GE
Grid Solutions

350
Feeder Protection System
Feeder protection and control

Instruction manual

350 revision: 2.3x
Manual P/N: 1601-9086-AP
GE publication code: GEK-113507X

imagination at work

WORLDWIDE 10 YEAR WARRANTY

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GE Multilin Inc. 350 Feeder Protection System instruction manual for revision 2.3x.

Part number: 1601-9086-AP (September 2017)

Storage

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

NOTICE

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

This product cannot be disposed of as unsorted municipal waste in the European Union. For proper recycling return this product to your supplier or a designated collection point. For more information go to www.recyclethis.info.

⚠CAUTION

GENERAL SAFETY PRECAUTIONS - 350

- Failure to observe and follow the instructions provided in the equipment manual(s) could cause irreversible damage to the equipment and could lead to property damage, personal injury and/or death.
- 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.
- 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.
- 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.
- At all times, equipment ground terminal must be grounded during device operation and service.
- In addition to the safety precautions mentioned all electrical connections made must respect the applicable local jurisdiction electrical code.
- Before working on CTs, they must be short-circuited.
- 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.
- This product uses optical electronic devices (line or point sensors) to sense arc flash fault conditions. It is recommended to follow proper housekeeping measures and establish a regularly scheduled preventive maintenance routine to ensure proper device operation.
- 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, the user should follow the cautions mentioned in the arc flash installation section.
- This guide is intended to provide protective relay application guidance to mitigate arc flash incident energy. This guide does not endorse energized work. This guide does not claim that protective relaying can totally protect personnel from the dangers of an arc flash. The only way to completely prevent injury from arc flash events is to de-energize the equipment and properly follow safe lockout/tagout procedures to ensure the equipment remains de-energized.

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.**

For further assistance

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

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Markham, Ontario
Canada L6C 0M1
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4. ACTUAL VALUES

350 Feeder Protection System

Chapter 1: Introduction

Overview

The 350 is a microprocessor-based relay for primary and backup over-current protection of medium and low voltage distribution feeders. The relay is also suitable for providing over-current and backup protection for small and medium size motors, transformers, generators, and distribution bus-bars. The small footprint and the withdrawable option make the 350 relay ideal for panel mounting on either new or retrofit installations. The combination of proven hardware, a variety of protection and control features, and communications, makes the relay ideal for total feeder protection and control. Equipped with serial (RS485), USB, and Ethernet ports with the possibility of adding redundancy (IEC62439, PRP and HSR), and a wide selection of protocols such as Modbus, DNP3.0, IEC 60870-5-103, 60870-5-104, IEC61850 GOOSE, OPC-UA, the 350 relay is the best-in-class for MCCs and PCCs, SCADA and inter-relay communications. The 350 relay provides excellent transparency with respect to power system conditions and events, through its four-line 20-character display, as well as the EnerVista 3 Series Setup program. Conveniently located LEDs provide indication of relay operation, alarm, and pickup, as well as breaker, and relay status.

The 350 relay provides the following key benefits:

- Withdrawable small footprint – saves on rewiring and space. (non-draw out version is also available)
- Multiple protection groups with the added flexibility of switching through a wide selection of overcurrent protection and control features.
- Fast setup (Quick Setup) menu for power-system setup and a simple overcurrent protection configuration.
- Large four-line LCD display, LEDs, and an easy-to-navigate keypad.
- Multiple communication protocols for simultaneous access when integrated into monitoring and control systems.

Description of the 350 Feeder Protection System

CPU

Relay functions are controlled by two processors: a Freescale MPC5554 32-bit microprocessor measures all analog signals and digital inputs and controls all output relays; a Freescale MPC520B 32-bit microprocessor controls all the 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 960 Hz low pass 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 12-bit A/D converter before finally being passed on to the CPU for analysis.

Both current and voltage are sampled thirty-two times per power frequency cycle. These 'raw' samples are scaled in software, then placed into the waveform capture buffer, thus emulating a fault recorder. The waveforms can be retrieved from the relay via the EnerVista 3 Series Setup software for display and diagnostics.

Frequency

Frequency measurement is accomplished by measuring the time between zero crossings of the Bus VT phase A voltage. The signals are passed through a low pass filter to prevent false zero crossings. Sampling is synchronized to the Va-x voltage zero crossing which results in better co-ordination for multiple 350 relays on the same bus.

Phasors, Transients, and Harmonics

Current waveforms are processed four times every cycle with a DC Offset 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; one that will not overreach.

Processing of AC Current Inputs

The DC Offset Filter is an infinite impulse response (IIR) digital filter, which removes the DC 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 bypass the DC Offset Filter. This filter ensures no overreach of the overcurrent protection.

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

Protection Elements

Protection elements are processed up to four times every cycle to determine if a pickup has occurred or a timer has expired. The protection elements use RMS current/voltage, based on the magnitude of the phasor. Hence, protection is impervious to both harmonics and DC transients.

NOTE

Arc Flash protection elements are processed up to 8 times every cycle.

Figure 1-1: Functional block diagram

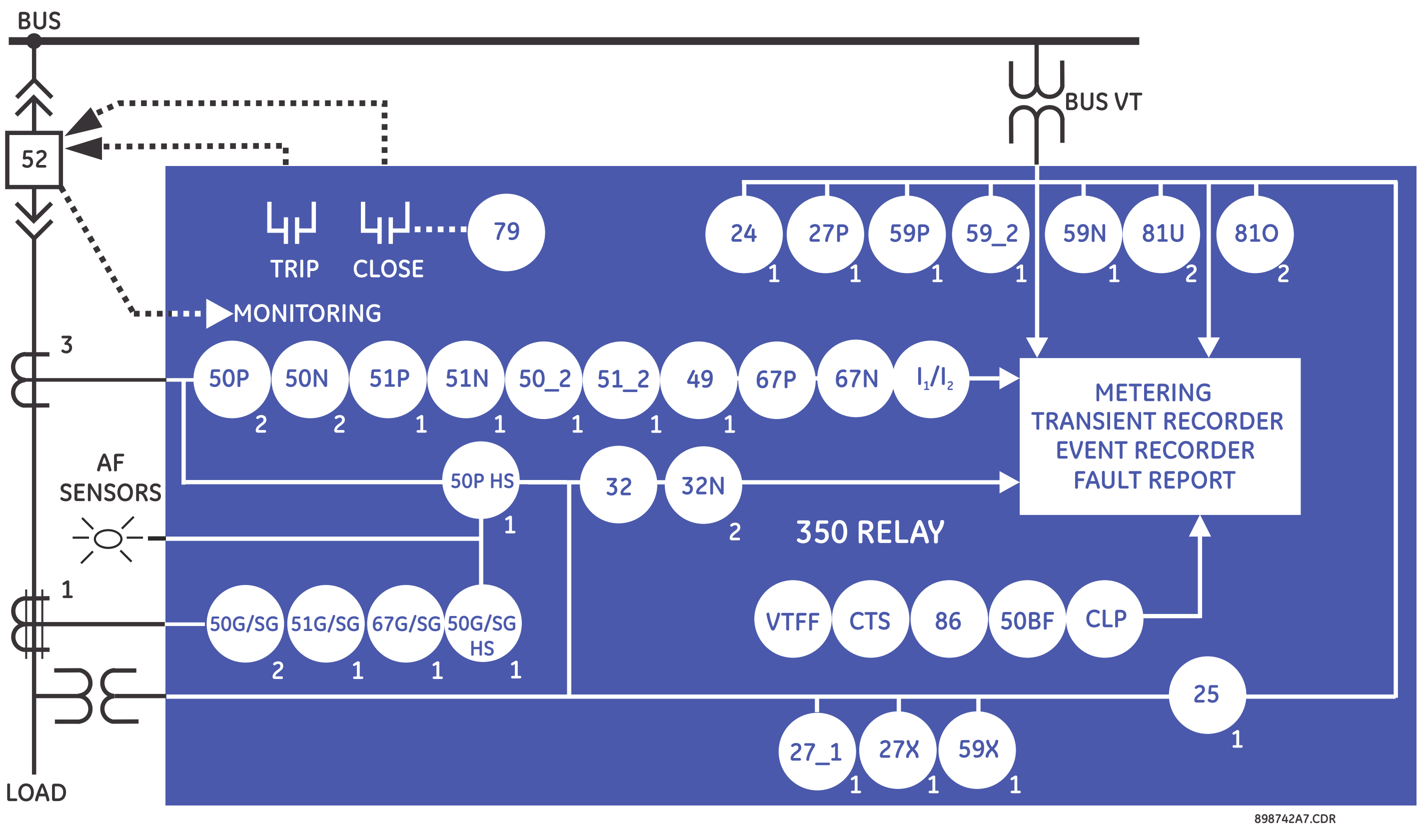


Table 1-1: ANSI device numbers and functions

ANSI Code	61850 Logical Node	Description
24	PVPH	Volts per Hertz
25	RSYN1	Synchrocheck
27_1	psseqPTUV1	Positive Sequence Undervoltage
27P	phsPTUV1, phsPTUV2, phsPTUV3, phsPTUV4	Phase Undervoltage
27X	auxPTUV1	Auxiliary Undervoltage
32	PDOP1, PDOP2	Directional Power
32N	ndPDOP	Wattmetric Ground Fault
I1/I2 (46BC)	-	Broken Conductor
49	PTTR1	Thermal Overload
50_2	ngseqPIOC1	Negative Sequence Overcurrent
50BF	RBRF1	Breaker Failure
50G/SG	gndPIOC1, gndPIOC2/ hsePIOC1, hsePIOC2	Ground/Sensitive Ground Instantaneous Overcurrent
50N	ndPIOC1, ndPIOC2	Neutral Instantaneous Overcurrent
50P	phsPIOC1, phsPIOC2	Phase Instantaneous Overcurrent
51_2	ngseqPTOC1	Negative Sequence Time Overcurrent
51G/SG	gndPTOC1/hsePTOC1	Ground/Sensitive Ground Time Overcurrent
51N	ndPTOC1	Neutral Time Overcurrent
51P	phsPTOC1	Phase Time Overcurrent
59_2	ngseqPTOV1, ngseqPTOV2	Negative Sequence Overvoltage

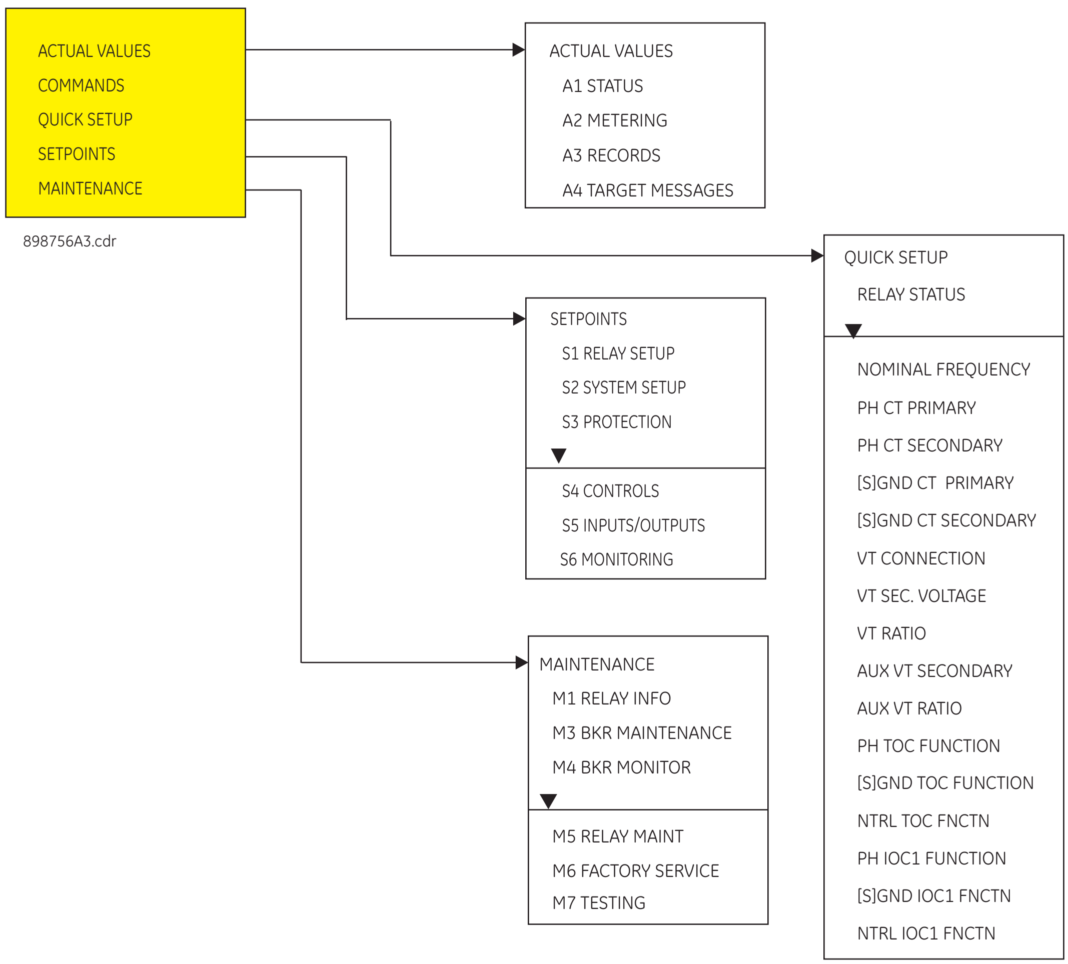
ANSI Code	61850 Logical Node	Description
59N	ndPTOV1, nfPTOV2, ndPTOV3, ndPTOV4	Neutral Overvoltage
59P	phsPTOV1, phsPTOV2, phsPTOV3, phsPTOV4	Phase Overvoltage
59X	auxPTOV1	Auxiliary Overvoltage
60CTS	-	CT Supervision
67G/SG	gndRDIR1/hseRDIR1	Ground/Sensitive Ground Directional Element
67N	ndRDIR1	Neutral Directional Element
67P	phsRDIR1	Phase Directional Element
79	RREC1	Autoreclose
81O	PTOF1, PTOF2, PTOF3, PTOF4	Overfrequency
81U	PTUF2, PTUF2, PTUF3, PTUF4	Underfrequency
86	-	Lockout
CLP	-	Cold Load Pickup
VTFF (60VTS)	-	Voltage Fuse Failure
-	MMXU1	Voltage, Energy, Power Metering

Table 1-2: Other device functions

Description
2nd Harmonic Blocking
Arc Flash Detector
Ambient Temperature
Breaker Control
Breaker Health
Breaker Maintenance
CT Failure Detection
Demand (in metering)
Digital Counters
DNP 3.0 Communications
Event Recorder
Fault Report
Flexcurves
HSR Communications
IEC 60870-5-103 Communications
IEC 60870-5-104 Communications
IEC 61850 Communications
IEC 61850 GOOSE Communications
Lockout (86)
Logic Elements
Metering: current, voltage, power, PF, energy, frequency, 2nd harmonics
Modbus User Map
Modbus RTU Communications
Modbus TCP Communications
Non-volatile Latches
OPC-UA Communications
Output Relays

Description
PRP Communications
Relay Maintenance
Remote Inputs (32)
Setpoint Groups (2)
Test Mode
Transient Recorder (Oscillography)
Trip and Close Coil Monitoring
User Curves
User-programmable LEDs
Virtual Inputs (32)
Virtual Outputs (32)

Figure 1-2: Main Menu structure



350 order codes

The information to specify a 350 relay is provided in the following order code figure.

Figure 1-3: Order Codes

	350 – * * * * * * * * * * * *	
Interface	350	350 Feeder Protection System
User Interface	E	English without programmable LEDs
	L	English with programmable LEDs
Phase Currents[a]	PX	No CT
	P0	1 A or 5 A configurable phase current inputs
	P1	1 A 3-phase current inputs
	P5	5 A 3-phase current inputs
Ground Currents[b]	GX	No CT
	G0	1 A and 5 A configurable ground current input
	G1	1 A ground current input
	G5	5 A ground current input
	S0	1 A or 5A configurable sensitive ground current input
	S1	1 A sensitive ground current input
	S5	5 A sensitive ground current input
Power Supply	L	24 to 48 V DC
	H	125 to 250 V DC/120 to 230 V AC
Input/Output[c]	E	Standard (10 Inputs, 7 relay outputs)
	A	Standard (10 inputs, 5 relay outputs, 2 MOSFET loads) + 4 Arc Flash detectors
Current Protection[d]	N	None (voltage and frequency relay, requires a PX/GX configuration)
	E	Extended configuration: User selectable 49, 50P(2), 50G/SG(2), 50N(2), 51P(1), 51G/SG(1), 51N(1)
	M	Advanced configuration: Extended + 51_2 or 46(1), 50_2 (1) or 46(1), I1/I2(46BC)
Control	N	CLP, Lockout (86)
	C	CLP, 50BF, Lockout (86), Autoreclose (79)
Other Options[e]	N	No selection
	V	27P(4), 27X(1), 27P_1(1), 59P(4), 59N(4), 59X(1), 59_2(2), 81O(4), 81U(4), 25(1), VTFF(1), 24(1), Voltage Metering (requires a PX/GX configuration)
	D	Neutral and Ground Directional Overcurrent Protection: 67N(1), 67G/SG(1), 60CTS
	M	Voltage, Power, and Energy Metering, 60CTS
	R	Phase, Neutral, and Ground Directional Overcurrent Protection: 67P(1), 67N(1), 67G/SG(1), 32N(2), VTFF + Voltage, Power, and Energy Metering, 60CTS
	P	Extended Protection: 27P(2), 27X(1), 27P_1 (1), 59P(2), 59N(1), 59X(1), 59_2(1), 81O(2), 81U(2), 67P(1), 67N(1), 67G/SG(1), VTFF(1), 25(1), 60CTS, Voltage, Power, and Energy Metering
	W	Advanced Protection: Extended + 32(2)
Communications[f]	S N	Standard: Front USB, Rear RS485: Modbus RTU, DNP3.0, IEC60870-5-103
	1 E	Standard + Ethernet (Copper & Fiber - MTRJ), Modbus TCP/IP, DNP3.0, IEC 60870-5-104
	2 E	Standard + Ethernet (Copper & Fiber - MTRJ), Modbus TCP/IP, DNP3.0, IEC 60870-5-104, IEC 61850 GOOSE
	3 E	Standard + Ethernet (Copper & Fiber - MTRJ), Modbus TCP/IP, DNP3.0, IEC 60870-5-104, IEC 61850
	4 E	Standard + Ethernet (Copper & Fiber - MTRJ),Modbus TCP/IP, DNP3.0, IEC 60870-5-104, IEC 61850, OPC-UA
	5 E	Standard + Ethernet (Dual Fiber - MTRJ),Modbus TCP/IP, DNP3.0, IEC 60870-5-104, IEC 61850, OPC-UA, PRP, HSR, 1588, PTP
Case Design	D	Protection Relay with drawout design
	N	Protection Relay with non-drawout design
	X	Protection Relay (drawout design) with no chassis
Harsh Environment	N	None
	H	Harsh Environment Conformal Coating

a. Phase Current options "PX/P0" and Ground Current options "GX/G0" are only available with the non-drawout Case Design "N".
b. Ground Currents "G1/G5" and "S1/S5" must match the corresponding "P1/P5" Phase Currents (i.e. 5A and 1A must not be mixed).
Ground Current "GX" requires "PX" Phase Current, and is only available with Case "N", Current Protection "N", Other Options "V", and Input/Output "E".
Ground Current "G0/S0" must match the "P0" Phase Current, and is only available with the non-drawout Case Design "N".
c. Input/Output option "A" is only available with the non-drawout Case Design "N"
d. Current Protection option "S" has been discontinued.
e. CLP, 79, and 50BF are not supported when "V" is selected under Other Options.
f. Communications option "4E" allows the selection of either IEC 61850 or OPC-UA; both cannot be used at the same time.
Communications option "5E" is only available with Case Design "D" or "X".

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NOTE

Features related to each order number are subject to change without notice.

Arc Flash System

The 350 protection relay with Input/Output option "A" supports up to 4 Arc Flash sensors, which are ordered separately so that the connected sensor fiber lengths can be customized.

	AFC –	*	*	
AF System Component		E	|	Sensor Fiber Extension (black sensor fiber with two single bulkhead connectors, used with loop sensors)
		L	|	Loop Sensor with transparent sensor fiber
		P	|	Point Sensor with black sensor fiber
Sensor Fiber Length			XX	Sensor fiber length: 01 to 35 meters for Point Sensors and Extensions 01 to 70 meters for Loop Sensors

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NOTICE

The total sensor fiber length connected to each loop sensor must not exceed 70 meters of single sensor fiber. Black sensor fiber is duplex, and must be doubled in calculations.

For example, a loop sensor with a 25 meter transparent sensor fiber plus a sensor fiber extension of 10 meters would have a total of 2 x 10m + 25m = 45m of single sensor fiber.

NOTICE

The total sensor fiber length connected to each point sensor must not exceed 35 meters of black (duplex) cable.

NOTE

Generally each loop sensor is used with a sensor fiber extension, in order to minimize exposure to ambient light when running the sensor fiber between cabinets. A duplex sensor fiber extension connects the relay to the loop sensor, and can be gently pulled apart to connect to the loop sensor connectors if they are not adjacent. Consider your installation needs carefully when ordering sensor and extension lengths.

Empty chassis

The 350 protection relay chassis used with a drawout relay is available separately, for use as a partial replacement or in test environments. Many features are supported by the cards and ports within the chassis, as is reflected in the chassis order code.

NOTE

The chassis order code and drawout relay order code must match exactly.

NOTICE

A drawout relay cannot be used in a chassis with different order code options.

Figure 1-4: 350 chassis order codes

350 – CH –	*	*	*	*	*	*	
Phase Currents	P1	|	|	|	|	|	1 A 3-phase current inputs
	P5	|	|	|	|	|	5 A 3-phase current inputs
Ground Currents[a]		G1	|	|	|	|	1 A ground current input
		G5	|	|	|	|	5 A ground current input
		S1	|	|	|	|	1 A sensitive ground current input
		S5	|	|	|	|	5 A sensitive ground current input
Other Options			N	|	|	|	No selection
			D	|	|	|	Neutral and Ground Directional Overcurrent Protection: 67N(1), 67G/SG(1), 60CTS
			M	|	|	|	Voltage, Power, and Energy Metering, 60CTS
			R	|	|	|	Phase, Neutral, and Ground Directional Overcurrent Protection: 67P(1), 67N(1), 67G/SG(1), 32N(2), VTFF + Voltage, Power, and Energy Metering, 60CTS
			P	|	|	|	Extended Protection: 27P(2), 27X(1), 27P_1 (1), 59P(2), 59N(1), 59X(1), 59_2(1), 81O(2), 81U(2), 67P(1), 67N(1), 67G/SG(1), VTFF(1), 25(1), 60CTS, Voltage, Power, and Energy Metering
			W	|	|	|	Advanced Protection: Extended + 32(2)
Communications[b]				S	N	|	Standard: Front USB, Rear RS485: Modbus RTU, DNP3.0, IEC60870-5-103
				1	E	|	Standard + Ethernet (Copper & Fiber - MTRJ), Modbus TCP/IP, DNP3.0, IEC 60870-5-104
				2	E	|	Standard + Ethernet (Copper & Fiber - MTRJ), Modbus TCP/IP, DNP3.0, IEC 60870-5-104, IEC 61850 GOOSE
				3	E	|	Standard + Ethernet (Copper & Fiber - MTRJ), Modbus TCP/IP, DNP3.0, IEC 60870-5-104, IEC 61850
				4	E	|	Standard + Ethernet (Copper & Fiber - MTRJ),Modbus TCP/IP, DNP3.0, IEC 60870-5-104, IEC 61850, OPC-UA
				5	E	|	Standard + Ethernet (Dual Fiber - MTRJ),Modbus TCP/IP, DNP3.0, IEC 60870-5-104, IEC 61850, OPC-UA, PRP, HSR, 1588, PTP
Harsh Environment						N	None
						H	Harsh Environment Conformal Coating

a. Ground current options "G1/G5" must match the corresponding "P1/P5" Phase currents
b. Communications option "4E" allows the selection of either IEC 61850 or OPC-UA; both cannot be used at the same time.

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Other accessories

- 1819-0103 350 Retrofit Kit for 735
- 1819-0102 350 Retrofit Kit for IAC Relay
- 1819-0101 350 Retrofit Kit for MDP Relay
- 1819-0100 350 Retrofit Kit for S1/S2 Cut-Out
- 18L0-0075 3 Series Depth reducing collar - 1.375"
- 18L0-0076 3 Series Depth reducing collar - 3.00"
- 18L0-0080 3 Series IP20 Kit
- 3S-NDO-STCONKIT 3 Series NDO straight terminal block kit
- 0804-0458 USB A-B configuration cable - 6'

NOTE

Refer to the *3 Series Retrofit Instruction Manual* for the retrofit of Multilin MI, MII, MLJ, and TOV relays.

Specifications

NOTE

Specifications are subject to change without notice.

NOTE

All accuracies defined below are at nominal frequency (50Hz or 60Hz) unless otherwise stated.

NOTE

To obtain the operating element time delay, i.e. from fault injection until operation, add the operate time to the curve time.

To obtain the total element 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, with the exception of Arc Flash SSR loads.

Password security

PASSWORD SECURITY

Master Password:	8 to 10 alpha-numeric characters
Settings Password:	3 to 10 alpha-numeric characters for local and remote access
Control Password:	3 to 10 alpha-numeric characters for local and remote access

Protection

BROKEN CONDUCTOR (I1/I2 OR 46BC)

Minimum operating positive current:	0.05 to 1.00 × CT in steps of 0.01 × CT
Maximum operating positive current:	0.05 to 5.00 × CT in steps of 0.01 × CT
Pickup level:	20.0% to 100.0% in steps of 0.1%
Dropout level:	97% to 98% of the pickup level
Pickup time delay:	0.000 to 65.535 s in steps of 0.001 s
Timer accuracy:	± 3% of delay setting or ± ¾ cycle (whichever is greater) from pickup to operate
Operate time:	<30 ms at 60 Hz

WATTMETRIC GROUND FAULT (32N)

Measured power:	zero sequence
Number of elements:	1
Characteristic angle:	0° to 359° in steps of 1°
Pickup threshold:	0.001 to 1.200 pu in steps of 0.001 pu
Pickup level accuracy:	± 2% or ± 0.03 pu, whichever is greater
Hysteresis:	3% or 0.001 pu, whichever is greater
Pickup delay:	Definite Time (0.00 to 600 .0 s in steps of 0.1 s), Inverse Time, or Flexcurve
Inverse time multiplier:	0.01 to 2.00 in steps of 0.01
Curve timing accuracy:	± 3.5% of operate time or ± ¼ cycle (whichever is greater) from pickup to operate
Operate time:	<30 ms at 60 Hz

DIRECTIONAL POWER (32)

Measured power:	3-phase
Characteristic angle:	0° to 359° in steps of 1°
Power pickup range:	-1.200 to 1.200 × Rated Power in steps of 0.001
Pickup level accuracy:	2.5% or 0.01 pu, whichever is greater
Hysteresis:	2% or 0.001 × Rated Power, whichever is greater
Pickup time delay:	0.0 to 600.0 s in steps of 0.1 s
Operate time:	< 55 ms at 1.1 × pickup at 60 Hz < 65 ms at 1.1 × pickup at 50 Hz
Timer accuracy:	± 3% of delay setting or ± ¼ cycle (whichever is greater) from pickup to operate

VOLTS PER HERTZ (24)

Inputs:	Van (Wye VTs), Vab (Delta VTs)
Pickup Level:	0.80 to 4.00 × V/Hz in steps of 0.01 × V/Hz
Dropout Level:	97% to 98% of pickup
Level Accuracy:	± 0.02 × V/Hz or 2% of set value, whichever is greater
Time Curves:	Definite Time, Inverse A/B/C, FlexCurves A/B
TD Multiplier:	0.00 to 600.00 s in steps of 0.01 s
Reset Delay:	0.00 to 600.00 s in steps of 0.01 s
Time Accuracy:	± 3% of operate time of ±15 cycles (whichever is greater) for values greater than 1.1 × pickup

PHASE/NEUTRAL/GROUND/NEGATIVE SEQUENCE TIME OVERCURRENT (51P/51N/51G/51_2)

Pickup Level:	0.05 to 20.00 × CT in steps of 0.01 × CT
Dropout Level:	97% of Pickup @ I > 1 × CT Pickup - 0.02 × CT @ I < 1 × CT
Curve Shape:	ANSI Extremely/Very/Moderately/Normally Inverse Definite Time (0.1 s base curve) IEC Curve A/B/C and Short Inverse IAC Extreme/Very/-/Short Inverse User Curve, FlexCurve™ A/B (programmable curves)
Curve Multiplier:	0.05 to 50.00 in steps of 0.01
Reset Time:	Instantaneous, Linear
Curve Timing Accuracy:	±3% of expected inverse time or 1.5 cycle, whichever is greater, from pickup to operate
Level Accuracy:	per CT input

SENSITIVE GROUND TIME OVERCURRENT (51SG)

Pickup Level:	0.005 to 3.000 × CT in steps of 0.001 × CT
Dropout Level:	97% of Pickup @ I > 0.1 × CT Pickup - 0.002 × CT @ I < 0.1 × CT
Curve Shape:	ANSI Extremely/Very/Moderately/Normally Inverse Definite Time (0.1 s base curve) IEC Curve A/B/C/Short Inverse IAC Extreme/Very/-/Short Inverse User Curve, FlexCurve™ A/B
Curve Multiplier:	0.05 to 50.00 in steps of 0.01
Reset Time:	Instantaneous, Linear
Curve Timing Accuracy:	±3% of expected inverse time or 1 cycle, whichever is greater, from pickup to operate
Level Accuracy:	per CT input

PHASE/NEUTRAL/GROUND/NEGATIVE SEQUENCE INSTANTANEOUS OVERCURRENT (50P/50N/50G/50_2)

Pickup Level:	0.05 to 20.00 x CT in steps of 0.01 x CT
Dropout Level:	97% of Pickup @ I > 1 x CT Pickup - 0.02 x CT @ I <1 x CT
Time Delay:	0.00 to 300.00 sec in steps of 0.01
Operate Time:	<30 ms @ 60Hz (I > 2.0 x PKP, No time delay) <35 ms @ 50Hz (I > 2.0 x PKP, No time delay)
Time Delay Accuracy:	1% or 1 cycle, whichever is greater (Time Delay selected)
Level Accuracy:	per CT input

SENSITIVE GROUND INSTANTANEOUS OVERCURRENT (50SG)

Pickup Level (Gnd IOC):	0.005 to 3.000 x CT in steps of 0.001 x CT
Dropout Level:	97% of Pickup @ I > 0.1 x CT Pickup - 0.002 x CT @ I < 0.1 x CT
Time Delay:	0.00 to 300.00 sec in steps of 0.01
Operate Time:	<30 ms @ 60Hz (I > 2.0 x PKP, No time delay) <35 ms @ 50Hz (I > 2.0 x PKP, No time delay)
Time Delay Accuracy:	1% or 1 cycle, whichever is greater (Time Delay selected)
Level Accuracy:	per CT input

PHASE DIRECTIONAL (67P)

Directionality:	Co-existing forward and reverse
Operating:	Phase Current (Ia, Ib, Ic)
Polarizing Voltage:	Quadrature Voltage (ABC phase sequence: Vbc, Vca, Vab) (CBA phase sequence: Vcb, Vac, Vba)
Polarizing voltage threshold:	0.05 to 1.25 x VT in steps of 0.01
MTA (Maximum Torque Angle):	From 0° to 359° in steps of 1°
Angle Accuracy:	±4°
Operational Delay:	20 to 30 ms

NOTE

The selection of the “P” or “R” option from “350 OTHER OPTIONS” in the order code table, will enable the Phase directional element. The polarizing voltage used for this element is the line voltage.

GROUND DIRECTIONAL (67G)

Directionality:	Co-existing forward and reverse
Operating:	Ground Current (Ig)
Polarizing Voltage:	$-V_0$ calculated using phase voltages (VTs must be connected in “Wye”) $-3V_0$ measured from Vaux input. ($3V_0$ provided by an external open delta connection).
MTA (Maximum Torque Angle):	From 0° to 359° in steps of 1°
Angle Accuracy:	±4°
Operational Delay:	20 to 30 ms

NOTE

The selection of the “D” option from “350 OTHER OPTIONS” in the Order Code table, will enable the Ground Directional element with voltage polarizing $3V_0$ measured from the Vaux voltage input.

NOTE

The selection of the “P”, “R”, or “W” option from “350 OTHER OPTIONS” in the order code table, will enable the Ground directional element. The polarizing voltage used for this element is the computed V_0 from the measured phase voltages.

NEUTRAL DIRECTIONAL (67N)

Directionality: .... Forward and reverse
Polarizing: .... Voltage, Current, Dual
Polarizing Voltage: .... - V_0 calculated using phase voltages (VTs must be connected in "Wye")
-$3V_0$ measured from Vaux input ($3V_0$ provided by an external broken delta connection).
Polarizing Current: .... I_G
MTA: .... From 0° to 359° in steps of 1°
Angle Accuracy: .... ±4°
Operational Delay: .... 20 to 30 ms

NOTE

The selection of the "D" option from "350 OTHER OPTIONS" in the Order Code table, will enable the Neutral Directional element with voltage polarizing $3V_0$ measured from the Vaux voltage input.

