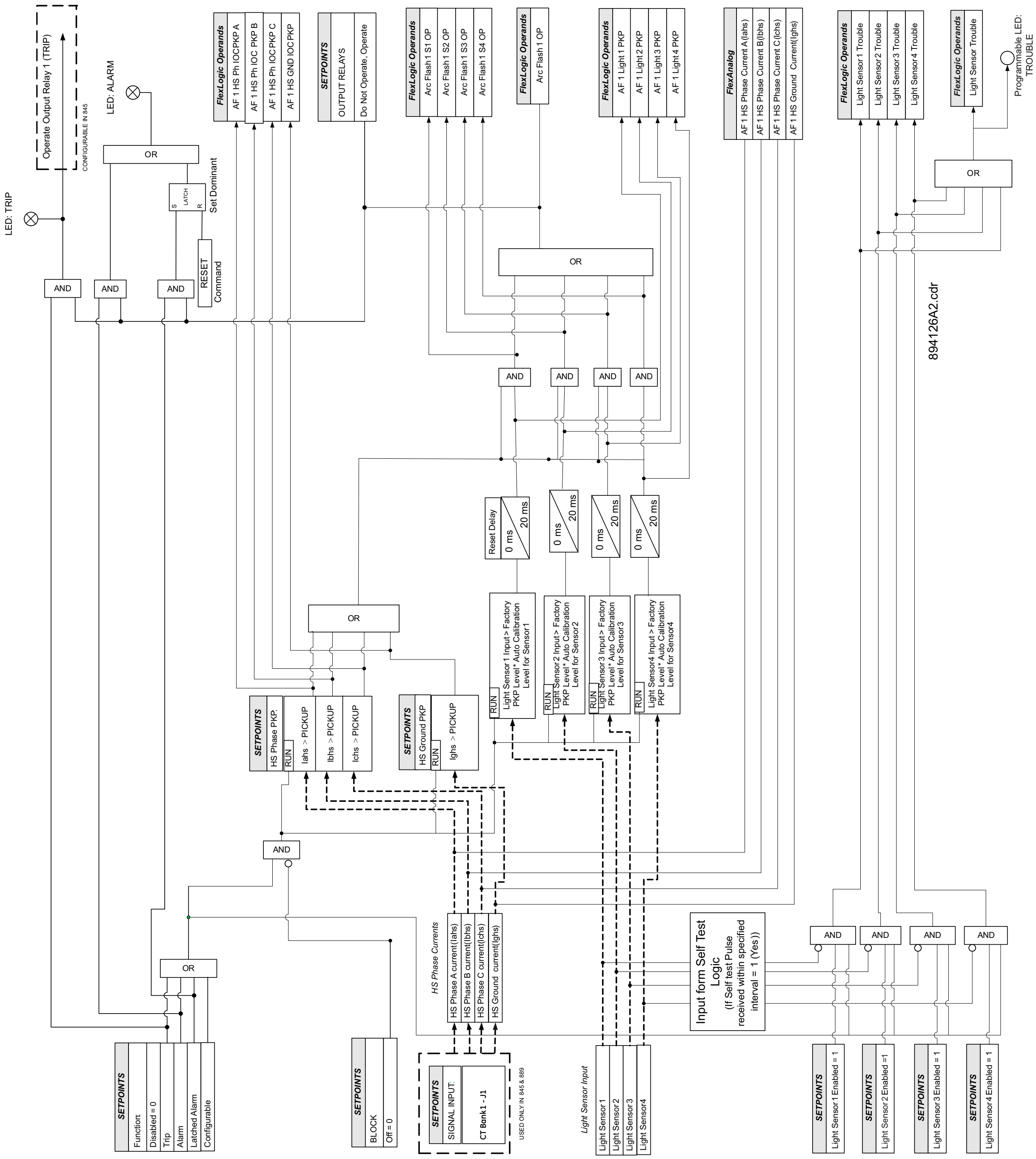
This setting enables or disables the events of the Arc Flash function.

TARGETS

Range: Self-reset, Latched, Disabled

Default: Latched

Figure 8-38: Arc Flash logic diagram



VT Fuse Failure (VTFF)

The 869 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

OUTPUT RELAY X

For details see Common Setpoints.

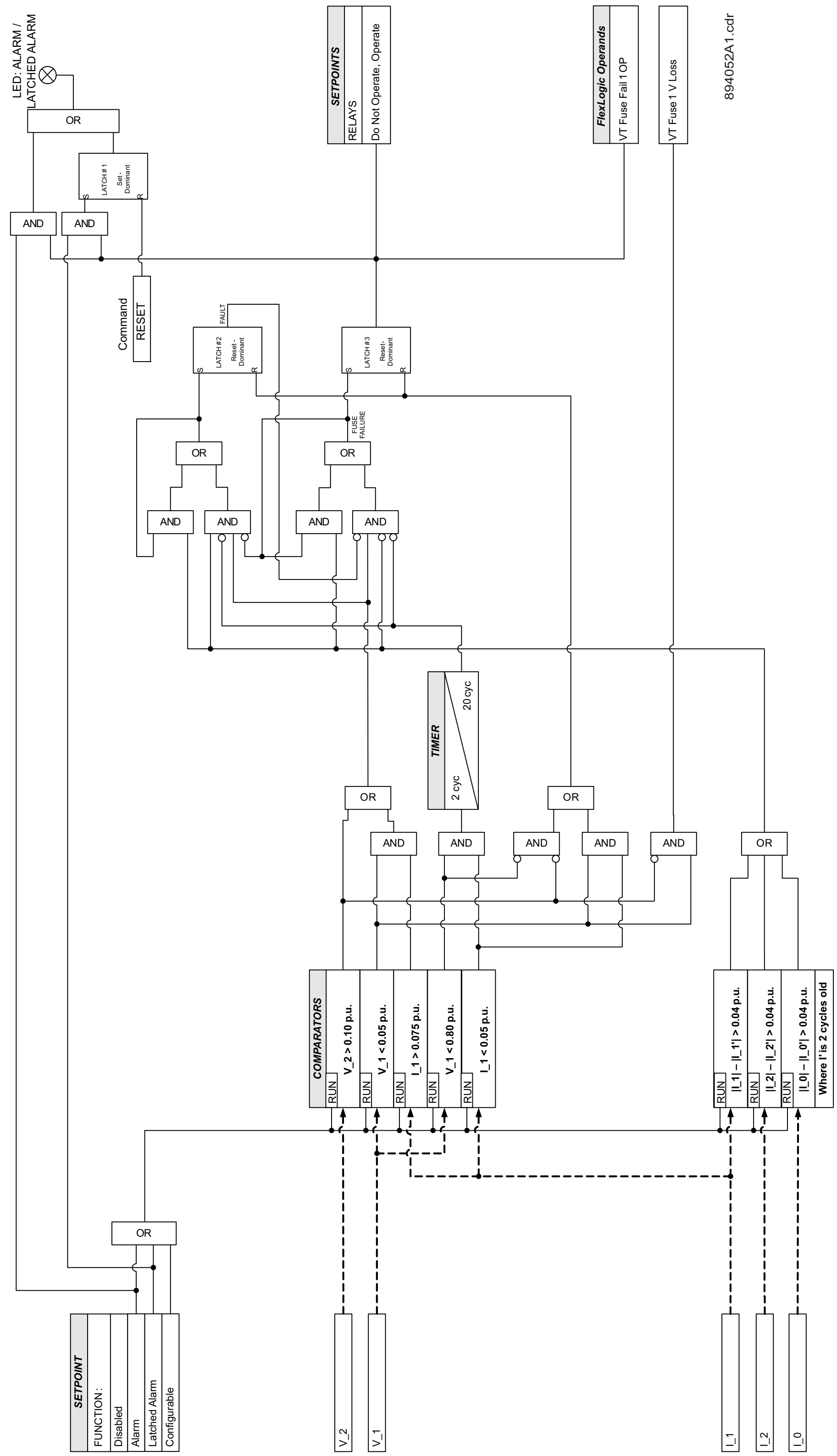
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

Range: Disabled, Self-reset, Latched
Default: Self-reset

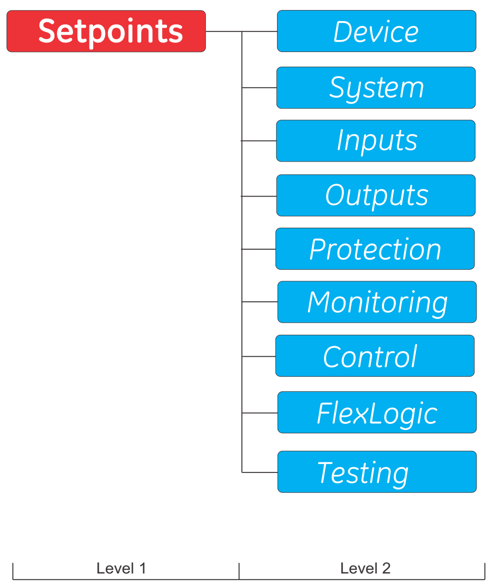
Figure 8-39: VT Fuse Failure logic diagram



869 Motor Protection System

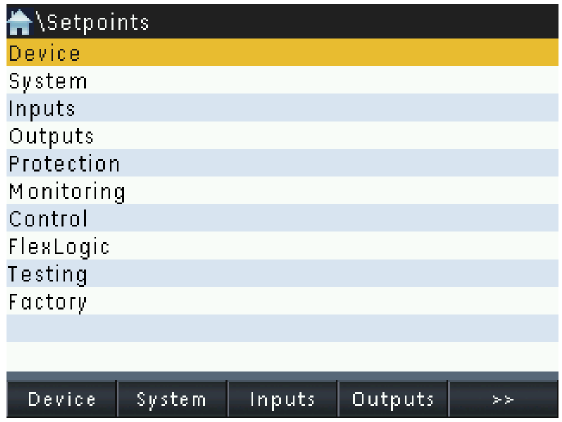
Chapter 9: FlexLogic and Other Setpoints

Figure 9-1: Main Setpoints Display Hierarchy



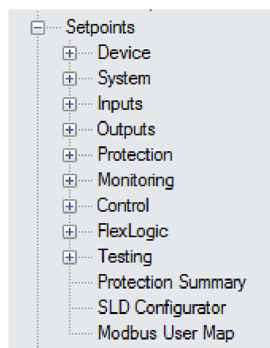
This chapter describes the FlexLogic and Testing setpoints in detail. Flexlogic setpoints provide access to the variable logic used with the relay. Testing setpoints include simulated current and voltage inputs, and test operations for LEDs, input contacts, and output relays.

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.

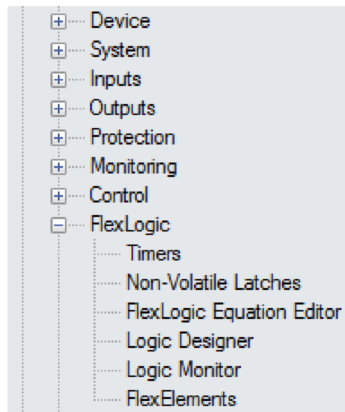
The SLD Configurator, as seen in the EnerVista 8 Series Setup software Setpoints menu, is described in detail in SLD Configurator.

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.

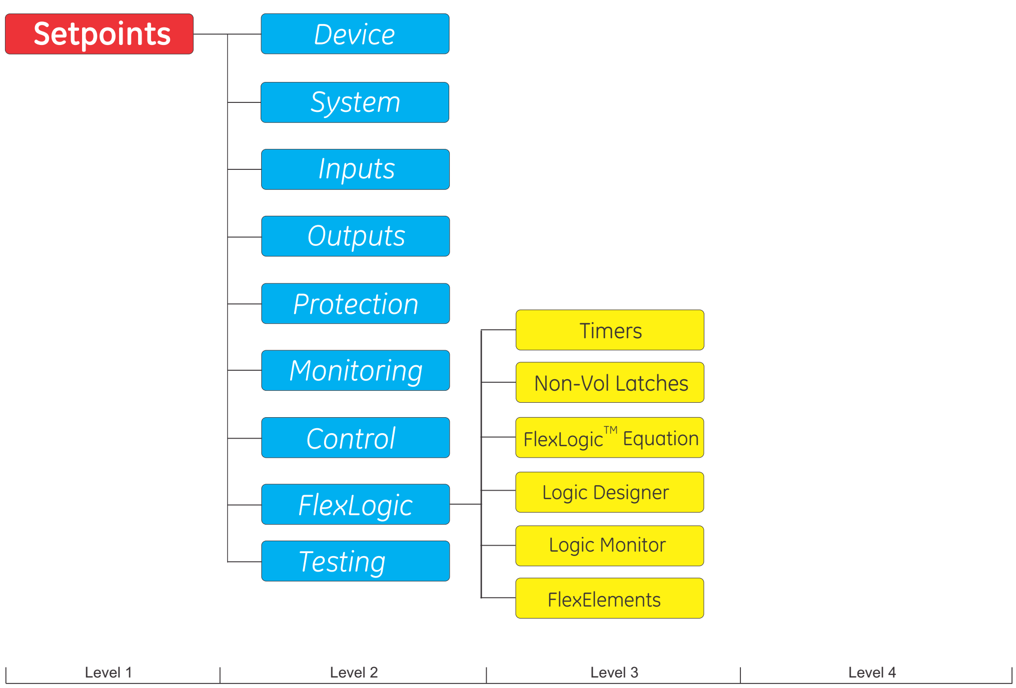
The major sub-systems of a generic 8 Series relay involved in this process are shown as follows.



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 869 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: 869 FlexLogic Operands

ELEMENT	OPERANDS	EVENT DESCRIPTION
Acceleration Time	Motor Accel Time OP	The acceleration time 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 AF 1 Light 2 PKP AF 1 Light 3 PKP AF 1 Light 4 PKP AF 1 HS Ph IOC PKP A AF 1 HS Ph IOC PKP B AF 1 HS Ph IOC PKP C AF 1 HS GND IOC PKP Arc Flash 1 S1 OP Arc Flash 1 S2 OP Arc Flash 1 S3 OP Arc Flash 1 S4 OP Arc Flash 1 OP Light Sensor 1 Trouble Light Sensor 2 Trouble Light Sensor 3 Trouble Light Sensor 4 Trouble Light Sensor Trouble	Light sensor 1 has detected light above threshold Light sensor 2 has detected light above threshold Light sensor 3 has detected light above threshold Light sensor 4 has detected light above threshold High speed IOC of phase A has picked up High speed IOC of phase B has picked up High speed IOC of phase C has picked up High speed IOC of Ground has picked up 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 event is detected due to detection of light in sensor 2 above threshold AND HS Phs/Gnd IOC element picked up 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 event is detected due to detection of light in sensor 4 above threshold AND HS Phs/Gnd IOC element picked up Arc Flash event is detected by at least one of the sensor elements AND HS Phs/Gnd IOC elements Detection of any trouble in light sensor 1 or corresponding fiber Detection of any trouble in light sensor 2 or corresponding fiber Detection of any trouble in light sensor 3 or corresponding fiber Detection of any trouble in light sensor 4 or corresponding fiber Detection of any trouble in any of the 4 light sensors or corresponding fibers
Auxiliary OV	Aux OV PKP Aux OV OP	Auxiliary overvoltage element has picked up Auxiliary overvoltage element has operated
BKR 1 / Contactor State Detection	BKR1 Open Contactor Open Sw Device Open BKR1 Closed Contactor Closed Sw Device Closed BKR1 Unknown State Contactor Unkwn Stat BKR1 Connected Contactor Connected BKR1 Disconnected Contactor Disconnect Sw Device Config	Breaker state is detected open Contactor state is detected open Switching device is detected open Breaker state is detected closed Contactor state is detected closed Switching device is detected closed Closed or Open Breaker state cannot be detected Closed or Open Contactor state cannot be detected Breaker has been connected to the power system Contactor has been connected to the power system Breaker has been detached from the power system Contactor has been detached from the power system At least one of the switching device status contacts is configured
Breaker (See also SM Field Breaker)	BKR[X] Opened BKR[X] Closed BKR[X] Unkwn State BKR[X] Connected BKR[X] Disconnected BKR[X] Configured BKR[X] Not Configured BKR[X] Trolley Bad Status	Breaker state is detected opened Breaker state is detected closed Close or Open breaker state cannot be detected Breaker has been connected to the power system Breaker has been detached from the power system Breaker status contact is configured Breaker status contact is not configured Breaker Trolley Status Bad status mode detected [X] - the element number.
Breaker Arcing	BKR1 Arc OP	Breaking arcing 1 element operated
Breaker Control	BKR[X] Remote Open BKR[X] Remote Close BKR[X] Rem Blk Open BKR[X] Rem Blk Close BKR[X] Remote Blk Opn By BKR[X] Remote Blk Cls By	Breaker Open command is initiated to Breaker 1 Breaker Close command is initiated to Breaker 1 The Open command to Breaker 1 is blocked The Close command to Breaker 1 is blocked The block open signal to Breaker 1 is bypassed The block close signal to Breaker 1 is bypassed [X] - the element number.
Breaker Failure	BF1 Retrip BF1 Highset OP BF1 Lowset OP BF1 52b Superv OP BF1 OP	Breaker failure 1 re-trip operated Breaker failure 1 operated with high level current supervision (includes breaker status supervision if set) Breaker failure 1 operated with low level current supervision (includes breaker status supervision if set) Breaker failure 1 operated with breaker status only Breaker failure 1 operated

ELEMENT	OPERANDS	EVENT DESCRIPTION
Breaker Health	BKR 1 Hlth PKP BKR 1 Hlth Trip PKP BKR 1 Hlth Cls PKP BKR 1 Hlth Chg PKP BKR 1 Arc PKP A BKR 1 Arc PKP B BKR 1 Arc PKP C BKR 1 Engy PKP A BKR 1 Engy PKP B BKR 1 Engy PKP C BKR 1 Hlth OP Fail BKR 1 Arc Fail BKR 1 Charge Fail	Breaker health has picked up Trip time of breaker health has picked up Close time of breaker health has picked up Spring charge time of breaker health has picked up Arc time of phase A of breaker health has picked up Arc time of phase B of breaker health has picked up Arc time of phase C of breaker health has picked up Arc energy of phase A of breaker health has picked up Arc energy of phase B of breaker health has picked up Arc energy of phase C of breaker health has picked up Breaker trip or close operation has failed Breaker arc time has failed Spring charge time has failed
Broken Rotor Bar	Brokn Rtr Bar PKP Brokn Rtr Bar OP	Broken Rotor Bar has picked up Broken Rotor Bar has operated
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 Control	Cnct1 Rem Open Cnct1 Rem Close Cnct1 Rem Blk Open Cnct1 Rem Blk Close Cnct1 Rem Blk Opn By Cnct1 Rem Blk Cls By	Remote Open command is initiated to Contactor 1 Remote Close command is initiated to Contactor 1 The Open command to Contactor 1 is blocked The Close command to Contactor 1 is blocked The block open signal to Contactor 1 is bypassed The block close signal to Contactor 1 is bypassed
Critical Failure Relay	Critical Fail OP	The critical failure relay operated
Contact Inputs	CI # On CI # Off	# – any contact input number
Contactor State Detection (See also SM Field Contactor)	Contactor Opened Contactor Closed Contactor Unkwn Stat Contactor Connected Contactor Disconnect Contactor Configured	Contactor state is detected open Contactor state is detected closed Closed or Open Contactor state cannot be detected Contactor has been connected to the power system Contactor has been detached from the power system Contactor status contacts are configured
Current Unbalance	Cur Unbal Alarm OP Cur Unbal OP Single Phasing OP	Current Unbalance alarm stage operates. Current Unbalance trip stage operates. Single Phasing operates.
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

ELEMENT	OPERANDS	EVENT DESCRIPTION
ESA	Bearing Flt PKP Stg 1 Bearing Flt OP Stg 1 Bearing Flt PKP Stg 2 Bearing Flt OP Stg 2 Mech Flt PKP Stg 1 Mech Flt OP Stg 1 Mech Flt PKP Stg 2 Mech Flt OP Stg 2 Stator Flt PKP Stg 1 Stator Flt OP Stg 1 Stator Flt PKP Stg 2 Stator Flt OP Stg 2 Baseline Data Capture Start Baseline Data Capture End Data Quality Check Fail	Bearing fault operand stage 1 has picked up Bearing fault operand stage 1 has operated Bearing fault operand stage 2 has picked up Bearing fault operand stage 2 has operated FEM fault operand stage 1 has picked up FEM fault operand stage 1 has operated FEM fault operand stage 2 has picked up FEM fault operand stage 2 has operated Stator T-T fault operand stage 1 has picked up Stator T-T fault operand stage 1 has operated Stator T-T fault operand stage 2 has picked up Stator T-T fault operand stage 2 has operated Capturing of baseline data has started Capturing of baseline data has ended The quality check of data has failed
Fast Underfrequency	Fast UF 1 PKP Fast UFl 1 OP Fast UF 2 to 8	Fast Underfrequency element 1 has picked up Fast Underfrequency element 1 has operated The same set of operands per Fast Underfrequency 1
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.
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
Ground Fault	GndFault Alarm PKP GndFault PKP GndFault Alarm OP GndFault OP	Ground Fault alarm stage picks up. Ground Fault trip stage picks up. Ground Fault alarm stage operates. Ground Fault trip stage operates.
Ground TOC	GND TOC 1 PKP GND TOC 1 OP	Ground time overcurrent 1 has picked up Ground time overcurrent 1 has operated
Ground IOC	GND IOC 1 PKP GND IOC 1 OP	Ground instantaneous overcurrent 1 has picked up Ground instantaneous overcurrent 1 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
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

ELEMENT	OPERANDS	EVENT DESCRIPTION
Local Control Mode	SBO Enabled Cnct[X] Local Open Cnct[X] Local Close Cnct[X] Loc Blk Open Cnct[X] Loc Blk Close Cnct[X] Loc Blk Open By Cnct[X] Loc Blk Cls By Cnct[X] Tag On Cnct[X] Tag Off Cnct[X] Selected	Select Before Operate control mode is enabled Local Open command has been initiated to Cnct[X] Local Close command has been initiated to Cnct[X] Open command to Cnct[X] is blocked Close command to Cnct[X] is blocked Open command to Cnct[X] is permitted, Block Open signal is bypassed Close command to Cnct[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 [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
Loss of Excitation	LOE Circle 1 PKP LOE Circle 1 OP LOE Circle 2 PKP LOE Circle 2 OP	Loss of excitation circle 1 pickup Loss of excitation circle 1 operate Loss of excitation circle 2 pickup Loss of excitation circle 2 operate
Mechanical Jam	Mech Jam PKP Mech Jam OP	The mechanical jam element has picked up The mechanical jam element has operated
Motor Thermal Model	Thermal PKP Thermal Trip OP Thermal Alarm OP Emergency Restart Emrg Restart Alarm Motor Stopped Motor Starting Motor Running Motor Overload Motor Tripped SM Running SM Stabilizing SM Sync SM Field Applied	The thermal model element has picked up The thermal model trip element has operated The thermal model alarm element has operated Emergency restart command initiated Emergency restart alarm is initiated The motor is stopped The motor is starting The synchronous motor is running in induction mode (no DC Field applied) A motor overload condition has occurred The motor is tripped The synchronous motor is running in synchronous mode The synchronous motor is in stabilizing mode after the DC Field is applied The synchronous motor is in re-synchronizing mode The synchronous motor DC Field is successfully applied
Neutral TOC	Ntrl TOC 1 PKP Ntrl TOC 1 OP	Neutral time overcurrent 1 has picked up Neutral time overcurrent 1 has operated
Neutral IOC	Ntrl IOC 1 PKP Ntrl IOC 1 OP Ntrl IOC 2	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 [X] PKP Ntrl OV [X] 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 IOC	NegSeq IOC 1 PKP NegSeq IOC 1 OP	Negative Sequence IOC has picked up Negative Sequence IOC 1 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
Out of Step	OOS OP OOS Lft Bld PKP OOS Rgt Bld PKP OOS Timer PKP	Out-of-step tripping element operated Positive-sequence impedance in mho and left blinder characteristic Positive-sequence impedance in mho and right blinder characteristic Out-of-step timer picked up
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

ELEMENT	OPERANDS	EVENT DESCRIPTION
OverFrequency	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 Alarm	Overload Alarm PKP Overload Alarm OP	Overload alarm has picked up. Overload alarm has operated.
Percent Differential	Percent Diff PKP A Percent Diff PKP B Percent Diff PKP C Percent Diff PKP Percent Diff Sat A Percent Diff Sat B Percent Diff Sat C Percent Diff Dir A Percent Diff Dir B Percent Diff Dir C Percent Diff OP A Percent Diff OP B Percent Diff OP C Percent Diff OP Percent Diff Warn	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 Saturation detected in stator phase A Saturation detected in stator phase B Saturation detected in stator phase C Phase A direction indicates an internal fault Phase B direction indicates an internal fault Phase C direction indicates an internal fault 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 10s
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 Ph TOC 2	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 OP	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
Phase Reversal	Phase Rev PKP Phase Rev OP Phase Rev Inhibit	The phase reversal element has picked up The phase reversal element has operated The phase reversal start inhibit occurs
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

ELEMENT	OPERANDS	EVENT DESCRIPTION
Power Factor	PF Trip PKP PF Trip OP PF Alarm PKP PF Alarm OP SM Resync Init Cmd SM Resync Failed	The power factor (trip) has pickup up The power factor (trip) has operated The power factor alarm has picked up The power factor alarm has operated Synchronous Motor Re-Synchronization Command Is Initiated Synchronous Motor Re-Synchronization Failed
Power System Setup	Ph Rot Inhibit Rev Ph Rot-CT BnkRev Ph Rot-VT Bnk	Reverse to forward or forward to reverse (ABC <-> ACB) phase rotation of either current or voltage or both has initiated. This operand remains high for 3 cycles after initiation. Currents phase rotation is switched from forward to reverse. Voltages phase rotation is switched from forward to reverse.
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.
Reactive Power	Pos var Alrm PKP Pos var Alrm OP Neg var Alrm PKP Neg var Alrm OP Pos var Trip PKP Pos var Trip OP Neg var Trip PKP Neg var Trip OP	Positive var alrm stage has picked up Positive var alrm stage has operated Negative var alrm stage has picked up Negative var alrm stage has operated Positive var trip stage has picked up Positive var trip stage has operated Negative var trip stage has picked up Negative var trip stage has operated
Reduced Voltage Start	Reduced Volt Ctrl Reduced Volt Fail	Asserted for one second upon a valid transition in any mode Asserted when an invalid transition occurs
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
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.
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

ELEMENT	OPERANDS	EVENT DESCRIPTION
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
Sensitive Ground TOC	SGnd TOC 1 PKP SGnd TOC 1 OP	Sensitive ground TOC has picked up Sensitive ground TOC has operated
Sensitive Ground IOC	SGnd IOC 1 PKP SGnd IOC 1 OP	Sensitive ground instantaneous overcurrent 1 has picked up Sensitive ground instantaneous overcurrent 1 has operated
Setpoint Access	Setpoint 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
Short Circuit	Short Circuit PKP Short Circuit OP	The short circuit element has picked up The short circuit element has operated
Speed2 Motor Protection	Speed2 TR 2-1 OP Motor Speed 2 Spd2 Accel Time OP Spd2 U/C ALM PKP Spd2 U/C ALM OP Spd 2 U/C PKP Spd 2 U/C OP	Asserted when the motor switches from speed 2 to speed 1 The motor is running at speed 2 The speed 2 acceleration time element has operated The speed 2 undercurrent alarm has picked up The speed 2 undercurrent alarm has operated The speed 2 undercurrent has picked up The speed 2 undercurrent has operated
Speed Protection	Speed Trip PKP Speed Trip OP Speed Alarm PKP Speed Alarm OP	Speed Trip has picked up Speed Trip has operated Speed Alarm has picked up Speed Alarm has operated
Start Supervision	Thermal Inhibit PKP Thermal Inhibit OP Max Start Rate PKP Max Start Rate OP Max Cold Start PKP Max Cold Start OP Max Hot Start PKP Max Hot Start OP Time Btwn Star PKP Time Btwn Start OP Restart Delay PKP Restart Delay OP Start Inhibit	Thermal Inhibit has picked up. Thermal Inhibit has operated. Maximum Starting Rate has picked up. Maximum Starting Rate has operated. Maximum Cold Starting Rate has picked up. Maximum Cold Starting Rate has operated. Maximum Hot Starting Rate has picked up. Maximum Hot Starting Rate has operated. Time Between Start has picked up. Time Between Start has operated. Restart Delay has picked up. Restart Delay has operated. Any Start Inhibit has operated: Thermal Inhibit OR Maximum Starting Rate OR Time Between Start OR Restart Delay OR Phase Rev Inhibit
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.
Stator Inter Turn Fault	Stat Trn Flt 1 PKP Stat Trn Flt 1 OP Stat Trn Flt 2 PKP Stat Trn Flt 2 OP	Stator Inter Turn Fault stage 1 has picked up Stator Inter Turn Fault stage 1 has operated Stator Inter Turn Fault stage 2 has picked up Stator Inter Turn Fault stage 2 has operated
Sync. Motor Field Breaker (SM Field Breaker)	FLD BKR Opened FLD BKR Closed FLD BKR Unkwn State FLD BKR Config FLD BKR Not Config	Field breaker state is detected opened Field breaker state is detected closed Close or Open field breaker state cannot be detected At least one input 41a or 41b is programmed to reflect the status of field breaker No input 41a or 41b is programmed to reflect the status of field breaker

ELEMENT	OPERANDS	EVENT DESCRIPTION
Sync. Motor Field Contactor (SM Field Contactor)	FLD CONT Opened FLD CONT Closed FLD CONT Unkwn State FLD CONT Config FLD CONT Not Config	Field contactor state is detected opened Field contactor state is detected closed Close or Open field contactor state cannot be detected At least one input 41a or 41b is programmed to reflect the status of field contactor No input 41a or 41b is programmed to reflect the status of field contactor
Sync. Motor Field Switching Device Control (FLD SW Device Control)	FLD Open Cmd Init FLD Close Cmd Init	Field breaker/contactor open comand is initiated Field breaker/contactor close comand is initiated
Sync. Motor DSP	Neg-pos Zero Crossing Pos-neg Zero Crossing	Negative to positive zero crossing of sync. motor AC field voltage measured across field discharge resistor. Positive to negative zero crossing of sync. motor AC field voltage measured across field discharge resistor.
Sync. Motor Field Overcurrent	FLD OC[X] PKP FLD OC[X] OP	Sync. Motor Field Overcurrent [X] has picked up. Sync. Motor Field Overcurrent [X] has operated.
Sync. Motor Field Overtemperature	FLD OC[X] PKP FLD OC[X] OP	Sync. Motor Field Overcurrent [X] has picked up. Sync. Motor Field Overcurrent [X] has operated.
Sync. Motor Field Overvoltage	FLD OverTemp[X] PKP FLD OverTemp[X] OP	Sync. Motor Field Overtemperature [X] has picked up. Sync. Motor Field Overtemperature [X] has operated.
Sync. Motor Field Undercurrent	FLD UC[X] PKP FLD UC[X] OP	Sync. Motor Field Undercurrent [X] has picked up. Sync. Motor Field Undercurrent [X] has operated.
Sync. Motor Field Undervoltage	FLD UV[X] PKP FLD UV[X] OP	Sync. Motor Field Undervoltage [X] has picked up. Sync. Motor Field Undervoltage [X] has operated.
Sync. Motor SC Speed-Dependent Thermal Protection	SC Thermal OP SC Thermal Alarm OP	The Sync. Motor SC Speed-Dep. Thermal protection element has operated The Sync. Motor SC Speed-Dep. Thermal protection alarm element has operated
Sync. Motor Power Factor Regulation	PF Reg Trouble PF Reg Output Error	Sync. Motor PF Regulation trouble Indicates error in the PF Regulation Output (terminals K15 & K16 in slot K) with possible indication of open-circuit condition when output is voltage type.
Sync. Motor Start Sequence Control	Start Seq Completed Start Seq INC Rel Torque Sync Cmd FLD Sync Cmd Load Applied Load Disconnected	Synchronous Motor Start Sequence Completed Synchronous Motor Start Sequence Incomplete (INC) Reluctance Torque based Field Synchronization Command is Initiated Field Synchronization Command is Initiated Synchronous Motor Load Applied Synchronous Motor Load Disconnected
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
Targets	Active Target	At least one target is detected active
Time of Day Timers	Time of Day 1 ON Time of Day 2 ON Time of Day 1 Start 1 Time of Day 1 Start 2 Time of Day 1 Start 3 Time of Day 2 Start 1 Time of Day 2 Start 2 Time of Day 2 Start 3 Time of Day 1 Stop Time of Day 2 Stop	Time of Day timer 1is on Time of Day timer 2is on 1 second pulse at Time of Day timer 1 Start Time 1 1 second pulse at Time of Day timer 1 Start Time 2 1 second pulse at Time of Day timer 1 Start Time 3 1 second pulse at Time of Day timer 2 Start Time 1 1 second pulse at Time of Day timer 2 Start Time 2 1 second pulse at Time of Day timer 2 Start Time 3 1 second pulse at set Time of Day timer 1 Stop Time 1 second pulse at set Time of Day timer 2 Stop Time
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.
Undercurrent	Undercur[X] Alarm PKP Undercur[X] Alarm OP Undercur[X] Trip PKP Undercur[X] Trip OP	Undercurrent[X] Alarm has picked up. Undercurrent[X] Alarm has operated. Undercurrent[X] Trip has picked up. Undercurrent[X] Trip has operated.
Underpower	Underpwr Alarm PKP Underpwr PKP Underpwr Alarm OP Underpwr OP	Underpower alarm stage picks up. Underpower trip stage picks up. Underpower alarm stage operates. Underpower trip stage operates.

ELEMENT	OPERANDS	EVENT DESCRIPTION
UnderFrequency	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
VFD	VFD Bypassed VFD Not Bypassed	The VFD is bypassed by the switch The VFD is not bypassed by the switch
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
Voltage Disturbance Voltage Swell Voltage Sag	VD[X] Rise Armed A VD[X] Rise Armed B VD[X] Rise Armed C VD[X] Rise Armed Volt Swell[X] {Alrm} OP A Volt Swell[X] {Alrm} OP B Volt Swell[X] {Alrm} OP C Volt Swell[X] {Alrm} OP VD[X] Drop Armed A VD[X] Drop Armed B VD[X] Drop Armed C VD[X] Drop Armed Volt Sag[X] {Alrm} OP A Volt Sag[X] {Alrm} OP B Volt Sag[X] {Alrm} OP C Volt Sag[X] {Alrm} OP PQ Rec Trigger	Phase A voltage swell has picked up. Phase B voltage swell has picked up. Phase C voltage swell has picked up. Phase A/B/C any one phase or all phase voltage swell has picked up. Phase A voltage swell has operated. Phase B voltage swell has operated. Phase C voltage swell has operated. Phase A/B/C any one phase or all phase voltage swell has operated Phase A voltage sag has picked up. Phase B voltage sag has picked up. Phase C voltage sag has picked up. Phase A/B/C any one phase or all phase voltage sag has picked up. Phase A Voltage Sag has operated. Phase A Voltage Sag has operated. Phase A Voltage Sag has operated. Phase A/B/C any one phase or all phase Voltage Sag has operated FlexLogic operand generated at the dropout edge of the Volt Swell [X] OP or the Volt Sag [X] OP events
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
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)

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: 869 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.	

TYPE	SYNTAX	DESCRIPTION	NOTES
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.	
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

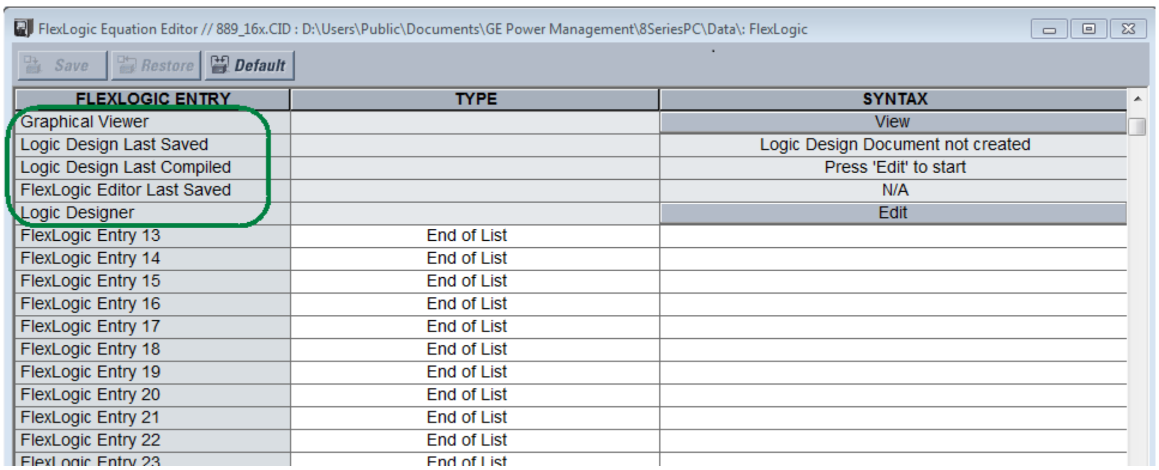
Path: Setpoints > FlexLogic > FlexLogic Equation

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.

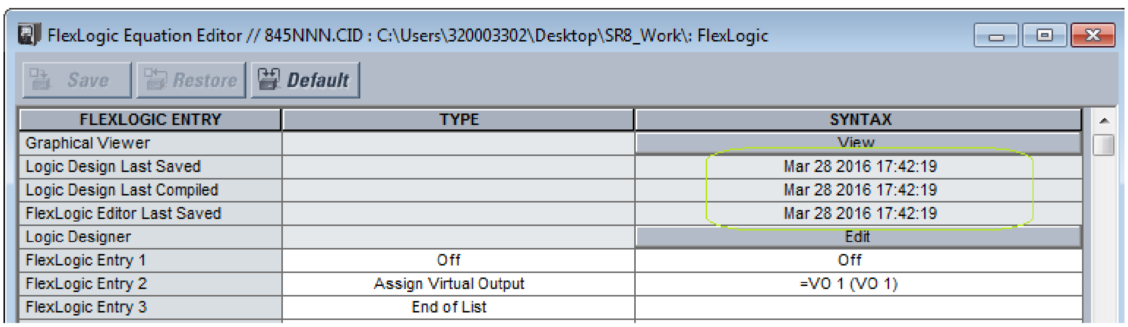
File Conversion and Handling of Time Stamps: When File Conversion is applied the three time stamps are processed (either carry forwarded, defaulted, updated with latest PC time) based on the Source and Destination File versions and Order code supported.