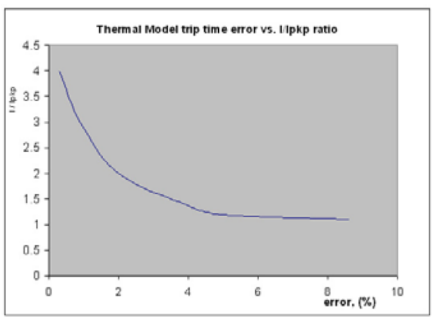
The selection of "P", "R", or "W" option from "350 OTHER OPTIONS" in the Order Code table, will enable the Neutral Directional elements with voltage polarizing V_0 computed from the measured phase voltage inputs.

The ground polarizing current, I_G, is available for selection in both cases.

THERMAL OVERLOAD (49)

Current: .... RMS current - max (Ia, Ib, Ic)
Pickup Accuracy: .... per current inputs
Timing Accuracy: .... See graph below

Figure 1-5:



The graph shows the trip time error with respect to the ratio of cable load and thermal model pickup setting. With a smaller I/Ipkp ratio, the time error tends to be higher, as accumulated through the logarithmic formula, the measurement error, and the time of measurement. For higher I/Ipkp ratios, the time to trip is substantially more accurate. Each point on the graph represents a trip time error, with the I/Ipkp ratio kept constant during the test.

PHASE/AUXILIARY/POSITIVE SEQUENCE UNDERVOLTAGE (27P, 27X, 27_1)

Minimum Voltage: .... Programmable from 0.00 to 1.25 × VT in steps of 0.01
Pickup Level: .... 0.00 to 1.25 × VT in steps of 0.01
Dropout Level: .... 102% of pickup (pickup > 0.1 × VT)
Pickup + 0.02 × VT (pickup < 0.1 × VT)
Curve: .... Definite Time, Inverse Time
Time Delay: .... 0.00 to 600.00 s in steps of 0.01
Operate Time: .... Time delay ±30 ms @ 60 Hz (V < 0.85 × PKP)
Time delay ±40 ms @ 50 Hz (V < 0.85 × PKP)
Time Delay Accuracy: .... at V < 0.85 PKP: ±3% of expected time, or 1 cycle, whichever is greater
Level Accuracy: .... Per voltage input

PHASE/AUXILIARY/NEUTRAL/NEGATIVE SEQUENCE OVERVOLTAGE (59P, 59X, 59N, 59_2)

Pickup Level:	0.00 to 1.25 x VT in steps of 0.01
Dropout Level:	98% of pickup (pickup > 0.1 x VT) Pickup - 0.02 x VT (pickup < 0.1 x VT)
Time Delay:	0.00 to 600.00 s in steps of 0.01
Operate Time:	Time delay ±35 ms @ 60Hz (V > 1.1 x PKP) Time delay ±40 ms @ 50Hz (V > 1.1 x PKP)
Time Delay Accuracy:	±3% of expected time, or 1 cycle, whichever is greater
Level Accuracy:	Per voltage input

UNDERFREQUENCY (81U)

Minimum Voltage:	0.00 to 1.25 x VT in steps of 0.01
Voltage DPO:	6% of minimum voltage setting
Pickup Level:	40.00 to 70.00 Hz in steps of 0.01
Dropout Level:	Pickup + 0.05 Hz
Time Delay:	0.10 to 600.0 s in steps of 0.01
Time Delay Accuracy:	0 to 6 cycles (Time Delay selected)
Operate Time:	Typically 10 cycles @ 0.1Hz/s change
Level Accuracy:	±0.03 Hz

OVERFREQUENCY (81O)

Minimum Voltage:	0.3 x VT
Pickup Level:	40.00 to 70.00 Hz in steps of 0.01
Dropout Level:	Pickup - 0.05 Hz
Time Delay:	0.1 to 600.0 s in steps of 0.01
Time Delay Accuracy:	0 to 6 cycles (Time Delay selected)
Operate Time:	Typically 10 cycles @ 0.1Hz/s change
Level Accuracy:	±0.03 Hz

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

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

NOTE

The operate times listed require that SSR output relays (Aux 5 and 6) be used for Arc Flash detection.

ARC FLASH SENSOR/FIBER

Number of Sensors:	4
Detection Radius:	180 degree
Maximum Duplex Fiber Length (Point Sensor):	35 m
Maximum Single Fiber Length (Loop Sensor):	70 m
Fiber Size:	1.0 mm core diameter 2.2 mm total diameter (single) 4.4 mm total diameter (duplex)
Mode:	Multi-mode
Connector:	Small Media Interface (SMI)
Fiber Type:	Plastic Optical Fiber
Bend Radius:	35 mm minimum
Product Type:	Class 1 Laser product

Metering

PARAMETER	ACCURACY (full scale for CT Input is 3 x CT)	RESOLUTION	RANGE
3-Phase Real Power (MW or kW)	±1% of full scale	0.1 MW	± 100000.0 kW
3-Phase Reactive Power (Mvar or kvar)	±1% of full scale	0.1 Mvar	± 100000.0 kvar
3-Phase Apparent Power (MVA or kVA)	±1% of full scale	0.1 MVA	± 100000.0 kVA
3-Phase Positive Watthour (MWh)	±1% of full scale	±0.001 MWh	50000.0 MWh
3-Phase Negative Watthour (MWh)	±1% of full scale	±0.001 MWh	50000.0 MWh
3-Phase Positive Varhour (Mvarh)	±1% of full scale	±0.001 Mvarh	50000.0 Mvarh
3-Phase Negative Varhour (Mvarh)	±1% of full scale	±0.001 Mvarh	50000.0 Mvarh
Power Factor	±0.05	0.01	-0.99 to 1.00
Frequency	±0.05 Hz	0.01 Hz	40.00 to 70.00 Hz

NOTE

Negative values (-) represent lead and positive values (+) represent lag.

CURRENTS
Parameters: Phase A, Phase B, Phase C, Neutral, Ground, Sensitive Ground, Positive Sequence, Negative Sequence, Zero Sequence, and 2nd Harmonic
Accuracy: See the Inputs section in Chapter 1: Specifications

VOLTAGES
Parameters: Wye VTs: AN, BN, CN, Negative Sequence, Zero Sequence and Auxiliary
Delta VTs: AB, BC, CA, Negative Sequence, Zero Sequence and Auxiliary
Accuracy: See the Inputs section in Chapter 1: Specifications

Data capture

TRANSIENT RECORDER
Buffer size: 3 s
No. of buffers: 1, 3, 6
No. of channels: 14
Sampling rate: 4, 8, 16, or 32 samples per cycle
Triggers: Manual Command
Contact Input
Virtual Input
Logic Element
Element Pickup/Trip/Dropout/Alarm
Data: AC input channels
Contact input state
Contact output state
Virtual input state
Logic element state
Data storage: RAM - battery backed-up

FAULT RECORDER
Number of records: 1
Content: Date and Time, first cause of fault, phases,
Currents: Ia, Ib, Ib, Ig/Isg, In - magnitudes and angles
Voltages: Van, Vbn, Vcn, Vab, Vbc, Vca, Vaux - magnitudes and angles
System frequency

EVENT RECORDER

Number of events:	256
Header:	relay name, order code, firmware revision
Content:	event number, date of event, cause of event,per-phase current, ground current, sensitive ground current, neutral current, per-phase voltage (VTs connected in "Wye"), or phase-phase voltages (VTs connected in "Delta"), system frequency, power, power factor, thermal capacity
Data Storage:	Retained for 3 days

CLOCK

Setup:	Date and time Daylight Saving Time
IRIG-B:	Auto-detect (DC shift or Amplitude Modulated) Amplitude modulated: 1 to 10 V pk-pk DC shift: 1 to 10 V DC Input impedance: 40 kOhm ± 10%
Accuracy with IRIG-B:	± 1 ms
Accuracy without IRIG-B:	± 1 min / month

Control

LOGIC ELEMENTS

Number of logic elements:	16
Trigger source inputs per element:	2 to 8
Block inputs per element:	2 to 4
Supported operations:	AND, OR, NOR, NAND, XOR, XNOR, Pickup / Dropout timers
Pickup timer:	0 to 60000 ms in steps of 1 ms
Dropout timer:	0 to 60000 ms in steps of 1 ms

BREAKER CONTROL

Operation:	Asserted Contact Input, Logic Element, Virtual Input, Manual Command
Function:	Opens / closes the feeder breaker

AUTORECLOSE (79)

Reclose attempts:	Up to 4 shots
Time Delay Accuracy:	0 to 3 cycles (AR Dead Time selected)
Elements:	Inputs, Outputs, Breaker Status (52 status)

SYNCHROCHECK (25)

Maximum frequency difference:	0.05 to 5.00 Hz in steps of 0.01 Hz
Maximum Angle difference:	2° to 80° in steps of 1°
Maximum Voltage difference:	10 to 10000 V in steps of 1 V
Dead Bus and Dead Line level:	0.00 to 1.25 × VT in steps of 0.01 × VT
Live Bus and Live Line level:	0.03 to 1.25 × VT in steps of 0.01 × VT

SECOND HARMONIC INHIBIT

Operating Parameter:	Current 2nd harmonic per phase or average
Pickup Level:	0.1% to 40.0% in steps of 0.1
Minimum Current:	0.03 to 3.00 × CT in steps of 0.01 × CT
Time Delay:	0.00 to 600.00 s in steps of 0.01 s
Time Delay Accuracy:	±3% of expected time or 2 cycles, whichever is greater
Level Accuracy:	±2% or ±10mA (whichever is greater)

BREAKER FAILURE (50BF)

Pickup Level: 0.05 to 20.00 × CT in steps of 0.01 × CT
Dropout Level: 97 to 98% of pickup
Timer 1 Delay: 0.03 to 1.00 s in steps of 0.01 s
Timer 2 Delay: 0.00 to 1.00 s in steps of 0.01 s
Time Delay Accuracy: 0 to 1 cycle (Timer 1, Timer 2)
Level Accuracy: per CT input
Reset Time: <14 ms typical at 2 × pickup at 60 Hz
<16 ms typical at 2 × pickup at 50 Hz

CT FAILURE

Inputs: Neutral Current IN,
Neutral Current VN (from three-phase VTs)
Ground Current Ig
Time Delay: 0.00 to 60.00 s in steps of 0.01 s
3IO level accuracy: per CT inputs
3VO level accuracy: per VT inputs
GND current level accuracy: see the specifications for phase and ground current inputs
Operate Time: 30 ms at 60 Hz
35 ms at 50 Hz

BREAKER TRIP COUNTER

Trip Counter Limit (Pickup): 1 to 10000 in steps of 1

LOCKOUT

Function: Latch Trip command to Relay 1 TRIP
Block Close to Relay 2 CLOSE
Operation: Any protection element

COLD LOAD PICKUP BLOCKING

Operation: Automatically (current level), or by command (asserted input)
Function: Block IOC functions, raise TOC pickup, for selected period of time
Time Delay Accuracy: 0 to 1 cycle (block Time)
±50 ms (outage time ≤5 min)
±1 s (outage time > 5 min)

FUSE FAIL (VTFF)

Time Delay: 1 s
Timing Accuracy: ±0.5 s
Elements: Trip or Alarm

AMBIENT TEMPERATURE

High Temperature Pickup: 20°C to 80°C in steps of 1°C
Low Temperature Pickup: -40°C to 20°C in steps of 1°C
Time Delay: 1 to 60 min in steps of 1 min
Temperature Dropout: Configurable 90 to 98% of pickup
Temperature Accuracy: ±10°C
Timing Accuracy: ±1 second

Monitoring

BREAKER HEALTH

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

DEMAND

Measured Values: Phase A/B/C present and maximum current, three-phase present and maximum 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

Real Power Pickup Level: 0.1 to 300000.0 in steps of 0.1 kW

Reactive Power Pickup Level: 0.1 to 300000.0 in steps of 0.1 kVar

Apparent Power Pickup Level: 0.1 to 300000.0 in steps of 0.1 kVA

Dropout Level: 96-98% of Pickup level

Level Accuracy: ± 2% (current demand only)

Inputs

CONTACT INPUTS

Inputs: 10

Selectable thresholds: 17, 33, 84, 166 VDC
±10%

Recognition time: 1/2 cycle

Debounce time: 1 to 64 ms, selectable, in steps of 1 ms

Maximum input voltage & continuous current draw: 300 VDC, 2 mA, connected to Class 2 source

Type: opto-isolated inputs

External switch: wet contact

PHASE & GROUND CURRENT INPUTS

CT Primary: 1 to 6000 A

Range: 0.02 to 20 × CT

Input type: 1 A, 5 A, or 1/5 A (must be specified with order)

Nominal frequency: 50/60 Hz

Burden: <0.1 VA at rated load

Accuracy at nominal frequency: 3%
±10 mA or ±20% of reading from 0.02 to 0.19 × CT, whichever is greater

CT withstand: 1 second at 100 A (1 A option)
1 second at 400 A (5 A or universal CT option)
2 seconds at 40 × rated current
continuous at 3 × rated current

SENSITIVE GROUND CURRENT INPUT

CT Primary: 1 to 600 A
Range: 0.002 to 3 × CT
Input type: 1 A, 5 A, or 1/5 A (must be specified with order)
Nominal frequency: 50/60 Hz
Burden: <0.1 VA at rated load
Accuracy at nominal frequency: 3%
±10 mA or ±20% of reading from 0.02 to 0.19 × CT, whichever is greater
CT withstand: 1 second at 100 A (1 A option)
1 second at 400 A (5 A or universal CT option)
2 seconds at 40 × rated current
continuous at 3 × rated current

PHASE/AUX VOLTAGE INPUTS

Source VT: 0.15 to 550 kV / 50 to 220 V
VT secondary range: 50 to 240 V
VT ratio: 1.0 to 5000.0 in steps of 0.1
Nominal frequency: 50/60 Hz
Relay burden: <0.25 VA at 120 V
Accuracy at nominal frequency: ±1.0% throughout range
Voltage withstand: 260 VAC continuous

Outputs

ARC FLASH OPTION

FORM-A RELAYS

Configuration: 2 (two) electromechanical
Contact material: silver-alloy
Operate time: <8 ms
Continuous current: 10 A
Make and carry for 0.2s: 30 A per ANSI C37.90
Break (DC inductive, L/R=40 ms): 24 V / 1 A
48 V / 0.5 A
125 V / 0.3 A
250 V / 0.2 A
Break (DC resistive): 24 V / 10 A
48 V / 6 A
125 V / 0.5 A
250 V / 0.3 A
Break (AC inductive): 720 VA @ 240 VAC Pilot duty A300
Break (AC resistive): 250 VAC / 10 A

Ratings per UL Certification:

Break (AC resistive): 250 VAC / 10 A GEN USE
Continuous Current: 10 A

FORM-A VOLTAGE MONITOR

Applicable voltage: 20 to 250 VDC
Trickle current: 1 to 2.5 mA

FORM-C RELAYS

Configuration:	3 (three) electromechanical
Contact material:	silver-alloy
Operate time:	<8 ms
Continuous current:	10 A
Make and carry for 0.2s:	30 A per ANSI C37.90
Break (DC inductive, L/R=40 ms):	24 V / 1 A 48 V / 0.5 A 125 V / 0.3 A 250 V / 0.2 A
Break (DC resistive):	24 V / 10 A 48 V / 6 A 125 V / 0.5 A 250 V / 0.3 A
Break (AC inductive):	720 VA @ 240 VAC Pilot duty A300
Break (AC resistive):	250 VAC / 10 A

Ratings per UL Certification:

Break (AC resistive):	250 VAC / 10 A GEN USE
Continuous Current:	10 A

SOLID STATE CONTACT

Configuration:	2 MOSFET
Operate time:	60 μs
Continuous current:	6 A
Make and carry for 1 s:	10 A
Break (DC resistive):	300 V / 6 A
Break (DC inductive L/R=40ms):	300 V / 6 A

Ratings per UL Certification:

Break:	24 VDC, 1 A Pilot Duty 48 VDC, 0.5 A Pilot Duty 125 VDC, 0.3 A Pilot Duty 250 VDC, 0.2 A Pilot Duty
Continuous Current:	6 A

TRIP / CLOSE SEAL-IN

Relay 1 trip seal-in:	0.00 to 9.99 s in steps of 0.01
Relay 2 close seal-in:	0.00 to 9.99 s in steps of 0.01

NON-ARC FLASH OPTION

FORM-A RELAYS

Configuration:	2 (two) electromechanical
Contact material:	silver-alloy
Operate time:	<8 ms
Continuous current:	10 A
Make and carry for 0.2s:	30 A per ANSI C37.90
Break (DC inductive, L/R=40 ms):	24 V / 1 A 48 V / 0.5 A 125 V / 0.3 A 250 V / 0.2 A
Break (DC resistive):	24 V / 10 A 48 V / 6 A 125 V / 0.5 A 250 V / 0.3 A
Break (AC inductive):	720 VA @ 240 VAC Pilot duty A300
Break (AC resistive):	250 VAC / 10 A

Ratings per UL Certification:

Break (AC resistive):	250 VAC / 10 A GEN USE
Continuous Current:	10 A

FORM-A VOLTAGE MONITOR

Applicable voltage:.. 20 to 250 VDC
Trickle current: .... 1 to 2.5 mA

FORM-C RELAYS

Configuration: .... 5 (five) electromechanical
Contact material:... silver-alloy
Operate time:... <8 ms
Continuous current:... 10 A
Make and carry for 0.2s: .... 30 A per ANSI C37.90
Break (DC inductive, L/R=40 ms):................ 24 V / 1 A
48 V / 0.5 A
125 V / 0.3 A
250 V / 0.2 A
Break (DC resistive): .... 24 V / 10 A
48 V / 6 A
125 V / 0.5 A
250 V / 0.3 A
Break (AC inductive):... 720 VA @ 240 VAC Pilot duty A300
Break (AC resistive):.. 250 VAC / 10 A

Ratings per UL Certification:

Break (AC resistive):.. 250 VAC / 10 A GEN USE
Continuous Current: .... 10 A

TRIP / CLOSE SEAL-IN

Relay 1 trip seal-in: .... 0.00 to 9.99 s in steps of 0.01
Relay 2 close seal-in: .... 0.00 to 9.99 s in steps of 0.01

Power supply

HIGH RANGE POWER SUPPLY

Nominal:...120 to 240 VAC
125 to 250 VDC
Range:...60 to 300 VAC (50 and 60 Hz)
84 to 250 VDC
Ride-through time: ....35 ms

LOW RANGE POWER SUPPLY

Nominal:...24 to 48 VDC
Range:...20 to 60 VDC

ALL RANGES

Voltage withstand: ....2 × highest nominal voltage for 10 ms
Power consumption: ....15 W nominal, 20 W maximum
20 VA nominal, 40 VA maximum
Fuse rating:...5A fuse; time lag, slow blow, 350V 4.5 O.D. X 14.5mm

Communications

SERIAL

RS485 port: ....Opto-coupled
Baud rates: ....up to 115 kbps
Response time: ....1 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

ETHERNET (COPPER)

Modes: ....10/100 MB (auto-detect)
Connector: RJ-45
Protocol: ....Modbus TCP, DNP3.0, IEC 60870-5-104, IEC 61850 GOOSE, IEC 61850, OPC-UA

ETHERNET (FIBER)

Fiber type: ....100 MB Multi-mode
Wavelength: ....1300 nm
Connector: ....MTRJ
Protocol: ....Modbus TCP, DNP3.0, IEC 60870-5-104, IEC 61850 GOOSE, IEC 61850, OPC-UA, PRP, HSR
Transmit power: ....-20 dBm
Receiver sensitivity: ....-31 dBm
Power budget: ....9 dB
Maximum input power: ....-11.8 dBm
Typical distance: ....2 km (1.25 miles)
Duplex: ....half/full
Maximum number of TCP/IP sessions: 3
Product type: ....Class 1 Laser product

USB

Standard specification: ....Compliant with USB 2.0
Data transfer rate: ....115 kbps

OPC-UA (OLE FOR PROCESS CONTROL - UNIFIED ARCHITECTURE)

DA Server: ....Transmission of real-time data to Clients
A&E Server: ....Transmission of Event information to Clients. Acknowledge and confirmation permitted from Client side

Testing and certification

TYPE TESTS

TEST	REFERENCE STANDARD	TEST LEVEL
Dielectric voltage withstand		
(high voltage power supply*)	60255-27	2200 VAC for one second
(low voltage power supply*)	60255-27	550 VAC for one second
* Test level is based on basic insulation principle (Power supply I/P terminals tested to Chassis ground).		
Impulse voltage withstand	EN60255-27	5 kV
Damped Oscillatory	IEC 60255-26 / IEC61000-4-18	2.5 kV CM, 1 kV DM
Electrostatic Discharge	IEC 60255-26 / IEC 61000-4-2	15 kV / 8 kV
RF immunity	IEC 60255-26 / IEC 61000-4-3	80 MHz - 1 GHz, 1.4 GHz - 2.7 GHz, 10 V/m
Fast Transient Disturbance	IEC 60255-26 / IEC 61000-4-4	2 kV / 4 kV
Surge Immunity	IEC 60255-26 / IEC 61000-4-5	0.5, 1 & 2 kV
Conducted RF Immunity	IEC 60255-26 / IEC 61000-4-6	150 kHz - 80 MHz, 26 MHz - 68MHz, 10V/m
Voltage interruption and Ripple DC	IEC 60255-26 / IEC 60255-4-11	15% ripple, 200ms interrupts
Radiated & Conducted Emissions	CISPR11 / CISPR22/ IEC 60255-26: Section 7.1.2 & 7.1.3	Class A
Sinusoidal Vibration	IEC 60255-21-1	Class 1
Shock & Bump	IEC 60255-21-2	Class 1
Seismic	IEC 60255-21-3	Class 2
Power magnetic Immunity	IEC 60255-26 / IEC 61000-4-8	1000 A/m, 100 A/m, 30A/m 300 A/m
Voltage Dip & interruption	IEC 60255-26 / IEC 61000-4-11	0, 40, 70, 80% dips, 250/ 300 cycle interrupts
Power frequency	IEC 60255-26 / IEC 61000-4-16	Level 4
Voltage Ripple	IEC 60255-26 / IEC 61000-4-17	15% ripple
Ingress Protection	IEC 60529	IP54 front
Environmental (Cold)	IEC 60068-2-1	-40°C 16 hrs
Environmental (Dry heat)	IEC 60068-2-2	85°C 16hrs
Relative Humidity Cyclic	IEC 60068-2-30	6 day variant 2
EFT	IEEE / ANSI C37.90.1	4KV, 2.5Khz
Damped Oscillatory	IEEE / ANSI C37.90.1	2.5KV, 1Mhz
RF Immunity	IEEE / ANSI C37.90.2	35V/m (max field), (80 MHz-1 GHz with 1 KHz sine and 80% AM modulation)
ESD	IEEE / ANSI C37.90.3	8KV CD/ 15KV AD
	UL 508	e83849 NKCR
Safety	UL C22.2-14	e83849 NKCR7
	UL 1053	e83849 NKCR

APPROVALS

	Applicable Council Directive	According to:
	Low voltage directive	2014/35/EU
CE compliance	EMC Directive	2014/30/EU
		UL 508
North America	cULus	UL 1053
		C22.2. No 14
EAC	Machines and Equipment	TR CU 010/2011
Lloyd's Register	Rules and Regulations for the Classifications of Ships	Marine Applications: ENV2, ENV3
IEC 61850	IEC 61850 Certificate Level B	IEC 61850-10
ISO	Manufactured under a registered quality program	ISO9001

EAC

The EAC Technical Regulations (TR) for Machines and Equipment apply to the Customs Union (CU) of the Russian Federation, Belarus, and Kazakhstan.

Item	Description
Country of origin	Spain or Canada; see label on the unit
Date of manufacture	See label on the side of the unit
Declaration of Conformity and/or Certificate of Conformity	Available upon request

Physical

DIMENSIONS

NOTE

Refer to Chapter 2 for details

NON-DRAWOUT UNIT

Height:.................. 7.98" (202.7 mm)
Width:.................. 6.23" (158.2 mm)
Length:.................. 9.35" (237.5 mm)

DRAWOUT UNIT

Height:.................. 7.93" (201.51 mm)
Width:.................. 6.62" (138.2 mm)
Length:.................. 9.62" (244.2 mm)

WEIGHT

NON-DRAWOUT UNIT

Weight (net): .... 2.9 kg (6.4 lbs)
Weight (gross):.................. 4.0 kg (8.6 lbs)

DRAWOUT UNIT

Weight (net): .... 3.9 kg (8.6 lbs)
Weight (gross):.................. 5.0 kg (11.0 lbs)

Environmental

OPERATING ENVIRONMENT	
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:	2000 m (max)
Pollution Degree:	II
Overvoltage Category:	III
Ingress Protection:	IP54 Front, IP20 cover (optional)
Noise:	0 dB

350 Feeder Protection System

Chapter 2: Installation

Mechanical installation

This section describes the mechanical installation of the 350 system, including dimensions for mounting and information on module withdrawal and insertion.

This equipment is **Suitable for mounting on the flat surface of a Type 1 Enclosure**

Dimensions

The dimensions of the 350 are on the following pages. Additional dimensions for mounting and panel cutouts are shown in the following sections.

Figure 2-1: 350 dimensions - Drawout unit

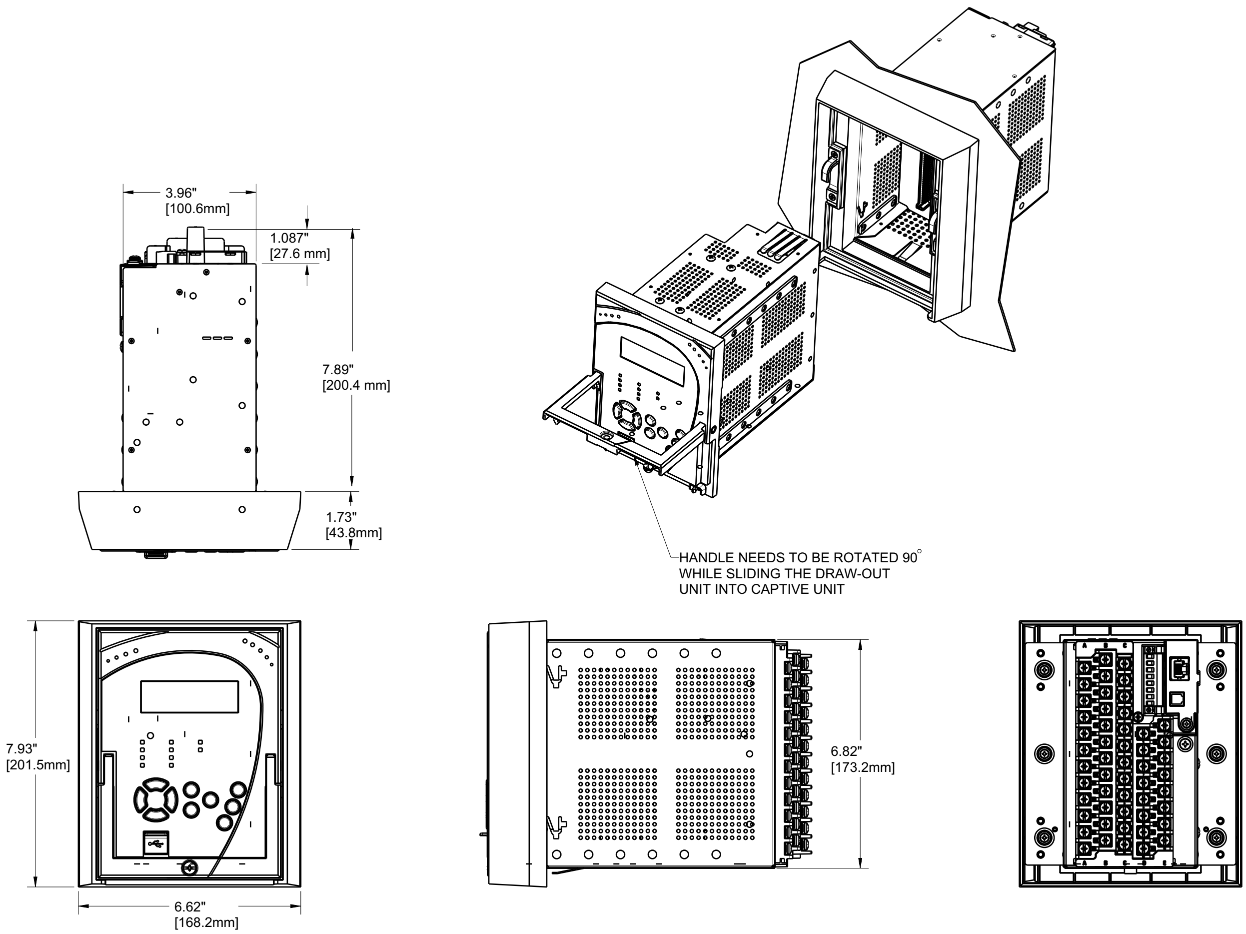
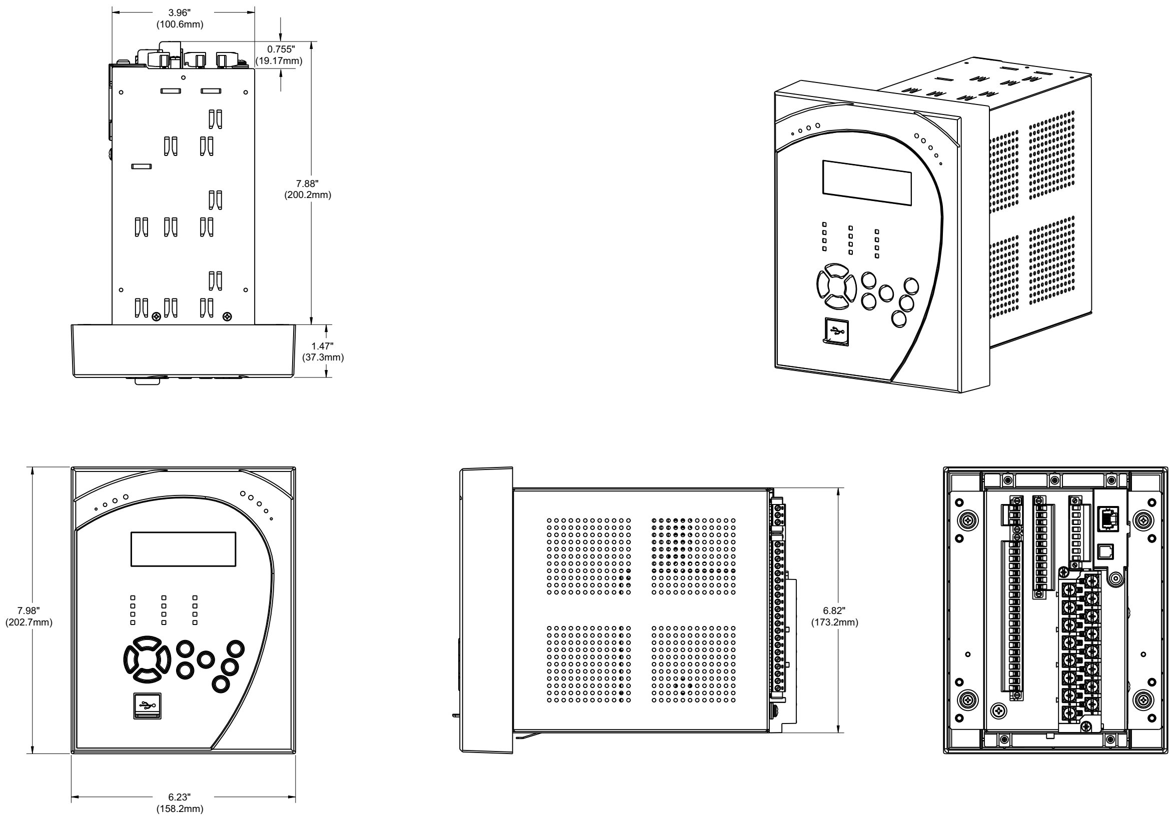


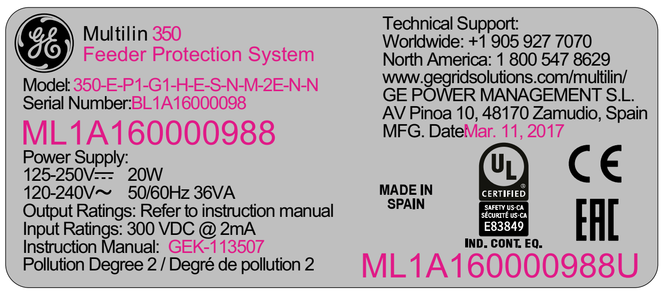
Figure 2-2: 350 dimensions - Non-drawout unit



Product identification

The product identification label is located on the side panel of the 350 . This label indicates the product model, serial number, and date of manufacture.

Figure 2-3: 350 Product labels



NOTE

The pink color text (i.e. Model, Serial Number, Instruction Manual, MFG Date) is for reference only. The text can vary.

Mounting

Standard panel mount

The standard panel mount and cutout dimensions are illustrated in the following figures.