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

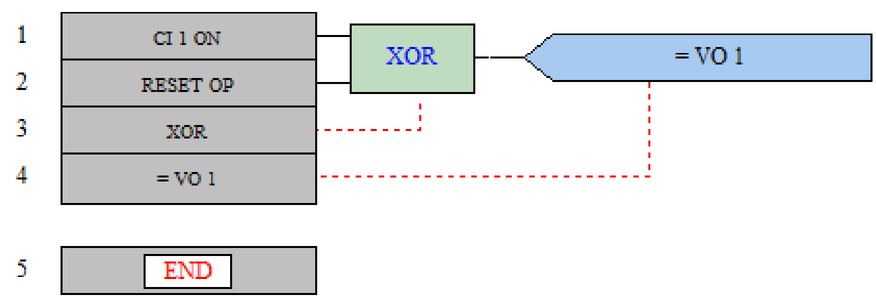
To verify that the FlexLogic equation(s) and its selected parameters produce the desired logic, the expression can be viewed by converting the derived equation into a graphic diagram. It is strongly recommended and helpful to view an equation as a graphic diagram before it is saved to the 869 device 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:

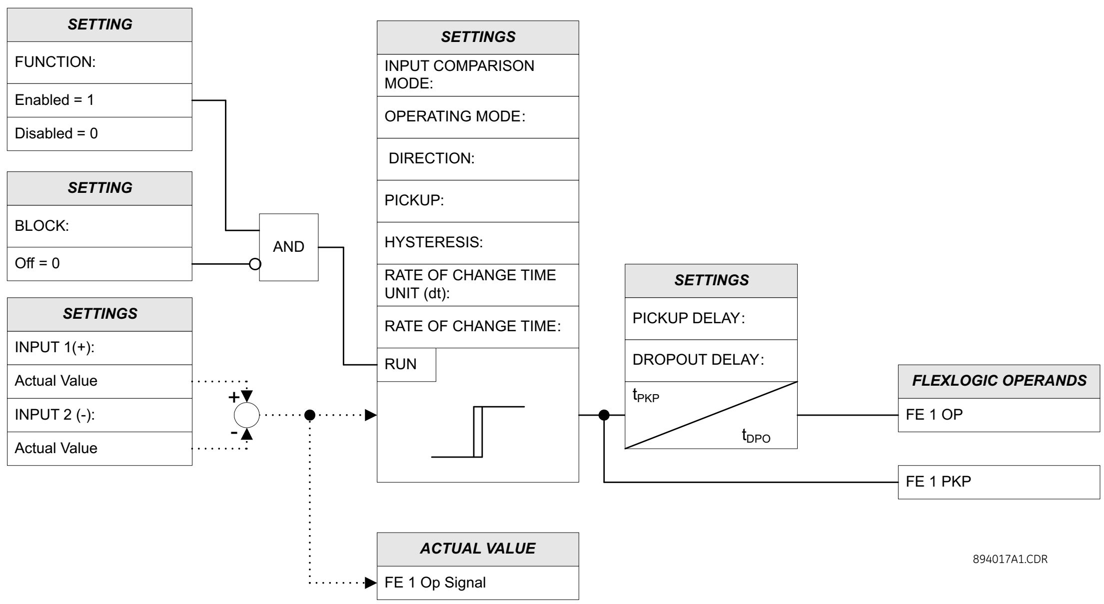
1. The analog inputs for any FlexElement must be from the same "gender":
   - current and current (in any combination, phase-symmetrical, phase-phase, kA-A, differential, restraint, etc.)
   - voltage and voltage (as above)
   - active power and active power (Watts and Watts)
   - reactive power and 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.

OPERATING MODE

Range: Signed, Absolute

Default: Signed

The element responds directly to the differential signal if this setting is set to "Signed". The element responds to the absolute value of the differential signal if this setting is set to "Absolute".

Sample applications for the "Absolute" setting include monitoring the angular difference between two phasors with a symmetrical limit angle in both directions; monitoring power regardless of its direction, or monitoring a trend regardless of whether the signal increases or decreases.

INPUT COMPARISON MODE

Range: Level, Delta

Default: Level

The element responds directly to the differential signal – as defined by the Input 1 (+), Input 2 (-) if the Operating Mode setting is set to Level.

The element responds to the rate of change of its operating signal if this setting is set to "Delta". The setpoint's Rate of Change Time Unit (dt), and Rate of Change Time (dt) specify how the rate of change is derived. Providing the conditions (Under or Over) for the actual rate-of-change are satisfied, in Delta mode the FlexElement can operate in either direction, no matter if the operating signal is increased or decreased. The operating signal is the difference between the two selected inputs.

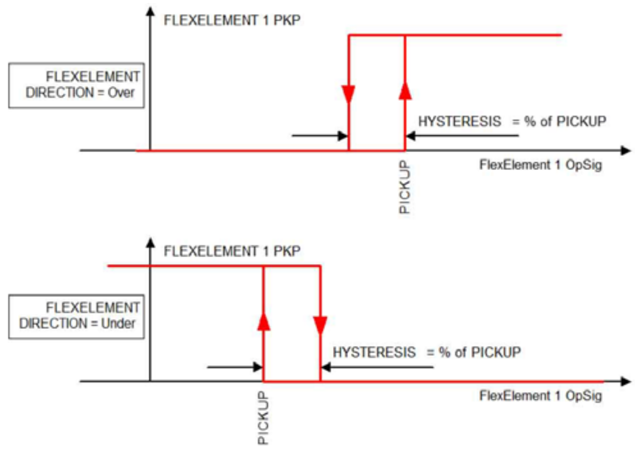
DIRECTION

Range: Over, Under

Default: Over

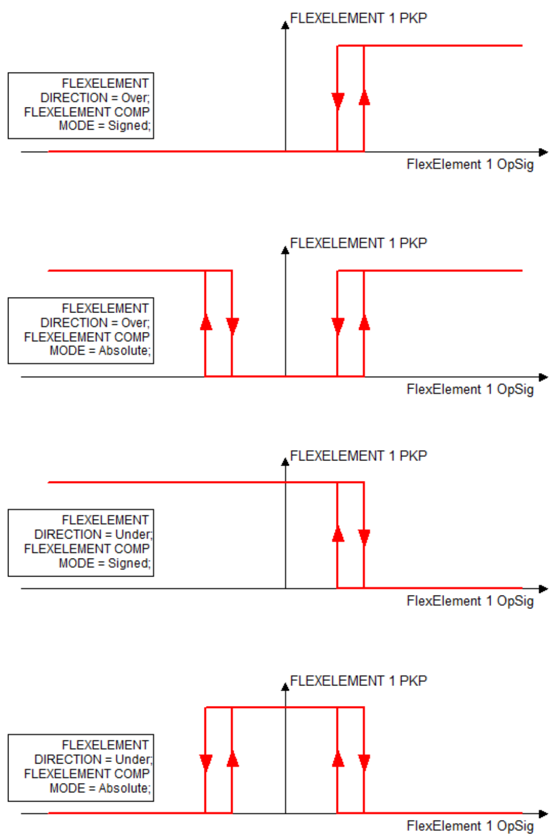
This setting enables the relay to respond to either high or low values of the operating signal. The following figure explains the application of the Direction, Pickup and Hysteresis settings.

Figure 9-8: Direction, Pickup, and Hysteresis setpoints



In conjunction with the Operating Mode setting, the element could be programmed to provide two extra characteristics as shown in the figure following.

Figure 9-9: Operating Input setpoint



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
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
Current Unbalance	BASE = 100%
Source Energy (Positive and Negative Watthours, Positive and Negative Varhours)	EBASE = 10000 MWh or MVAh, respectively
Differential and Restraint Currents (Percent Differential)	I_{BASE} = Primary of the CT with maximum primary current rating
Thermal Capacity Used	BASE = 100%
Thermal Lockout Time	BASE = 10 minutes
Thermal Model Load and Biased Motor Load	BASE = 1.00 pu of FLA
Trip Time on Overload	BASE = 10 seconds
SM SC Spd-Dep TC Used	BASE = 100%
SM SC Spd-Dep Trip Time on OL	BASE = 10 seconds
SM Field VAC	BASE = 1000 V
SM Field VDC	BASE = 350 V

Measured or calculated analog value related to:	Base Unit
SM Field Amps	BASE = Max FLD Amps Primary (set under System > Current Sensing > SM FLD Amps -K2)
Rotor Slip	BASE = 100%
K2 Field VAC Freq	f_{BASE} = nominal frequency as entered in the SYSTEM SETUP menu
SM PF Error	BASE = 1.00
SM Field Resistance	BASE = 100

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”.

PICKUP DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s

Default: 0.000

This setting specifies the pickup delay of the element.

DROPOUT DELAY

Range: 0.000 to 6000.000 s in steps of 0.001 s

Default: 0.000

This setting specifies the reset delay of the element.

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

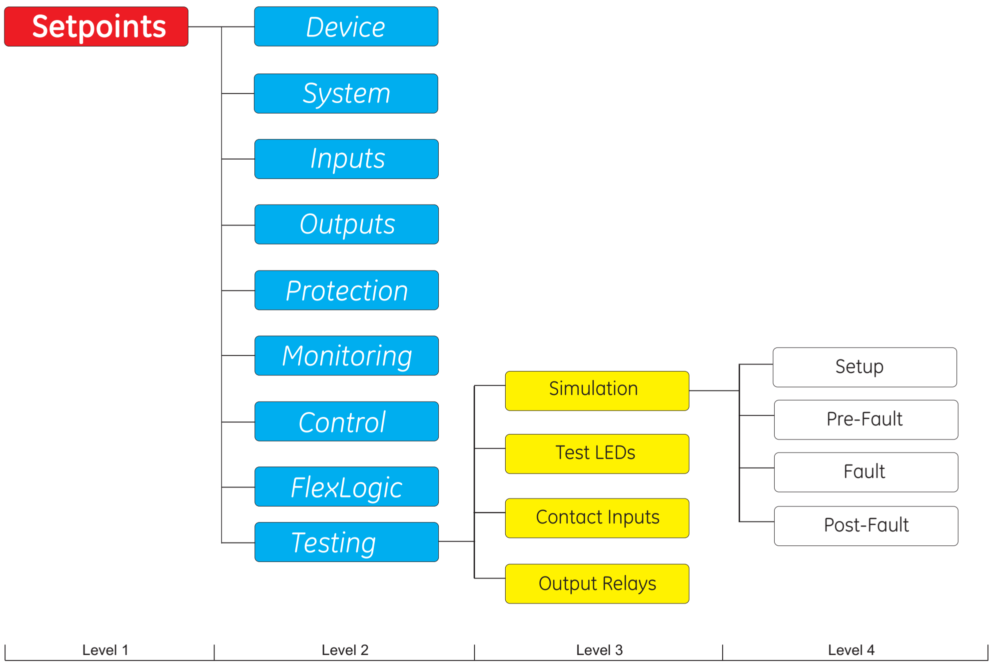
- Input 1(+): Total Arcing Current
- Input 2(-): Off
- Operating Mode: Absolute
- Input Comparison Mode: Level
- Direction: Over
- Pickup: 2.500 pu
- Hysteresis: 0.0 %

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 9-10: 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) 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) Prefault Phase Ig:

Range:
For Ground CT: 0.000 to 46.000 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

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) 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) 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) Fault Phase Ig:

Range:
For Ground CT: 0.000 to 46.000 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) Fault Ia(Ib,Ic,Ig) Angle:

Range: -359.9° to 0.0° in steps of 0.1
Default: 0.0°

J1(K1) 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) Fault Phase Ig:

Range:
For Ground CT: 0.000 to 46.000 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) 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) 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) Postfault Phase Ig:

Range:
For Ground CT: 0.000 to 46.000 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) 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

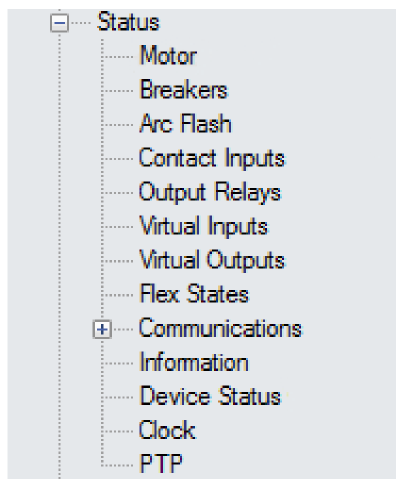
Default: Off

GE
Grid Solutions

869 Motor Protection System

Chapter 10: Status

Figure 10-1: Main Status Screen

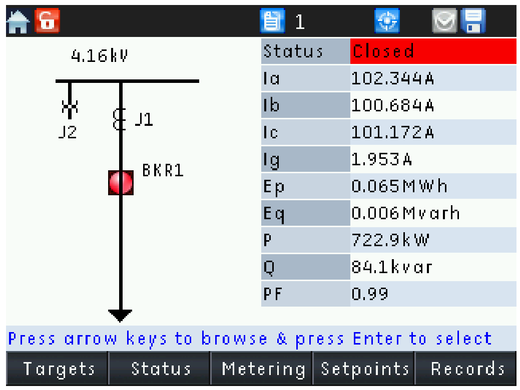


Summary

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.

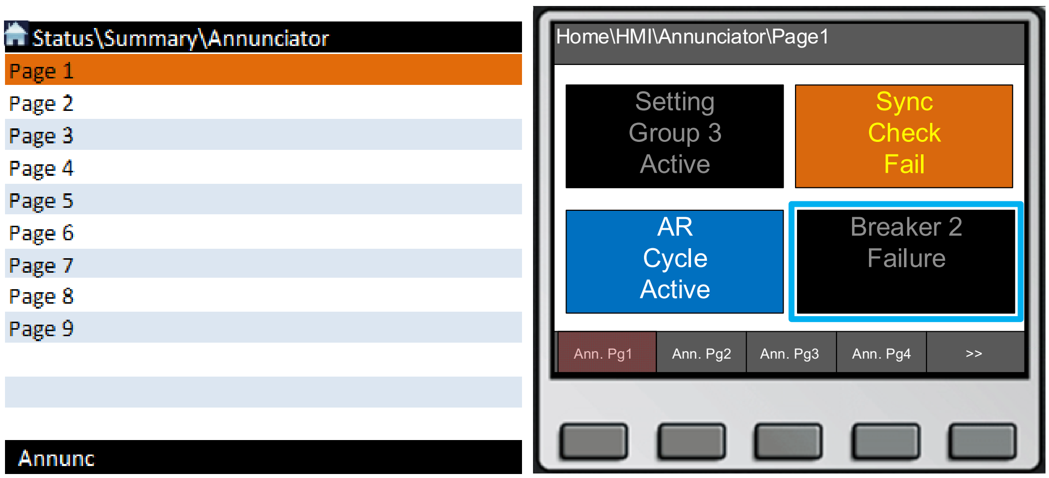
If the Up/Dn/Left/Right keys are used, the selection moves to the closest available breaker/switch from the currently highlighted object. To select the breaker/switch, press the enter key. Upon pressing the Enter key, the tab labels change to the programmable tab pushbutton labels and a flash message 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.

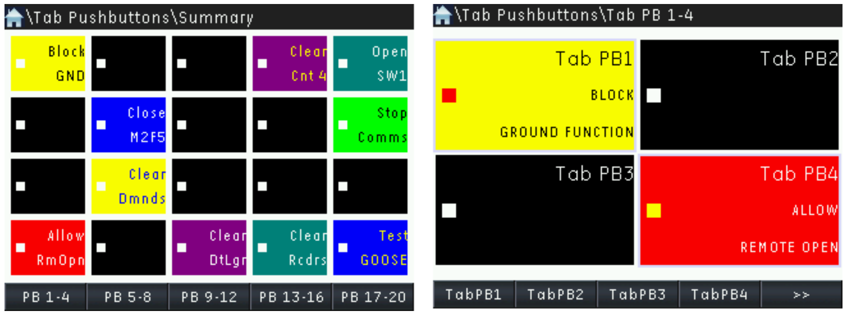
NOTICE

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.

Motor

The motor start screen is shown as follows.

Path: **Status > Motor**

MOTOR STATUS

Range: Tripped, Stopped, Starting, Running, SM Stabilizing, SM Running, SM Resync, Overload

Default: Stopped

These messages describe the motor status at any given point in time. All motor status operands are mutually exclusive.

SM Stabilizing, SM Running, and SM Resync are only applicable to synchronous motor (SM) applications and require appropriate synchronous motor order code options.

For the sake of brevity, the term 'switching device' is used for Breaker and Contactor devices.

Motor Stopped and Tripped conditions are detected based on the current level and switching device status (52a or 52b). When a switching device is not configured* or a switching device is not connected then monitoring of switching device status is no longer possible and the Stopped, Tripped, and Start MOTOR STATUS are based only on current level monitoring.

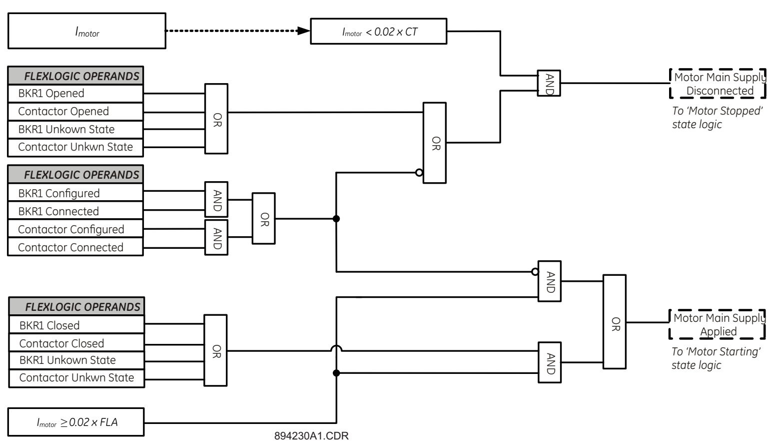
NOTE

*A switching device is not configured when setpoints Contact Input 52a and Contact Input 52b are both set to "Off" under **Setpoints > Control > Breaker > Contactor**.

NOTE

** A switching device is not connected when both FlexLogic operands "BRK1 Connected" and "Contactor Connected" are not asserted under **Setpoints > Control > Breaker (Contactor)**.

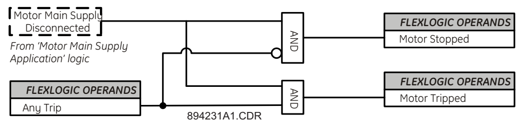
Figure 10-5: Motor main supply application logic



The Motor Tripped condition is detected when the Any Trip operand is asserted, the motor current ($I_{motor,}$ defined equation 13 in Thermal Model) is below 2% of CT, and the switching device is open. However, when the switching device is not configured then the Motor Tripped condition is detected when Any Trip operand is asserted and the current is below 2% of CT. Resetting of the Motor Tripped can be done by resetting the trip condition.

The state machine initially sets the Motor Stopped operand, as the switching device is open and motor current is less than 2% of CT. Also, to detect a Motor Stopped condition it is important to first reset any trip or the Any Trip operand is deserted. When the switching device is not configured the Motor Stopped condition is detected based on current only. Also, for the case when motor condition or status is solely based on the monitoring of currents, idling condition (current becomes ideally zero) during Motor Running in synchronous motor application can result in the Motor Stopped instead of Motor Running. To prevent this, the 869 must always be programmed to monitor the status of the switching device by means of contact input of the relay.

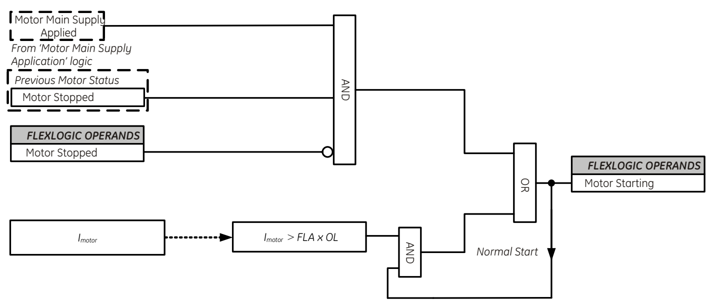
Figure 10-6: Motor Stopped and Trip state logic



The Motor Starting state is asserted if the previous motor status is Motor Stopped and a load current greater than 2% of FLA is detected, the Motor Starting operand becomes true. The Motor cannot start if the previous condition is Motor Tripped unless Any Trip is reset.

For normal motor starting, the Motor Starting condition remains asserted until currents fall below FLA x Overload Factor setting. As soon as motor current falls below FLA x the Overload Factor setting, the Motor Running operand is set.