⚠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 mounting - Drawout

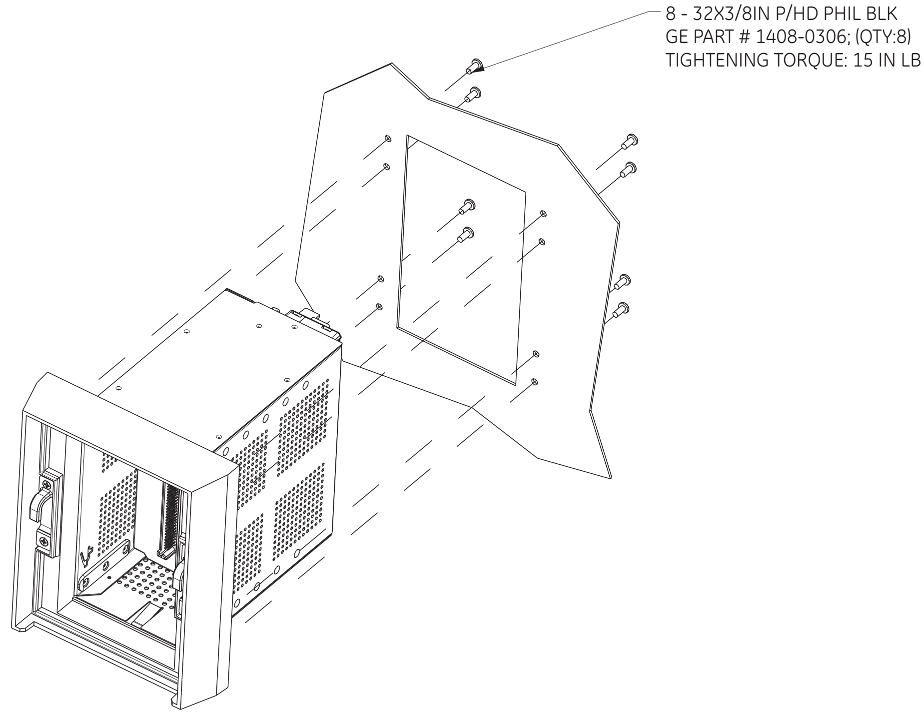


Figure 2-5: Standard Panel mounting - Non-drawout

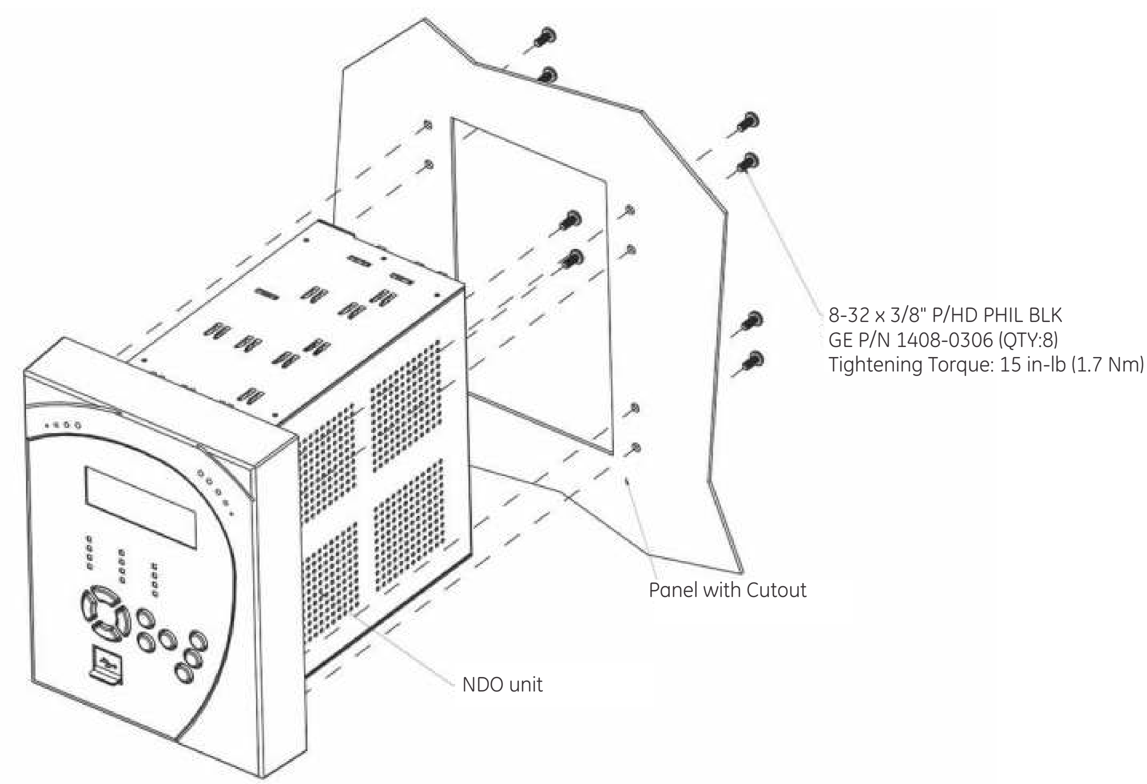
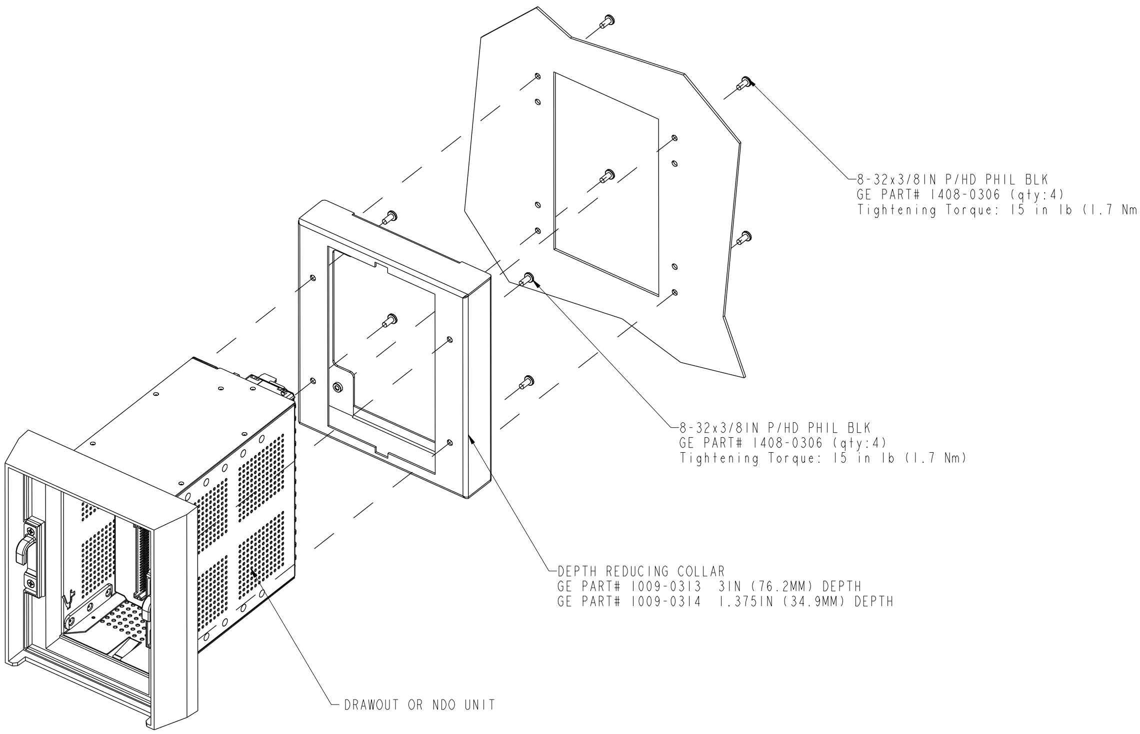


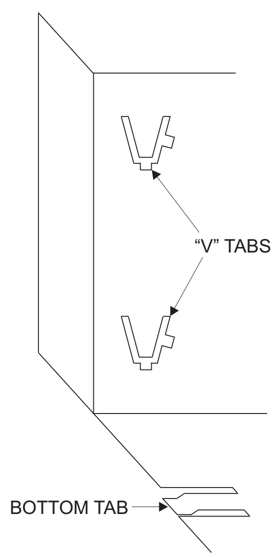
Figure 2-6: Depth Reducing collar (optional)



Panel mounting with depth reducing collar:

1. Mount the collar of required depth (1.375" or 3") to the unit (captive or non-drawout) using 4 screws (see above).
2. Mount the combination of unit and collar to the panel using 4 screws as shown above.

Figure 2-7: Mounting tabs (optional)

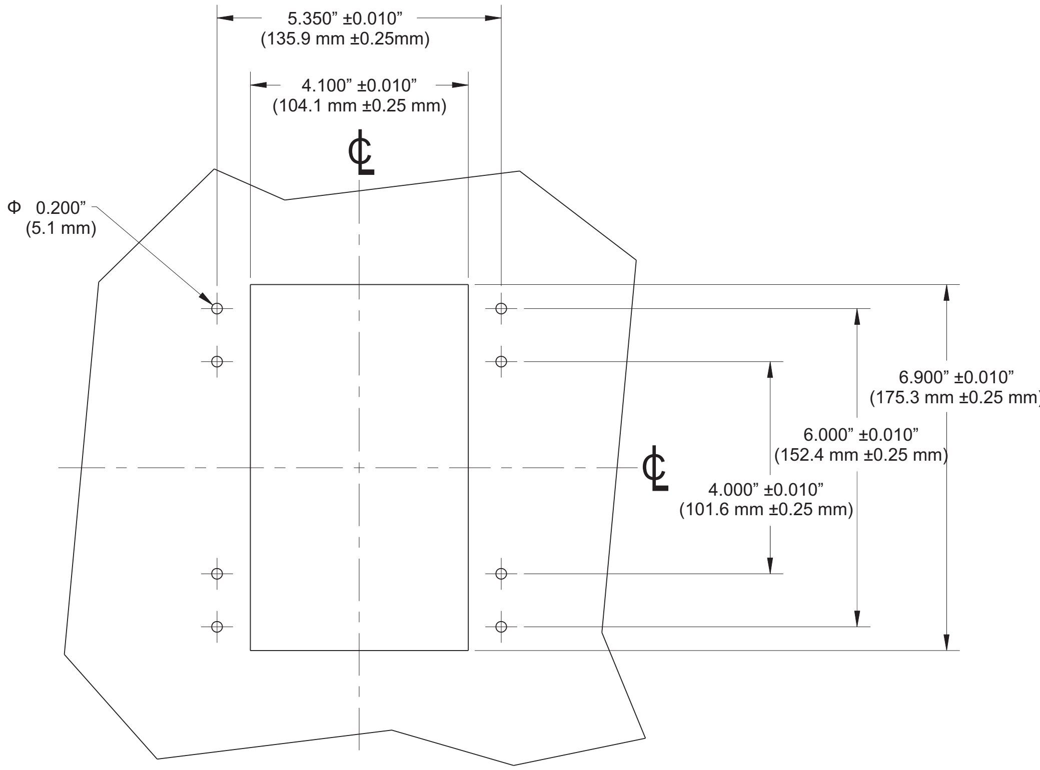


1. From the front of the panel, slide the empty case into the cutout until the bottom tab clicks into place (see above).
2. From the rear of the panel screw the case into the panel at the 8 screw positions shown above.

3. If added security is required, bend the retaining "V"tabs outward, to about 90°. These tabs are located on the sides of the case and appear as shown above.

The relay can now be inserted and can be panel wired.

Figure 2-8: Panel cutout dimensions



Mounting using the S1/S2/MDP/IAC or SR735 adapter plate

Retrofit Kit	Kit Part Number	Adapter Plate	Washer Lock (8)	Machine Screws (8)	Flat Washers (4)	Screws with ext. Lock Washers (4)
350 Retrofit Kit for 735	1819-0103	1463-0012	1430-0003	1408-0015	1430-0039	1410-0112
350 Retrofit Kit for IAC Relay	1819-0102	1463-0011	1430-0003	1408-0015	1430-0039	1410-0112
350 Retrofit Kit for MDP Relay	1819-0101	1463-0011	1430-0003	1408-0015	1430-0039	1410-0112
350 Retrofit Kit for S1/S2 Cut-Out	1819-0100	1463-0011	1430-0003	1408-0015	1430-0039	1410-0112

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.

The adaptor plate for mounting the 350 directly over the existing S1/S2/MDP/IAC or SR735 mounting plate, is shown below:

Figure 2-9: Adaptor Plate mounting - Drawout case

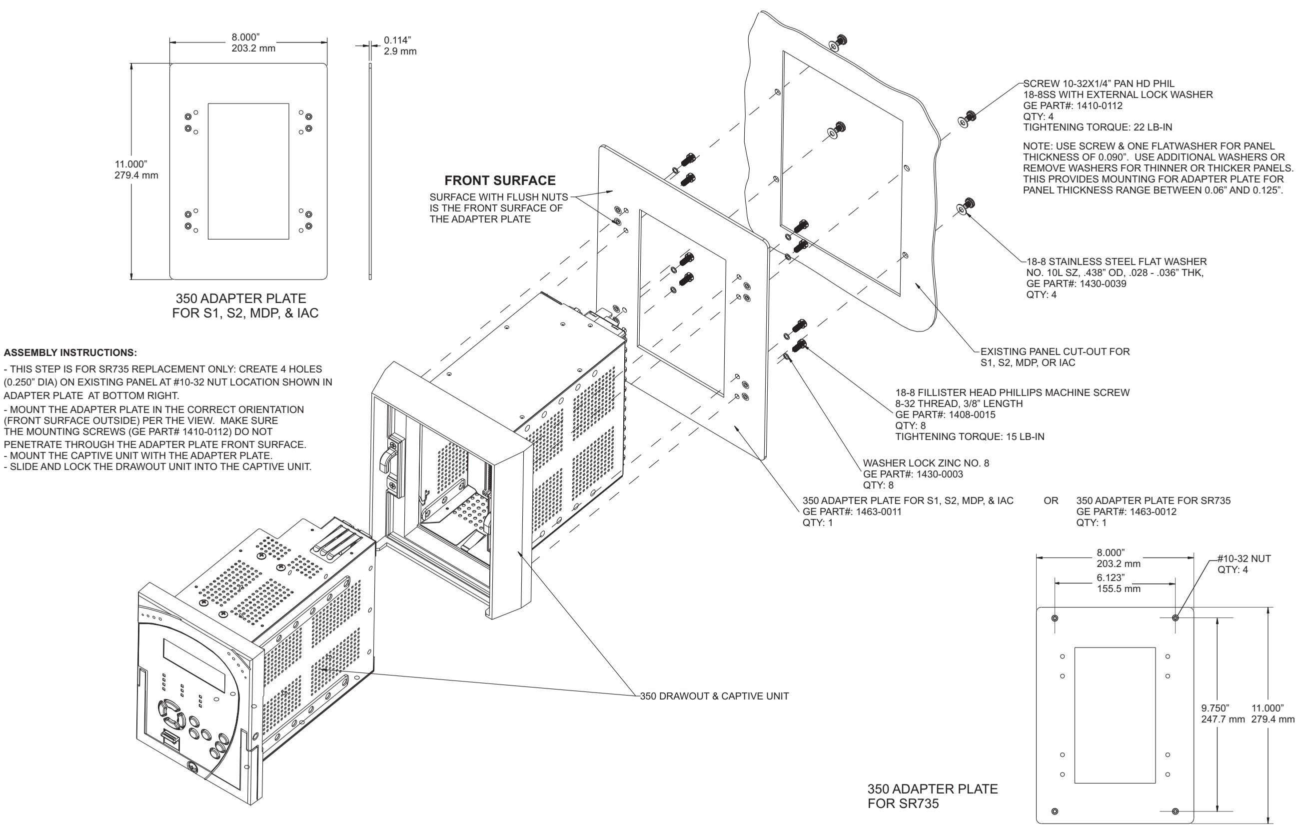


Figure 2-10: Non-drawout - Adapter plate mounting

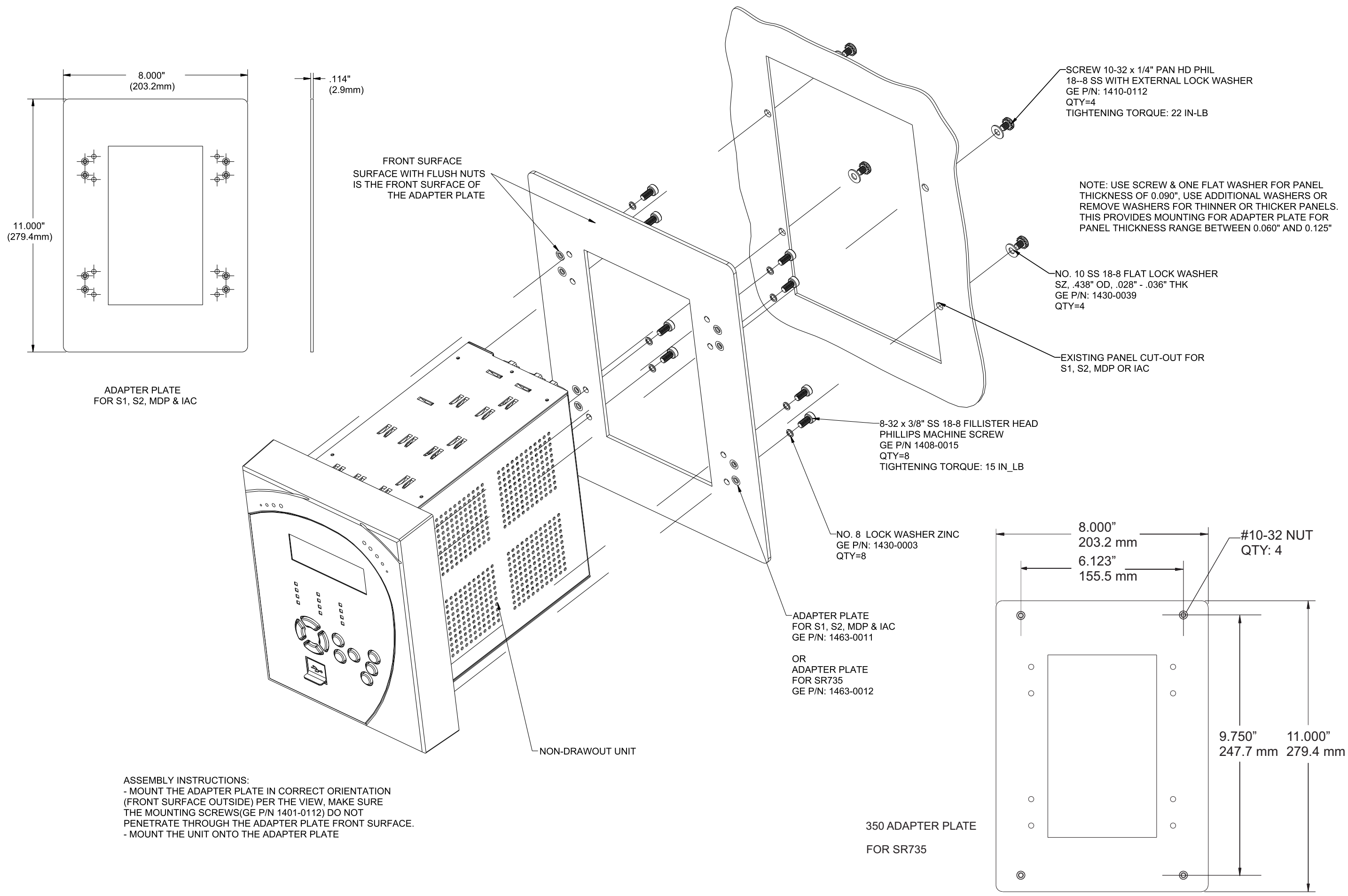
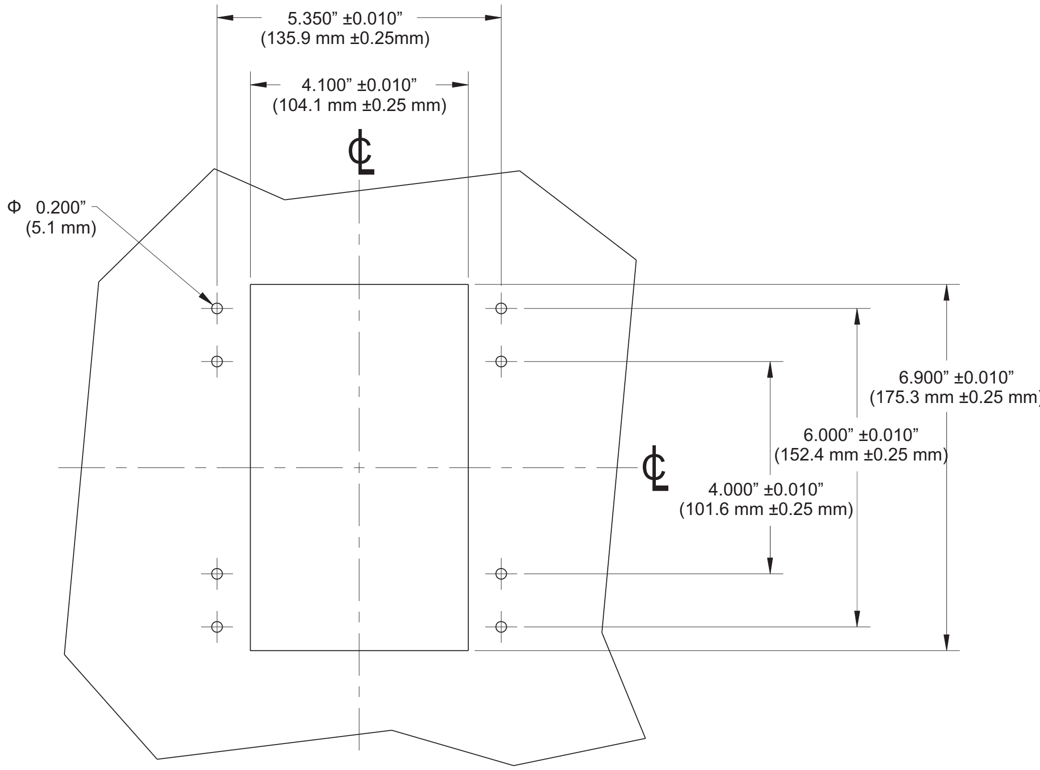
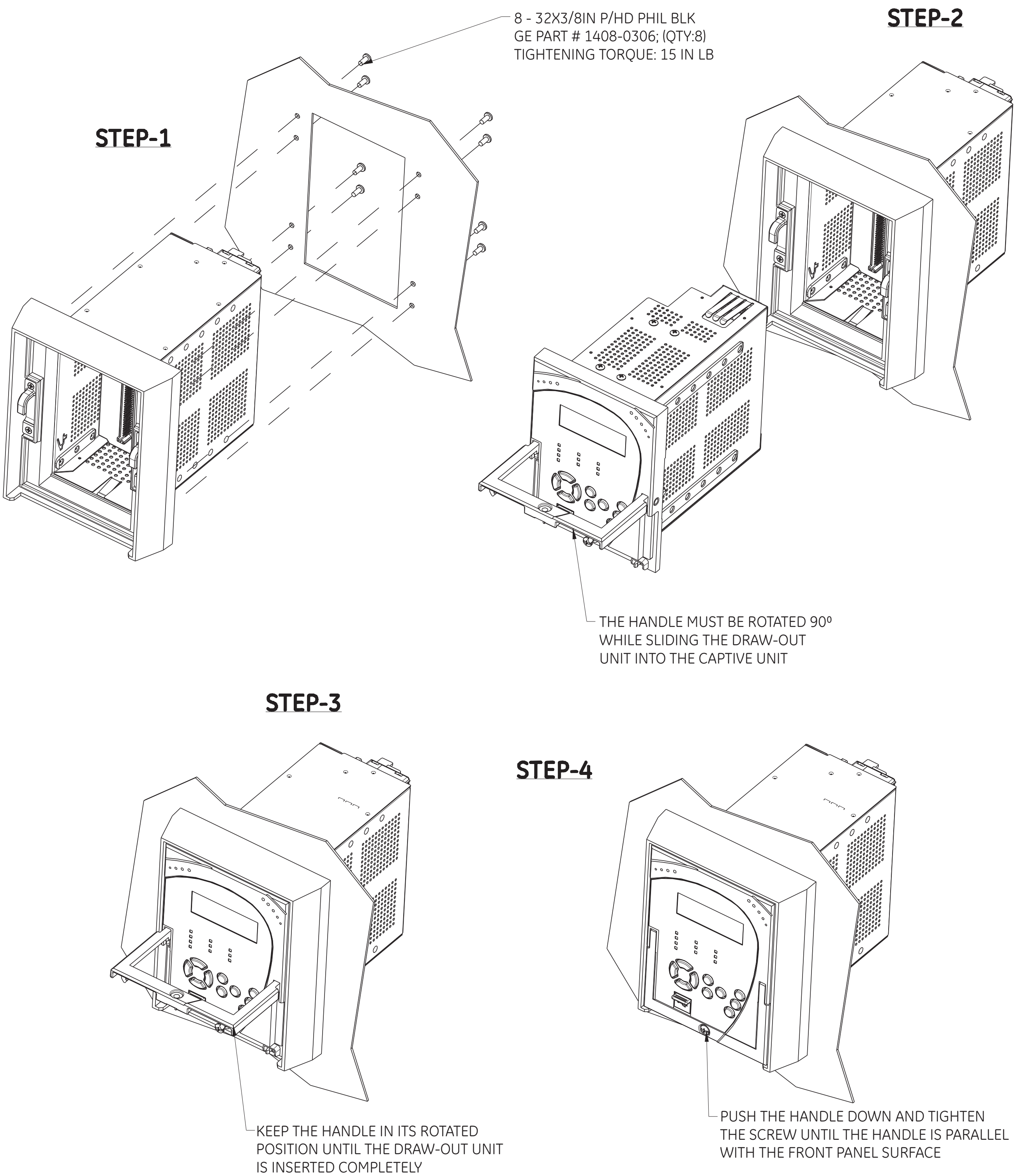


Figure 2-11: Panel cutout dimensions



Drawout unit withdrawal and insertion

Figure 2-12: Unit withdrawal and insertion diagram



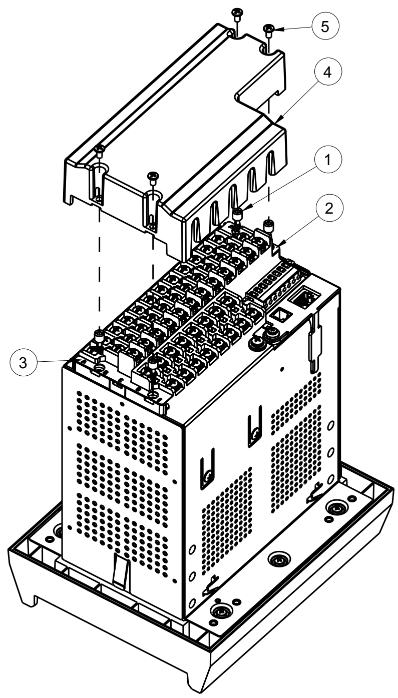
IP20 Cover (optional)

The IP20 cover minimizes potential dangers to users by preventing finger contact with electrical connections at the back of the 3 Series drawout units.

Attaching the cover

The steps for attaching the IP20 cover (optional) to the drawout unit are as follows:

Figure 2-13: IP20 Cover mounting - Drawout unit only



1. Place 4 custom standoffs (item#1) using the suggested tightening torque of 8lb-in in the following order:

   A. Remove the 2 mounting screws near letters A and C, of label ABC (item#2), and mount 2 standoffs.

   B. Remove the 2 mounting screws near the letters B and E, of label ABCDE (item#3), and mount 2 standoffs.

2. Place the IP20 cover (item#4) and secure it with 4 screws (item#5) using the suggested tightening torque of 8lb-in.

NOTE

Make sure the device terminals are wired before placing the cover. Use the 5 slots located on each side of the cover to guide the wires outside of the cover.

Retrofit kit for IP20

Before attaching the cover, remove the old labels from the device (see item#2 and item#3) and replace them with the new labels from the retrofit kit. Attach the cover as described in the previous section.

Arc flash sensors

Arc flash sensors house the fiber optics that are used to detect the arc flash. Mounting details depend on the sensor type (point or loop).

For detailed installation, testing and maintenance guidance for Arc Flash sensors, see GET-20057 *3 Series Arc Flash Application Note*.

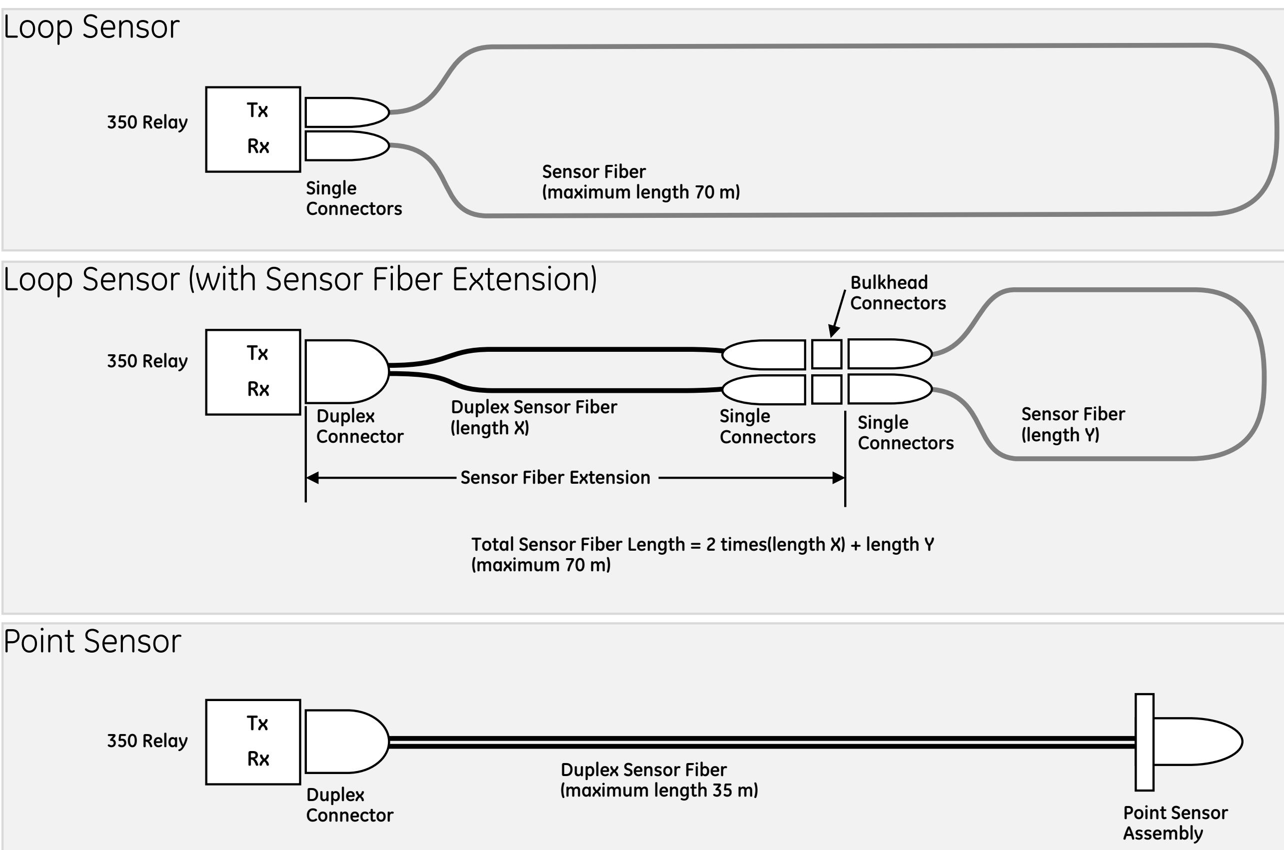
⚠CAUTION

If the relay 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.