Figure 10-7: Motor Starting state logic

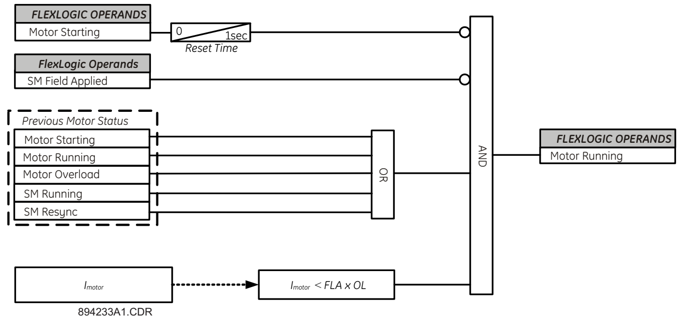


In induction motor applications, the motor can only be in the Motor Running condition following a Motor Starting or Motor Overload condition when neither Motor Starting nor Motor Overload are asserted.

In synchronous motor applications, the motor can either run in induction mode or in synchronous mode. The motor runs in induction mode during the Motor Starting condition when no DC Field is applied. In some synchronous motor applications such as light load applications, motors can also go from synchronous to induction mode when, during the synchronizing mode, the DC Field is lost and the motor continues its operation in induction mode.

In synchronous motor applications, the Motor Running state remains asserted until a successful DC Field is applied to synchronize the motor. Successful application of the DC field is monitored by the FlexLogic operand 'SM Field Applied', as shown below. The motor state also becomes Motor Running when, during normal operation, the DC field is lost and the motor continues running in induction mode. The Motor Running state indicates synchronous motor operation in induction mode.

Figure 10-8: Motor Running state logic

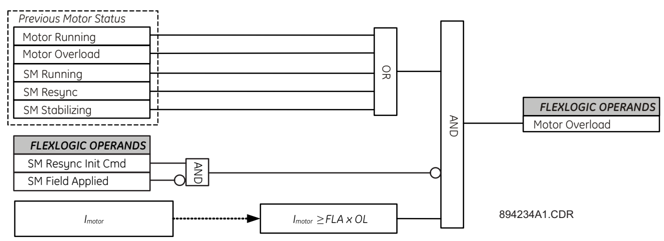


In induction motor applications, if the current rises above FLA x Overload Factor while in the Running state, the Motor Overload operand is set. If the current then falls below FLA x Overload Factor, the Motor Overload operand is reset and the Running operand is set.

In synchronous motor applications, during both the induction and synchronous modes, if the current rises above FLA x Overload Factor, the motor state becomes Motor Overload.

Note that in synchronous motor applications, during the overload condition, (Imotor FLA x OL) if the Power Factor Resync mode function (**Monitoring > Functions > Power Factor**) initiates a command to resynchronize the motor and the DC field is removed, the motor state is set to SM Resync.

Figure 10-9: Motor Overload state logic



In 2-Speed Motor applications, when the motor is switched from speed 1 to speed 2, FLA and CT Primary switch to Speed2 Motor FLA and Speed2 CT Primary (both set under **System > Motor > Setup**). In addition, during the transition from speed 1 to speed 2 the current may drop below 2% and the Motor Stopped status may become true. To prevent this, if the previous status is Running (or Starting or Overload), the 2-Speed Motor Protection is “Enabled,” and the Speed2 Motor Switch is true, then the motor status (Motor Running, Starting or Overload) is maintained for 1 second. After 1 second, if the motor current detected is less than the FLA x OL setting, the Motor Running operand is maintained; otherwise either the Overload or Stopped condition is declared.

During a transition from speed 2 to speed 1, if the previous status is Running (Starting or Overload), the 2-Speed Motor Protection is “Enabled,” and the Speed2 Motor Switch is true, then the motor status (Motor Running, Starting or Overload) is maintained for Speed2 Switch 2-1 Delay + 1 second.

NOTE

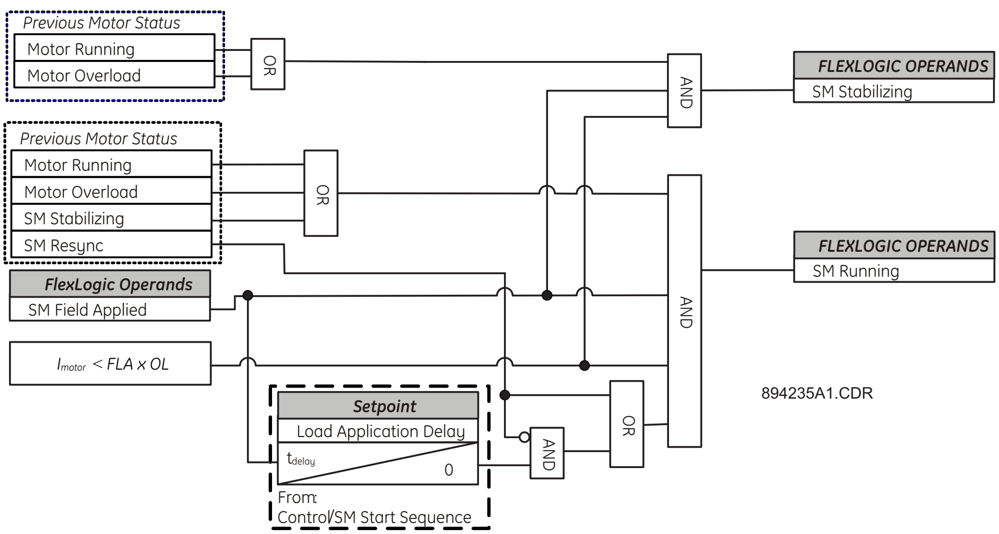
In synchronous motors, an idling condition results in the current ideally equal to zero. During the motor running condition, this can result in a Motor Stopped condition instead of an SM Running condition. To prevent this, it is strongly recommended that the 869 is always programmed to monitor the status of the switching device using a relay contact input.

Description of Synchronous Motor Specific State Operands

SM Stabilizing: After successful application of the motor DC field excitation (as described under the SM Field Applied Successfully setpoint below), the motor state machine asserts the SM Stabilizing state. The SM Stabilizing state remains high until the Load Application Delay timer expires. For more details on the Load Application Delay, see the SM Start Sequence Control function. The SM Stabilizing state indicates the successful application of motor DC-field excitation, but without a load applied.

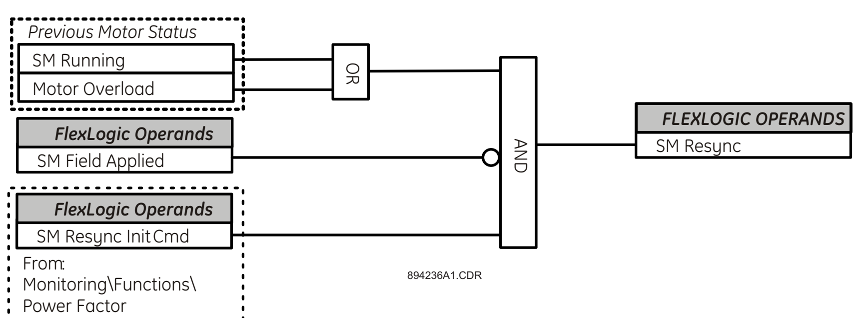
SM Running: As soon as the Load Application Delay timer expires, the SM Running state is asserted, indicating the successful synchronization of the synchronous motor with a load applied. If the Load Application Delay is set to zero, the SM Running state becomes high as soon as the motor DC-field excitation is applied. To set both the SM Stabilizing and SM Running states to high, the motor currents (stator currents) must be below the overload level (FLA x OL). Otherwise, Motor Overload is asserted by the state machine.

Figure 10-10: Motor SM Stabilizing and SM Running state logic



SM Resync: The SM Resync state is set high when the synchronous motor goes into resynchronization mode i.e. the motor DC-field excitation is removed by the relay Power Factor protection (in Resync Mode) while the motor remains running without a field applied (induction mode operation). This state requires that the Power Factor element be enabled and the PF Mode set to "Resync".

Figure 10-11: Motor SM Resync state logic



THERMAL CAPACITY USED

Range: 0 to 100%

Default: 0%

The Thermal Capacity Used value is continuously calculated and displayed when the thermal model element is enabled. When RTD Bias is enabled, this value shows the biased thermal capacity used.

ESTIMATED TRIP TIME ON OL

Range: 0 to 65000 s in steps of 1

Default: 0 s

The Estimated Time to Trip on OL is displayed when the motor is Starting, Running or in Overload condition. This value represents the estimated time to trip (in seconds) from the thermal model assuming that the motor current remains at its current level. It is obtained from the thermal model curve and takes into account that some percent of the thermal capacity has already been used. When RTD Bias is enabled, Estimated Trip Time on OL will take into account biased thermal capacity used.

SMFIELD APPLIED SUCCESSFULLY

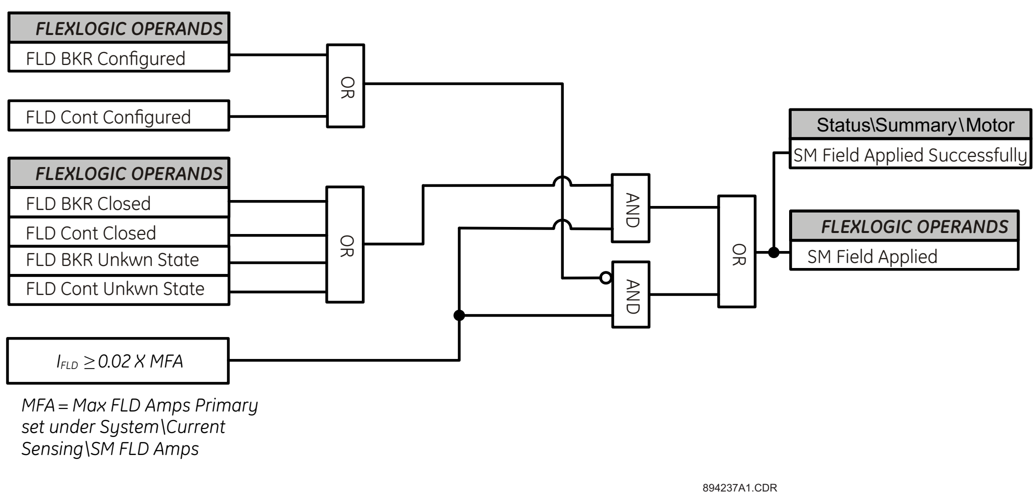
Range: No, Yes

Default: No

Successful application of a DC Field to the synchronous motor is detected based on the field current level (IFLD ≥ 0.02 x MFA, where MFA equals 'Max FLD Amps Primary' set in **System > Current Sensing > SM FLD Amps**) and the field switching device status (41a or 41b).

When a switching device is not configured* monitoring of the switching device status is not possible. In this case the SM Stabilizing, SM Running and SM Resync states are based on the monitoring of field current level only.

Figure 10-12: Successful application of DC field



NOTE

*A switching device is not configured when setpoints Contact Input 52a and Contact Input 52b are both set to "Off" under **Setpoints > Control > Breaker > Contactor**.

NOTE

The Start Inhibit lockout times (four values: Thermal Lockout, Max Start Rate, Time Btwn Starts, and Restart Delay) are constantly displayed regardless of the motor status. The times continuously decrease and when any value reaches zero, the respective lockout is removed.

Thermal Lockout Time

Range: 0 to 65000 s

SM Field Applied Successfully

Range: YES, NO

Max Start Rate LO Time

Range: 0 to 65000 s

Max C/H Start Rate LO Time

Range: 0 to 65000 s

Time Btwn Starts LO Time

Range: 0 to 65000 s

Restart Delay LO Time

Range: 0 to 65000 s

Total Motor Lockout Time

Range: 0 to 65000 s

The Total Motor Lockout Time displays the highest value of all calculated Start Inhibit lockout times: Thermal, Maximum Starting Rate, Time Between Starts and Restart Delay.

Motor Speed

Range: Low Speed, High Speed

Default: Low Speed

The motor is running at high speed when 2-Speed motor protection is employed and the Speed2 Motor Switch is closed. Otherwise, the motor speed will be determined as Low Speed.

Motor Running Hours

Range: 0 to 100000 hrs

Motor Running Hours shows the total motor running time.

Breakers and Contactors

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.

FIELD BREAKER STATUS

Path: **Status > Field Breaker Status**

STATE

Range: Not Configured, Opened, Closed, State Unknown

FIELD CONTACTOR STATUS

Path: **Status > Contactor > Contactor 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.

FIELD CONTACTOR STATUS

Path: **Status > Field Contactor Status**

STATE

Range: Not Configured, Opened, Closed, State Unknown

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 10-13: Status of Virtual Inputs, HMI

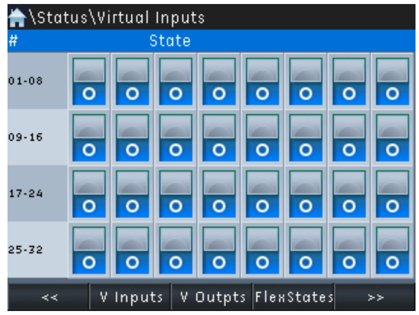


Figure 10-14: Status of Virtual Inputs, Enervista 8 Series Setup software

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 10-15: Status of Virtual Outputs, HMI

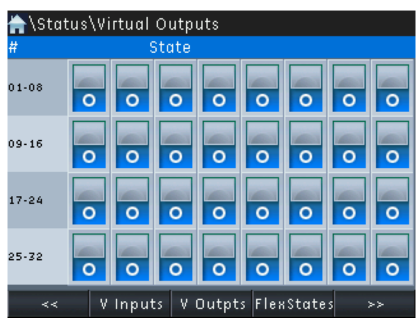


Figure 10-16: Status of Virtual Outputs, Enervista 8 Series Setup software

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

The selected Flex state parameter is available for status monitoring and the Modbus memory map, when the selected operand is asserted.

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 869 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 869 server supports a subset of the server features described in part 7.2 of the IEC61850 standard.

GOOSE MESSAGING

As indicated above, the 869 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 869 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.

GE
Grid Solutions

869 Motor Protection System

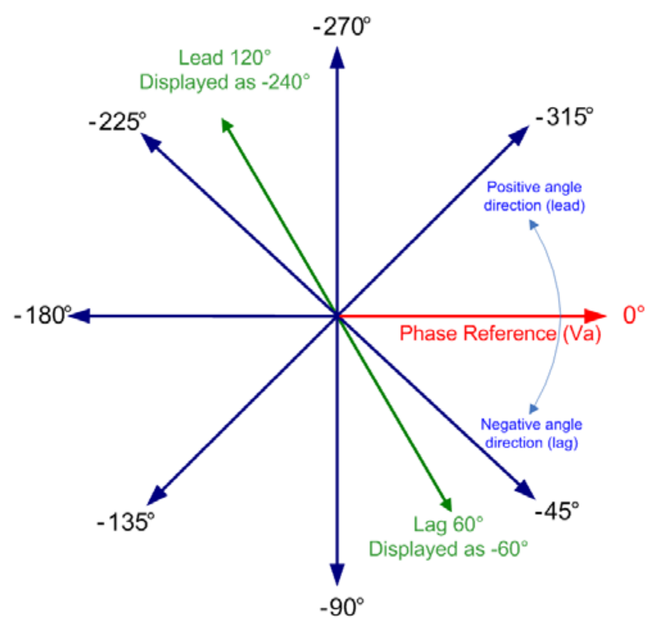
Chapter 11: Metering

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 menu

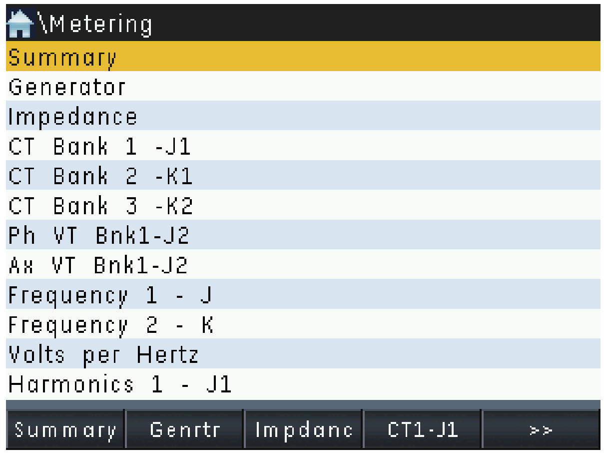
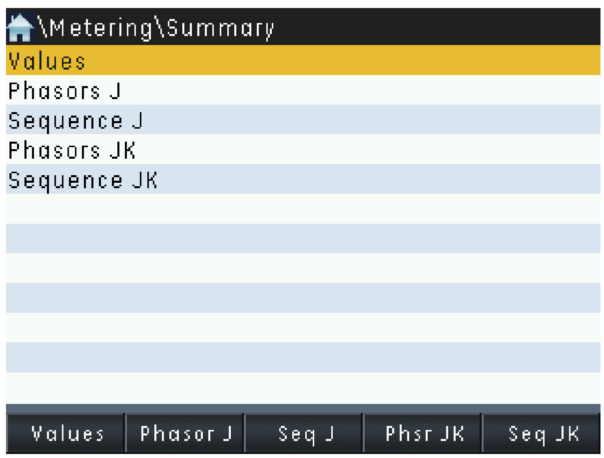
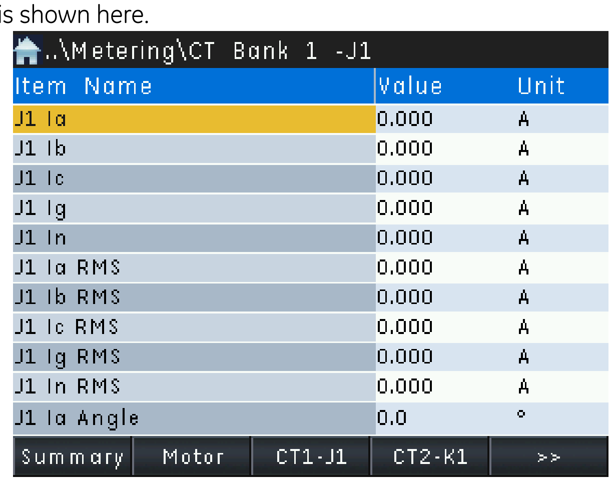


Figure 11-3: An example of the Metering\Summary submenu

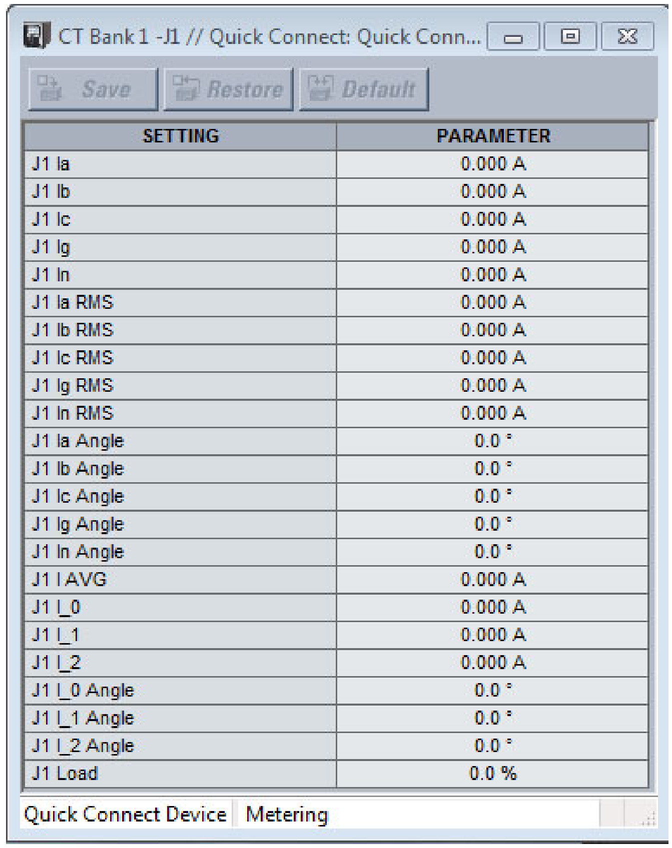


All the measured values can be viewed on the front panel display or monitored by remote devices through the communication system. An example of the HMI display showing actual currents is shown here.