⚠CAUTION

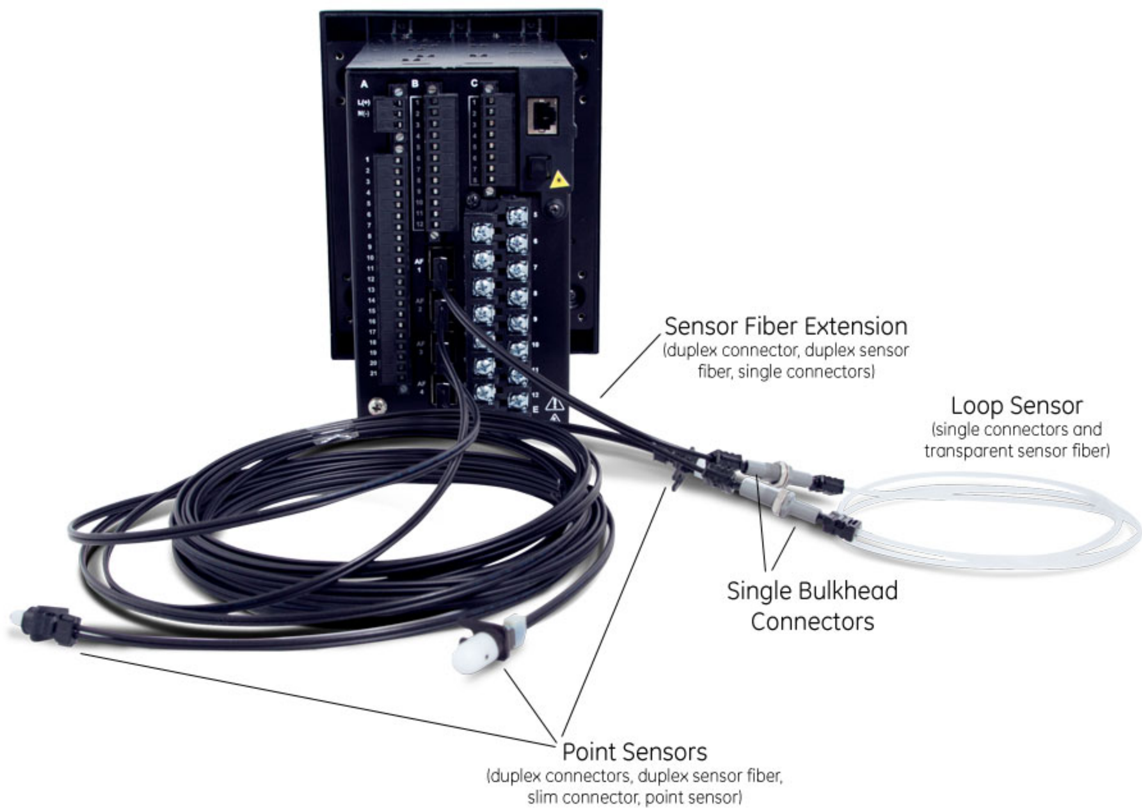
This product uses optical electronic devices (line or point sensors) to sense arc flash fault conditions. It is recommended to follow proper housekeeping measures & establish a regularly scheduled preventive maintenance routine to ensure proper device operation. For maintenance recommendations, see GET-20057 *3 Series Arc Flash Application Note*

Arc flash sensors are available in two different configurations, point and loop. Loop sensors can be used with a black-coated sensor fiber extension to connect the ends of the loop sensor to the 350 relay through panels up to 51 mm (2 inches) thick.



Arc flash sensors of either type can be connected to any of the four arc flash ports on the back of the 350 relay, as shown.

Figure 2-14: Arc flash sensors connected to a 350 relay



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 35 mm (1.3 inches). 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 or other live conductors.

- 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.

Point sensor installation

Figure 2-15: Arc flash point sensor without sensor fiber connected

Figure 2-16: Point sensor and slim connector dimensions

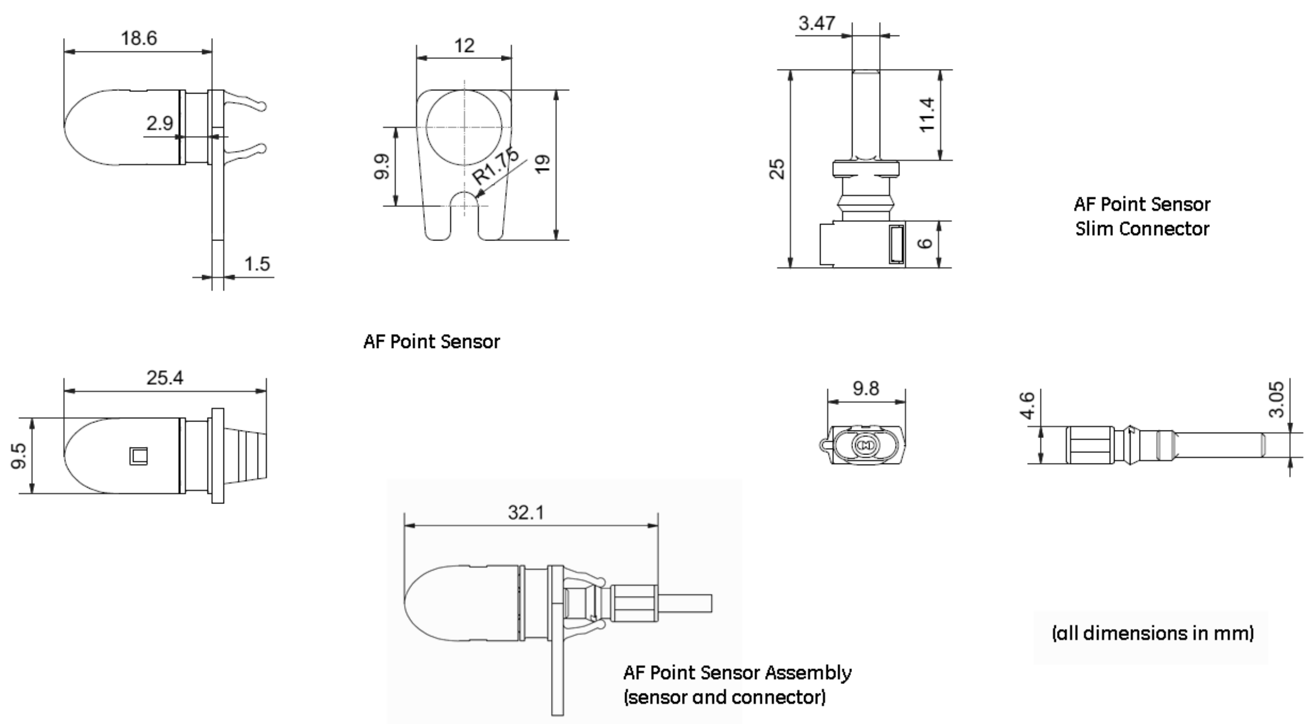
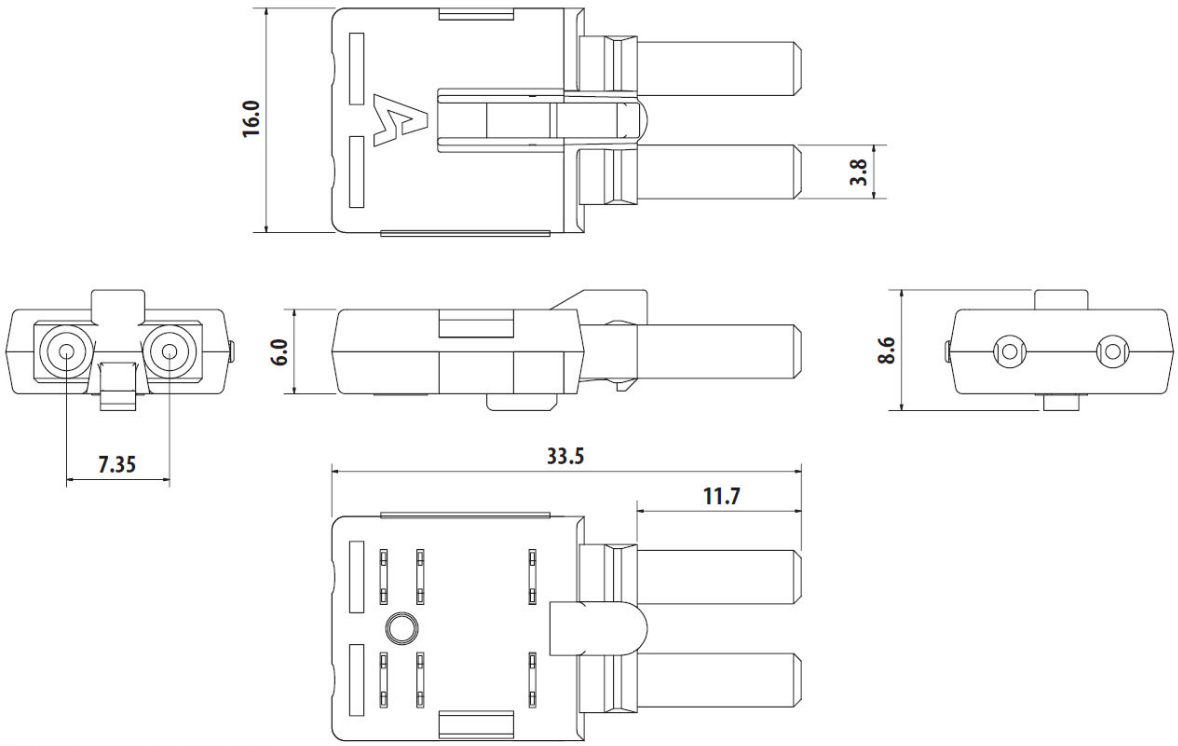


Figure 2-17: Duplex connector dimensions (point sensor, and sensor fiber extension for loop sensor)



Note: Dimensions are in mm

The point sensor fiber includes a duplex connector to connect to the back of the 350 relay on one end, and a compressed slim connector that connects to the sensor itself on the other end.

Before installing the AF sensor units, ensure that all other drilling and installation is complete to minimize possible damage to the sensitive unit and connected sensor fiber cable. Choose a location for the sensor clear of any obstructions that could shield the sensor from arc flash light.

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.

General installation:

1. Choose a location for the point sensor.

   Arc flash point sensors should be installed clear of any obstructions that could shield the sensor from arc flash light, and less than 2m (6ft 6") from any potential arc flash source.

   The sensor head should be pointed towards the most likely source of arc flash.

   For further guidance selecting point sensor locations, see GET-20057 *3 Series Arc Flash Application Note*.
2. Remove the slim connector from the point sensor assembly.
3. Carefully route the duplex sensor fiber from the point sensor location to the back of the relay unit, minimizing loops and curves for the strongest possible signal. Ensure all sensor fiber handling precautions are followed.

The slim connecter fits through holes with a diameter of 11 mm or greater, and can be threaded through holes drilled in any panels between the relay and arc flash detection location.

NOTE

Install protective grommets when routing sensor fiber through metal walls.

4. Mount the point sensor using either a cable tie mount or through-hole mount, as detailed below.
5. Reconnect the slim connector to the point sensor.

Arc flash point sensors can be installed in one of two ways, using a cable tie mount or a through-hole mount.

Cable tie mount:

- Requires a 2.5-mm-wide cable tie.
- Mount the sensor on a stick or similar using the cable tie, as shown in the following figure.

Figure 2-18: AF point sensor, cable tie mount

Through-hole mount

- Requires a standard or self-tapping M3 screw, and optionally an M3 washer.
- Mount the sensor through a 10 mm hole made in the surface of any mechanical structure inside the switchgear or on the surface of one side of the switchgear itself, as shown in the following figure.

Figure 2-19: AF point sensor, through-hole mount

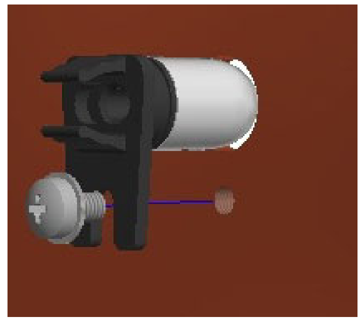


Figure 2-20: AF point sensors connected to 350 relay

Make sure there is no dirt or dust inside the point sensor or on the surface because it reduces the capturing efficiency of the device, increases its transmission loss, or both. If the point sensor is covered with dust, clean it by blowing or wiping the dust off the point sensor.

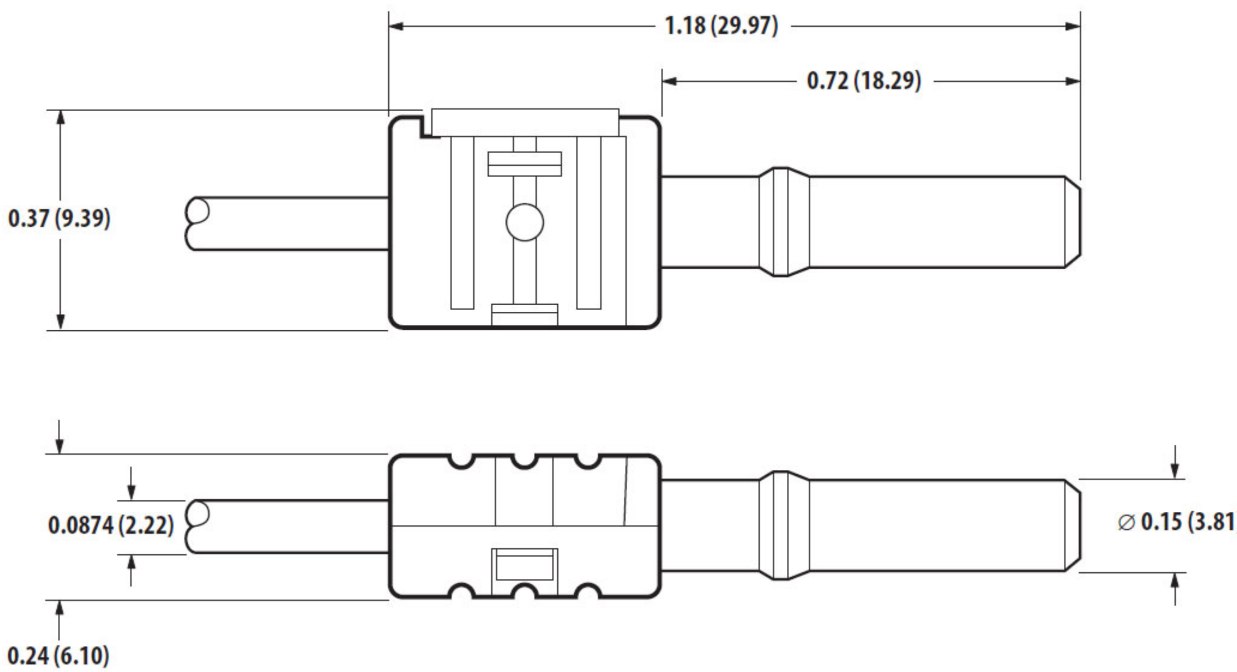
NOTICE

The material of the point sensor is not affected by water-based cleaning agents, dish soap, or organic solvents with an alcohol (ethanol) base. Do not use solvents or solvent mixtures that contain acids because they can attack or dissolve the optical plastic material.

Loop sensor installation

The loop sensor transparent sensor fiber has a single connector on either end. The sensor fiber extension has a duplex connector on one end, two single connectors on the other end, and comes with two single bulkhead connectors. Both come in custom lengths, which can be ordered to fit your installation.

Figure 2-21: Single connector dimensions (loop sensor, and sensor fiber extension for loop sensor)



All dimensions are in inches and (millimeters).

Figure 2-22: Duplex connector dimensions (point sensor, and sensor fiber extension for loop sensor)

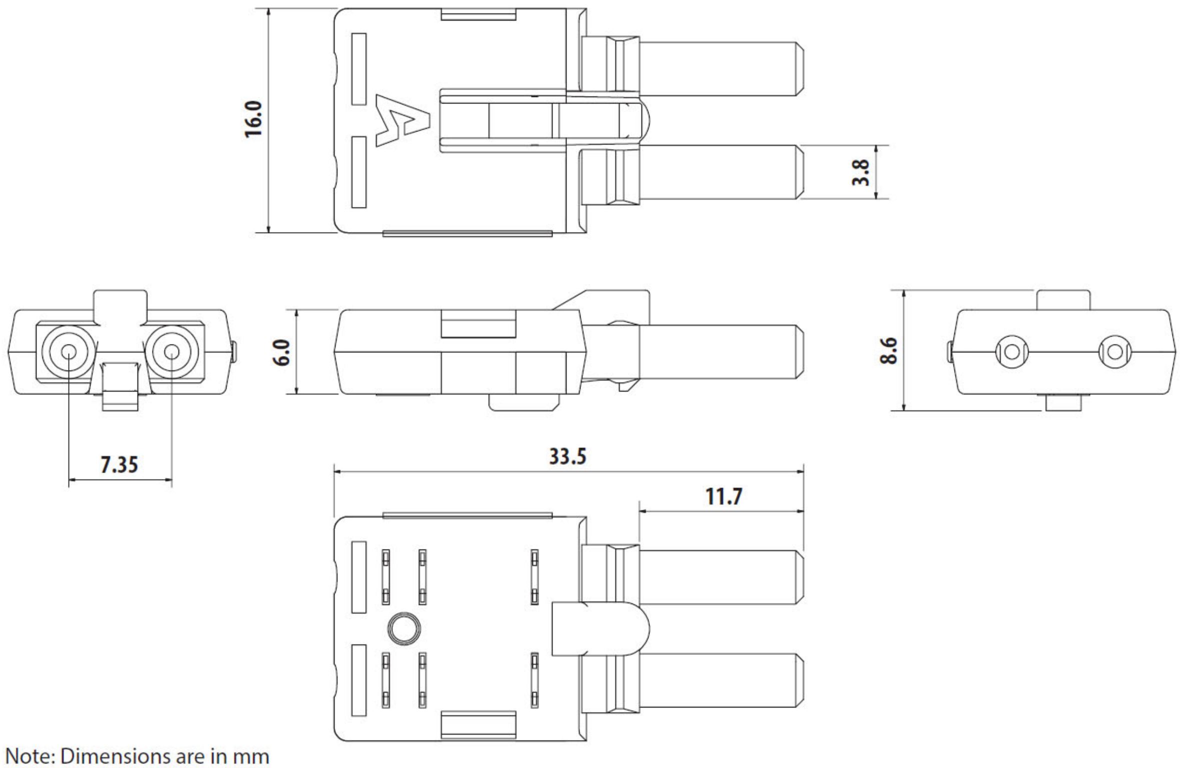


Figure 2-23: Single bulkhead connector dimensions

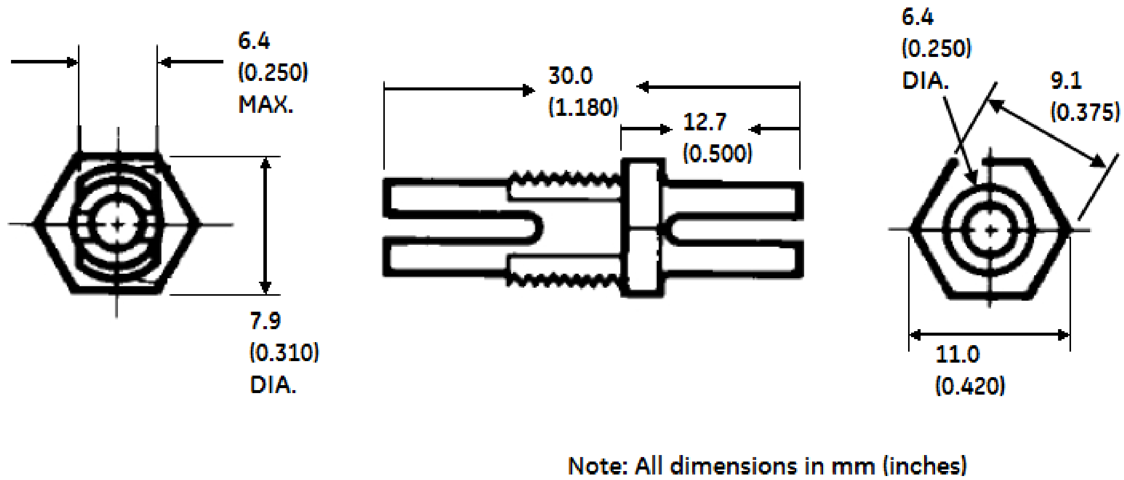
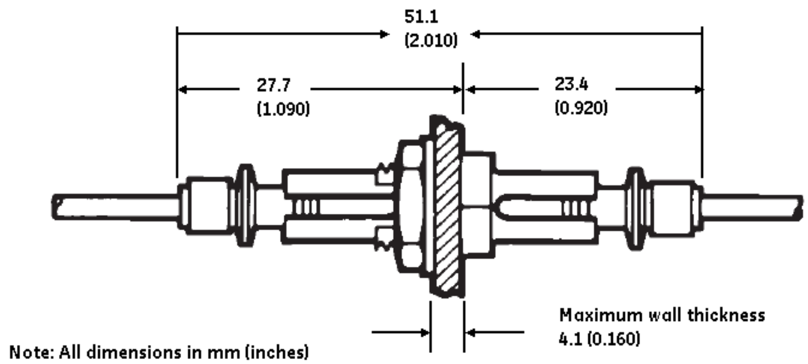


Figure 2-24: Single bulkhead connector with single connectors and sensor fiber



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

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.

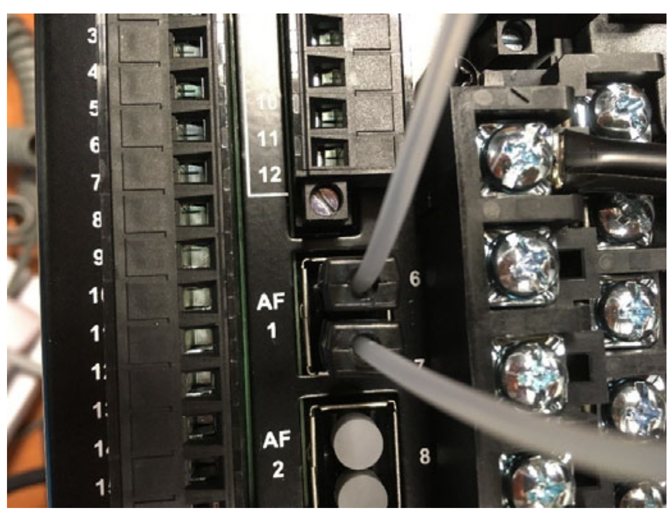
NOTICE

The loop sensor fiber can be connected directly to the 350 relay without a sensor fiber extension, however, care must be taken to ensure correct alignment of the loop sensor single connectors into the 350 light sensor input.

Installing the loop sensor fiber without an extension:

1. Plan the path of the loop sensor fiber, looping through the chamber or chambers requiring arc flash detection. See GET-20057 *3 Series Arc Flash Application Note* for detailed examples of loop sensor installation.
2. Ensure that both ends of the loop remain close together and can reach the 350 relay light sensor inputs.
3. Install the loop sensor carefully, following all sensor fiber handling guidelines.
4. Plug the single connectors into the back of the 350 relay, ensuring correct alignment as shown.

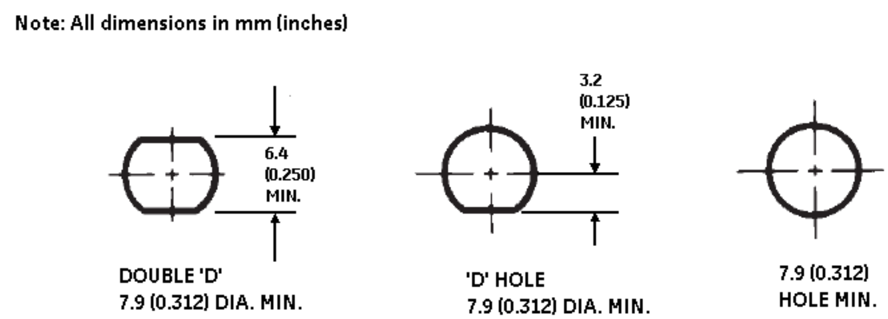
Figure 2-25: Loop sensor fiber direct to relay - correct installation



Installing the loop sensor fiber with a sensor fiber extension:

1. Plan the path of the loop sensor fiber, looping through the chamber or chambers requiring arc flash detection. See GET-20057 *3 Series Arc Flash Application Note* for detailed examples of loop sensor installation.
2. Ensure that both ends of the loop remain close enough together to be reached by the sensor fiber extension. If needed, gently pull apart the duplex sensor fiber extension from the end with two single connectors, being careful not to bend the fiber with a radius of less than 35 mm (1.3 inches).
3. Ensure that the sensor fiber extension is long enough to reach the 350 relay from the bulkhead connector location.
4. Mount the bulkhead connector on the side of the chamber, following the drill hole dimensions provided. Note that the single bulkhead connector uses washers 11.0 mm (0.420 in) wide, so the drill holes must be spaced accordingly if the loop sensor path begins and ends in the same place.

Figure 2-26: Bulkhead connector cutout



5. Install the loop sensor carefully, following all sensor fiber handling guidelines.
6. Plug the ends of the loop sensor into the bulkhead connectors.
7. Plug the single connectors on the sensor fiber extension into the other sides of the bulkhead connectors, and the duplex connector into the back of the 350 relay.

Electrical installation

This section describes the electrical installation of the 350 system, including typical wiring diagrams and terminal identification.

Typical wiring diagrams

Figure 2-27: Typical wiring diagram - Drawout

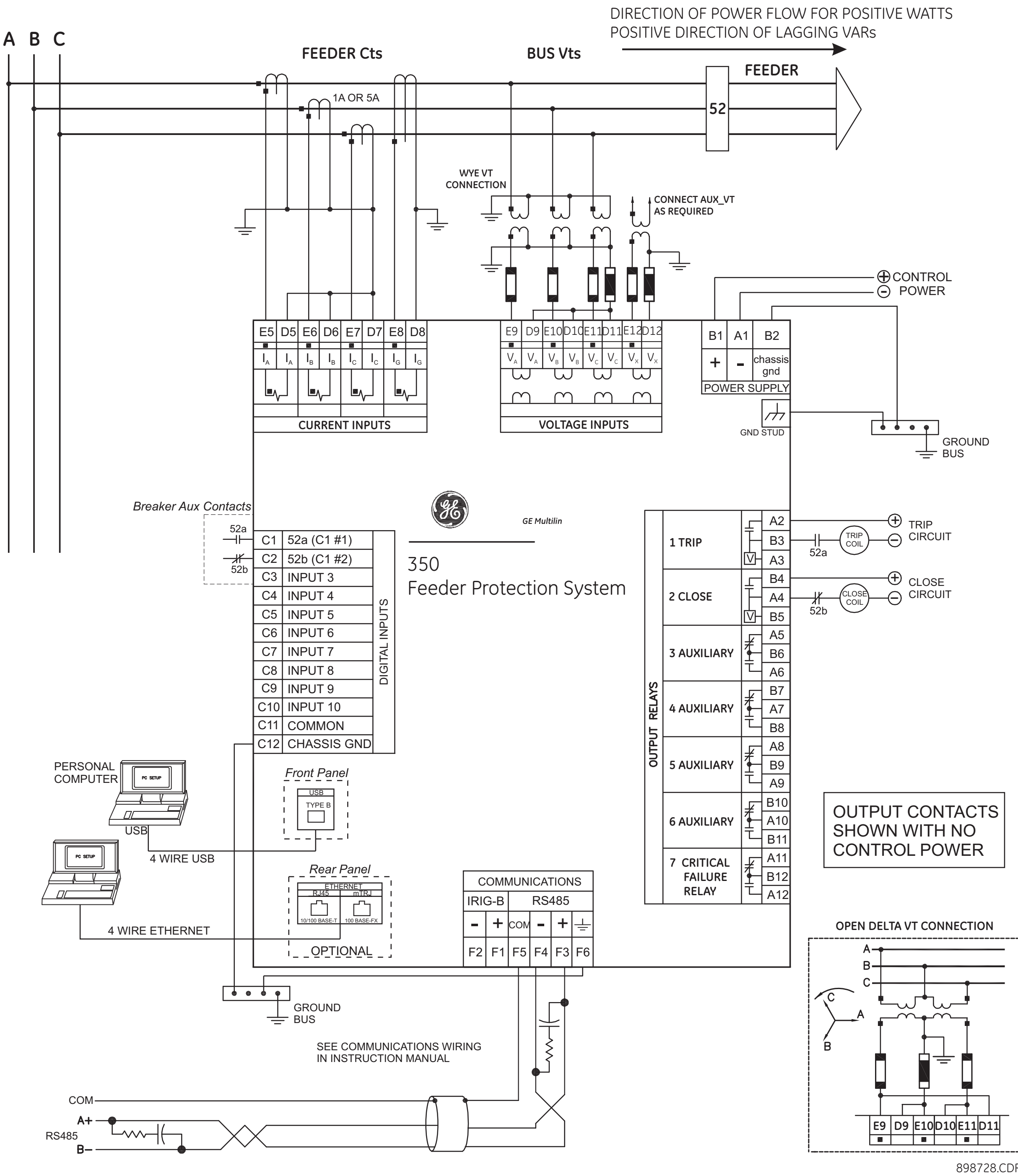
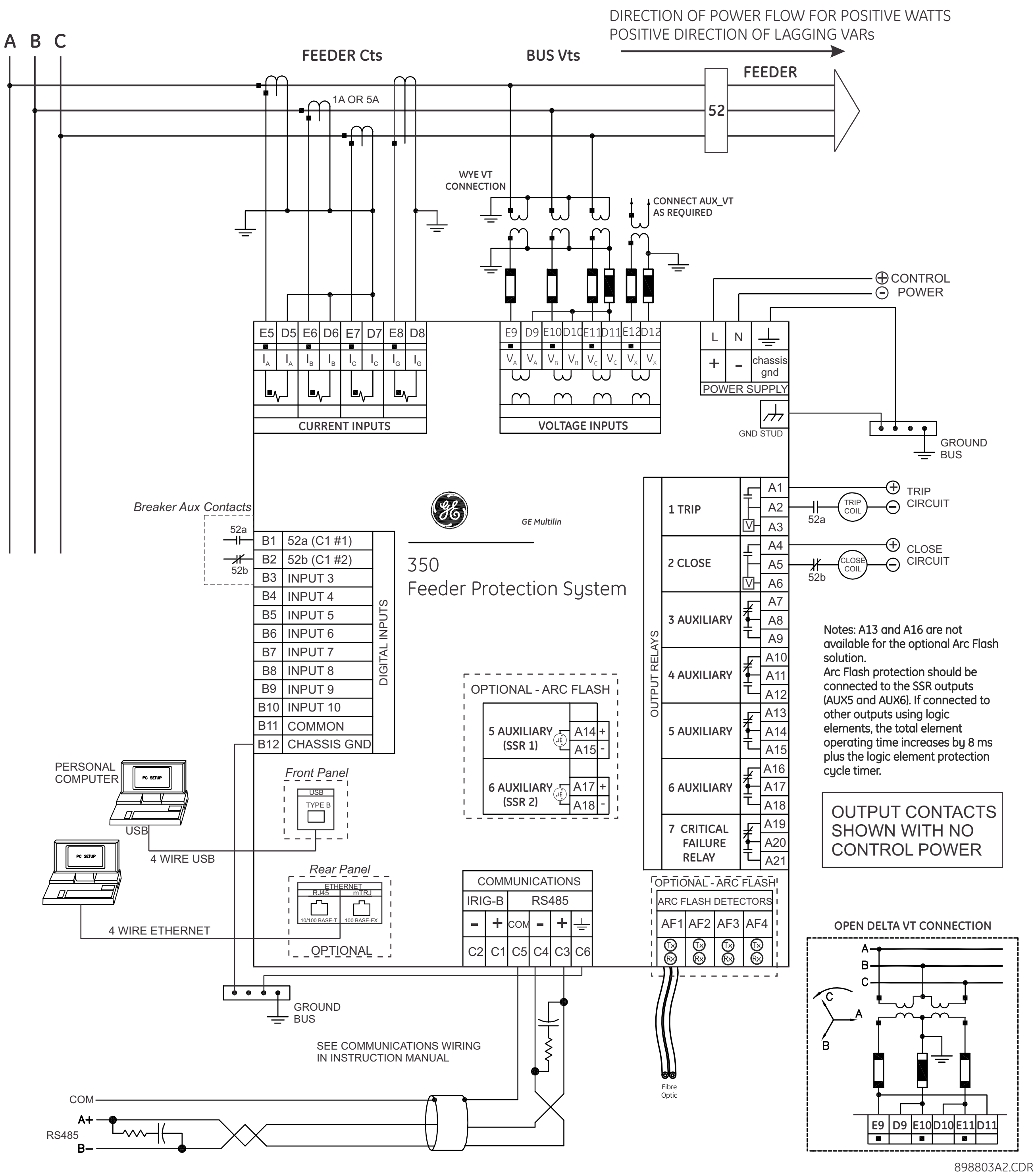


Figure 2-28: Typical wiring diagram - Non-drawout



350 Terminal identification

NOTE

When installing two lugs on one terminal, both lugs should 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 2-29: Orient the Lugs correctly...