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 11-4: Current Metering Screen (EnerVista 8 Series)



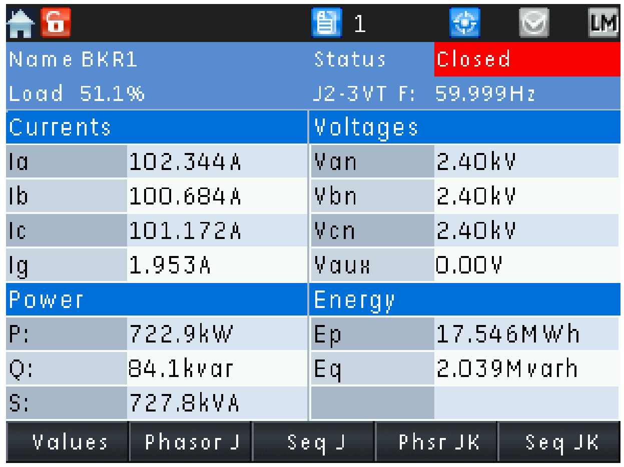
SETTING	PARAMETER
J1 Ia	0.000 A
J1 Ib	0.000 A
J1 Ic	0.000 A
J1 Ig	0.000 A
J1 In	0.000 A
J1 Ia RMS	0.000 A
J1 Ib RMS	0.000 A
J1 Ic RMS	0.000 A
J1 Ig RMS	0.000 A
J1 In RMS	0.000 A
J1 Ia Angle	0.0 °
J1 Ib Angle	0.0 °
J1 Ic Angle	0.0 °
J1 Ig Angle	0.0 °
J1 In Angle	0.0 °
J1 I AVG	0.000 A
J1 I_0	0.000 A
J1 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 %

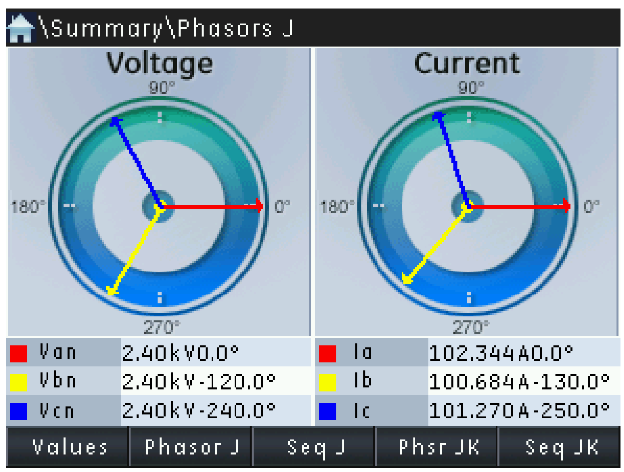
The complete list of actual values available in the Metering menu is covered in the following sections.

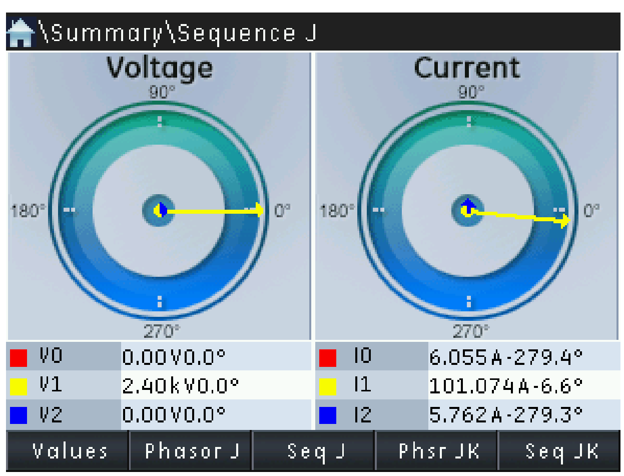
Summary

Path: Metering > Summary

The Metering Summary menu consists of display screens, including a graphical presentation of key phasor quantities.







Motor

Percent Differential Current

Path: Metering > Motor > Percent Differential

Phase A differential (Ia Diff)

Range: 0.000 to 120000.000 A

Phase B differential (Ib Diff)

Range: 0.000 to 120000.0000 A

Phase C differential (Ic Diff)

Range: 0.000 to 120000.000 A

Phase A restraint (Ia Restr)

Range: 0.000 to 120000.000 A

Phase B restraint (Ib Restr)

Range: 0.000 to 120000.000 A

Phase C restraint (Ic Restr)

Range: 0.000 to 120000.000 A

The phasors of differential and restraint currents are displayed in primary amperes.

The phasors of differential and restraint currents are displayed in primary amperes.

Motor Load

Path: Metering > Motor > Motor Load

MOTOR LOAD

Range: 0.00 to 40.00 x FLA in steps of 0.01 x FLA

The value represents the average of the three RMS load currents.

MOTOR CURRENT UNBALANCE

Range: 0.0 to 100.0% in steps of 0.1%

The Current Unbalance is defined as the ratio of negative-sequence to positive-sequence current, I_2 / I_1 when the motor is operating at a load (I_{avg}) greater than FLA. If the motor I_{avg} is less than FLA, unbalance is defined as $I_2 / I_1 \times I_{avg} / FLA$. A full explanation of the calculation of this value is presented for the Current Unbalance element.

THERM MODEL BIASED LOAD

Range: 0.00 to 40.00 x FLA in steps of 0.01 x FLA

This value represents the unbalance bias motor load that shows the equivalent motor heating current caused by the Unbalance Bias K factor.

FLTD MODEL LOAD

Range: 0.00 to 40.00 x FLA in steps of 0.01 x FLA

The value represents the average of the three filtered RMS load currents. The filtered RMS load currents represent the moving average of the RMS values obtained by using the motor load averaging filter of length equal to setpoint Motor Load Filter Interval (set under System/Motor/Setup). Motor load averaging filter is only applicable when Motor Load Filter Interval is set non-zero. Otherwise, this value is equal to the Motor Load. See figure “Motor Load Averaging Filter for VFD and Cyclic Load Motor Application”.

FLTD RMS Cur A/B/C

Range: 0.000 to 120000.000 A

This value represents the filtered value of the RMS phase current A/B/C. The filtered RMS phase current represents the moving average of the RMS values obtained by using the motor load averaging filter of length equal to the setpoint Motor Load Filter Interval (set under System/Motor/Setup). The Motor load averaging filter is only applicable when Motor Load Filter Interval is set non-zero. Otherwise, this value is equal to the platform RMS phase current. See figure “Motor Load Averaging Filter for VFD and Cyclic Load Motor Applications“.

FLTD MAG Cur A/B/C

Range: 0.000 to 120000.000 A

This value represents the filtered value of the phasor magnitude (Mag) phase current A/B/C. The filtered Mag phase current represents the moving average of the Mag values obtained by using the motor load averaging filter of length equal to the setpoint Motor Load Filter Interval (set under System/Motor/Setup). The Motor load averaging filter is only applicable when the Motor Load Filter Interval is set non-zero. Otherwise, this value is equal to the platform phasor magnitude phase current. See figure “Motor Load Averaging Filter for VFD and Cyclic Load Motor Application“.

Sync. Motor Field Winding

Path: **Metering > Motor > Sync Motor Field Winding**

ROTOR SLIP

Range:

Default:

This value represents .

SM PF REGULATOR OUTPUT

Range: Populates based on OUTPUT RANGE selection under the path **Setpoints > Control > SM PF Regulation**

Default: 0.00

This value represents the PF Regulation control output.

SM PF ERROR

Range: -1.00 to 1.00 in steps of 0.01

Default: 0.00

This value represents the difference (error) between the PF setpoint (target level) and measured value (feedback).

SM Field Resistance

Range: 0.00 to 500.00 ohms in steps of 0.01 ohms

Default: 0.00 ohms

This value represents the field resistance calculate from the primary side values of the field current and field voltage.

Speed

Path: **Metering > Motor > Speed**

SPEED

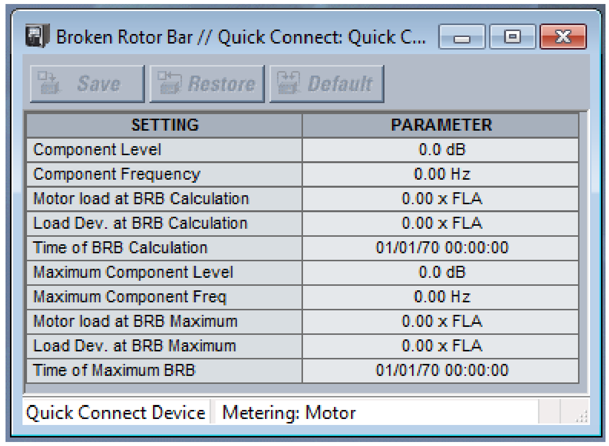
Range: 0 to 8640 RPM in steps of 1

Default: 0

Broken Rotor Bar

The effective operating quantities of the Broken Rotor Bar element are displayed here.

Path: **Metering > Motor > Broken Rotor Bar**



SETTING	PARAMETER
Component Level	0.0 dB
Component Frequency	0.00 Hz
Motor load at BRB Calculation	0.00 x FLA
Load Dev. at BRB Calculation	0.00 x FLA
Time of BRB Calculation	01/01/70 00:00:00
Maximum Component Level	0.0 dB
Maximum Component Freq	0.00 Hz
Motor load at BRB Maximum	0.00 x FLA
Load Dev. at BRB Maximum	0.00 x FLA
Time of Maximum BRB	01/01/70 00:00:00

NOTE

The algorithm runs only for the "Motor Running" condition and is blocked on any other motor status. The sample gathering and processing takes approximately 11 seconds in 60 Hz and 13 seconds in 50 Hz system, after all blocks are removed and all supervising conditions are satisfied.

Stator Inter-Turn Fault

Path: **Metering > Motor > Stator Inter-Turn Fault**

OPERATING QUANTITY

Range: 0.000 to 20.000 in steps of 0.001

Default: 0.400

This value represents the operating quantity of the Stator Inter-Turn Fault element.

LEARNED UNBAL Z

Range: 0.000 to 10.000 in steps of 0.001

Default: 0.200

This value represents the inherent asymmetries in the machine at the time of commissioning and without stator inter-turn fault. This value is defined as Unbalance Base Impedance (Z_{UBbase}) and calculated during the learning phase of the Stator Inter-Turn Fault algorithm.

TIME OF LEARNED UNBAL Z CALC

Range: Date/Time Format (MM/DD/YY HH:MM:SS)

Default: 01/01/08 00:00:00

This value represents the time when the learning phase has finished the calculation of the last averaged Unbalance Base Impedance (Z_{UBbase}).

MAX OPERATING QUANTITY

Range: 0.000 to 20.000 in steps of 0.001

Default: 0.500

This value represents the maximum of the operating quantity.

MAX LEARNED UNBAL Z

Range: 0.000 to 10.000 in steps of 0.001

Default: 0.200

This value represents the maximum of the learned Unbalance Base Impedance (Z_{UBbase}).

Bearing, Mechanical and Stator Fault

Path: Metering > Motor > Bearing Fault Baseline

Path: Metering > Motor > Bearing Fault Monitoring

Path: Metering > Motor > Mech Fault Baseline

Path: Metering > Motor > Mech Fault Monitoring

Path: Metering > Motor > Stator Fault Baseline

Path: Metering > Motor > Stator Fault Monitoring

AVG NORM PEAK MAG at k = 1 (2 or 3)

Normalized peak magnitude in dB at each frequency is calculated as the ratio of FFT magnitudes at specific frequency and at fundamental frequency for each k-factor. These normalized peak magnitude values are computed and stored continuously during baseline mode for each load bin and k-factor. All the dB values are averaged for each load bin and k-factor and stored as Avg. Norm Peak Mag @ k=1,2,3 in a file at the end of baseline period.

AVG ENERGY AT PEAK MAG at k=1 (2 or 3)

Energy magnitude is extracted as the area within +/- vicinity (0.5 Hz) of frequency (for each k-factor) corresponding to the highest normalized peak magnitude. These energy values are computed and stored continuously during baseline mode for each load bin. All the dB values are averaged for each load bin value and stored as Avg. Energy at Peak Mag at k=1,2,3 in a file at the end of the baseline period.

LOAD BIN

Load bin (1 to 12) represents at which loading condition the motor (or bearing, or mechanical fault, or stator fault) is computed from the 1 to >110% range with each bin comprising 10% load interval and 100% representing rated load.

TIME OF BASELINE COMPUTATION

Time of baseline computation is the time extracted when the Avg. highest normalized peak magnitude (base line) and Avg. energy at peak magnitude (base line) values are computed at the end of the base line period.

NORMALIZED PEAK MAGNITUDE at k=1 (2 or 3)

Normalized Peak Magnitude in dB represents the peak magnitude observed in FFT computation at all corresponding fault frequencies representing fault at k = 1,2,3 for a specific load bin.

ENERGY AT PEAK MAG at k=1 (2 or 3)

Energy at Peak Magnitude in dB represents the area observed within +/- 0.5 Hz region in FFT computation at the fault frequency corresponding to NORMALIZED PEAK MAGNITUDE at k=1 (2 or 3) for a specific load bin.

MAX CHANGE IN MAG dB at k=1 (2 or 3)

Max Change in Mag in dB represents the highest after the difference between normalized dB magnitude calculated with respect to baseline normalized peak magnitude dB (for all k-factors) for a specific load bin.

MAX CHANGE IN ENERGY at k=1 (2 or 3)

Max Change in Energy in dB, represents the highest difference between energy magnitude calculated with respect to baseline energy dB (for all k-factors) for a specific load bin.

ESTIMATED SPEED

The 869 relay estimates speed based on rated input power, rated speed and power input to the motor. This field displays estimated speed.

TIME OF FAULT COMPUTATION

This time represents the 8 Series local time at which the Highest normalized peak and energy magnitudes are computed within each ESA cycle.

Short Circuit

Path: Metering > Motor > Short Circuit

NOTE

These values are only seen if
Setpoints \ Protection \ Group1\Motor \ Short Circuit \ Function = NOT Disabled.

SC RMS Ia

Range: 0.000 to 120000.000 A in steps of 0.001

SC RMS Ib

Range: 0.000 to 120000.000 A in steps of 0.001

SC RMS Ic

Range: 0.000 to 120000.000 A in steps of 0.001

Impedance

Positive Sequence Impedance

The positive sequence impedance is shown here. The ohm values are presented in secondary ohms. Positive sequence impedance 1 is calculated using 3-phase J1 Currents and 3-phase J2 Voltages. Positive sequence impedance 2 is calculated using 3-phase K1 Currents and 3-phase J2 Voltages.

Path: Metering > Impedance > Positive Impedance 1 (X)

Z1 Resistance

Range: 0.00 to 6553.50 ohms in steps of 0.01

Z1 Reactance

Range: 0.00 to 6553.50 ohms in steps of 0.01

Z1 Magnitude

Range: 0.00 to 6553.50 ohms in steps of 0.01

Z1 Angle

Range: -359.9° to 359.9° in steps of 0.1

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)

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

Sensitive Ground (Isg)
Range: 0.000 to 1200.000 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

Sensitive Ground (Isg RMS)
Range: 0.000 to 1200.000 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°

Sensitive Ground Angle (Isg 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°

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°

Synchronous Motor Slot-K2 Values

Path: Metering > SM Slot - K2

SM Field VAC
Range: 0.00 to 3000.00 V in steps of 0.01 V

SM Field VDC
Range: 0.00 to 3000.00 V in steps of 0.01 V

SM Field Amps
Range: 0.00 to 3000.00 A in steps of 0.01 A

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

FLD VAC Frequency
Range: 0.000 to 120.000 Hz in steps of 0.001 Hz

FLD VAC Frq Rate of Chge
Range: -120.00 to 120.00 Hz/sec in steps of 0.01 Hz/sec

Fast Underfrequency

The frequency and rate of change monitored in the Fast Underfrequency element are displayed here only if the element is enabled.

Path: Metering > Fast Underfrequency

Fast Frequency
Range: 20.000 to 70.000 Hx in steps of 0.01

Fast Rate of Change
Range: -120.00 to 120.00 Hz/s in steps of 0.01

Harmonics 1(Harmonics 2)

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**

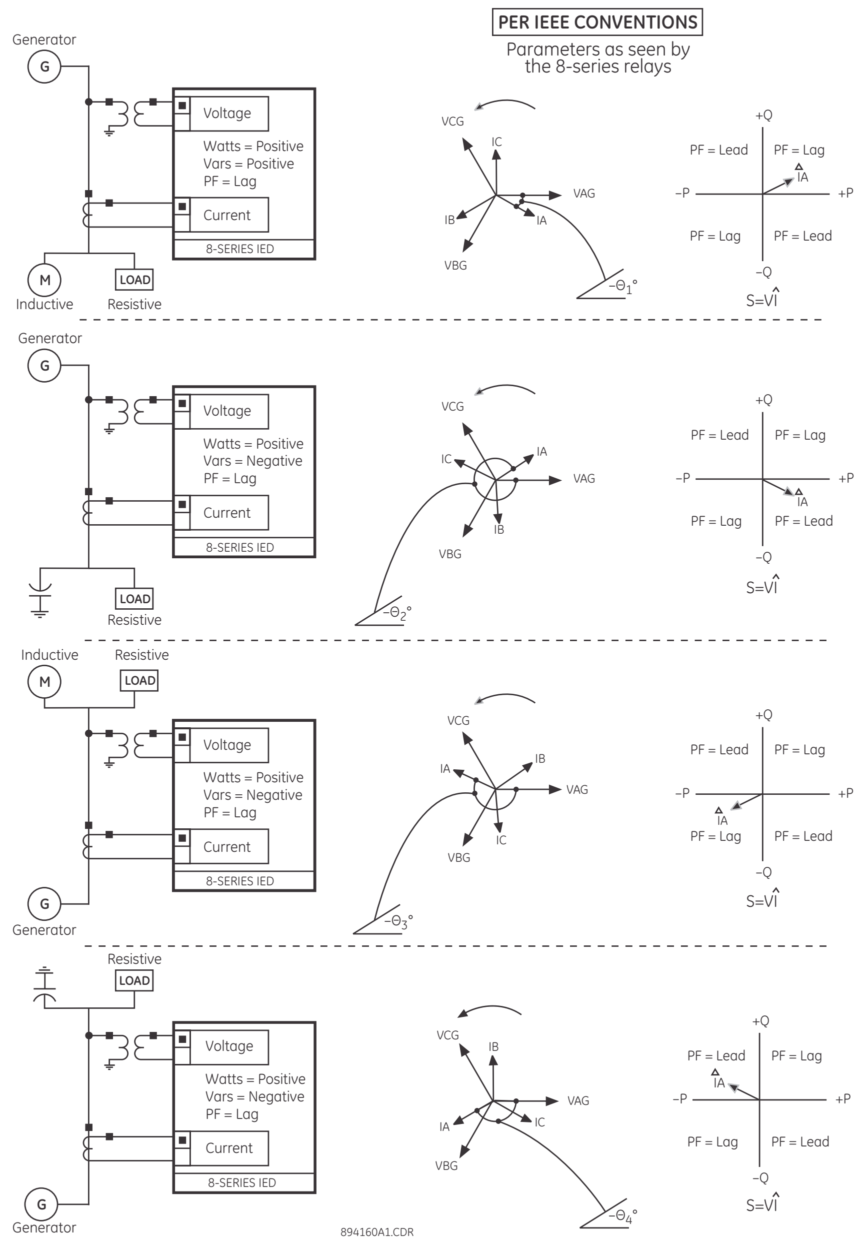
Power

The following figure illustrates the convention used for measuring power and energy in the 8 Series devices.

NOTE

Power 1 is calculated using 3-phase J1 Currents & 3-phase J2 Voltages.

Figure 11-5: 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

Power Demand

For real/reactive/apparent power quantities, the relay displays the Demand values over the most recent time interval. The time interval refers to the time since the last reset.

Power demand quantities can be reset to zero by either of the following methods:

- **Records > Clear Records** command - resets the corresponding demand quantities.
- Using any operand programmed under the setpoint Reset Demand (**Monitoring > Functions > Demand**) - resets the max and min demand values
- using any operand programmed under **Device > Clear Records** - resets the max and min demand values.

NOTE

If average current drops below 0.02 x CT, calculation of the minimum real/reactive/ apparent demand is blocked, and metering remains at the level measured at the time of the block.

Path: **Metering > Power Demand 1(X)**

Reset Dmd Date/Time MM/DD/YY 00:00:00

Real Demand (Real Dmd)

Range: 0.0 kW to 214748364.7 kW

MMax Real Dmd

Range: 0.0 kW to 214748364.7 kW

Date/Time Real Dmd MM/DD/YY 00:00:00

Reactive Demand (Reactive Dmd)

Range: 0.0 kvar to 214748364.7 kvar

Max Reactive Dmd

Range: 0.0 kvar to 214748364.7 kvar

D/T Reactive Dmd MM/DD/YY 00:00:00

Apparent Demand (Apparent Dmd)

Range: 0.0 kVA to 214748364.7 kVA

Max Apparent Dmd

Range: 0.0 kVA to 214748364.7 kVA

D/T Apparent Dmd MM/DD/YY 00:00:00

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**.

Hottest Stator RTD #

Range: 1 to 13

Hottest Stator RTD Temp

Range: -40 to 250°C (-40 to 482°F)

This value shows the hottest RTD temperature from the group of RTDs when setpoint Application is programmed as Stator. The other conditions to display this value are: RTD N must not be Disabled (both Trip and Alarm functions) and must not be detected Shorted or Open RTD.

Hottest Bearing RTD #

Range: 1 to 13

Hottest Bearing RTD Temp

Range: -40 to 250°C (-40 to 482°F)

This value shows the hottest RTD temperature from the group of RTDs when setpoint Application is programmed as Bearing.

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**.

Hottest Stator RRTD # 1

Range: 1 to 12

Hottest Stator RRTD Temp 40°C

Range: -40 to 250°C

This value shows the hottest RRTD temperature from the group of RRTDs when setpoint Application is programmed as Stator. The other conditions to display this value are: RRTD n must not be Disabled (both Trip and Alarm functions) and must not be detected Shorted or Open RTD.

Hottest Bearing RRTD #2

Range: 1 to 12

Hottest Bearing RRTD Temp 40°C

Range: -40 to 250°C

This value shows the hottest RTD temperature from the group of RRTDs when setpoint Application is programmed as Bearing.

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

GE
Grid Solutions

869 Motor Protection System

Chapter 12: Records

Events

The 869 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).

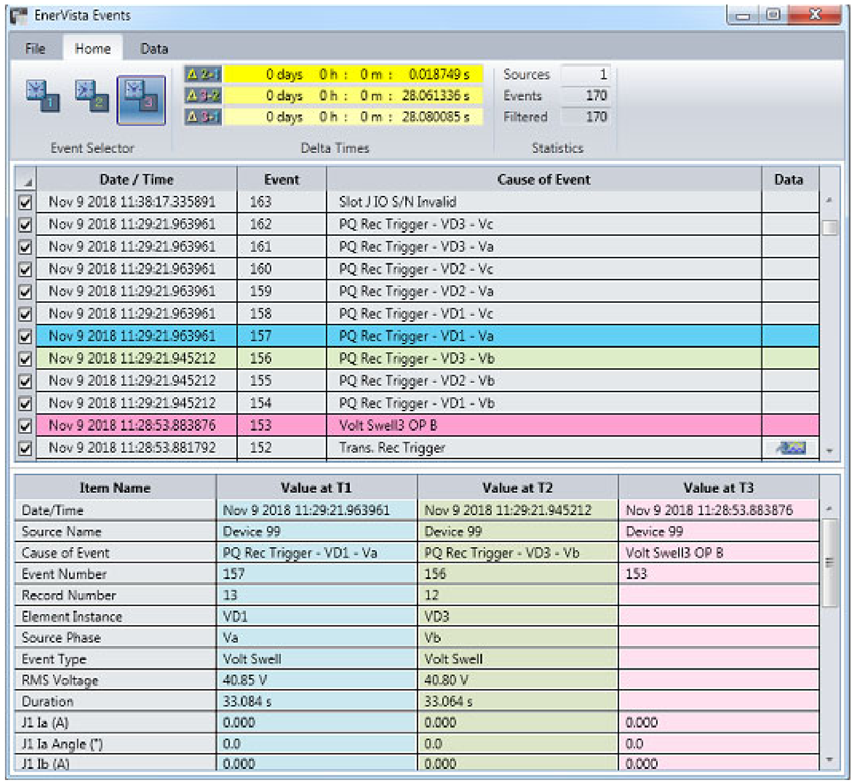
To open the Event Viewer for a connected device, follow these steps in the EnerVista 8 Series Setup software:

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).

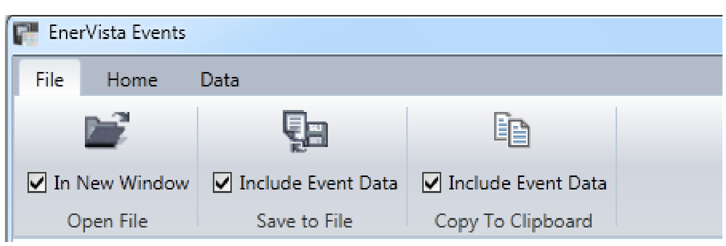
☐	Date/Time	Cause of Event	Data
☑	Nov 10 2017 10:20:20.842706	Fault Rpt Trig — Fault report symbol	
☑	Nov 10 2017 10:19:08.006650	Trans. Rec Trigger — Oscillography record symbol	

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.



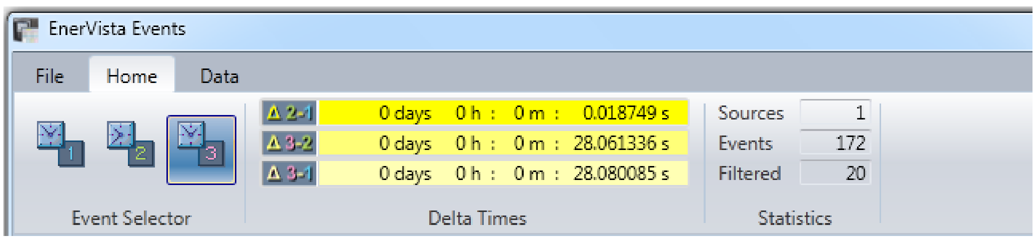
- **Open File**: opens a window to browse to an events file (of type .eev, .txt. or .evt) and opens it in the existing Event Viewer window, or in a new Event Viewer window.
  - Check **In New Window** to open the file in a new Event Viewer window.

- **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.

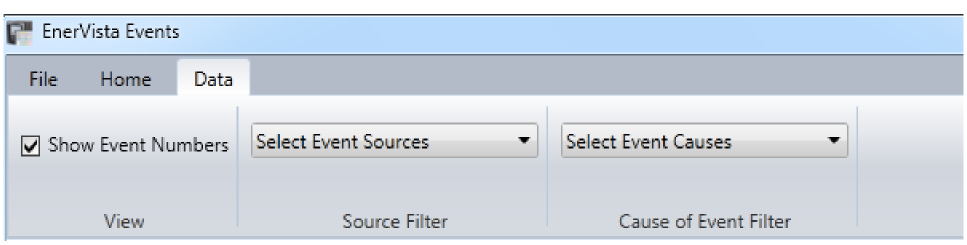
The absolute times between the three selected events are displayed above the **Delta Times** label.

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

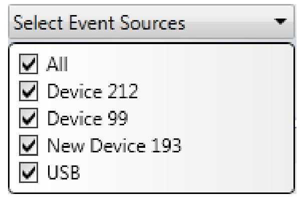
Use the **Data** tab to filter the events shown in the Event Viewer.



- **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 869 device.

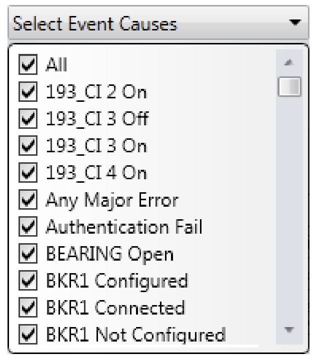
- **Select Event Sources**: provides a drop-down list of all available event sources (devices and files). Uncheck a device or file to hide the associated events from the main list.

  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 869 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

Motor Start Records

When a motor start status is detected by the 869 relay, a start data record is triggered and begins to sample and record the following parameters at a rate of 1 sample every 100 ms:

Motor Start Record Values	Type	Asynchronous Motor Applications*	Synchronous Motor Applications**
True RMS values of the phase A current (Ia)	FlexAnalog	•	•
True RMS values of the phase B current (Ib)		•	•
True RMS values of the phase C current (Ic)		•	•
Average of true RMS values of the three-phase currents (Iavg)		•	•
True RMS value of the ground current (Ig)		•	•
Current unbalance (%)		•	•
True RMS values of the phase A-N, B-N, and C-N voltages (Van, Vbn, and Vcn) if VT is Wye connected or phase A-B, B-C and C-A voltages (Vab, Vbc, and Vca) if VT is delta connected.)		•	
Average of the three-phase Voltage (V Avg L-N if VT is Wye Connected or V Avg L-L if VT is Delta Connected)			•
Three-phase real power		•	•
Three-phase reactive power		•	
Three-phase power factor		•	•
Thermal capacity used (%)		•	•
Frequency		•	•
Rotor Slip			• (brush-type only)
SM Field VAC			•
SM Field VDC			•
SM Field Amps			•
SM SC Spd-Dep TC Used			• (brush-type only)
Motor Status (Stopped, Starting, Running, SM Stabilizing, SM Running, SM Resync, Overload, Tripped)	FlexLogic Operand	•	•
Start Seq. Completed			•
Start Seq INC			•
Load Applied			•
SM Field Applied			•

NOTE

* Requires Order Code selection 'NN/S1/S5' for Phase Currents - Slot K Bank 1/2

** Requires Order Code selection 'C5/D5' for Phase Currents - Slot K Bank 1/2

1-second pre-trigger data and 59-second post-trigger data are recorded. The data record ignores all subsequent triggers and continues to record data until the active record is finished.

A total of 6 records are stored in the relay. Record # 1 is the baseline record; it is written to only by the first start that occurs after the user clears the motor start records. Records #2 to 6 are a rolling buffer of the last 5 motor starts. A new record automatically shifts the rolling buffer and overwrites the oldest record, #2.

The record files are formatted using the COMTRADE file format. The files can be downloaded and displayed via EnerVista 8 Series Setup software. All the files are stored in non-volatile memory, so that information is retained when power to the relay is lost.

The viewing, customizing and saving the Motor Start Records is the same as the Transient Records.

Clearing start records (RECORDS > CLEAR RECORDS > MOTOR START RECORDS) clears the stored files. The date and time are recorded when clearing. An event 'Clear Start Rec' is sent to the Event Record. The records can also be cleared using EnerVista 8 Series Setup.

Path: **Records > Motor Start Records**

Motor Start Statistics

Path: **Records > Motor Start Statistics 1(5)**

START DATE/TIME

Range: mm/dd/yy and hh:mm:ss
Default: 01/01/08 and 00:00:00

START ACCELERATION TIME

Range: 0.000 to 250.000 s in steps of 0.001Default: 0.000 s

START EFFECTIVE CURRENT

Range: 0.00 to 20.00 x FLA in steps of 0.01Default: 0.00 x FLA

START PEAK CURRENT

Range: 0.00 to 20.00 x FLA in steps of 0.01Default: 0.00 x FLA

Up to five starts are reported. When the buffer is full the newest record overwrites the oldest one.

Learned Data

The 869 measures and records individual data records, as indicated below, all from actual motor operation. The latest individual data record "set" can be viewed using the Learned Data feature on the relay. The data, when input cumulatively to the Learned Data Recorder (see below) can be used to evaluate changes/trends over time. Note that learned values are calculated even when features requiring them are disabled.

The Learned Data recorder measures and records up to 250 data record "sets," all from actual motor operation. The data can be used to evaluate changes/trends over time. All available stored motor learned data records can only be retrieved using EnerVista 8 Series Setup program from Records > Learned Data Records menu

Clearing learned data (**RECORDS > CLEAR RECORDS > LEARNED DATA**) resets all these values to their minimum values and clears the stored file. The date and time is recorded when clearing. An event 'Clear Learned Rec' is sent to the Event Record. The next record is be captured after N successful starts.

NOTE

Each of the learned features discussed below must not be used until at least N successful motor starts and stops have occurred, where N is defined by the setting in **SETPOINTS > SYSTEM > MOTOR > NUMBER OF STARTS TO LEARN**.

The last stored Motor Learned Data records can be viewed from the following menu.

Path: **Records > Learned Data**

RECORDS SINCE CLEAR

This value shows the number of records since the last clearance.

LAST CLEAR DATE/TIME

Range: MM/DD/YY HH:MM:SS

This value is the date and time on which the record was cleared.

LEARNED ACCELERATION TIME

Range: 0.000 to 250.000 s in steps of 0.001 s

The learned acceleration time is the longest acceleration time measured over the last N successful starts, where N is defined by the setting in **SETPOINTS > SYSTEM > MOTOR > NUMBER OF STARTS TO LEARN**. Acceleration time is the amount of time the motor takes to reach the running state from stopped. A successful motor start is one in which the motor reaches the running state.

If acceleration time is relatively consistent, the learned acceleration time plus suitable margin can be used to manually fine-tune the acceleration protection setting. The learned acceleration time must not be used until several successful motor starts have been measured.

LEARNED STARTING CURRENT

Range: 0.00 to 20.00 x FLA in steps of 0.01 x FLA

The learned starting current is the average starting current measured over the last N successful starts, where N is defined by the setting in **SETPOINTS > SYSTEM > MOTOR > NUMBER OF STARTS TO LEARN**. The effective current is used as starting current as defined in the element of Acceleration Time. A successful motor start is one in which the motor reaches the running state.

LEARNED START TCU

Range: 0 to 100% in steps of 1%

The Learned Start Thermal Capacity is the largest Start Thermal Capacity Used value calculated by the thermal model over the last N successful, where N is defined by the setting in **SETPOINTS > SYSTEM > MOTOR > NUMBER OF STARTS TO LEARN**. The Start

Thermal Capacity Used is the amount of thermal capacity used during starting. A successful motor start is the one in which the motor reaches the running state. If the thermal capacity used during starting is relatively consistent, the Learned Start Thermal Capacity Used value plus suitable margin can be used to manually fine-tune the thermal start inhibit margin. See the Start Supervision section of the 869 Instruction manual,this manual, for a description of how the Learned Start Thermal Capacity Used is calculated. The Learned Start Thermal Capacity Used value must not be used until at least N successful motor starts have occurred.

LAST ACCELERATION TIME

Range: 0.000 to 250.000 s in steps of 0.001 s

The last acceleration time is measured after a successful motor start.

LAST STARTING CURRENT

Range: 0.00 to 20.00 x FLA in steps of 0.01 x FLA

The last starting current is measured after a successful motor start.

LAST START TCU

Range: 0 to 100% in steps of 1%

The last start thermal capacity used is measured after a successful motor start.

LEARNED AVERAGE LOAD

Range: 0.00 to 20.00 x FLA in steps of 0.01 x FLA

Learned average load is the average motor current, expressed as a multiple of FLA over a period of time, when the motor status is Running. The period of data window is tAVER, specified in **SETPOINTS > SYSTEM > MOTOR > LOAD AVERAGE CALC. PERIOD**. If the run time of a start/stop sequence is less than t_{AVER}, the Learned Average Load averages all available samples. The calculation is ignored during motor starting. The data will be updated every t_{AVER} minutes once the motor status is Running. In the case of two-speed motors with different FLA values for the two speeds, the FLA used for each current sample is the one in effect at the time that sample was taken.

LEARNED AVERAGE kW

Range: 0.0 to 100000.0 kW in steps of 0.1 x kw

Learned average kW is the average motor real power when the motor status is Running. The period of data window is t_{AVER}, specified in **SETPOINTS > SYSTEM > MOTOR > LOAD AVERAGE CALC. PERIOD**. If the run time of a start/stop sequence is less than t_{AVER}, the Learned Average kW averages all available samples. The calculation is ignored during motor starting. The data will be updated every t_{AVER} minutes once the motor status is Running.

LEARNED AVERAGE kvar

Range: 0.0 to 100000.0 kvar in steps of 0.1 x kvar

Learned average kvar is the average motor reactive power when the motor status is Running. The mechanism is the same as the Learned Average kW.

LEARNED AVERAGE PF

Range: -0.99 to 1.00 in steps of 0.01

Learned average PF is the average motor power factor when the motor status is Running. The mechanism is the same as the Learned Average kW.

AVERAGE RUN TIME (DAYS/HR/MIN)

Range: 0 to 100000 Days; 0 to 23 Hours; 0 to 59 Minutes

The average Run Time of the last N starts at the time the record was saved. If the amount of minutes exceeds 59, the Average Run Time (Hours) is increased by one, and this value rolls over to zero and continues. If the amount of hours exceeds 23, the

Average Run Time (Days) is increased by one, and this value rolls over to zero and continues. N is defined by the setting in **Setpoints > System > Motor > Number of Starts to Learn**.

SPEED – MAX

Range: 0 to 8200 RPM

The maximum speed is recorded. If the measured speed is greater than the maximum value already stored, the maximum value is set to this latest value. The maximum value is maintained in non-volatile memory to carry over a relay power interruption. The Speed element is configured accordingly.

ANALOG INPUT 1(4) – MIN/MAX

Range: -500000 to 500000 units

The maximum/minimum analog input values are recorded. If the analog input value is greater than the maximum value already stored, the maximum value is set to this latest value. The maximum value is maintained in non-volatile memory to carry over a relay power interruption. Analog Inputs elements are configured accordingly.

RTD 1(13) MAX TEMPERATURE

Range: -40 to 250°C

The maximum temperature experienced by each of the RTDs.Once a second each of the RTD temperature values is captured. For each RTD, if the captured RTD temperature value is greater than the RTD maximum temperature already stored, the RTD maximum temperature is set to the latest captured RTD temperature value. The RTD maximum temperature values are maintained in non-volatile memory to carry over a relay power interruption. RTD elements are configured accordingly.