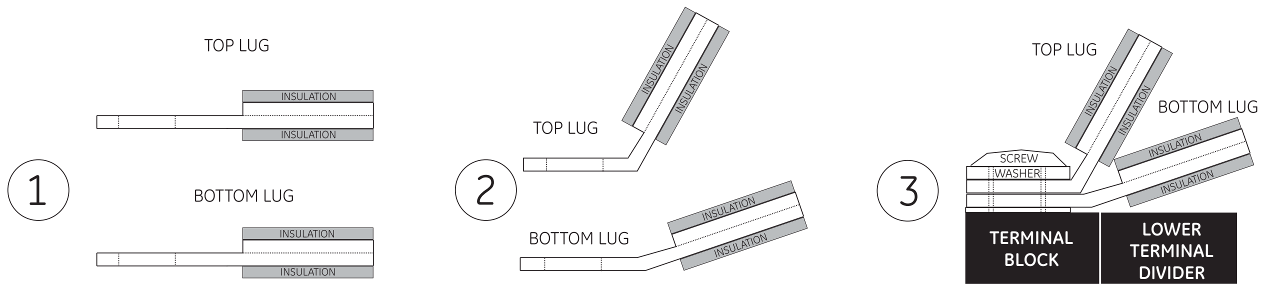


Figure 2-30: CORRECT INSTALLATION METHOD

Figure 2-31: INCORRECT INSTALLATION METHOD (lower lug reversed)

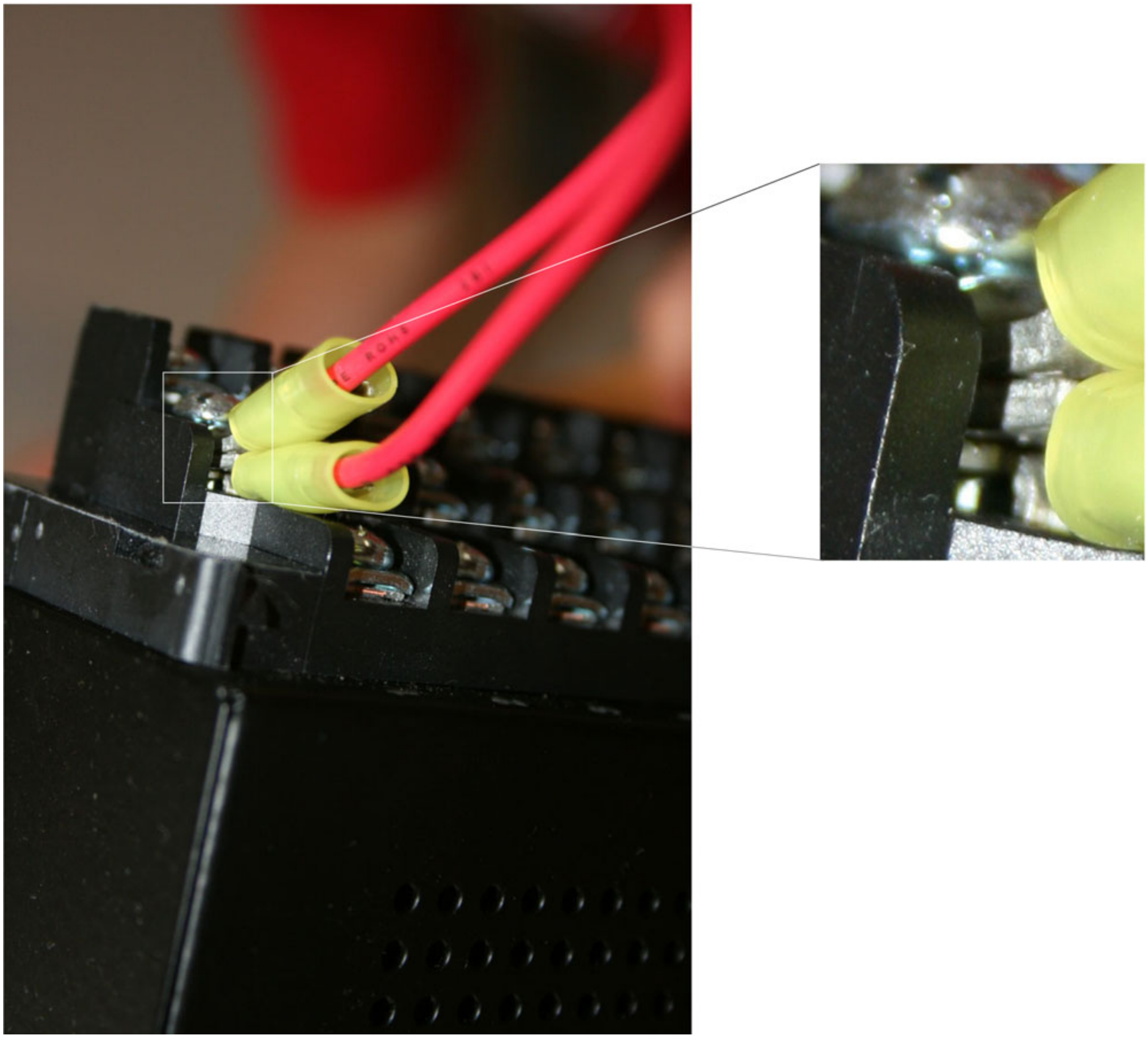


Figure 2-32: 350 Terminal Identification - standard(drawout)

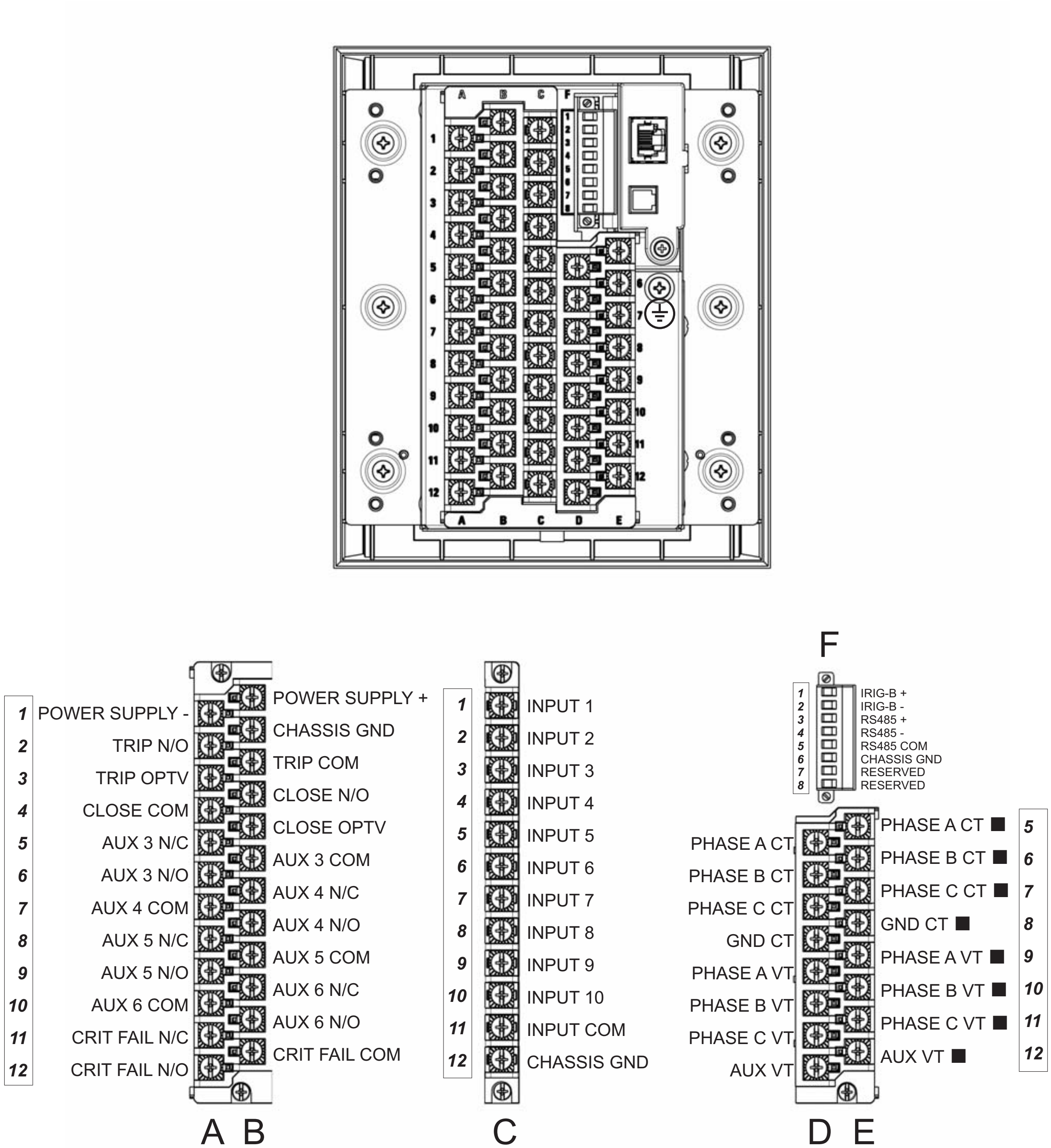
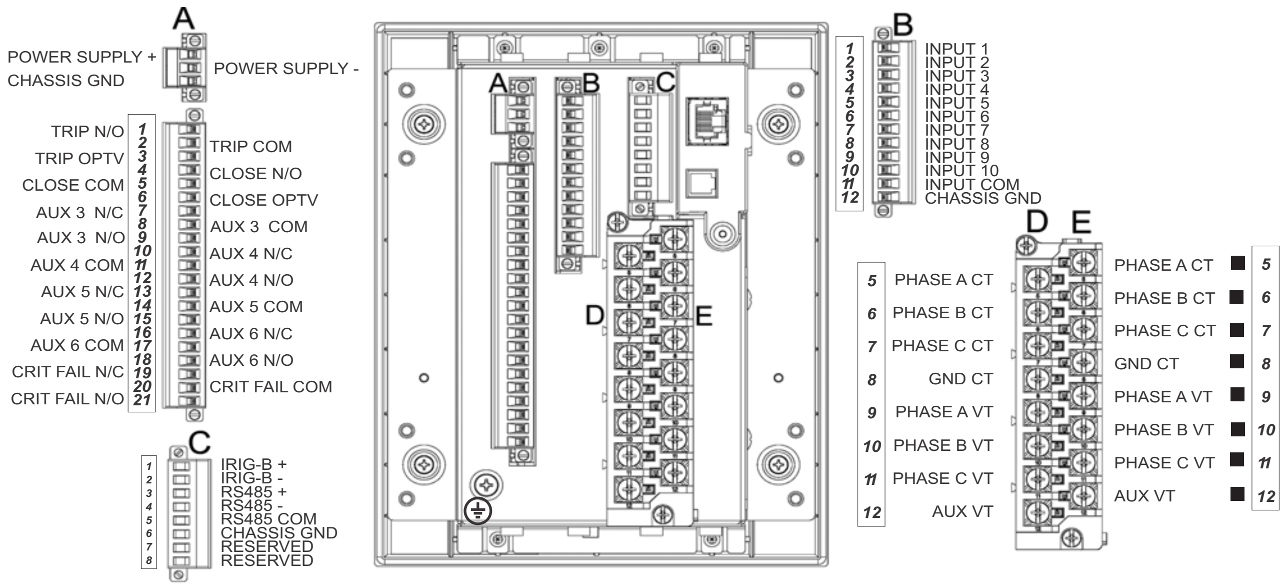


Figure 2-33: 350 Terminal Identification - Non-drawout



Wire range

Use the following guideline when selecting wires or lugs to connect to terminal blocks A,B,C,D,E (Drawout case design), and terminal blocks D,E (Non-drawout case design):

- 12 AWG to 22 AWG (3.3 mm^2 to 0.3 mm^2): Single wire termination with/without 9.53 mm (0.375") maximum diameter ring terminals.
- 14 AWG to 22 AWG (2.1 mm^2 to 0.3 mm^2): Multiple wire termination with matching wire sizes and stranding. Two wires maximum per circuit.
- 14 AWG to 22 AWG (2.1 mm^2 to 0.3 mm^2): Multiple wire termination with 9.53 mm (0.375") maximum diameter ring terminals. Two ring terminals maximum per circuit.
- Suggested wiring screw tightening torque, tighten to 12 in-lb (1.35 N-m).
- The uncovered communications cable shield connected to the common terminal should not exceed 1" (2.5 cm) for proper EMC shielding of the communications cable.
- Minimum suggested temperature rating for the conductors is 75C.
- Wire type: copper

Phase sequence and transformer polarity

For correct operation of the relay features, the user must follow the instrument transformer polarities, shown in the Typical Wiring Diagram. Note the solid square markings shown with all instrument transformer connections. When the connections adhere to this 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.

Current inputs

The 350 relay has four (4) channels for AC current inputs, each with an isolating transformer. There are no internal ground connections on the current inputs. Current transformers with 1 to 6000 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 will correctly measure up to 20 times the current input's nominal rating. Time overcurrent curves become horizontal lines for currents above the 20 × CT rating. This becomes apparent if the pickup level is set above the nominal CT rating.**

⚠CAUTION **Before working on CTs, they MUST be short circuited.**

Ground and sensitive ground CT inputs

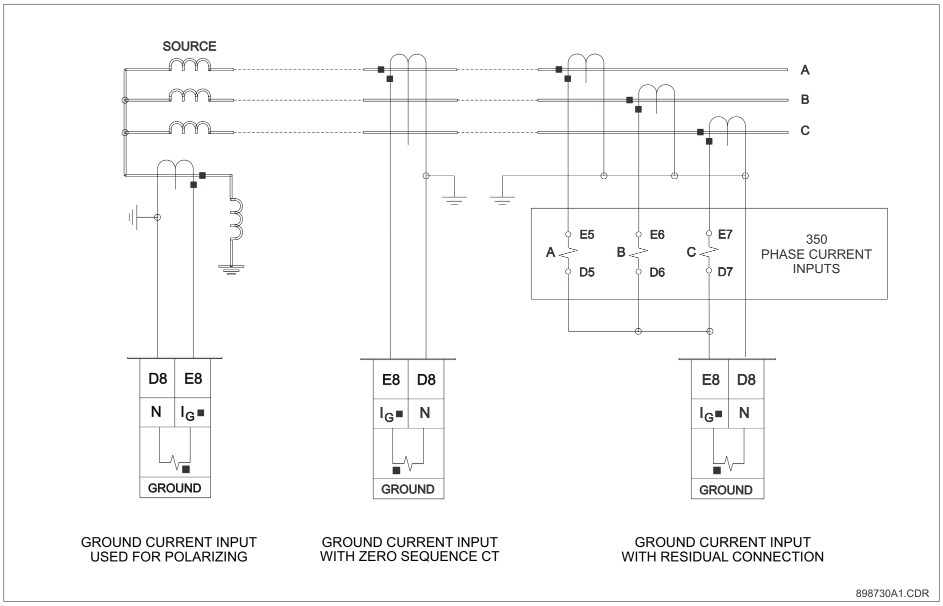
One dedicated ground input is referred to throughout this manual as the **Ground Current** or **Sensitive Ground Current** input. Before making ground connections, consider that the relay automatically calculates the neutral (residual) current from the sum of the three phase current phasors. The following figures show three possible ground connections (or three possible sensitive ground connections).

The ground input (Terminals D8 and E8) is used in conjunction with a Zero Sequence CT as source, or in the neutral of wye-connected source CTs. The ground current input can be used to polarize the neutral directional element. When using the residual connection set the GROUND CT PRIMARY setpoint to a value equal to the PHASE CT PRIMARY setpoint.

In cases where the relay is equipped with sensitive ground CT (terminals D8 and E8) the sensitive ground current input is intended for use either with a CT in a source neutral of a high-impedance grounded system, or on ungrounded systems. On ungrounded systems it is connected residually with the phase current inputs. In this case, the SENSTV GND CT PRIMARY setpoint should be programmed to a value equal to the PHASE CT PRIMARY setpoint. The sensitive ground current input can be connected to a Zero Sequence CT for increased sensitivity and accuracy when physically possible in the system.

NOTE: The Sensitive Ground input must only be used on systems where the maximum ground current does not exceed current input specifications.

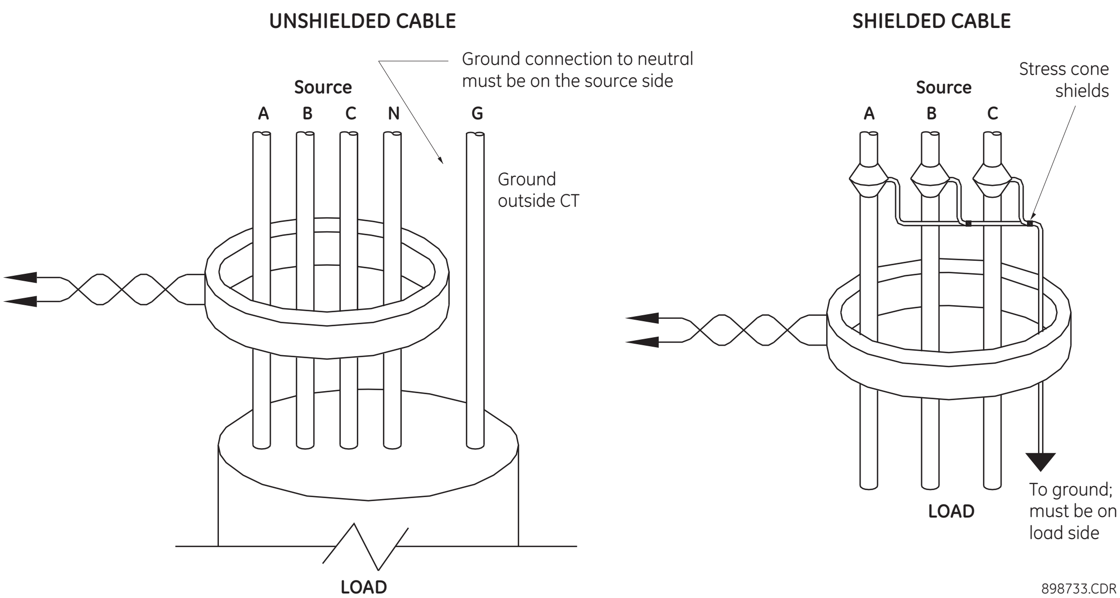
Figure 2-34: Ground/Sensitive Ground wiring



Zero sequence CT installation

The various CT connections and the exact placement of a Zero Sequence CT, for ground fault current detection, are shown in the figure below. Twisted pair cabling on the Zero Sequence CT is recommended.

Figure 2-35: Zero sequence core balance (CT) installation



Voltage inputs

The 350 relay has 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 50 to 240 V range.The three phase inputs are designated as the “bus voltage”. The Bus VT connections most commonly used, wye and delta (or open delta), are shown in the typical wiring diagram.

NOTE

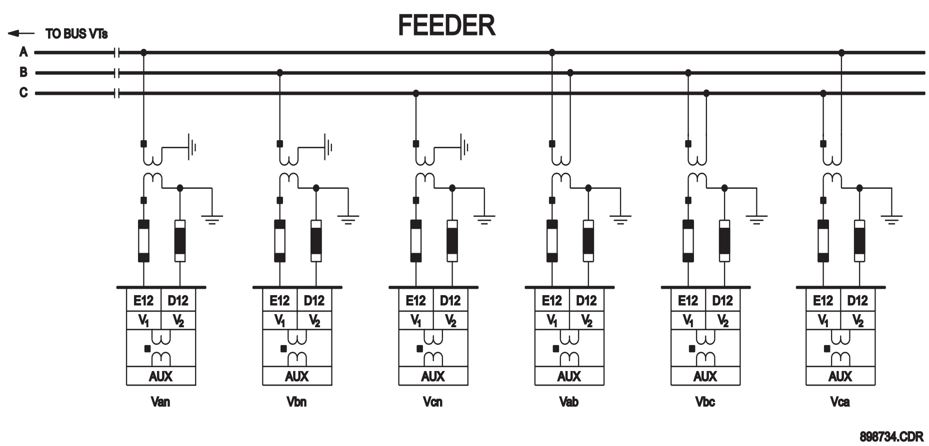
If Delta VTs are used, the zero sequence voltage (V0) and neutral/sensitive ground polarizing voltage (–V0) will be zero. Also, with the Delta VT connection, the phase-neutral voltage cannot be measured and will not be displayed.

NOTE

The 350 relay can be applied to both metering and protection feeders with up to 550 kV phase-to-phase voltage. Please ensure that the selected VT ratio and VT secondary do not result in a primary voltage exceeding 550 kV.

The single phase input is designated as the “Aux VT Input”. The Aux VT input channel can be connected for either phase-neutral voltage Van, Vbn, Vcn, or for phase-phase voltage Vab, Vbc, Vca as shown below.

Figure 2-36: Auxiliary VT connections



Control power

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 safe, normal operation regardless of control power supply type.

The label found on the relay specifies its order code or model number. The installed power supply's operating range will be one of the following:

LO: 24 to 48 V DC (Range: 20 to 60 V DC)

HI: 125 to 250 V DC/120 to 240 V AC (Range: 84 to 250 V DC/60 to 300 V AC (50 and 60 Hz))

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.

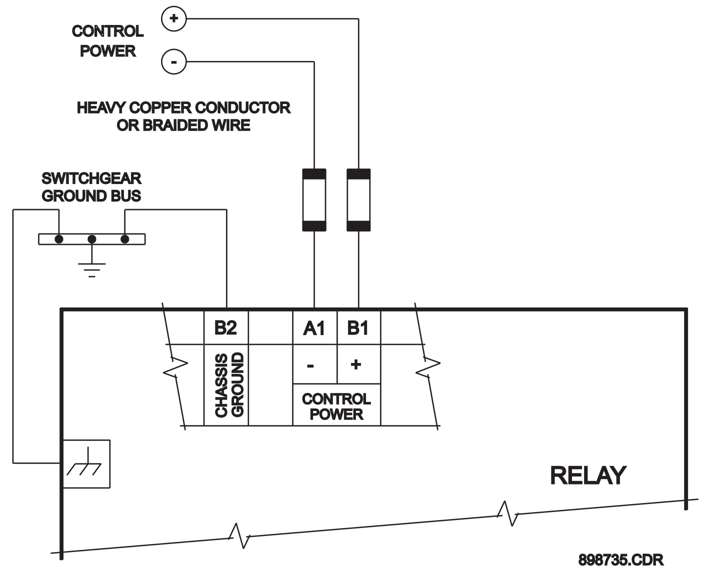
CAUTION

Isolate power prior to servicing.

NOTE

An external switch, circuit breaker, or other protective device **must** be connected near to the equipment.

Figure 2-37: Control power connection



Contact inputs

External contacts can be connected to the relay's ten (10) digital inputs. These contacts are wet only.

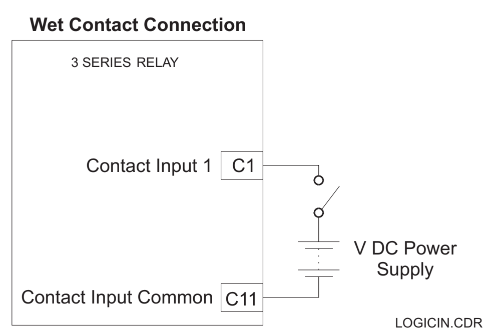
The inputs can be programmed to different thresholds depending on the DC voltage (17, 33, 84, 166).

⚠CAUTION

Ensure correct polarity on contact input connections and do not connect any contact input circuits to ground or else relay hardware may be damaged.

A wet contact has one side connected to the positive terminal of an external DC power supply. The other side of this contact is connected to the required contact input terminal. In addition, the negative side of the external source must be connected to the relay's DC negative rail at Terminal C11. The maximum external source voltage for this arrangement is 300 V DC.

Figure 2-38: Wet contact connections



Trip and Close output relays

The 350 relay is equipped with seven electromechanical output relays: two special relays designed for Breaker trip and close (Relay 1 “Trip”, Relay 2 “Close”), four general purpose relays (Auxiliary Relays 3 to 6), and a Critical Failure relay. The special purpose relays have fixed operating characteristics and the general purpose relays can be configured by the user.

Operation of the Trip and Close output relays is designed to be controlled by the state of the circuit breaker as monitored by a 52a or 52b contact.

- The Trip and Close relays reset after the breaker is detected in a state corresponding to the command. When a relay feature sends a command to one of these special relays, it will remain operational until the requested change of breaker state is confirmed by a breaker auxiliary contact and the initiating condition has reset.
- If the initiating feature resets, but the breaker does not change state, the output relay will be reset after a default interval of 2 seconds.
- If neither of the breaker auxiliary contacts, 52a nor 52b, is programmed to a contact input, the Trip Relay is de-energized after either the delay programmed in the Breaker Failure feature, or a default interval of 100 ms after the initiating input resets. The Close Relay is de-energized 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 40 ms.

52a Contact Configured	52b Contact Configured	Relay Operation
Yes	Yes	Trip Relay remains operational until 52b indicates an open breaker. Close Relay remains operational until 52a indicates a closed breaker.
Yes	No	Trip Relay remains operational until 52a indicates an open breaker. Close Relay remains operational until 52a indicates a closed breaker.
No	Yes	Trip Relay remains operational until 52b indicates an open breaker. Close Relay remains operational until 52b indicates a closed breaker.
No	No	Trip Relay operates until either the Breaker Failure delay expires (if the Breaker Failure element is enabled), or 100 ms after the feature causing the trip resets. Close Relay operates for 200 ms.

Breaker monitoring (Trip and Close coil monitoring) is performed by a built-in voltage monitor on Form A output relays: #1 Trip, and #2 Close. The voltage monitor is connected across each of the two Form A contacts, and the relay effectively detects healthy current through the circuit. In order to do this, an external jumper must be connected between terminals A2 and A3 for Trip coil monitoring, or/and B4, and B5 for Close coil monitoring.

As long as the current through the Voltage Monitor is above the threshold of the trickle currents (see Technical Specification for Form A output relays), the circuit integrity for the Trip (Close) coil is effectively normal. If the Trip (Close) coil circuit gets disconnected, or if in general a high resistance is detected in the circuitry, a Trip (Close) alarm will be set and the “ALARM” and “MAINTENANCE” LEDs will be on.

Example 1: The figures below show the two different connections of the breaker trip (close) coil to the relay’s trip output #1 terminals (output #2 Close coil monitoring) for both no voltage monitoring and voltage monitoring of the trip (close) circuit integrity.

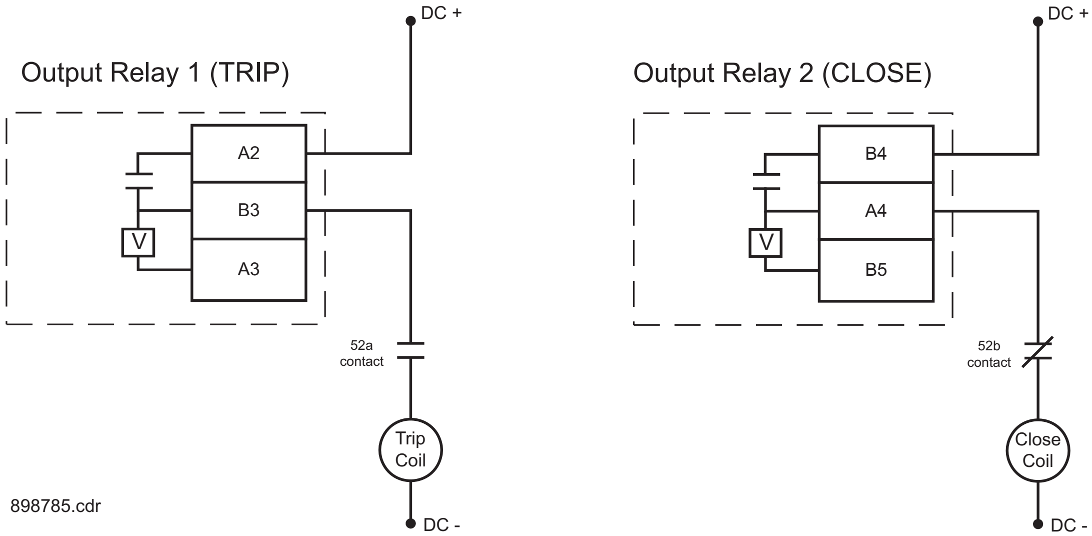
NOTE

To monitor the trip coil circuit integrity, use the relay terminals A2 and B3 to connect the Trip coil, and provide a jumper between terminals A2 (optional voltage) and A3.

NOTE

To monitor the close coil circuit integrity, use the relay terminals B4 and A4 to connect the Close coil, and provide a jumper between terminals B4 (optional voltage) and B5.

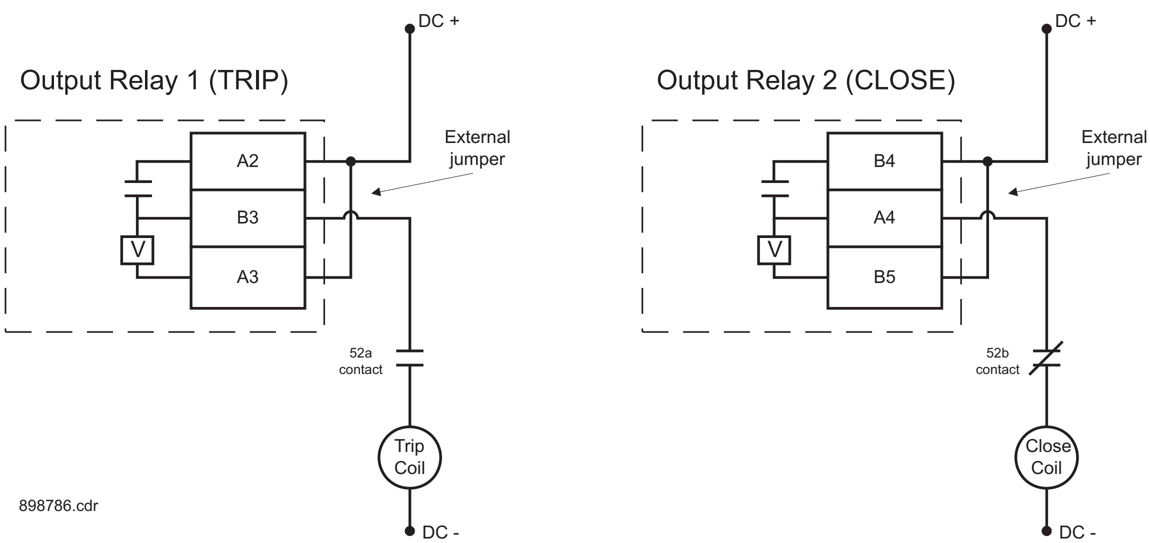
Figure 2-39: Trip and Close circuits with no voltage monitoring



NOTE

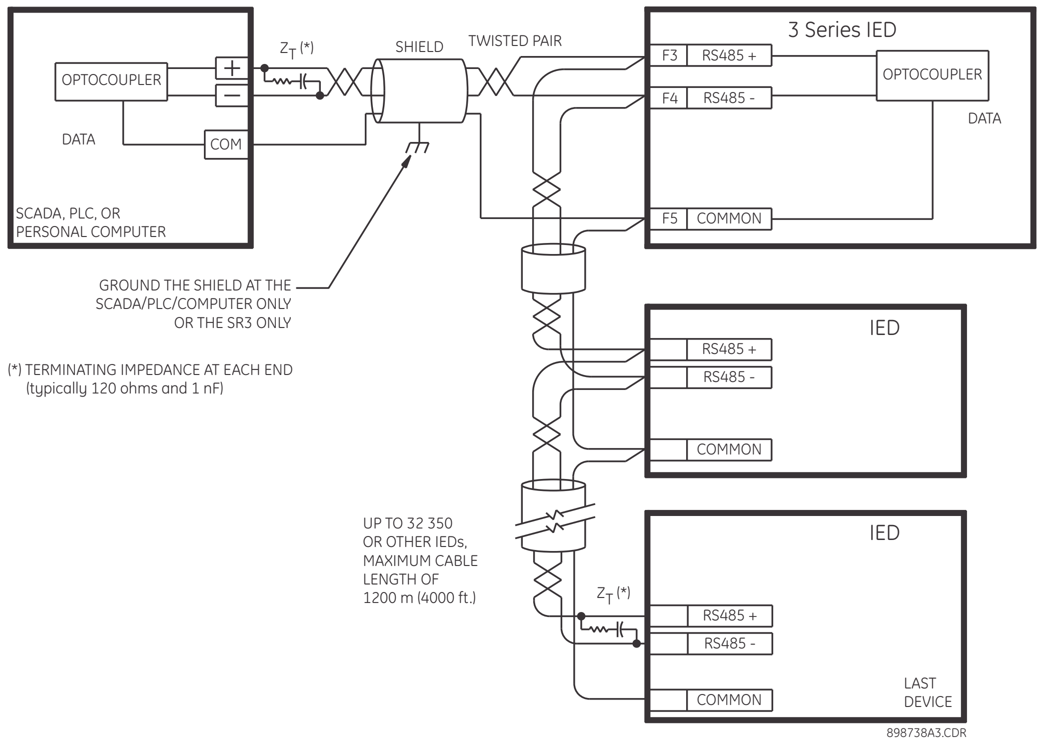
All AUX contacts are shown when the breaker is open.

Figure 2-40: Trip and close circuits with voltage monitoring



Serial communications

Figure 2-41: RS485 wiring diagram



One two-wire RS485 port is provided. Up to 32 350 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 (for example, Belden #9841) and total wire length should not exceed 1200 meters (4000 ft.). Commercially available repeaters will allow for transmission distances greater than 1200 meters.

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 optocoupled data interface is used to prevent noise coupling.

NOTICE

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 350 . 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 350 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. Observing these guidelines will ensure a reliable communication system immune to system transients.

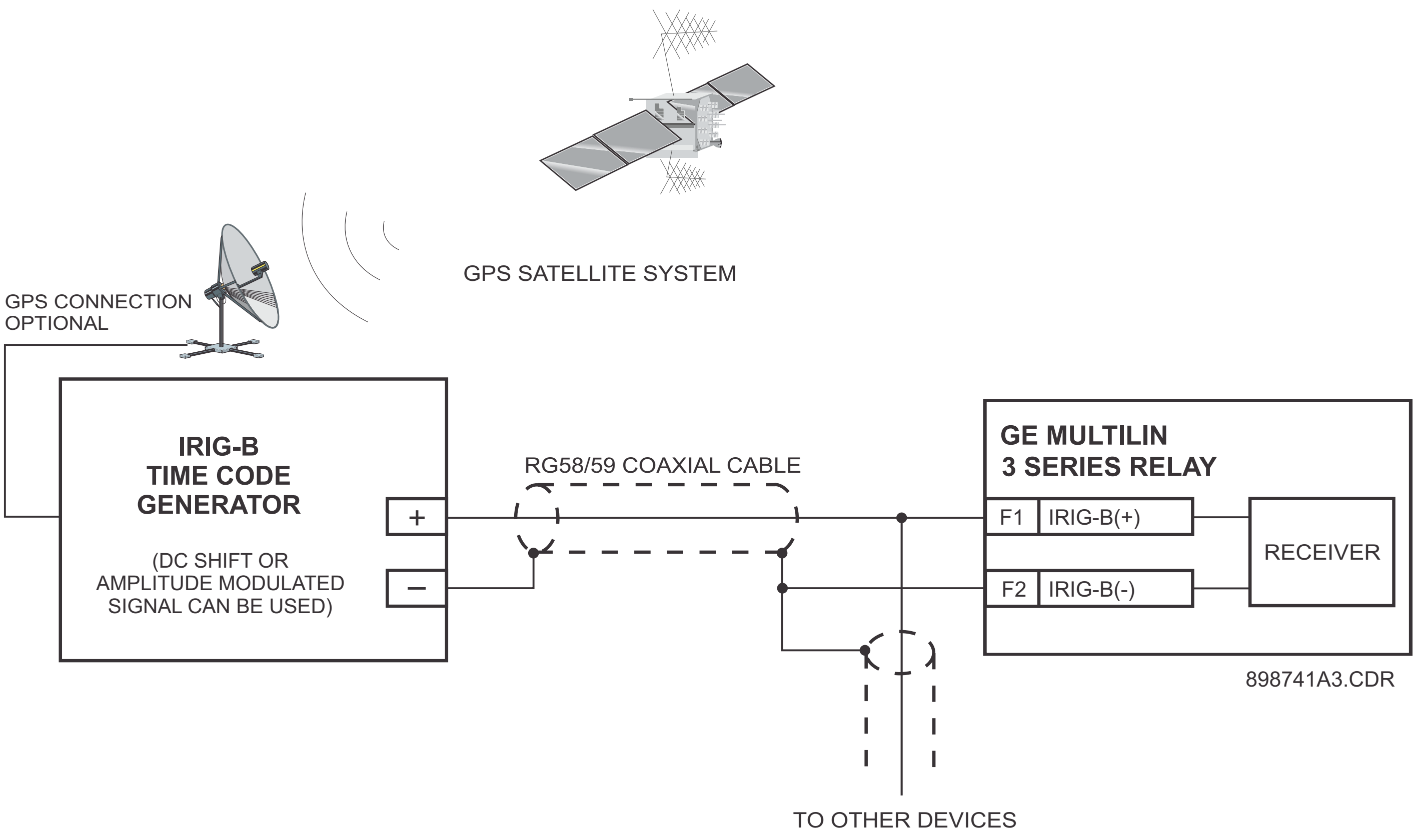
The uncovered communications cable shield connected to the common terminal should not exceed 1” (2.5 cm) for proper EMC shielding of the communications cable.

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 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 350 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.

The uncovered communications cable shield connected to the common terminal should not exceed 1” (2.5 cm) for proper EMC shielding of the communications cable.

Figure 2-42: IRIG-B connection



350 Feeder Protection System

Chapter 3: Interfaces

There are two methods of interfacing with the 350 Feeder Protection System.

- Interfacing via the relay keypad and display.
- Interfacing via the EnerVista 3 Series Setup software.

This section provides an overview of the interfacing methods available with the 350 using the relay control panels and EnerVista 3 Series Setup software. For additional details on interface parameters (for example, settings, actual values, etc.), refer to the individual chapters.

Front control panel interface

Figure 3-1: 350 Feeder Protection System Front Panel - Non-programmable LEDs

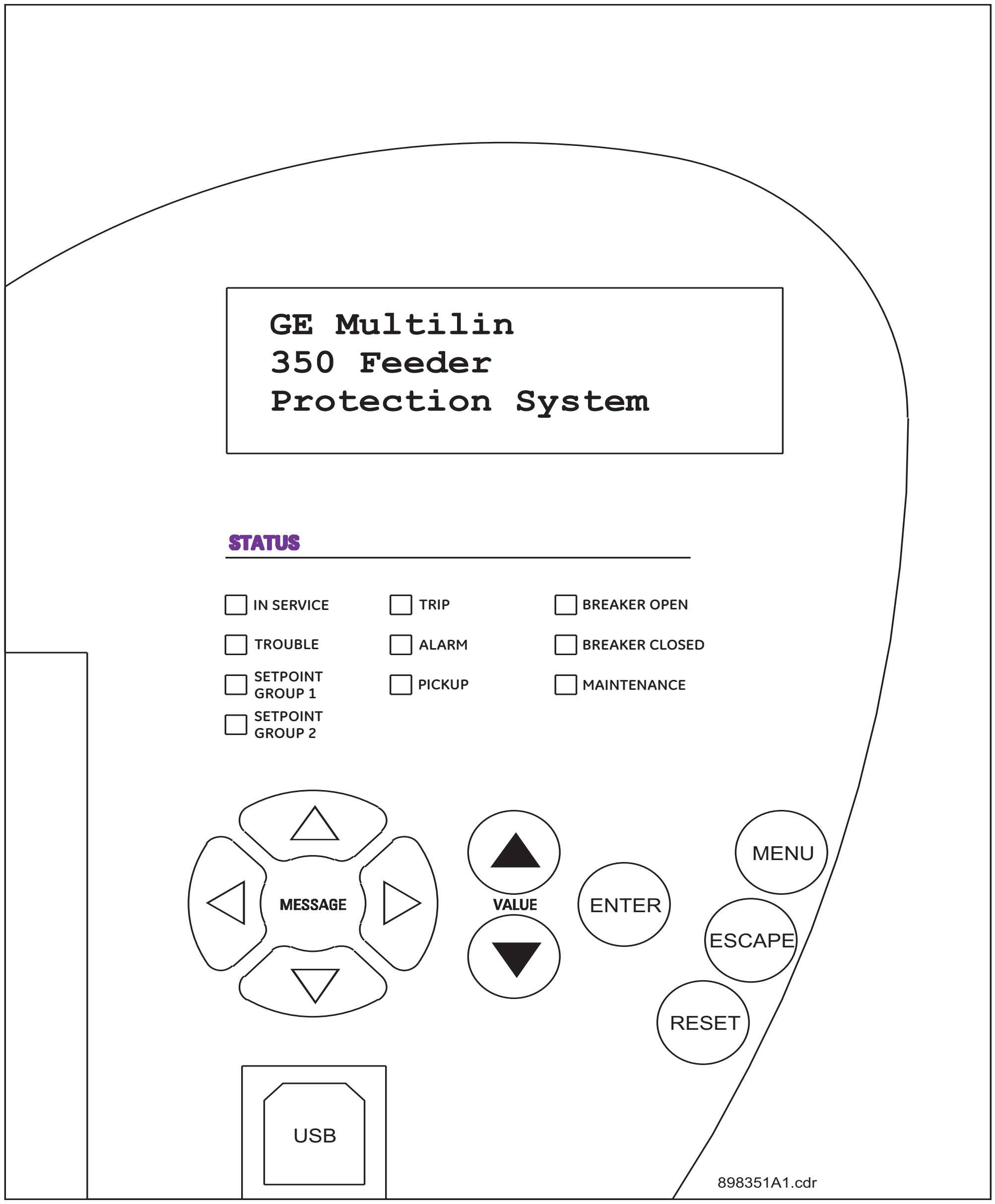
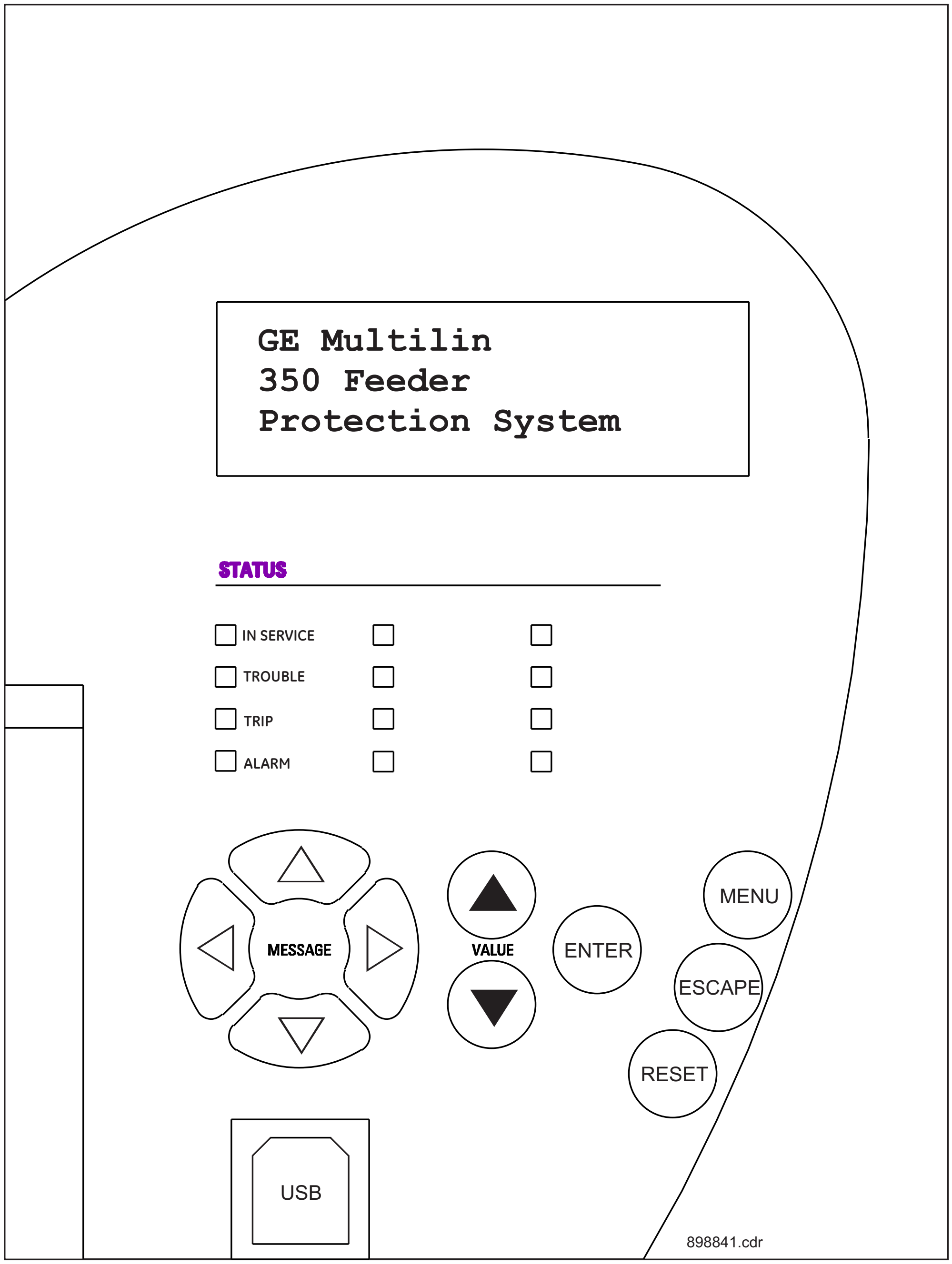


Figure 3-2: 350 Feeder Protection System Front Panel - Programmable LEDs



Description

The relay front panel provides an interface with a liquid crystal display, LED status indicators, control keys, and a USB program port. The display and status indicators show the relay information automatically. The control keys are used to select the appropriate message for entering setpoints or displaying measured values. The USB program port is also provided for connection with a computer running the EnerVista 3 Series Setup software.

Display

The 80-character liquid crystal display (LCD) allows visibility under varied lighting conditions. When the keypad and display are not being used, system information is displayed after a user-defined period of inactivity. Pressing the Menu key during the display of default message returns the display to the last message shown before the default message appeared. Any trip, alarm, or pickup is displayed immediately, automatically overriding the default message.

Working with the Keypad

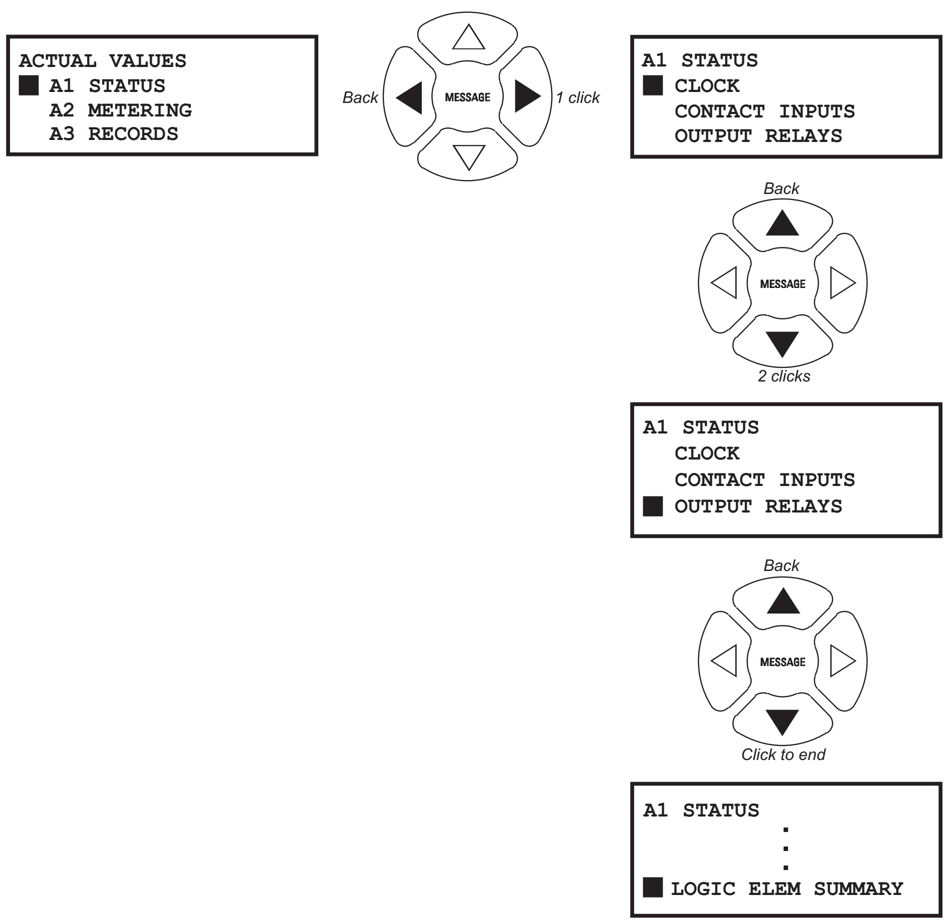
The 350 display messages are organized into a Main Menu, pages, and sub-pages. There are four main menus labeled Actual Values, Quick Setup, Setpoints, and Maintenance. Pressing the MENU key followed by the MESSAGE key scrolls through the five Main Menu headers, which appear in sequence as follows:

Figure 3-3: The five Main Menu headers

```
ACTUAL VALUES
COMMANDS
QUICK SETUP
SETPOINTS
MAINTENANCE
```

Pressing the **MESSAGE** ► key or the **ENTER** key from these Main Menu pages will display the corresponding menu Page. Use the MESSAGE ▲ and MESSAGE ▼ keys to scroll through the Page headers.

Figure 3-4: Typical paging operation from Main Menu selection



When the display shows **SETPOINTS**, pressing the **MESSAGE** ► key or the **ENTER** key will display the page headers of programmable parameters (referred to as setpoints in the manual). When the display shows **ACTUAL VALUES**, pressing the **MESSAGE** ► key or the **ENTER** key displays the page headers of measured parameters (referred to as actual values in the manual).

Each page is broken down further into logical sub-pages of messages. The **MESSAGE** ▲ and **MESSAGE** ▼ keys are used to navigate through the sub-pages. A summary of the setpoints and actual values pages can be found in the Chapters : Setpoints and Actual Values, respectively.

The **ENTER** key is dual purpose. It is used to enter the sub-pages and to store altered setpoint values into memory to complete the change. The **MESSAGE** ► key can also be used to enter sub-pages but not to store altered setpoints.

The **ESCAPE** key is also dual purpose. It is used to exit the sub-pages and to cancel a setpoint change. The **MESSAGE** ◄ key can also be used to exit sub-pages and to cancel setpoint changes.

The **VALUE** keys are used to scroll through the possible choices of an enumerated setpoint. They also decrement and increment numerical setpoints.

The **RESET** key resets any latched conditions that are not currently active. This includes resetting latched output relays, latched Trip LEDs, breaker operation failure, and trip / close coil failures. The Autoreclose Scheme is also reset with the shot counter being returned to zero and the lockout condition being cleared.

The **MESSAGE** ▲ and **MESSAGE** ▼ keys scroll through any active conditions in the relay. Diagnostic messages are displayed indicating the state of protection and monitoring elements that are picked up, operating, or latched.

LED status indicators - Front panel with non-programmable LEDs

- **IN SERVICE: Green**

  This LED will be continuously "ON", when the relay is set to "Ready" under **S1 RELAY SETUP > INSTALLATION > RELAY STATUS**, and no major self-test errors have been detected.

- **TROUBLE: Orange**

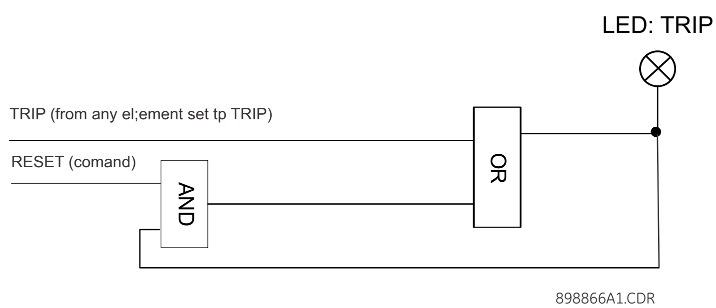
  This LED will turn "ON", when the relay is in the not programmed (Not Ready) state under **S1 RELAY SETUP > INSTALLATION > RELAY STATUS**, or upon detection of a major self-test error. The relay will turn back to "IN-SERVICE" if no major self-test error is present.

- **SETPOINT GROUP 1, 2: Green**

  These LEDs indicate the group of active protection elements. If setpoint group 1 is lit green, only the protection elements under group 1 will be active. The protection elements from group 2 will be inactive. The settings for each protection element can be edited and displayed regardless of the active group.

- **TRIP: Red**

  This indicator turns on when the relay detects a fault and sends a trip command to the trip output relay. The LED will reset by initiating a reset command from either the RESET pushbutton Breaker Control, or communications; in all cases after the fault condition has cleared.



- **ALARM: Orange**

  This LED will flash upon detection of an alarm condition, with element functions selected as "alarm". The LED will automatically turn off if the alarm condition clears. The LED will remain steady "ON", if the function of the operated protection was selected as "latched alarm".

- **PICKUP: Orange**

  This indicator will light ON upon pickup condition generated by any of the relay features. The indicator will turn off if no pickup condition is detected.

- **BREAKER OPEN: Red/Green/Orange/Off – programmable color, default Green**

  When the breaker is open, this indicator will be on continuously.

- **BREAKER CLOSED: Red/Green/Orange/Off – programmable color, default Green**

  When the breaker is closed, this indicator will be on continuously.

- **MAINTENANCE: Orange**

  This LED may indicate both breaker or relay maintenance depending on the programmed maintenance elements. The LED will turn on upon operation of a maintenance element.

NOTE

Refer to M7 Testing for information on testing LED status indicators.

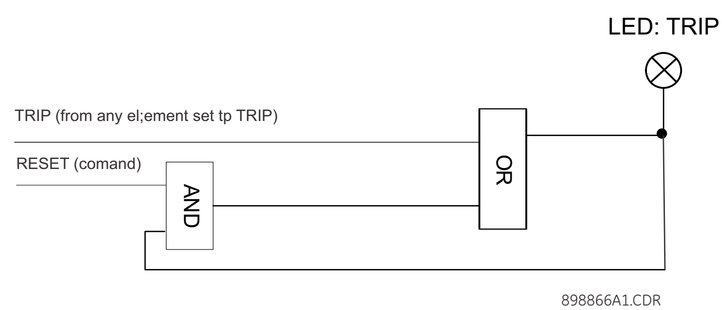
LED status indicators - Front panel with programmable LEDs

- **IN SERVICE: Green**

  This LED will be continuously "ON", when the relay is set to "Ready" under **S1 RELAY SETUP > INSTALLATION > RELAY STATUS**, and no major self-test errors have been detected.
- **TROUBLE: Orange**

  This LED will turn "ON", when the relay is not programmed (Not Ready) state under **S1 RELAY SETUP > INSTALLATION > RELAY STATUS**, or upon detection of a major self-test error. The relay will turn back to "IN-SERVICE" if no major self-test error is present.
- **TRIP: Red**

  This indicator turns on when the relay detects a fault and sends a trip command to the trip output relay. The LED will reset by initiating a reset command from either the RESET pushbutton Breaker Control, or communications; in all cases after the fault condition has cleared.



- **ALARM: Orange**

  This LED will flash upon detection of an alarm condition, with element functions selected as "alarm". The LED will automatically turn off if the alarm condition clears. The LED will remain steady "ON", if the function of the operated protection was selected as "latched alarm".
- **LED 1: Red - programmable source signal and type**
- **LED 2: Orange - programmable source signal and type**
- **LED 3: Orange - programmable source signal and type**
- **LED 4: Orange - programmable source signal and type**
- **LED 5: Red/Orange/Green/Off - programmable source signal, type, and color**
- **LED 6: Red/Orange/Green/Off - programmable source signal, type, and color**
- **LED 7: Red/Orange/Green/Off - programmable source signal, type, and color**
- **LED 8: Red/Orange/Green/Off - programmable source signal, type, and color**

NOTE

Refer to M7 Testing for information on testing LED status indicators.

Relay messages

Target messages

Target messages are automatically displayed for any active condition on the relay such as pickups, trips, or alarms.

The relay displays the most recent event first, and after 5 seconds will start rolling up the other target messages until the conditions clear and/or the RESET command is initiated. The Target Messages can be reviewed by pressing either the MESSAGE UP or MESSAGE DOWN key. If a RESET command is not performed but any of the other faceplate pushbuttons is pressed, the display will not show the target messages unless the user navigates to **ACTUAL VALUES > A4 TARGET MESSAGES**, where they can be reviewed. If the target messages have not been cleared before the user presses a pushbutton different from “RESET”, they will reappear on the screen after the time specified under the **SETPOINTS > S1 RELAY SETUP > FRONT PANEL > MESSAGE TIMEOUT** setting, that will start timing out from the last pressed pushbutton. The following shows the format of a typical Target Message:

Figure 3-5: Typical target message

```
A4 TARGET MESSAGES
  Cause <function>
  State: Operate
 ▼ Phase:
```

Example of a Phase IOC1 operation - phase A:

Phase IOC1 function: Trip

```
A4 TARGET MESSAGES
  Ph IOC1 Trip
  State: Operate
 ▼ Phase:A
```

Cause <Function>

The first line contains information of the cause of operation (the name of the operated element), and the element function.

State: Operate

This line from the display shows the state of the element: Pickup, Operated, Alarm.

Phase: A

The last line from the display shows the phase that picked up or operated.

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 problems indicate a problem with the relay that does not compromise protection of the power system. 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 will:

- Turn on the "TROUBLE" LED at the same time as the "IN SERVICE" LED is on.
- Display the error on the relay display.

- Record the minor self-test error in the Event Recorder.

Upon detection of a **major** problem, the relay will:

- De-energize critical failure relay (Output Relay 7).
- Inhibit operation of all other output relays (1 to 6).
- Turn off the "IN SERVICE" LED; turn on the "TROUBLE" LED.
- Flash the "ALARM" LED.
- Display the cause of major self-test failure.
- Record the major self-test failure in the Event Recorder.

Figure 3-6: Typical Self-test warning

```
A4 TARGET MESSAGES
  UNIT FAILURE:
  Contact Factory:
  Error code:1
```

Table 3-1: Minor Self-test Errors

Self-test Error Message	Latched Target Message?	Description of Problem	How Often the Test is Performed	What to do
MAINTENANCE ALERT: IRIG-B Failure	No	A bad IRIG-B input signal has been detected.	Every 5 seconds*	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.
MAINTENANCE ALERT: Clock Not Set	No	Clock time is the same as the default time.	Every 5 seconds*	Set the date and time in PRODUCT SETUP.
MAINTENANCE ALERT: Comm Alert 1, 2, or 3	No	Communication error between CPU and Comms board.	Every 5 seconds*	If alert doesn't self-reset, then contact factory. Otherwise monitor recurrences as errors are detected and self-reset.
MAINTENANCE ALERT : Ethernet Link Fail	No	Communication error between 350 and Network.	Detected Instantaneously	Check Ethernet cable and Ethernet connection. Check health of the network. Check status of external routers and switches. Check that IP settings are not 0.0.0.0
MAINTENANCE ALERT: High Ethernet Traffic	No		Every 5 seconds*	

Self-test Error Message	Latched Target Message?	Description of Problem	How Often the Test is Performed	What to do
MAINTENANCE ALERT: High Ambient Temperature	No	The ambient temperature is above 80°C.	Every 1 hour	Increase ventilation to the surroundings.
MAINTENANCE ALERT: Daughter Error	No	The rear Communications daughter board type does not match the order code.	Every 5 seconds*	Replace the rear communications daughter board with the correct board.
MAINTENANCE ALERT: Comms Serial Invalid	No	The internal communications board does not match the order code.	Every 5 seconds*	Contact factory.

* Failure is logged after the detection of 5 consecutive failures - that is after 25 seconds

Table 3-2: Major Self-test Errors

Self-test Error Message	Latched Target Message?	Description of Problem	How Often the Test is Performed	What to do
UNIT FAILURE: Contact Factory (XXXX)	Yes	This warning is caused by a unit hardware failure. Failure code (XXXX) is shown.	Every 5 seconds*	Contact the factory and provide the failure code.
RELAY NOT READY: Check Settings	No	PRODUCT SETUP INSTALLATION setting indicates that relay is not in a programmed state.	On power up and whenever the PRODUCT SETUP INSTALLATION setting is altered.	Program all required settings then set the PRODUCT SETUP INSTALLATION setting to "Programmed".

* Failure is logged after the detection of 5 consecutive failures - that is after 25 seconds

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 4 seconds.

Figure 3-7: Typical Flash message

```
S3 PHASE IOC
  BLOCK 1
  Logic Element 8
  <SETPOINT STORED>
```

SETPOINT STORED

This flash message is displayed in response to the **ENTER** key while on any setpoint message (see example above). The edited value was stored as entered.

COMMAND EXECUTED

This flash message is displayed in response to executing a command: ON, OFF, YES, NO, etc.

INVALID PASSWORD

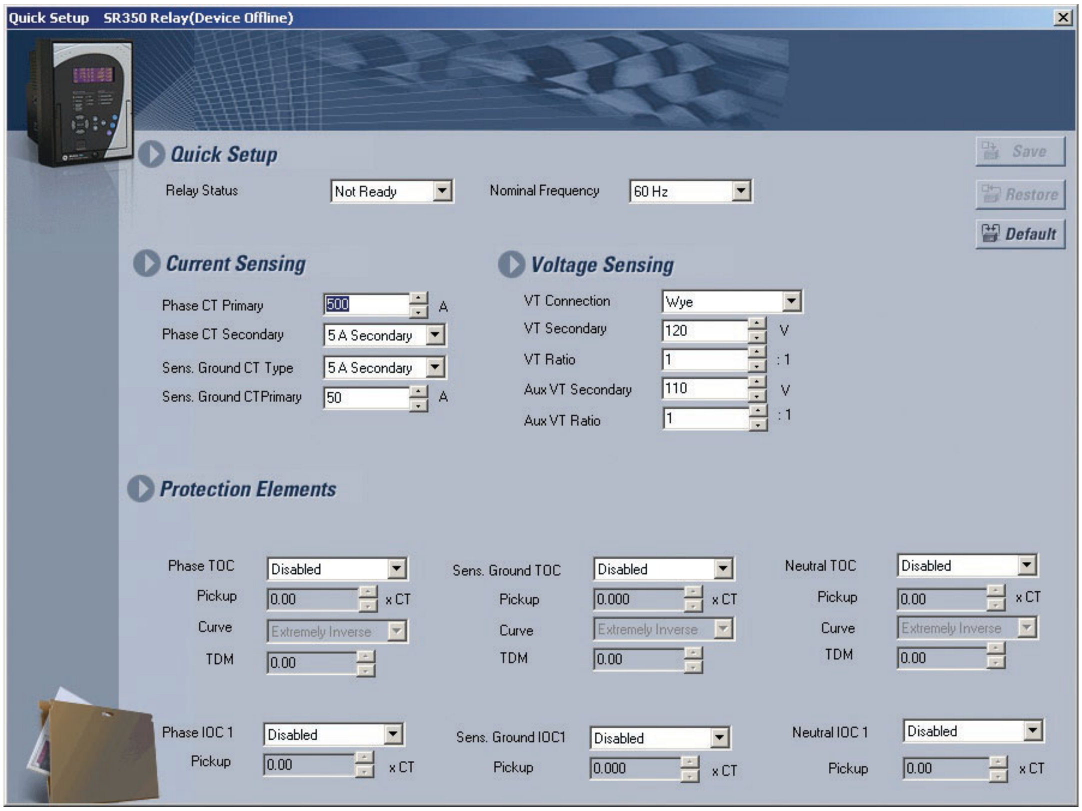
This flash message appears upon an attempt to enter an incorrect password, as part of password security.

AR IN PROGRESS

This flash message appears when the Autoreclosure is in progress performing the configured sequence.

Software setup

Quick setup - Software interface



- **The Quick Setup** window allows you to configure important settings from different screens in the relay by adding them to a common window.
- **Quick Setup** window options are available for a single device or a file.
- **The Quick Setup** Window option is accessed from the "Tree" which launches on clicking.

EnerVista 3 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 3 Series Setup software is available from GE Multilin to make this as convenient as possible. With EnerVista 3 Series Setup 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 350 firmware

The EnerVista 3 Series Setup software allows immediate access to all 350 features with easy to use pull down menus in the familiar Windows environment. This section provides the necessary information to install EnerVista 3 Series Setup , upgrade the relay firmware, and write and edit setting files.

The EnerVista 3 Series Setup software can run without a 350 connected to the computer. In this case, settings may be saved to a file for future use. If a 350 is connected to a PC and communications are enabled, the 350 can be programmed from the setting screens. In addition, measured values, status and trip messages can be displayed with the actual value screens.

Hardware and software requirements

The following requirements must be met for the EnerVista 3 Series Setup software.

- Pentium 4 (Core Duo recommended)
- Windows XP with Service Pack 2 (Service Pack 3 recommended) , Windows 7 (32-bit or 64-bit), Windows 8.1 (32-bit or 64-bit), Windows 10 (32-bit or 64-bit)
- 1 GB of RAM (2 GB recommended)
- 500 MB free hard drive space (1 GB recommended)
- 1024 x 768 display (1280 x 800 recommended)

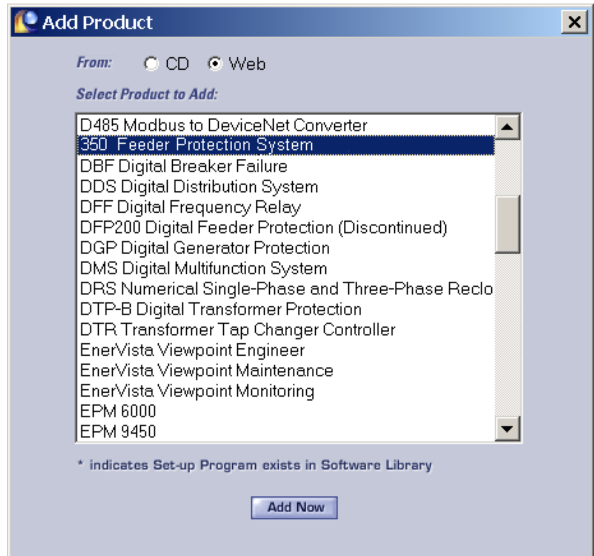
The EnerVista 3 Series Setup software can be installed from either the GE EnerVista CD or the GE Multilin website at http://www.gegridsolutions.com/multilin

Installing the EnerVista 3 Series Setup software

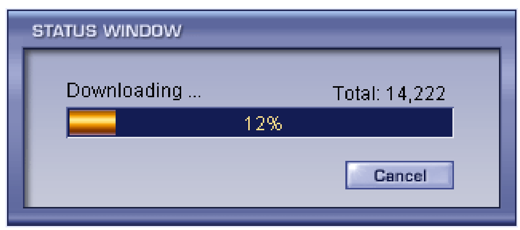
After ensuring the minimum requirements indicated earlier, use the following procedure to install the EnerVista 3 Series Setup software from the enclosed GE EnerVista CD.

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 350 Feeder 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 350 .