Additional Learned value for Synchronous Motor Applications

When the 869 order code is for synchronous motor (SM) applications, the following additional parameters are learned:

LEARNED START SM SC TCU

Range: 0 to 100% in steps of 1%

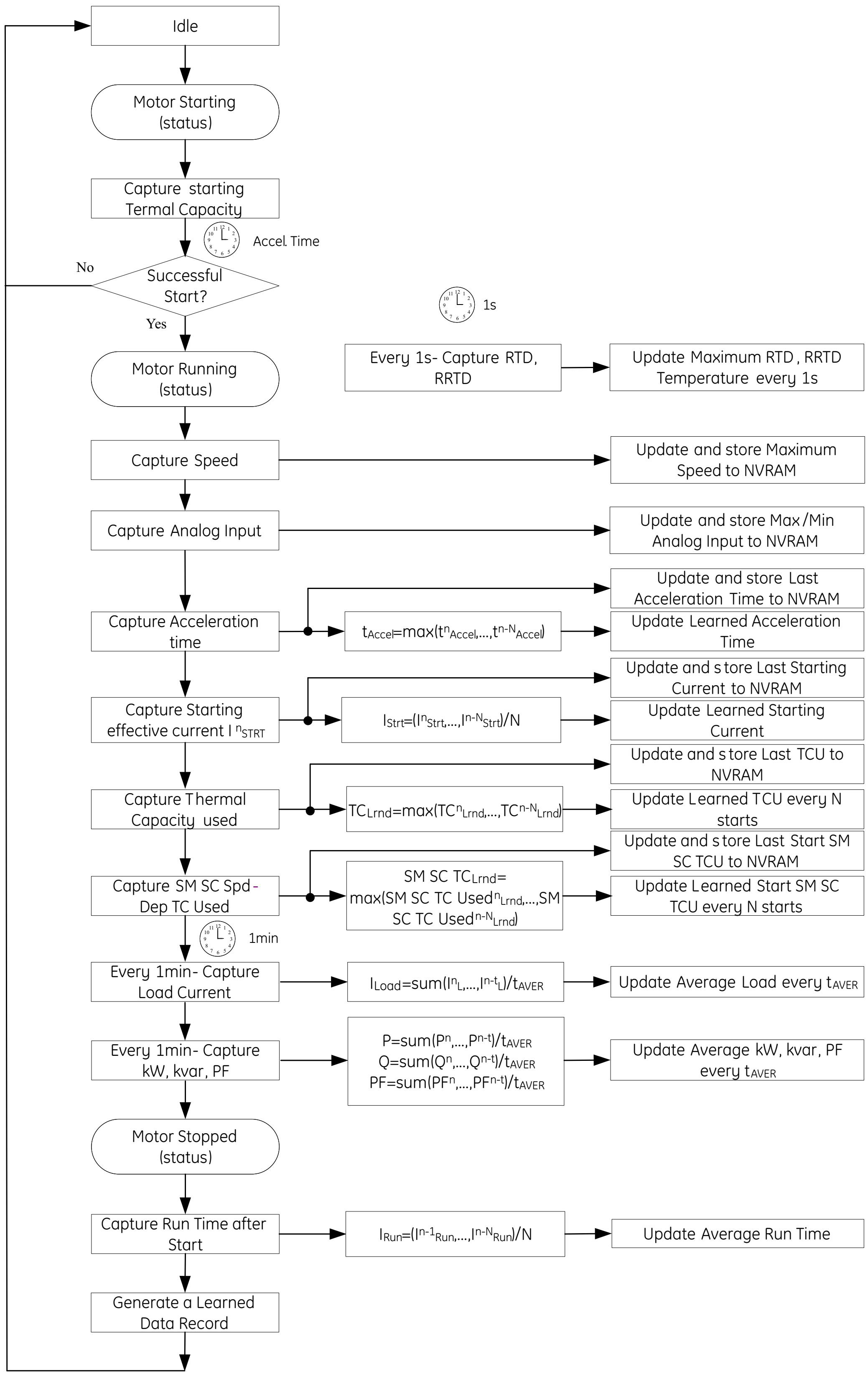
This value specifies the learned speed-dependent thermal capacity of the squirrel-cage (SC) rotor windings of a brush-type synchronous motor (SM). The learned start thermal capacity is the largest start thermal capacity used value calculated by the SM Speed-dependent Thermal Protection over the last N successful starts, where N is defined by the setting in **Setpoints > System > Motor > Number of Starts to Learn**.

LAST START SM SC TCU

Range: 0 to 100% in steps of 1%

The last Start SM SC Thermal Capacity used is measured after a successful motor start.

Figure 12-1: Motor learned Data Functionality



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

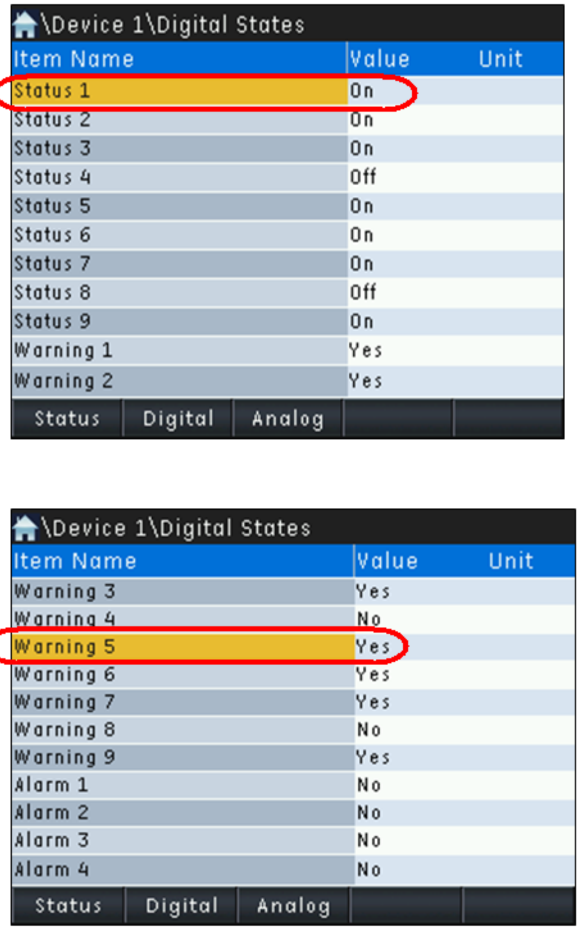
Default: Off

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 12-2: 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

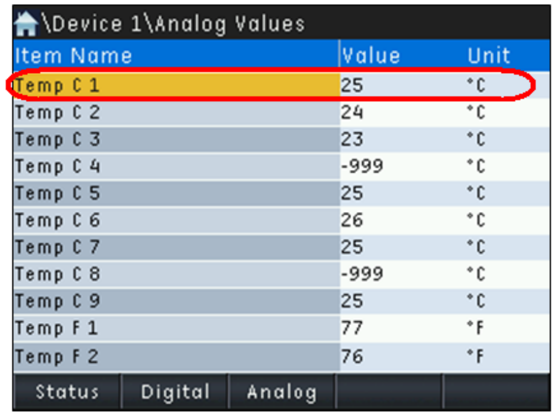
Up to 64 FlexAnalog operands can be shown here.

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 12-3: Example for Analog Values of the default BSG3 RMD profile



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

Power Quality

From the EnerVista 8 Series Setup click "View Records from PQ Event File" to open the file pqevt.txt and displays all saved events (maximum 30).

Path: **Records > PwrQuality Events > Event X**

Element Instance
Default: VD1
Range: VD1, VD2, VD3

Source Phase
Default: None
Range: None, Va, Vb, Vc

Event Type
Default: None
Range: None, Volt Sag, Volt Swell

RMS Voltage

Default: 0.00 V

Range: 0.00 to 1000000.00 V in steps of 0.01 V

For Volt Sag events, RMS Voltage is the minimum voltage recorded during the event duration, while for Volt Sag events the RMS Voltage is the maximum voltage recorded during the event duration.

Date/Time

Default: 01/01/70 00:00:00

Range: Date/Time Format (MM/DD/YY HH:MM:SS)

Date/Time is recorded at the end of the Volt Sag or Volt Swell condition.

Duration

Default: 0.000 s

Range: 0.000 to 600.000 s in steps of 0.001

Volt Swell and Volt Sag event Duration is recorded in terms of seconds, and is the total length of time from the rising edge of the pickup to dropout.

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

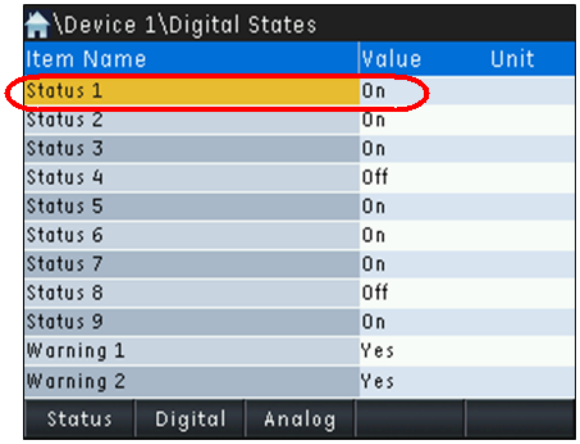
Default: Off

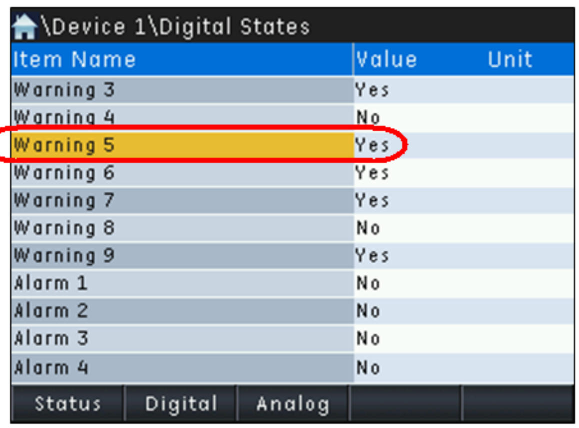
Up to 32 FlexLogic operands can be shown here.

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 12-4: 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

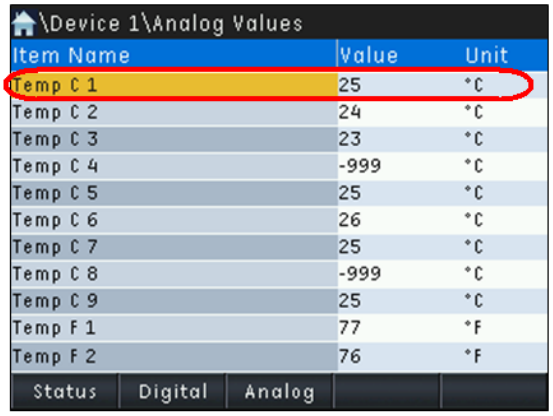
Up to 64 FlexAnalog operands can be shown here.

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 12-5: 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.

GE
Grid Solutions

869 Motor 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 869 product remedial action can be required. The 869 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 869 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

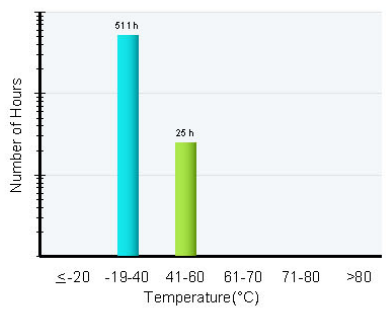
Generated At:	May 14, 2015 03:15 PM

DEVICE ENVIRONMENT STATISTICS

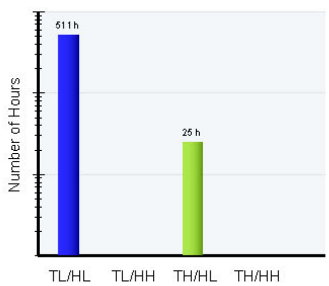
Summary	
Time In Service	22 Days 8 Hrs 53 Mins 6 Secs
Time Since Last Power cycle	0 Days 1 Hrs 46 Mins 26 Secs
Minimum Ambient Temperature	25.71°C
Maximum Ambient Temperature	42.61°C
Average Ambient Temperature	37.82°C

Summary	
Minimum Humidity	13.14%
Maximum Humidity	30.45%
Average Humidity	13.14%

Ambient Temperature

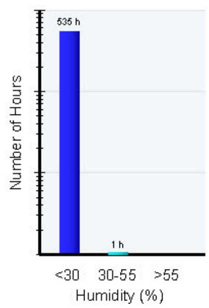


Ambient / Humidity Combination

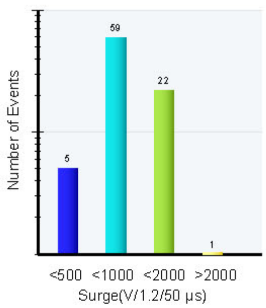


TL: Temp < 40°C
TH: Temp > 40°C
HL: Humidity < 55%
HH: Humidity > 55%

Humidity



Surge Detection



8 Series EnerVista SETUP

Version 1.40

Motor Health Report

The motor health reporting function is included with every 869 relay, providing critical information on the historical operating characteristics of the motor during motor starting and stopping operations during a programmable time period. The report can be generated as a PDF file using the EnerVista 8 Series Setup software. The health report includes seven categories:

- **Device Overview** gives general information on the motor, including requested period, user name, device name, order code, firmware version, motor and system settings, and motor total running time.
- **Status Overview** summarizes the historical learned data and gives an evaluation of the status of the motor, including the oldest and latest values of acceleration time, starting current, start thermal capacity used, average motor load, average power and power factor, and average running time. The data are extracted from the category of Motor Starting Learned Information below.
- **Trip Summary** gives a summary of the events that have tripped the motor.
- **Motor Operating History** analyzes the operands in the Event Records to count the amount of events in terms of Motor Starting/Running, Manual Stop Commands, Trip Commands, Lockouts, Alarm Conditions, and Emergency Restarts.
- **Motor Starting Learned Information** collects the learned data from the element of Motor Learned Data, including acceleration time, starting current, start thermal capacity used, average motor load, average power and power factor, and average running time. Every time a successful start occurs, a Learned Data Record is created. The relay stores the previous 250 Learned Data Records.
- **Motor Start Records** displays the start data recorded in the element of Motor Start Records, including average of three-phase RMS currents, ground current, average of three-phase RMS voltages, real and reactive power, power factor, thermal capacity used, frequency and motor status. When a motor start status is detected, a start data record is triggered, where 1-second pre-trigger data and 59-second post-trigger data are recorded. A total of 6 records are stored in the relay. Record # 1 is the baseline record and it is written to only by the first start that occurs after clearing the motor start records. The rest records are a rolling buffer of the last 5 motor starts.
- **Motor Stopping/Tripping** gives details on the events that are specifically related to the stopping and the tripping of the motor.

The analysis in Trip Summary, Motor Operating History and Motor Stopping/Tripping is based on the classification of operands stored in the Event Records. The classification rules are listed in the table below.

NOTE

To ensure the listed operands are able to be classified, the Events function in the associated elements needs to be enabled.

Figure 13-2: Event Classification Rules

Element	Operand	Trip Summary				Motor Operating History						Motor Stopping/Tripping																		
		Overload/Thermal	Current	Volt/Frequency/Power	Miscellaneous	Starting/Running	Manual Stop Commands	Trip Commands	Lockouts	Alarm Conditions	Emergency Restarts	Overload Trip	Mechanical Jam	Short Circuit	Underpower	Current Unbalance	RTD Temperature	Ground Fault	Under/Over Voltage	Under/Over Frequency	Manual/Remote Stop	Acceleration Time	Percent Differential	Overcurrent	Undercurrent	Phase Reversal	Directional Power	Field Under/Over Voltage	Field Under/Over Current	Field Overtemperature
Current	Ph IOC 1 OP		X					X																X						
	Ph IOC 2 OP		X					X																X						
	Ph TOC 1 OP		X					X																X						
	Ntrl IOC 1 OP		X					X																X						
	Ntrl IOC 2 OP		X					X																X						
	Ntrl TOC 1 OP		X					X																X						
	GND IOC 1 OP		X					X																X						
	GND TOC 1 OP		X					X																X						
	NegSeq IOC 1 OP		X					X																X						
Voltage	Phase UV 1 OP			X				X											X											
	Phase UV 2 OP			X				X											X											
	Phase OV 1 OP			X				X											X											
	Phase OV 2 OP			X				X											X											
	Aux OV OP			X				X											X											
	Neutral OV 1 OP			X				X											X											
	Neg Seq OV 1 OP			X				X											X											
Frequency	Underfreq 1 OP			X				X												X										
	Underfreq 2 OP			X				X												X										
	Underfreq 3 OP			X				X												X										
	Underfreq 4 OP			X				X												X										
	Overfreq 1 OP			X				X												X										
	Overfreq 2 OP			X				X												X										
Pwr	DirPwr 1 OP			X				X																			X			
	DirPwr 2 OP			X				X																			X			
Motor	Thermal Alarm OP									X																				
	Thermal Trip OP	X						X				X																		
	SC Thermal Trip OP	X						X				X																		
	SC Thermal Alarm OP									X																				
	Motor Accel Time OP				X			X														X								
	Mech Jam OP		X					X					X																	
	Underpwr Alarm OP									X																				
	Underpwr OP			X				X							X															
	Short Circuit OP		X					X						X																
	Cur Unbal Alarm OP									X																				
	Cur Unbal OP		X					X								X														
	Single Phasing OP		X					X								X														
	GndFault Alarm OP									X																				
	GndFault Trip OP		X					X										X												
	Overload Alarm OP									X																				
	Undercurr Alarm OP									X																				
	Undercurr Trip OP		X					X																	X					
	Percent Diff Warn									X																				
	Percent Diff OP		X					X															X							
	RTD # Open									X																				
	RTD # Shorted									X																				
	RTD # Alarm OP									X																				
	RTD # Trip OP	X						X									X													
	Thermal Inhibit OP								X																					
	Max Start Rate OP								X																					
	Time Btwn Start OP								X																					
	Restart Delay OP								X																					
	Phase Reversal OP			X				X																		X				

Figure 13-3: Event Classification Rules - continued

Element	Operand	Trip Summary				Motor Operating History						Motor Stopping/Tripping																		
		Overload/Thermal	Current	Volt/Frequency/Power	Miscellaneous	Starting/Running	Manual Stop Commands	Trip Commands	Lockouts	Alarm Conditions	Emergency Restarts	Overload Trip	Mechanical Jam	Short Circuit	Underpower	Current Unbalance	RTD Temperature	Ground Fault	Under/Over Voltage	Under/Over Frequency	Manual/Remote Stop	Acceleration Time	Percent Differential	Overcurrent	Undercurrent	Phase Reversal	Directional Power	Field Under/Over Voltage	Field Under/Over Current	Field Overtemperature
Motor Cont.	Phase Rev Inhibit								X																					
	Broken Rtr Bar OP									X																				
	FLD OC1 Alarm OP									X																				
	FLD OC 1 Trip OP		X					X																					X	
	FLD OC 2 Alarm OP									X																				
	FLD OC 2 Trip OP		X					X																					X	
	FLD UC 1 Alarm OP									X																				
	FLD UC 1 Trip OP		X					X																					X	
	FLD UC 2 Alarm OP									X																				
	FLD UC 2 Trip OP		X					X																					X	
	FLD OV 1 Alarm OP									X																				
	FLD OV 1 Trip OP			X				X																			X			
	FLD OV 2 Alarm OP									X																				
	FLD OV 2 Trip OP			X				X																			X			
	FLD UV 1 Alarm OP									X																				
	FLD UV 1 Trip OP			X				X																			X			
	FLD UV 2 Alarm OP									X																				
	FLD UV 2 Trip OP			X				X																			X			
	Motor Running					X																								
	Cnct1 Local Open						X														X									
	SW1 Local Open						X														X									
	BKR1 Local Open						X														X									
	Cnct1 Rem Open																				X									
	SW1 Remote Open																				X									
	BKR1 Remote Open																				X									
	Emergency Restart										X																			
Monitor	Trip Coil Mon 1 OP									X																				
	Cls Coil Mon 1 OP									X																				
	BKR1 Arc OP									X																				
	BKR1 Hlth PKP									X																				
	BKR1 Hlth OP Fail									X																				
	BKR1 Arc Fail									X																				
	BKR1 Charge Fail									X																				
	Current Dmd PKP									X																				
	RealPwr Dmd PKP									X																				
	ReactvPwr Dmd PKP									X																				
	ApprntPwr Dmd PKP									X																				
	BF1 OP									X																				
	VT Fuse Fail 1 OP									X																				
	VT Fuse 1 V Loss									X																				
	FLD OverTemp 1 Alrm OP									X																				
	FLD OverTemp 1 Trip OP							X																						X
	FLD OverTemp 2 Alrm OP									X																				
	FLD OverTemp 2 Trip OP							X																						X

General Maintenance

The 869 requires minimal maintenance. As a microprocessor-based relay, its characteristics do not change over time. The expected service life of a 869 is 20 years when the environment and electrical conditions are within stated specifications.

While the 869 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.

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869 Motor Protection System

Appendix A

Application Notes

Contactor Current Supervision

In some cases, the fault current can exceed the current which the contactor is rated to interrupt. If such a condition has been detected, the 869 blocks the operation of the output relay 1 “Trip” and operates a selected auxiliary output relay. The same auxiliary output relay has to be wired to the upstream switching device (usually a breaker) that is rated to interrupt the fault current. Finally, if the current has not decreased below the contactor rated current for a programmable time, the block to the output relay 1 is removed.

The sequence described above is intended to prevent damages to the contactor. In order to use this sequence, the user has to configure the IOC 1 protection element, build a FlexLogic Equation and configure output relays “Trip” and “Auxiliary”.

In the example below, Auxiliary output relay 4 has to be wired to the upstream switching device.

1. IOC 1 configuration

Function = Configurable

Input = RMS

Pickup = [Contactor rated current, e.g. 10.000 x CT]

Direction = Disabled

Pickup Delay = [Duration of Trip relay block, e.g. 1.000 s]

Dropout Delay = 0.000

Block = Off

Output Relay 4 = Disabled

Events = Enabled

Targets = Latched

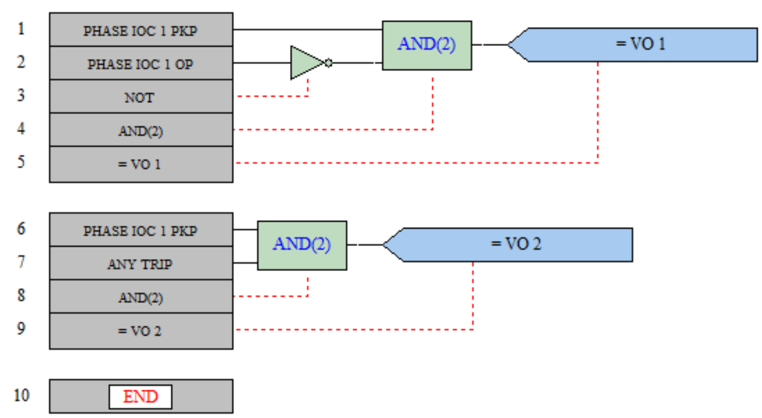
SETTING [GROUP 1]	PARAMETER
Function	Configurable
Input	RMS
Pickup	10.000 x CT
Direction	Disabled
Pickup Delay	1.000 s
Dropout Delay	0.000 s
Block	Off
Output Relay	Relay : Disabled
Events	Enabled
Targets	Latched

2. FlexLogic equation

Example build of a FlexLogic Equation

View Graphic	View	View
FlexLogic Entry 1	Protection/Currents	Phase IOC 1 PKP
FlexLogic Entry 2	Protection/Currents	Phase IOC 1 OP
FlexLogic Entry 3	NOT	1 Input
FlexLogic Entry 4	AND	2 Inputs
FlexLogic Entry 5	Assign Virtual Output	= VO 1
FlexLogic Entry 6	Protection/Currents	Phase IOC 1 PKP
FlexLogic Entry 7	Any Trip	Any Trip
FlexLogic Entry 8	AND	2 Inputs
FlexLogic Entry 9	Assign Virtual Output	= VO 2
FlexLogic Entry 10	End of List	

The above build represented graphically



3. Output relays configuration

The output relay settings can be changed via the EnerVista 8 Series Setup software.

Trip	
Trip Seal-In Time	0.04 s
Trip Block Trip	Virtual Output 1 On

Aux Relay 4	
Aux Relay 4 Name	Upstr Trip
Aux Relay 4 Operate	Virtual Output 2 On
Aux Relay 4 Type	Self-Reset
Aux Relay 4 Events	Enabled

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869 Motor Protection System

Appendix B

Appendix B includes the warranty and revision history.

Warranty

For products shipped as of 1 October 2013, GE Grid Solutions warrants most of its GE manufactured products for 10 years. For warranty details including any limitations and disclaimers, see the GE Grid Solutions 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 1: Revision History

MANUAL P/N	RELEASE DATE
1601-0450-A1	June 2014
1601-0450-A2	July 2014
1601-0450-A3	December 2014
1601-0450-A4	May 2015
1601-0450-A5	August 2015
1601-0450-A6	March 2016
1601-0450-A7	December 2016
1601-0450-A8	July 2017
1601-0450-A9	February 2018
1601-0450-AA	March 2018

Table 1: Revision History

MANUAL P/N	RELEASE DATE
1601-0450-AB	July 2018
1601-0450-AC	December 2018
1601-0450-AD	May 2019

Major Updates

Table 2: Major Updates for 869-AD

Chapter	CHANGES
general	New Synchronous Motor Features: SM Speed-Dependent Thermal Protection, SM Field Undercurrent, SM Field Overcurrent, SM Field Undervoltage, SM Field Overvoltage, Sm Start Sequence Control, Incomplete Start Sequence Function, SM Field Overtemperature Other new features: Fast Underfrequency, Local Control Mode, Updated features: Mechanical Jam, Power Factor Regulation Minor corrections throughout. Menu diagrams updated throughout.
cover	Manual revision number from AC to AD
1	Overview, Single Line Diagram, and feature tables updated. Security Overview note added re. Enervista Viewpoint Monitor. Order codes updated. Specifications added for new features. Metering specifications updated.
2	Dimensions (figure 2-2) updated with two different terminal strip types. Typical wiring diagram updated to 892769A3. (figure 2-18). Synchronous Motor typical wiring diagrams (brushless and brush-type) added. (figures 2-21 and 2-22) Synchronous motor field switching devices (contactor and breaker) typical wiring diagrams added. (figure 2-23) Terminal Strip Type section added. Output relay tables updated. Magnetic Module installation section updated. VDN section added.
3	SM SLD added to Single Line Diagram section.
5	Annunciator description updated. Current Sensing section updated. New Diagram 894257A1. Power System section updated. New diagram 824256A1. Motor Setup description updated. VFD section note added. SM Field Breaker section added. New diagram 824246A1. SM Field Contactor section added. New diagram 824247A1. MODBUS Protocol settings updated (ALL). FlexCurve ST section added.

Table 2: Major Updates for 869-AD

Chapter	CHANGES
6	Synchronous Motor section added with new features. New diagrams 894238A1, 894239A1, 894240A1, 894241A1, 894242A1. Thermal Model: description updated and logic updated to 894101A2 and 894102A6. Mechanical Jam minor updates and logic updated to 894095A2. Loss of Excitation: Logic updated to 894172A2 and 894173A2. Overload Alarm: Logic updated to 894097A2. Acceleration Time: description updated and logic updated to 894088A2. Phase Reversal description updated and logic updated to 894161A2. Out-of-step: Logic updated to 894229A1. Reactive Power: Note added, logic updated to 894174A2. Electrical Signature Analysis (ESA) setpoint added and logic updated to 894208A3. Phase Directional OC: table updated and logic updated to 894260A1. Fast Underfrequency section added.
7	SM Field Overtemperature section added. New diagram 894243A1. SM Power Factor Regulation added. New diagrams 894244A1, 894245A1 Rotor Bar: note added. Synchronous Motor Power Factor logic diagram added 894255A1. Stator Inter-turn fault logic updated to 894152A4.
8	Local Control Mode description updated and logic for contactor updated to 894201A3. SM Start Sequence Control section added. New DIagrams 894249A1, 894250A1, 894251A1, 894252A1, 894253A1, 894254A1. SM Field Switching Device Control section added. New diagrams 894248A1, 894258A1, 894259A1.
9	Annunciator operands added. Motor Thermal Model FlexLogic operands updated. Synchronous Motor and Fast Underfrequency operands added. Power Factor operands updated FlexElements description updated. Base Units table updated.
10	Information section descriptions updated. Breakers section changed to Breakers and Contactors and updated. Motor description updated. Added diagrams 894230A1, 894231A1, 894232A1, 894233A1, 894234A1, 894235A1, 894236A1. Added synchronous motor state operands. Added setpoint SM FIELD APPLIED SUCCESSFULLY and diagram 894237A1.
11	Sync. Motor Field Winding section added. Energy section updated.
12	Event Viewer section added. Motor Start Records description updated.
13	Motor Health Report section updated.

Table 3: Major Updates for 869-AC

Chapter	CHANGES
general	New: Voltage Disturbance, Voltage Swell, Voltage Sag, Time of Day Timers, Sensitive Ground Instantaneous Overcurrent, Sensitive Ground Time Overcurrent. Minor corrections throughout.
cover	Manual revision number from AB to AC

Table 3: Major Updates for 869-AC

Chapter	CHANGES
1	Order Codes updated. Specifications, Protection, added Sensitive Ground TOC and IOC. Specifications, Monitoring, Added Voltage Disturbance, Voltage Swell, Voltage Sag, Time of Day Timers. 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	Added Optional external I/O card K terminal mapping. Added External Summation Percent Differential Wiring diagram. Wire Size updated.
3	Configuring USB Address added.
5	Added Power Sensing setpoint RESET EVENT ENERGY. Updated Current Sensing section. Data Logger setpoint RATE updated.
6	Added Sensitive Ground Instantaneous Overcurrent Added Sensitive Ground Time Overcurrent
7	Updated Demand setpoints and logic diagrams. Added Time of Day Timers.
9	Added FlexLogic operands for Sensitive Ground Instantaneous Overcurrent, Sensitive Ground Time Overcurrent, Voltage Disturbance, Voltage Swell, Voltage Sag, Time of Day Timers, IEC 61850 mappings.
11	Added Energy Log.
12	Added Power Quality Events.

Table 4: Major Updates for 869-AB

Chapter	CHANGES
cover	Manual revision number from AA to AB
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 added. 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.
7	Trip and Close Circuit Monitoring section updated. Harmonic Detection logic diagram updated.
9	FlexElements RTD base unit corrected.

Table 5: Major Updates for 869-AA

Chapter	CHANGES
cover	Manual revision number from A9 to AA
1	Specifications, Metering, Voltage Accuracy for open delta connections updated
3	Added note about online label templates.
5	Security setpoint descriptions added. FlexCurves setpoint updated. Output Relay 1 TRIP logic diagram updated.
8	Setpoint group example updated.

Table 6: Major Updates for 869-A9

Chapter	CHANGES
general	New: RMIO/RRTDs, I/O cards, FlexCurve OL.
cover	Manual revision number from A8 to A9, and Product version revision from 2.0x to 2.2x
1	Note and link to online store for available order codes updated. Order codes updated for 2.2, including new I/O cards. RMIO order codes added. Operator role clarified. Specifications: FlexCurves, ESA, Fast Underfrequency, RTDs, Contact Inputs, Output Relays, 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.
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	Updated Motor Setup. Added Device > Clear Records section. Updated Transient Recorder section. Data Logger FUNCTION description updated. Display Properties: German added to Language settings. Breakers section updated to specify number supported. Flexcurve OL added to Flexcurves section.
6	Added SIGNAL INPUT, and VT INPUT setpoints to protection elements as applicable. Updated Underfrequency logic diagram. Updated Thermal Model section.
7	Added SIGNAL INPUT, and VT INPUT setpoints to monitoring elements as applicable. Updated ESA section. RTD Temperature section updated with new RRTDs. Speed Protection nate added and logic diagram updated.

Table 6: Major Updates for 869-A9

Chapter	CHANGES
8	Added SIGNAL INPUT, and VT INPUT setpoints to control elements as applicable. Added Breaker Control note.
9	Updated Test section.
10	Added Settings Audit section.
n/a	Minor corrections throughout.

Table 7: Major Updates for 869-A8

Chapter	CHANGES
cover	Manual revision number from A7 to A8, and Product version revision from 1.7x to 2.0x
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
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 Wattmetric Ground Fault logic diagram to 894053A2.cdr to add settings for CT and VT inputs

Table 7: Major Updates for 869-A8

Chapter	CHANGES
4	Added new ESA section to Setpoints > Monitoring
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 Contactor Control section to Setpoints > Control > Contactor Control
4	Added new Ethernet Loopback test section to Setpoints > Testing
4	Created new Contactor logic diagram 894206A1.cdr and revised the Contactor section in Setpoints > System > Motor > Setup > Switching Device
6	Added new Bearing, Mechanical and Stator fault section to Metering > Motor

Table 8: Major Updates for 869-A7

PAGE NUMBER (A6	PAGE NUMBER (A7)	CHANGES
		Manual revision number from A6 to A7, and Product version revision from 1.6x to 1.7x
1-7	1-8	Revised 869 Order Code information
1-21	1-21	Changed Time Delay to 200,000,000 ms for Introduction>Specifications>User-Programmable Elements>FlexCurves
2-9	210-	Replaced Typical Wiring diagram (892824A3.cdr) with new Typical Wiring diagram 892769A1.pdf
4-, 5-, 6-, 7-	4-, 5-, 6-, 7-	Removed the HMIs associated with the path descriptions in each chapter
-	4-7	Added new Custom Configuration section to Setpoints>Device
-	4-44	Added new Remote Modbus Device section to the Setpoints>Communications
4-34	4-31	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
4-143	4-133	Revised the Current unbalance section to include the inverse curves
-	4-144	Added new Loss of Excitation to section Setpoints>Protection>Motor
4-163	4-167	Removed the "Time" setting from the "Speed2 Acceleration" element found under Protection>Motor section

Table 8: Major Updates for 869-A7

PAGE NUMBER (A6	PAGE NUMBER (A7)	CHANGES
4-163	4-159	Removed the "Time" setting from the "Acceleration Time" element found under Protection>Motor section
-	4-283	Revised Power Factor feature for lead/lag in Setpoints>Monitoring>Functions
-	4-236	Added new Volts per Hertz section to Setpoints>Protection>Voltage Elements
-	4-65	Added the "Max. Acceleration Time" and "Speed2 Max. Accel. Time" settings to the System>Motor>Setup section
-	4-233	Added new Out-of-Step section to Setpoints>Protection>Impedance Elements
-	4-317	Added new RTD Trouble section to Setpoints>Monitoring
-	4-319	Added new Loss of Communications section to Setpoints>Monitoring
-	4-306	Added new Speed section to Setpoints>Monitoring
4-352	4-352	Updated the FlexLogic Operands table

Table 9: Major Updates for 869-A6

PAGE NUMBER (A5)	PAGE NUMBER (A6)	CHANGES
cover	cover	Manual revision number from A5 to A6, and Product version revision from 1.5x to 1.6x
cover	cover	Replaced GE Digital Energy with GE Grid Solutions throughout
1-18	1-17	Added Harmonic detection specification to Specifications>Monitoring
2-9	2-8	Revised the typical wiring diagram to 892824A3.cdr (renamed the analog output examples)
-	4-63	Added Configurable Snapshots section to Setpoints>Device
-	4-231	Added Auxiliary Undervoltage to Setpoints>Protection>Voltage Elements
-	4-283	Added Stator Inter-Turn Fault to Setpoints>Monitoring
-	4-310	Added Harmonic Detection section to Setpoints>Monitoring
4-350	4-315	Moved RTD Temperature from Setpoints>RTD Temperature to Setpoints>Monitoring>RTD Temperature
4-329	4-342	Revised the FlexLogic table to add Flexlogic operands for harmonic detection
4-355	4-365	Added Testing>Simulation section after FlexLogic section
-	5-4	Updated the Status chapter to include Last trip data section
-	6-6	Added Stator Inter-Turn Fault to Metering>Motor
6-9	6-10	Replaced "Harmonics 1" and "Harmonics 2" sections with "Harmonic 1 (Harmonics) 2"
6-12	6-14	"Current J1" renamed "Current 1"
-	6-18	Added FlexElements to Metering chapter

Table 9: Major Updates for 869-A6

PAGE NUMBER (A5)	PAGE NUMBER (A6)	CHANGES
-	7-2	Added Fault Reports to Records chapter
7-4	-	Removed Learned Data Records from Records chapter
7-7	7-6	"Motor Learned Data" renamed "Learned Data"

Table 10: Major Updates for 869-A5

PAGE NUMBER (A4)	PAGE NUMBER (A5)	CHANGES
		Manual revision number from A4 to A5, and Product version revision from 1.4x to 1.5x
1-8	1-8	Updated 869 order codes, see slots B, C, G and H
1-	1-9	Added Arc Flash specifications to Specifications>Protection
1-	1- 22, 1-23	Added Analog Inputs and Analog Outputs to Specifications> Inputs and Specifications>Outputs respectively
2-8	2-8	Revised Typical Wiring diagram to 892824A2.cdr
4-	4-100, 4-113	Added Analog Inputs and Analog Outputs details to Setpoints>Inputs and Setpoints>Outputs
4-	4-324	Added Arc Flash protection details to Setpoints>Control
4-323	4-323	Revised the FlexLogic table to add the new Flexlogic operands
4-341	4-350	Updated RTD Temperature details, i.e. table
5-	5-4	Updated Status chapter to include Arc Flash status description
6-	6-12, 6-14	Updated Metering chapter to include Arc Flash and Analog Inputs

Table 11: Major Updates for 869-A4

PAGE NUMBER (A3)	PAGE NUMBER (A4)	CHANGES
		Manual revision number from A3 to A4, and Product version revision from 1.3x to 1.4x
1-4	1-4	Added: 81R-frequency rate of change to ANSI device numbers table
1-8	1-8	Added 81R element (Voltage monitoring) to order code; added Flex State specification
1-18	1-19	Added Flex State specification
1-21	1-22	Removed 120 Ω Nickel, 100 Ω Nickel, 10 Ω Copper from Specifications>Inputs>RTD inputs (Types (3-wire))
2-8	2-8	Replaced drawing 892788B2.cdr with 892824A1.cdr and updated stop symbol for the breaker application, output relays
4-67	4-64	Added Device>Flex State description
4-102	4-102	Revised entire section Outputs>Output Relays and removed Auxiliary Output relays sub-section

Table 11: Major Updates for 869-A4

PAGE NUMBER (A3)	PAGE NUMBER (A4)	CHANGES
4-113	4-111	Updated Protection description list to add Frequency rate of change
4-242	4-243	Added: Frequency Elements>Frequency rate of change section
4-273	4-475	Replaced drawing 892745B1.cdr with 894059A2.cdr in Monitoring>Power Factor section
4-332	4-343	Removed 120 Ω Nickel, 100 Ω Nickel, 10 Ω Copper from RTD Temperature section (Type)
5-1	5-1	Removed heading for Lockout Times from Motor>Lockout Times
5-6	5-7	Added: Flex State status description
General	General	Minor Corrections

Table 12: Major Updates for 869-A3

PAGE NUMBER	CHANGES
	Manual revision number from A2 to A3, and Product version revision from 1.2x to 1.3x
Chapter 2	added specifications for new and modified features
Chapter 4	Added 2 Speed Motor protection, updated Acceleration time, updated Mechanical jam, added Reduced Voltage starting, updated RTD temperature, updated Thermal model, updated Undercurrent
Chapter 5	Added 2 Speed Motor protection
Chapter 6	Updated RTD
General	Minor Corrections

Table 13: Major Updates for 869-A2

PAGE NUMBER	CHANGES
	Manual revision number from A1 to A2, and Product version revision from 1.0x to 1.2x
Cover	Revised title
Chapter 1	Revised specifications and order code table
Chapter 2	Revised wiring diagrams, rear terminal descriptions
Chapter 3	Revised front panel display descriptions, EnerVista setup
Chapter 4	Revised setpoint descriptions, PC program screen shots, diagrams, and logic diagrams
Chapter 5, 6, 7	Revised some PC program screen shots and settings descriptions
Chapter 8	Revised Event Classification Rules figure, some images, and settings descriptions
Appendix A	added application note
Appendix B	added change notes and warranty description

Table 13: Major Updates for 869-A2

PAGE NUMBER	CHANGES
General	Minor Corrections