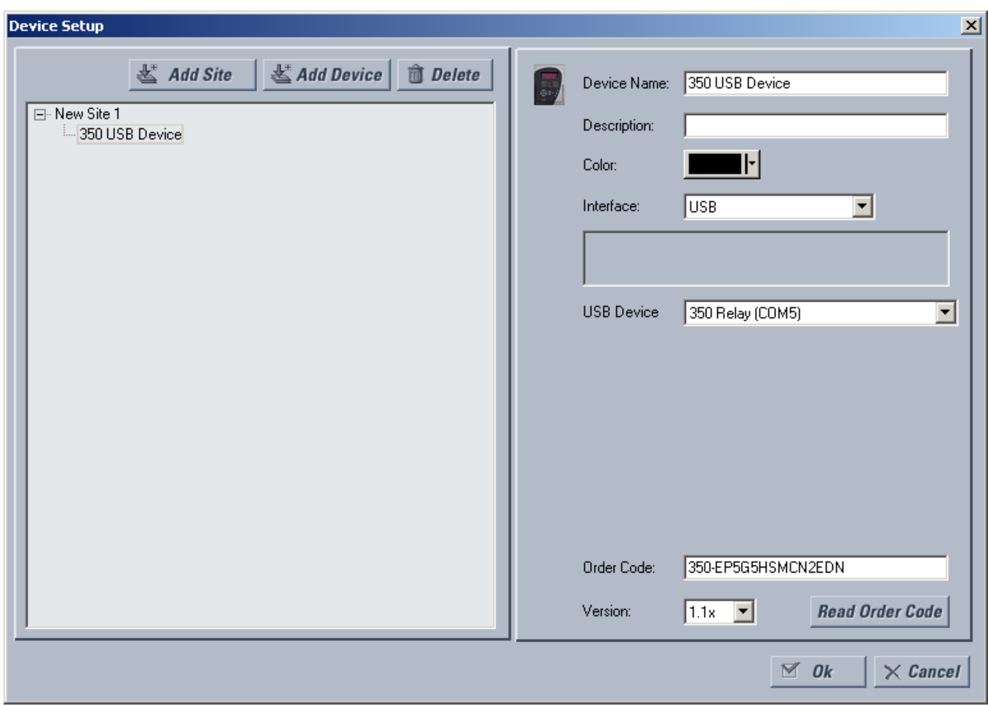
6. EnerVista Launchpad will obtain the latest installation software from the Web or CD and automatically start the installation process. A status window with a progress bar will be shown during the downloading process.



7. Select the complete path, including the new directory name, where the EnerVista 3 Series Setup software will be installed.
8. Click on **Next** to begin the installation. The files will be installed in the directory indicated, the USB driver will be loaded into the computer, and the installation program will automatically create icons and add EnerVista 3 Series Setup software to the Windows start menu.
9. The 350 device will be 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 350 Relay using the USB port:

10. Plug the USB cable into the USB port on the 350 Relay then into the USB port on your computer.
11. Launch EnerVista 3 Series Setup from LaunchPad.
12. In **EnerVista > Device Setup**:



13. Select **USB** as the Interface type.
14. Select **350 Relay** as the USB device.

Upgrading the software

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

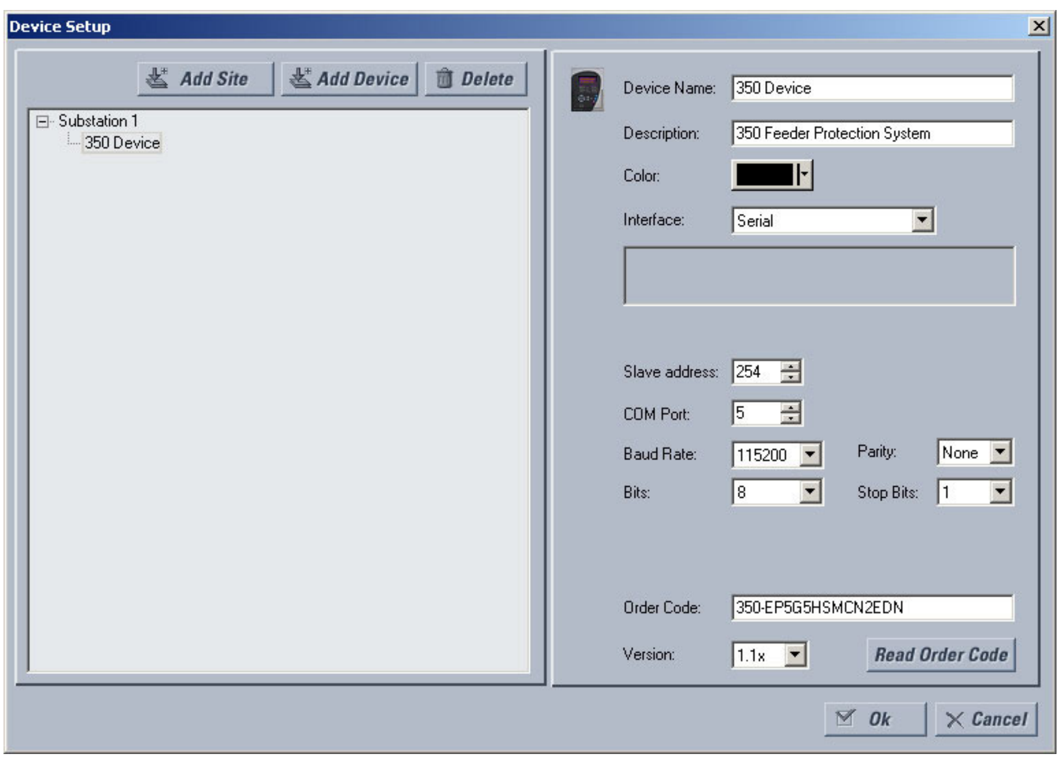
After upgrading, check the version number under **Help > About**. If the new version does not display, try uninstalling the software and reinstalling the new versions.

Connecting EnerVista 3 Series Setup to the relay

Configuring serial communications

Before starting, verify that the cable is properly connected to either the USB port on the front panel of the device (for USB communications) or to the RS485 terminals on the back of the device (for RS485 communications). This example demonstrates an USB connection. For RS485 communications, the GE Multilin F485 converter will be required. Refer to the F485 manual for additional details. To configure the relay for Ethernet communications, see *Configuring Ethernet Communications* below.

1. Install and start the latest version of the EnerVista 3 Series Setup software (available from the GE Multilin web site). 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 will appear in the upper-left list in the EnerVista 3 Series Setup window.
5. Click the **Add Device** button to define the new device.
6. Enter the desired name in the "Device Name" field and a description (optional) of the device.
7. Select “Serial” from the Interface drop-down list.

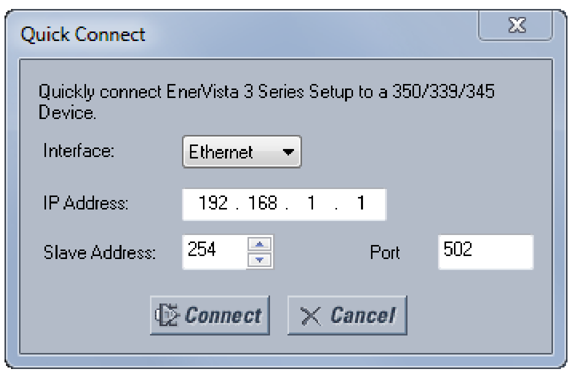


8. Click the **Read Order Code** button to connect to the 350 device and upload the order code.
9. Click **OK** when the relay order code has been received. The new device will be added to the Site List window (or Online window) located in the top left corner of the main EnerVista 3 Series Setup window.

The 350 Site Device has now been configured for USB communications. Proceed to *Connecting to the Relay* below, to begin communications.

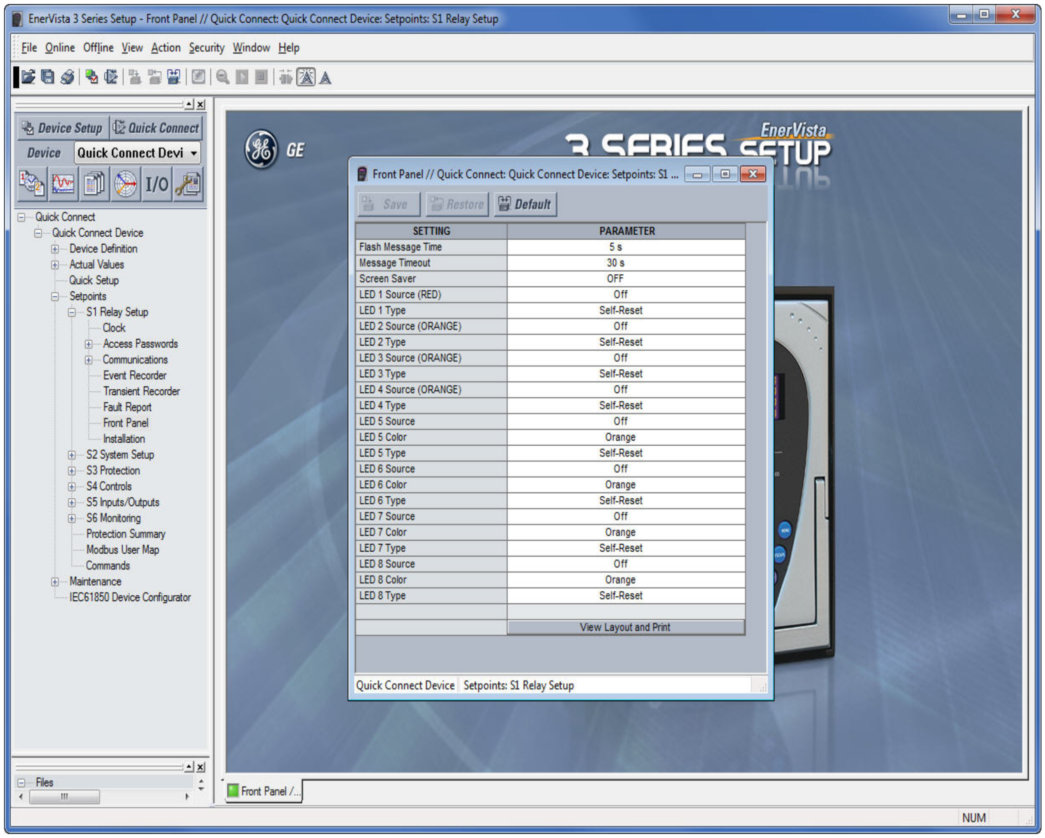
Using the Quick Connect feature

The **Quick Connect** button can be used to establish a fast connection through the front panel USB port of a 350 relay, or through the Ethernet port. The following window will appear when the **QuickConnect** button is pressed:



As indicated by the window, the "Quick Connect" feature can quickly connect the EnerVista 3 Series Setup software to a 350 front port if the USB is selected in the interface drop-down list. Select "SR3 Relay" and press the **Connect** button. Ethernet can also be used as the interface for Quick Connect as shown above.

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



The 350 Site Device has now been configured via the Quick Connect feature for either USB or Ethernet communications. Proceed to *Connecting to the Relay* below, to begin communications.

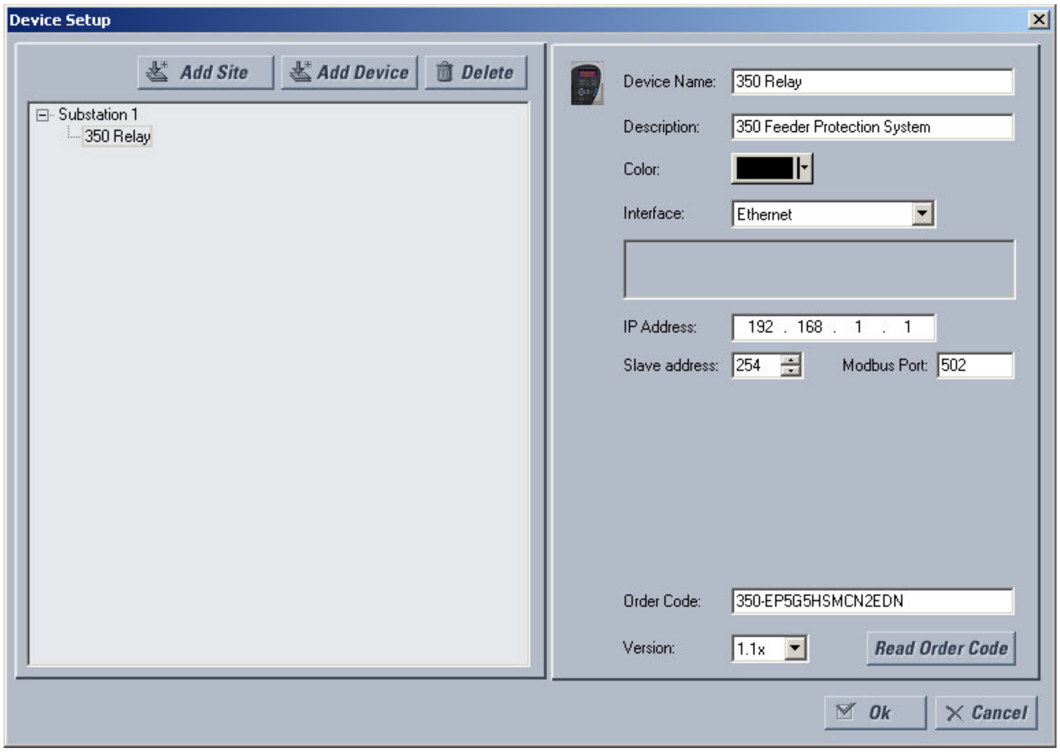
Configuring Ethernet communications

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

NOTE

350 supports a maximum of 3 TCP/IP sessions.

1. Install and start the latest version of the EnerVista 3 Series Setup Setup software (available from the GE EnerVista CD). 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 will appear 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 will display 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 350 relay (from the S1 RELAY SETUP > COMMUNICATIONS > ETHERNET menu).
9. Click the **Read Order Code** button to connect to the 350 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 3 Series Setup window.

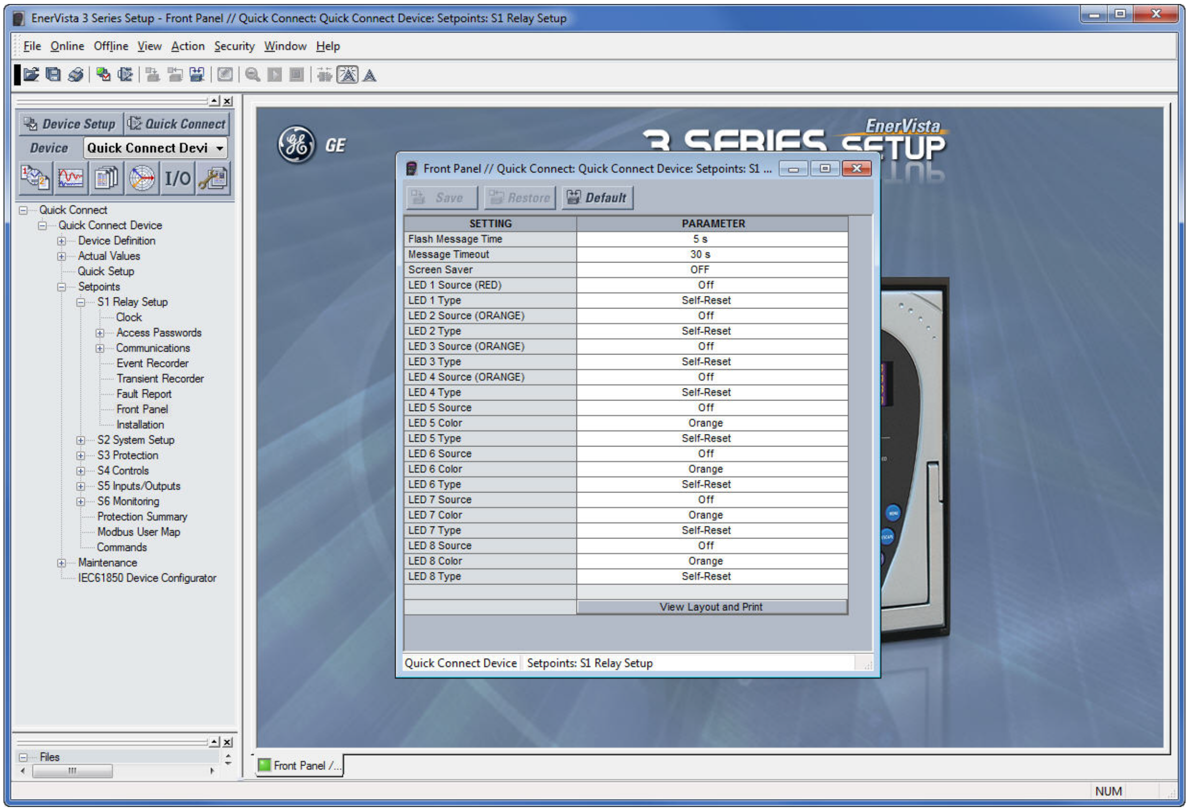
The 350 Site Device has now been configured for Ethernet communications. Proceed to the following section to begin communications.

Connecting to the relay

Now that the communications parameters have been properly configured, the user can easily communicate with the relay.

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
   Actual Values
   Quick Setup
   Setpoints
   Maintenance.
3. Expand the SETTINGS > RELAY SETUP list item and double click on **Front Panel** to open the Front Panel settings window as shown:



4. The Front Panel settings window opens with a corresponding status indicator on the lower left of the EnerVista 3 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 Front Panel 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 at will.

Working with setpoints and setpoint files

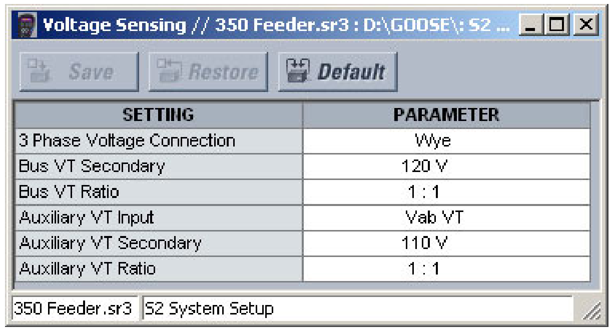
Engaging a device

The EnerVista 3 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.

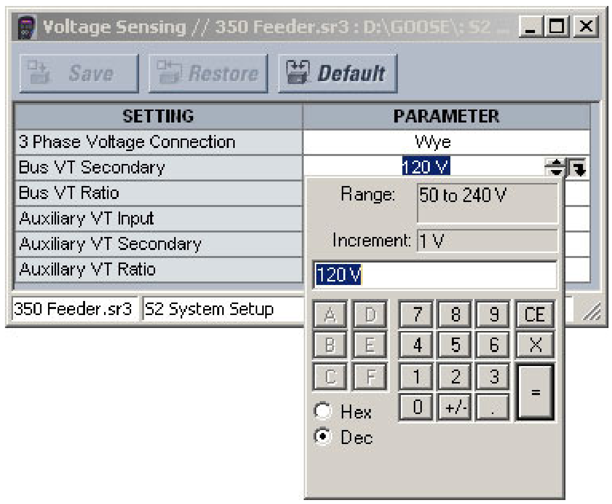
Entering setpoints

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

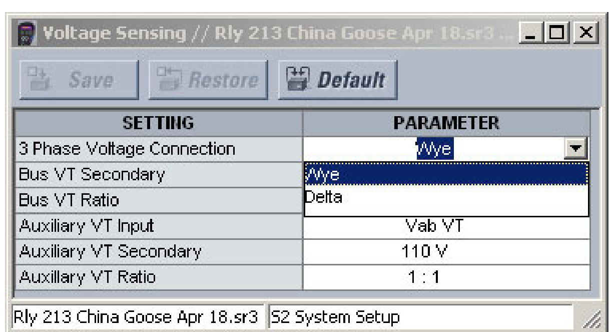
1. Establish communications with the relay.
2. Select the **Setpoint > System Setup > Voltage Sensing** menu item.
3. Select the Bus VT Secondary setpoint by clicking anywhere in the parameter box. This will display three arrows: two to increment/decrement the value and another to launch the numerical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



4. Clicking the arrow at the end of the box displays a numerical keypad interface that allows the user to enter a value 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. **3-Phase voltage connection** below), clicking anywhere within the setpoint value box displays a drop-down selection menu arrow. Select the desired value from this list.

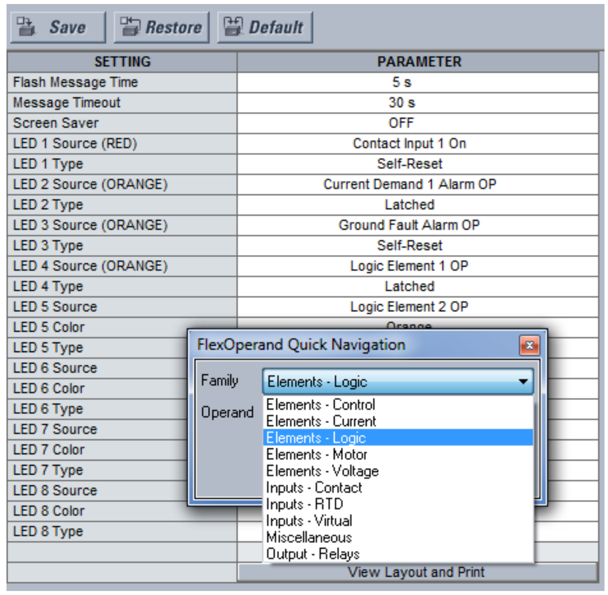


6. For setpoints requiring an alphanumeric text string (e.g. "relay name"), the value may be entered directly within the setpoint value box.
7. In the **Setpoint > System Setup > Voltage Sensing** dialog box, click on **Save** to save the values into the 350 . Click **YES** to accept any changes and exit the window. Click **Restore** to retain previous values. Click **Default** to restore Default values.

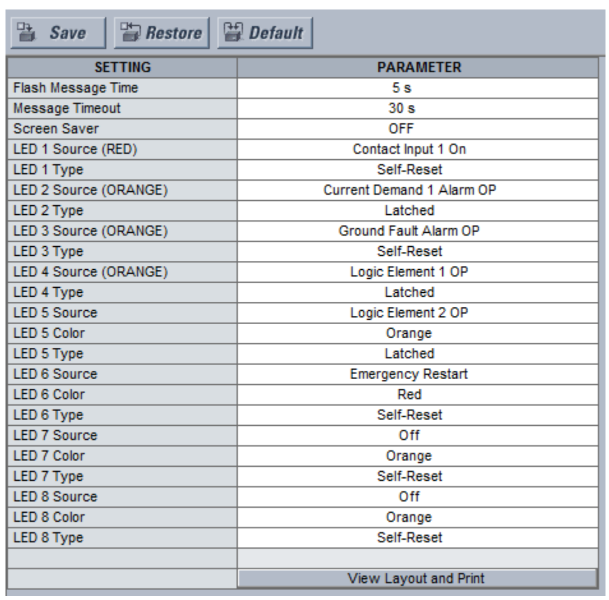
Setting programmable LEDs

Front panels with programmable LEDs have eight LEDs that are off by default, and must be set to a source signal and type. Four of these LEDs can also be set to different colors.

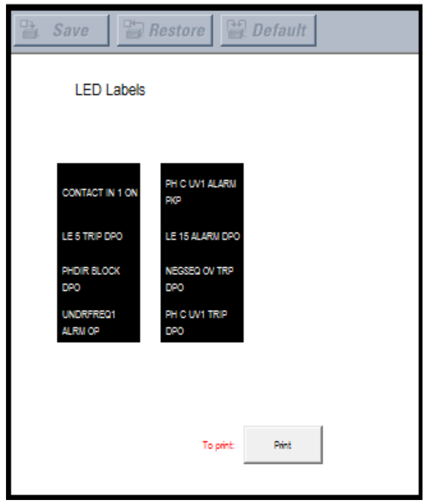
1. Establish communications with the relay.
2. Select the **Setpoint > S1 Relay Setup > Front Panel** menu item.
3. Select an LED Source setpoint by clicking anywhere in the parameter box beside an LED Source label. This opens a Quick Navigation window.



4. Select a Type for the LED (Latched or Self-Reset), and a Color if applicable.
5. Repeat this process for all programmable LED Source, Type, and Color parameters.



6. In the **Setpoint > S1 Relay Setup > Front Panel** dialog box, click **Save** to save the values into the 350 . Click **YES** to accept any changes. Click **Restore** to retain previous values. Click **Default** to restore Default values (all LEDs Off and colors Orange).
7. Click **View Layout and Print** to create a printable label for the front panel showing the programmable LED settings. Edit LED names manually by clicking the LED label and entering up to 20 characters. (Manual edits can be printed, but are not saved.)



8. Click **Print** to print a copy of the customized front panel label.

File support

Opening any EnerVista 3 Series Setup file will automatically launch the application or provide focus to the already opened application. If the file is a settings file (has a 'SR3' extension) which had been removed from the Settings List tree menu, it will be added back to the Settings List tree.

New files will be automatically added to the tree.

Using setpoint files

The EnerVista 3 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

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

The EnerVista 3 Series Setup displays relay setpoints with the same hierarchy as the front panel display.

Downloading and saving setpoint files

Back up a copy of the in-service settings for each commissioned 350 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.

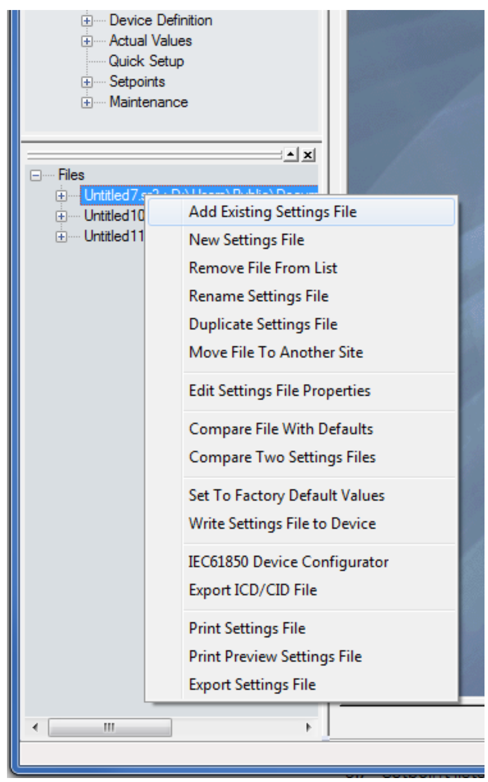
The setpoint files in the EnerVista 3 Series Setup window are accessed in the Files Window. Use the following procedure to download and save setpoint files to a local PC.

1. Ensure that the site and corresponding device(s) have been properly defined and configured as shown in *Connecting EnerVista 3 Series Setup to the Relay*, above.
2. Select the desired device from the site list.
3. Select the **Online > Read Device Settings** from Device 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 will request the name and destination path of the setpoint file. The corresponding file extension will be automatically assigned. Press **Receive** to complete the process. A new entry will be added to the tree, in the File pane, showing path and file name for the setpoint file.

Adding setpoint files to the environment

The EnerVista 3 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 files pane, right-click on **Files** and select the **Add Existing Setting File** item as shown:

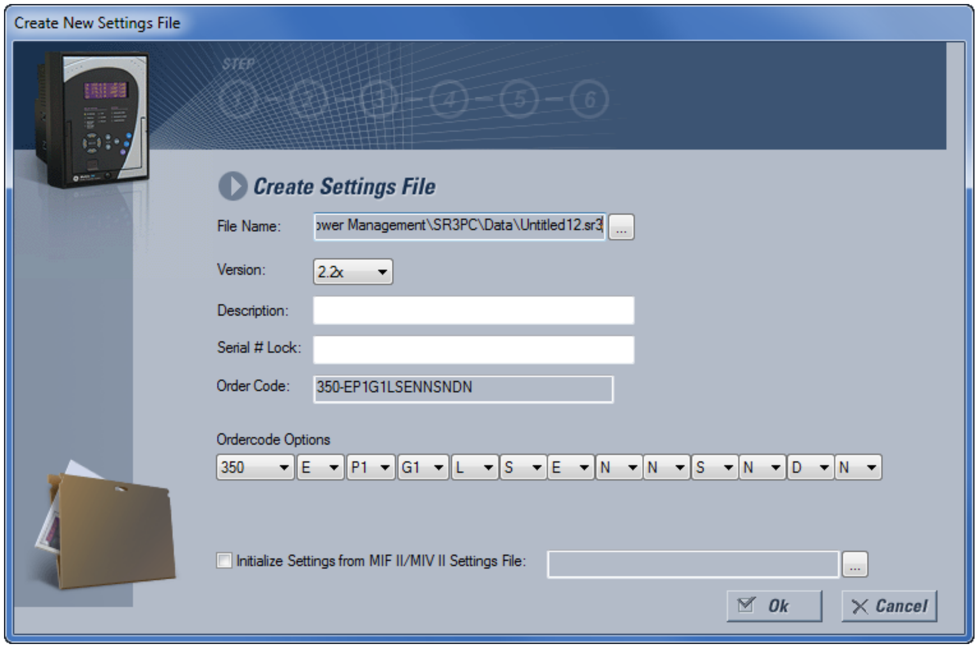


2. The Open dialog box will appear, prompting the user to select a previously saved setpoint file. As for any other MS Windows® application, browse for the file to be added then click **Open**. The new file and complete path will be added to the file list.

Creating a new setpoint file

The EnerVista 3 Series Setup software allows the user to create 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 File pane, right click on **File** and select the **New Settings File** item. The following box will appear, 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.



NOTE

Discontinued order codes may be included to maintain back-compatibility of setpoint files. For current order codes, refer to the GE Multilin website at http://www.gegridsolutions.com/multilin.

NOTE

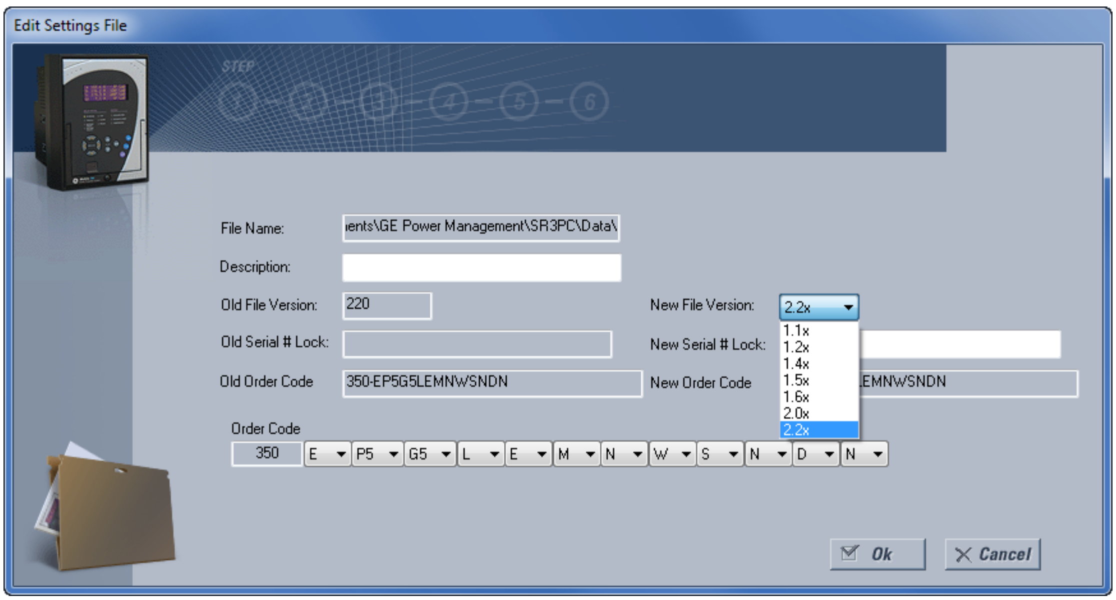
Refer to the *3 Series Retrofit Instruction Manual* for instructions on converting existing Multilin MIF II or MIV II setpoint files.

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 350 setpoint files should have the extension 'SR3' (for example, 'feeder1.SR3').
6. Click **OK** to complete the process. Once this step is completed, the new file, with a complete path, will be added to the EnerVista 3 Series Setup software environment.

Upgrading setpoint files to a new revision

It is often necessary to upgrade the revision for a previously saved setpoint file after the 350 firmware has been upgraded. This is illustrated in the following procedure:

1. Establish communications with the 350 relay.
2. Select the **Maintenance > M1 Relay Info** menu item and record the Firmware Revision.
3. Load the setpoint file to be upgraded into the EnerVista 3 Series Setup environment as described in the section, *Adding Setpoints Files to the Environment*.
4. In the File panel, 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 SR350_V140.sfd (Firmware Revision 1.40) and the current setpoint file revision is 1.20, change the setpoint file revision to “1.4x”.



NOTE

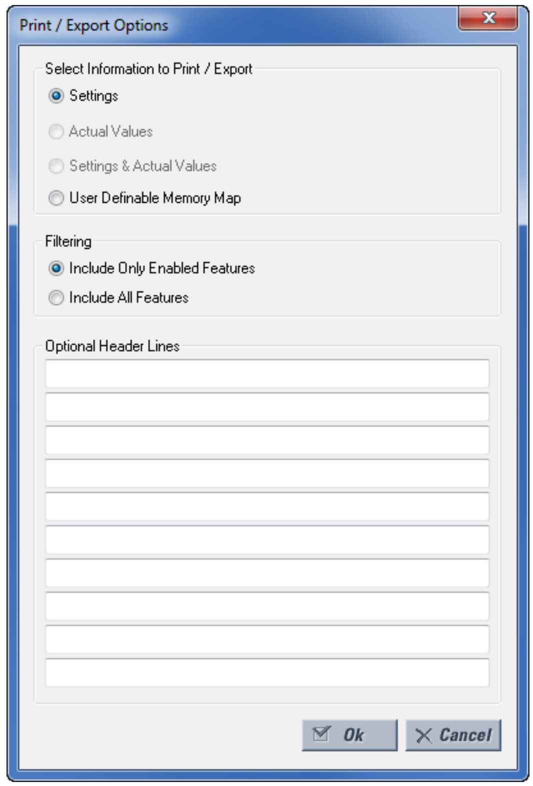
Discontinued order codes may be included to maintain back-compatibility of setpoint files. For current order codes, refer to the GE Multilin website at http://www.gegridsolutions.com/multilin.

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 350 .

Printing setpoints and actual values

The EnerVista 3 Series Setup software allows the user to print partial or complete lists of setpoints and actual values. 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 350 device.
2. From the main window, select the **Offline > Export Settings File** menu item.
3. The Print/Export Options dialog box will appear. Select **Settings** 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. The process for **Offline > Print Preview Settings File** is identical to the steps above.
5. Setpoint lists can be printed in the same manner by right clicking on the desired file (in the file list) or device (in the device list) and selecting the **Print Device Information** or **Print Settings File** options.

Printing actual values from a connected device

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

1. Establish communications with the desired 350 device.
2. From the main window, select the **Online > Print Device Information** menu item
3. The Print/Export Options dialog box will appear. Select **Actual Values** in the upper section and select either **Include All Features** (for a complete list) or **Include Only Enabled Features** (for a list of only those features which are currently used) in the filtering section and click **OK**.

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

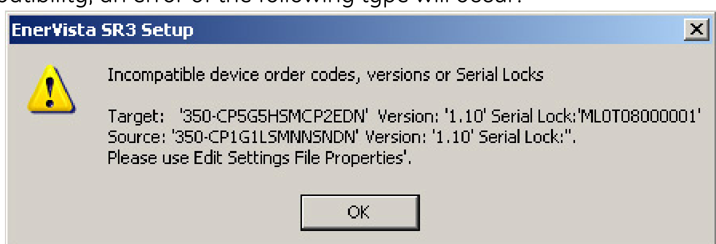
Loading setpoints from a file

CAUTION

An error message will occur when attempting to download 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 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 EnerVista 3 Series Setup 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 EnerVista 3 Series Setup 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 will occur:



If there are no incompatibilities between the target device and the settings file, the data will be transferred to the relay. An indication of the percentage completed will be 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 before uninstalling the EnerVista software or 350 device, for example to comply with data security regulations. On the computer, settings files can be identified by the .sr3 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 .sr3 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 using these commands:

ACTUAL VALUES > RECORDS

- **EVENTS RECORDS > CLEAR**
- **TRANSIENT RECORDS > CLEAR**

Upgrading relay firmware

To upgrade the 350 firmware, follow the procedures listed in this section. Upon successful completion of this procedure, the 350 will have new firmware installed with the factory default setpoints.The latest firmware files are available from the GE Multilin website at http://www.GEgridsolutions.com/multilin.

NOTE

EnerVista 3 Series Setup software prevents incompatible firmware from being loaded into a 350 relay.

NOTE

Before upgrading firmware, it is very important to save the current 350 settings to a file on your PC. After the firmware has been upgraded, it will be necessary to load this file back into the 350 . Refer to *Downloading and Saving Setpoints Files* for details on saving relay setpoints to a file.

Loading new relay firmware

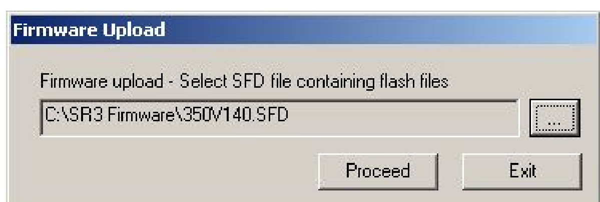
Loading new firmware into the 350 flash memory is accomplished as follows:

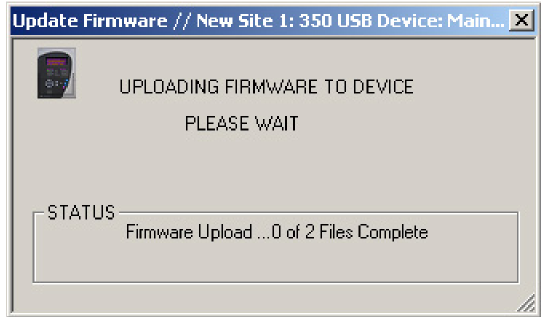
1. Connect the relay to the local PC and save the setpoints to a file as shown in *Downloading and Saving Setpoints Files*.
2. Select the **Maintenance > Update Firmware** menu item.
3. The EnerVista 3 Series Setup software will request the new firmware file. Locate the folder that contains the firmware files to load into the 350 . The firmware filename has the following format:

SR350_200.SFD

↑ **Firmware Rev #**

4. EnerVista 3 Series Setup software now prepares the 350 to receive the new firmware file. The 350 front panel will momentarily display "BOOT PROGRAM Waiting for Message," indicating that it is in upload mode.
5. While the file is being loaded into the 350 , a status box appears showing how much of the new firmware file has been transferred and the upgrade status. The entire transfer process takes approximately 10 minutes.





6. The EnerVista 3 Series Setup software will notify the user when the 350 has finished loading the file. Carefully read any displayed messages and click **OK** to return the main screen. **Cycling power to the relay is recommended after a firmware upgrade.**

After successfully updating the 350 firmware, the relay will not be in service and will require 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.

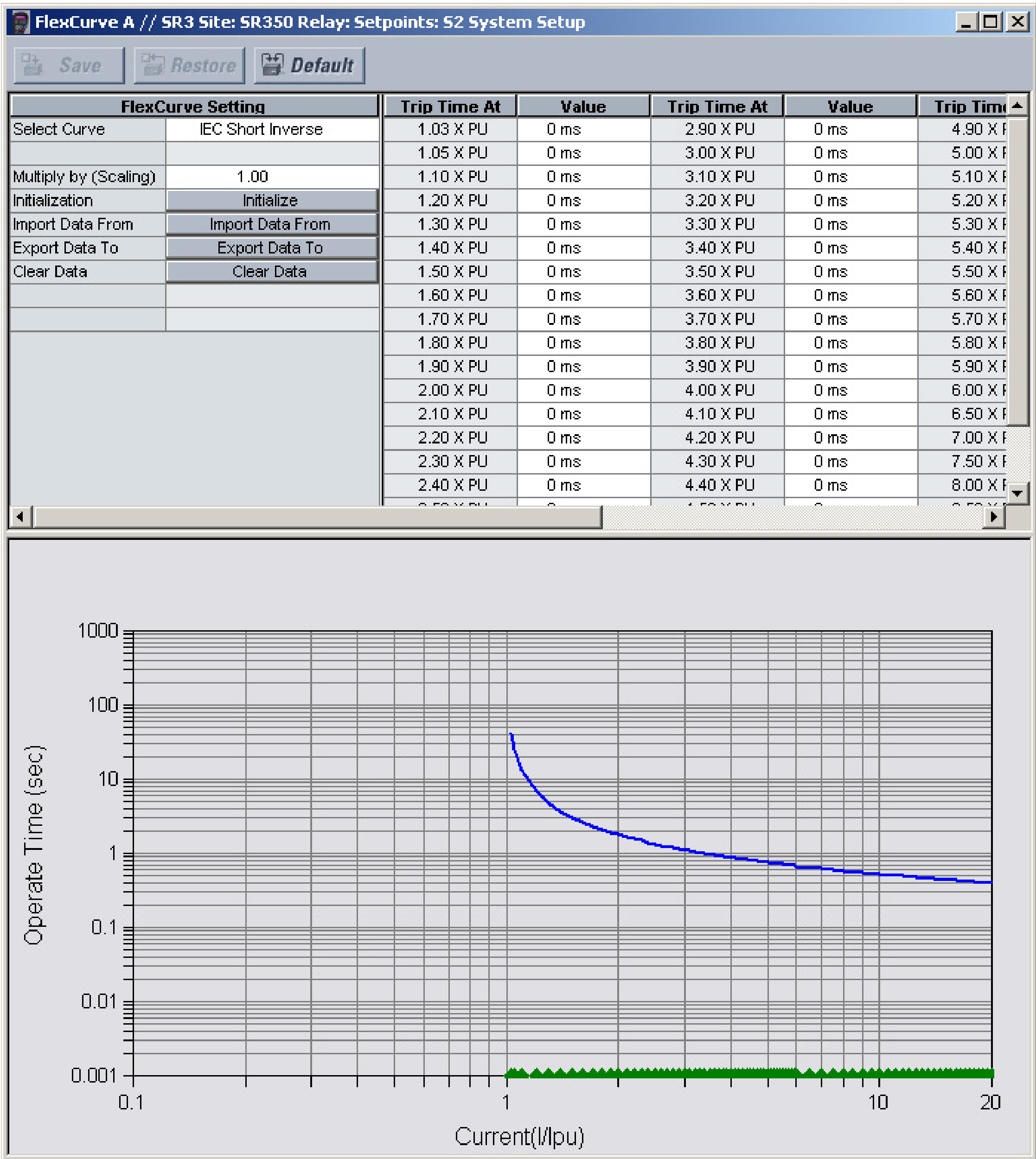
Modbus addresses assigned to firmware modules, features, settings, and corresponding data items (i.e. default values, min/max values, data type, and item size) may change slightly from version to version of firmware.

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

Advanced EnerVista 3 Series Setup features

Flexcurve editor

The FlexCurve Editor is designed to allow the user to graphically view and edit the FlexCurve. The Flexcurve Editor screen is shown below:



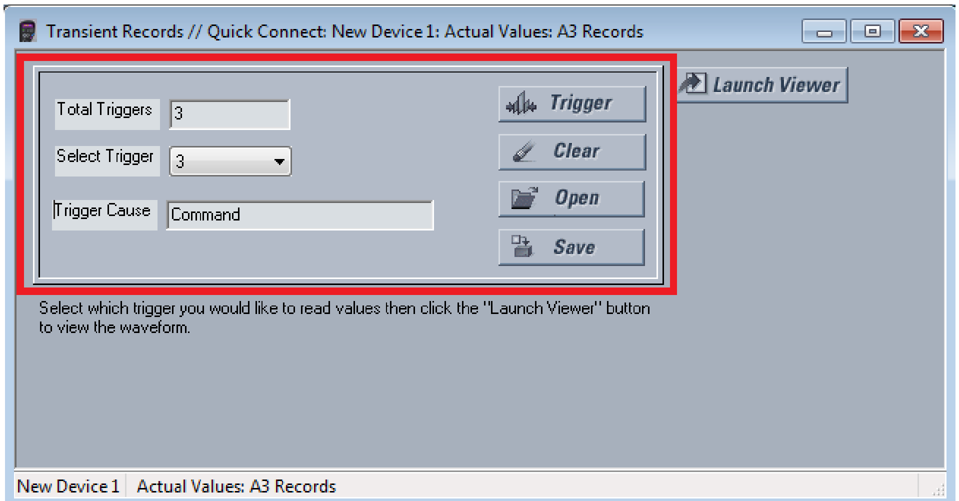
- The Operate Curves are displayed, which can be edited by dragging the tips of the curves
- A Base curve can be plotted for reference, to customize the operating curve. The Blue colored curve in the picture (in both curves) is a reference curve. It can be Extremely Inverse, Definite Time, etc.
- The Trip Times in the tables and curves work interactively i.e., changing the table value will affect the curve shape and vice versa.

- The user can save Configured Trip Times.
- The user can export Configured Trip Times to a CSV file
- The user can load Trip Times from a CSV File
- The screen above shows the model followed by 350 for viewing Flexcurves. Select **Initialize** to copy the trip times from the selected curve to the FlexCurve.

Transient recorder (Waveform capture)

The EnerVista 3 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.

- With EnerVista 3 Series Setup software running and communications established, select the **Actual Values > A3 Records > Transient Records** menu item to open the Transient Recorder Viewer window.



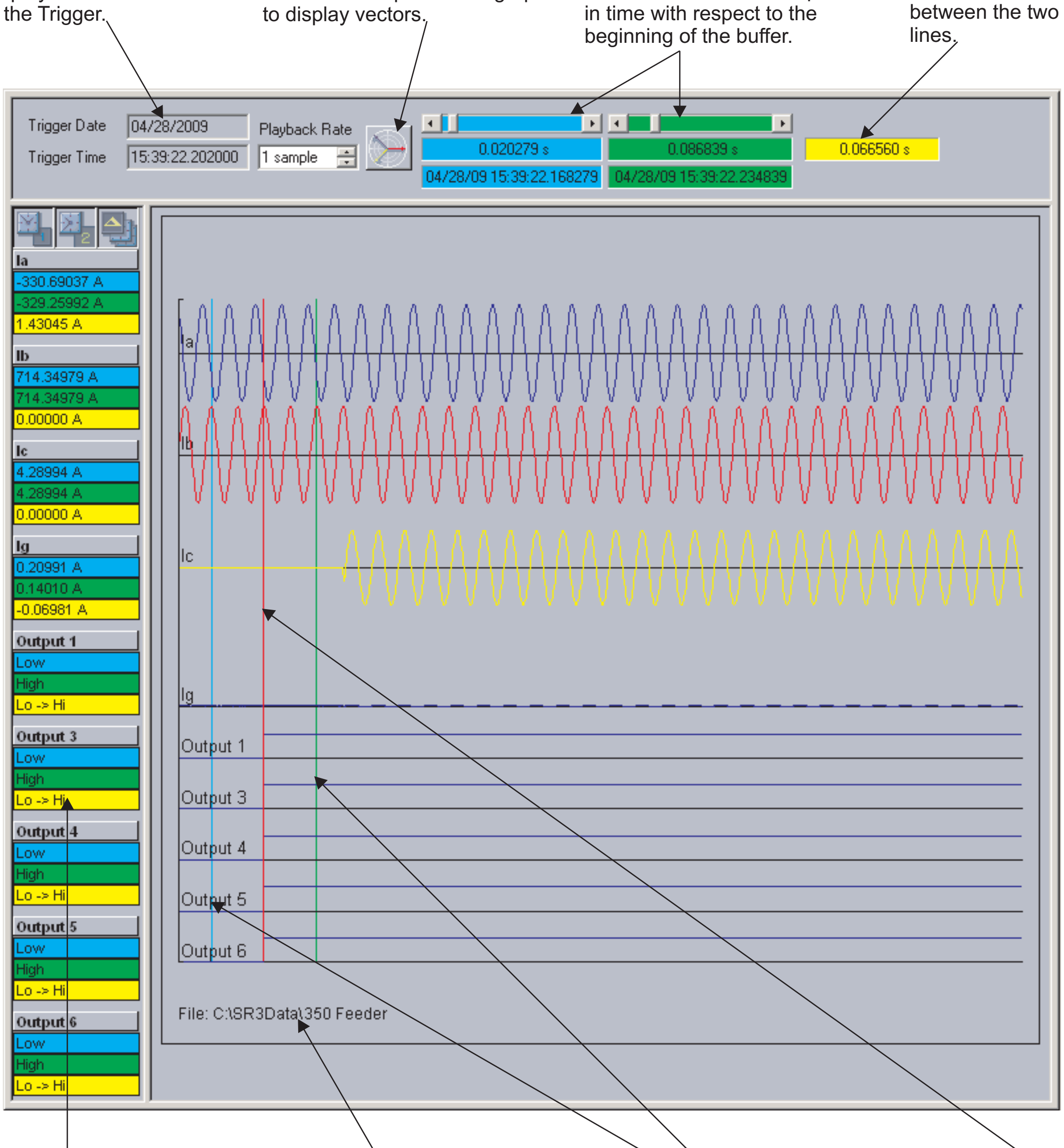
- Click on **Trigger Waveform** to trigger a waveform capture. Waveform file numbering starts with the number zero in the 350 , so that the maximum trigger number will always be one less than the total number of triggers available.
- Click on the **Save to File** button to save the selected waveform to the local PC. A new window will appear, 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.
- To view the captured waveforms, click on the **Launch Viewer** button. A detailed Waveform Capture window will appear as shown below.

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.



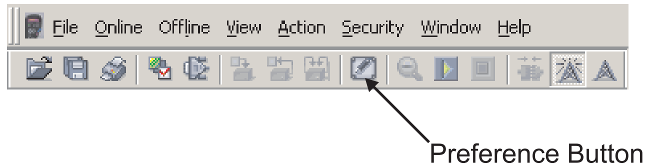
Display graph values at the corresponding cursor line. Cursor lines are identified by their colors.

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

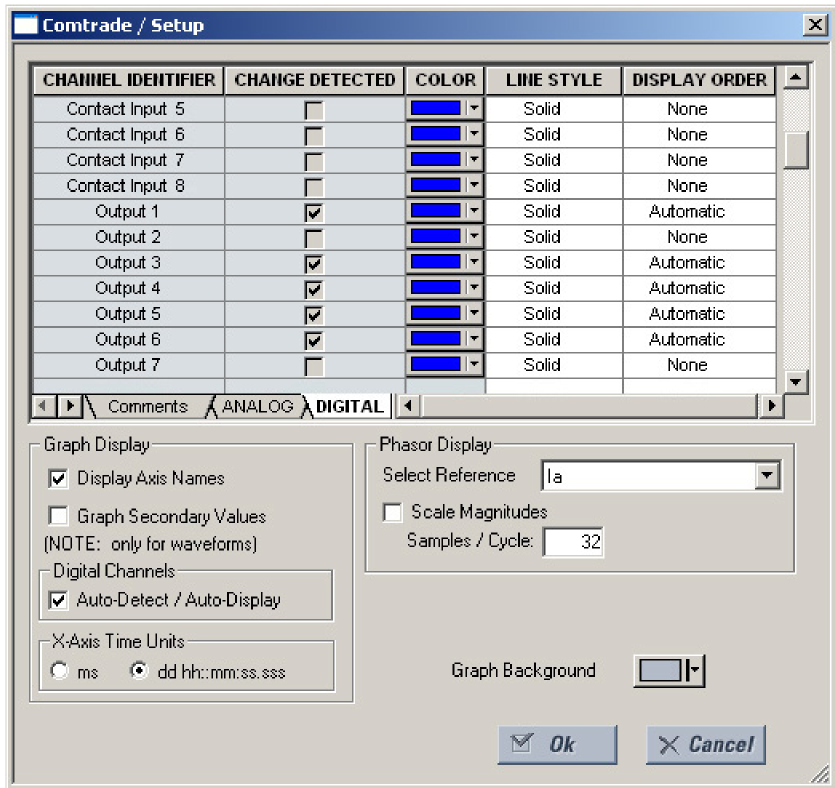
CURSOR LINES
To move lines, locate the mouse pointer over the cursor line, then click and drag the cursor to the new position.

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 will provide 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.

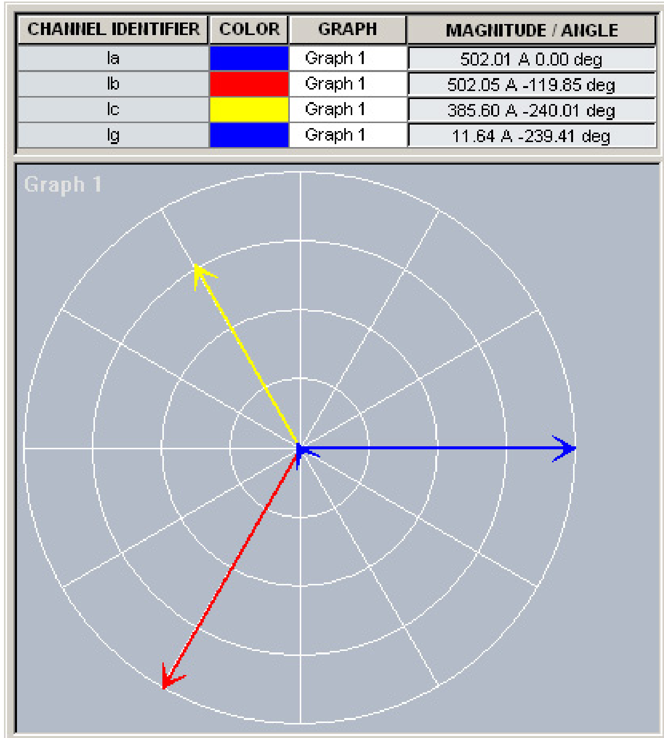


The following window will appear:



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 will reappear based on the selected graph attributes.

To view a vector graph of the quantities contained in the waveform capture, press the **Vector Display** 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

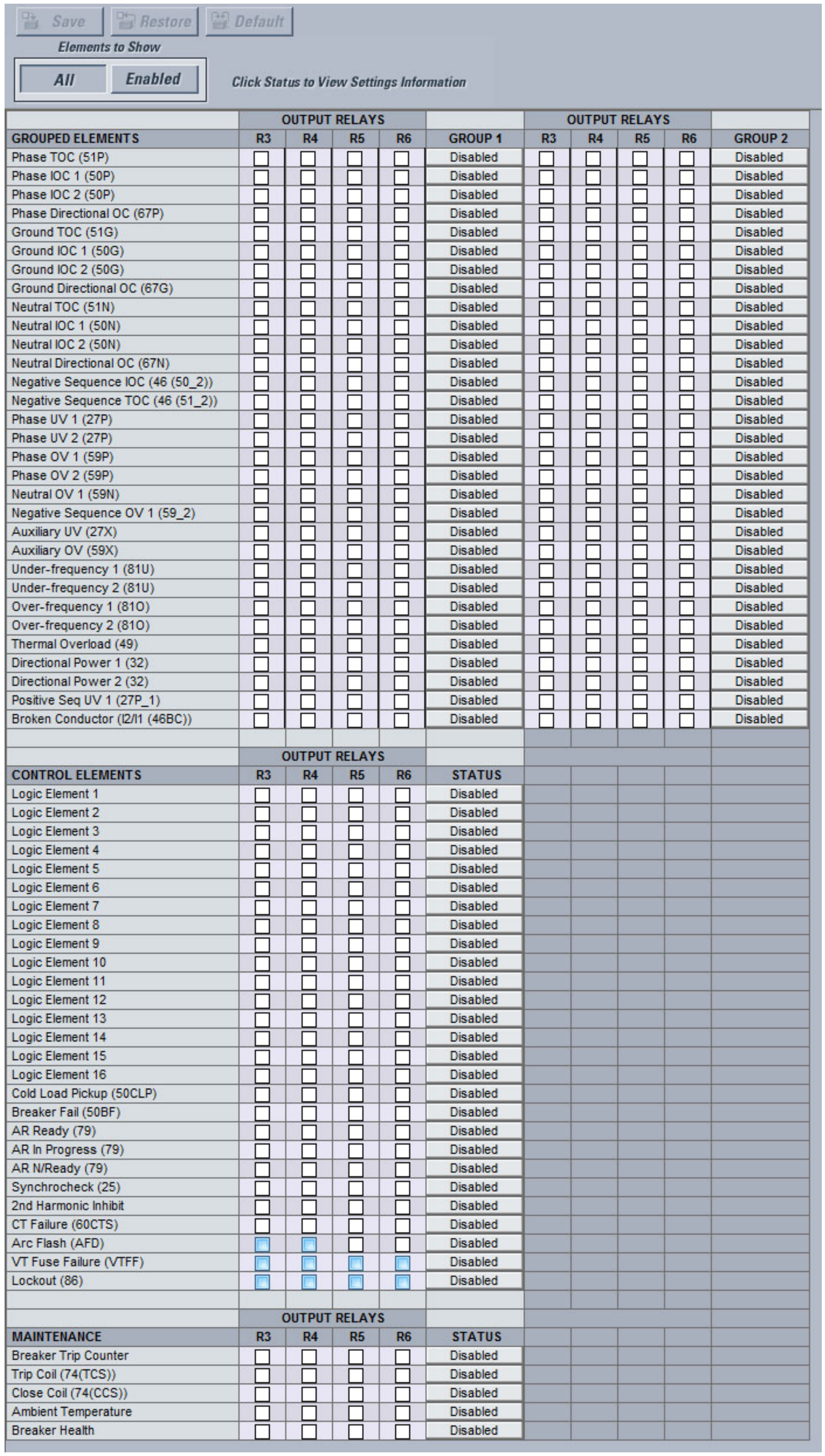
Protection summary

Protection Summary is a single screen which holds the summarized information of different settings from Grouped Elements, Control Elements and Maintenance screens.

Protection Summary Screen allows the user to:

- view the output relay assignments for the elements
- modify the output relay assignments for the elements
- view the enable/disable status of Control Elements
- navigate to the respected Protection Element screen on a button click.

An example of the Protection Summary screen follows:



GROUPED ELEMENTS	OUTPUT RELAYS R3	R4	R5	R6	GROUP 1	OUTPUT RELAYS R3	R4	R5	R6	GROUP 2
Phase TOC (51P)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Phase IOC 1 (50P)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Phase IOC 2 (50P)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Phase Directional OC (67P)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Ground TOC (51G)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Ground IOC 1 (50G)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Ground IOC 2 (50G)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Ground Directional OC (67G)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Neutral TOC (51N)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Neutral IOC 1 (50N)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Neutral IOC 2 (50N)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Neutral Directional OC (67N)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Negative Sequence IOC (46 (50_2))	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Negative Sequence TOC (46 (51_2))	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Phase UV 1 (27P)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Phase UV 2 (27P)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Phase OV 1 (59P)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Phase OV 2 (59P)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Neutral OV 1 (59N)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Negative Sequence OV 1 (59_2)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Auxiliary UV (27X)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Auxiliary OV (59X)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Under-frequency 1 (81U)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Under-frequency 2 (81U)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Over-frequency 1 (81O)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Over-frequency 2 (81O)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Thermal Overload (49)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Directional Power 1 (32)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Directional Power 2 (32)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Positive Seq UV 1 (27P_1)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Broken Conductor (I2/I1 (46BC))	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled

CONTROL ELEMENTS	OUTPUT RELAYS R3	R4	R5	R6	STATUS
Logic Element 1	☐	☐	☐	☐	Disabled
Logic Element 2	☐	☐	☐	☐	Disabled
Logic Element 3	☐	☐	☐	☐	Disabled
Logic Element 4	☐	☐	☐	☐	Disabled
Logic Element 5	☐	☐	☐	☐	Disabled
Logic Element 6	☐	☐	☐	☐	Disabled
Logic Element 7	☐	☐	☐	☐	Disabled
Logic Element 8	☐	☐	☐	☐	Disabled
Logic Element 9	☐	☐	☐	☐	Disabled
Logic Element 10	☐	☐	☐	☐	Disabled
Logic Element 11	☐	☐	☐	☐	Disabled
Logic Element 12	☐	☐	☐	☐	Disabled
Logic Element 13	☐	☐	☐	☐	Disabled
Logic Element 14	☐	☐	☐	☐	Disabled
Logic Element 15	☐	☐	☐	☐	Disabled
Logic Element 16	☐	☐	☐	☐	Disabled
Cold Load Pickup (50CLP)	☐	☐	☐	☐	Disabled
Breaker Fail (50BF)	☐	☐	☐	☐	Disabled
AR Ready (79)	☐	☐	☐	☐	Disabled
AR In Progress (79)	☐	☐	☐	☐	Disabled
AR N/Ready (79)	☐	☐	☐	☐	Disabled
Synchrocheck (25)	☐	☐	☐	☐	Disabled
2nd Harmonic Inhibit	☐	☐	☐	☐	Disabled
CT Failure (60CTS)	☐	☐	☐	☐	Disabled
Arc Flash (AFD)	☐	☐	☐	☐	Disabled
VT Fuse Failure (VTFF)	☐	☐	☐	☐	Disabled
Lockout (86)	☐	☐	☐	☐	Disabled

MAINTENANCE	OUTPUT RELAYS R3	R4	R5	R6	STATUS
Breaker Trip Counter	☐	☐	☐	☐	Disabled
Trip Coil (74(TCS))	☐	☐	☐	☐	Disabled
Close Coil (74(CCS))	☐	☐	☐	☐	Disabled
Ambient Temperature	☐	☐	☐	☐	Disabled
Breaker Health	☐	☐	☐	☐	Disabled

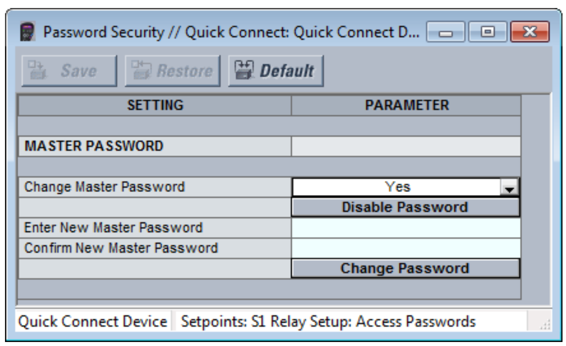
Password security

Password security is an optional feature of the 350 which can be setup using the EnerVista 3 Series Setup software. The password system has been designed to facilitate a hierarchy for centralized management. This is accomplished through a Master level access password which can be used for resetting lower level access passwords and higher level privileged operations. In cases where operational security is required as well as a central administrative authority then the use of the password system is highly encouraged. The feature robustness of this system requires it to be managed exclusively through the EnerVista 3 Series Setup software. This section describes how to perform the initial setup. For more details on the password security feature, refer to *Chapter 6 - Password Security*.

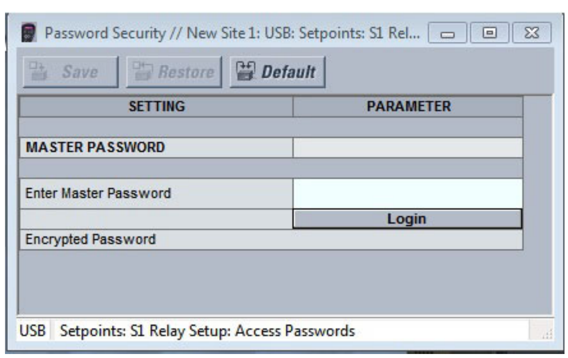
1. 350 devices shipped from the factory are initially set with security disabled. If the password security feature is to be used, the user must first change the Master Password from the initial Null setting, this can only be done over communications, not from the front panel keypad. The new Master Password must be 8 to 10 characters in length, and must have minimum 2 letters and 2 numbers. The letters are case sensitive. Set **Change Master Password** to Yes to enable password security. After entering a valid Master Password, enter the new Master Password again to confirm, then select **Change Password**.

NOTE

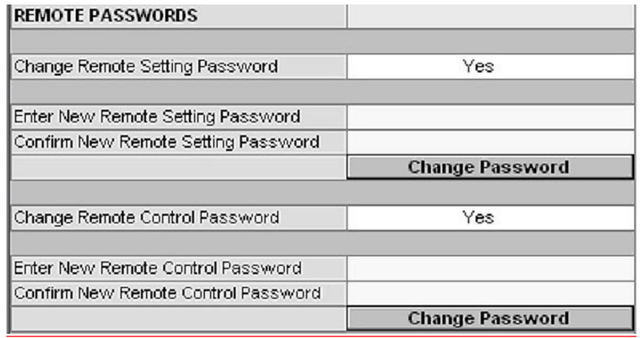
To disable password security, Set **Change Master Password** to Yes and then click **Disable Password**.



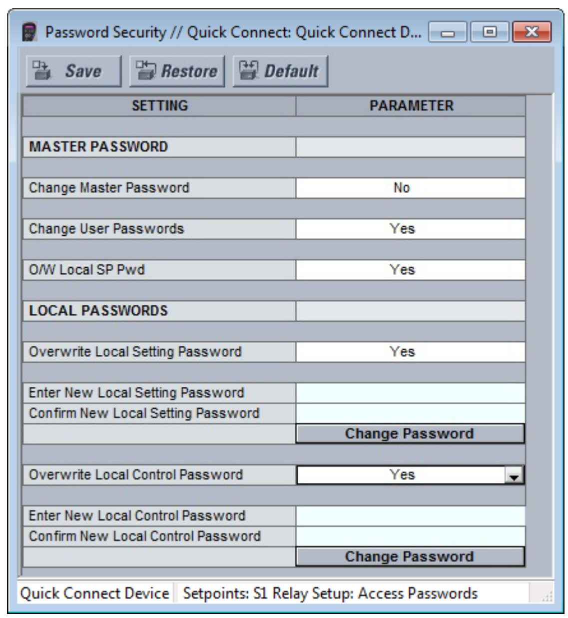
2. Now that the Master Password has been programmed, enter it again to log in to the Master Access level. The Master Level permits setup of the Remote and Local Passwords. If the Master Password has been lost, contact the factory.



3. With Master Level access, the user may disable password security altogether, or change the Master Password.
4. The Master Access level allows programming of the Remote Setpoint and Remote Control passwords. These passwords are initially set to a Null value, and can only be set or changed from a remote user over RS485 or Ethernet communications. Remote Passwords must be 3 to 10 characters in length.



5. Initial setup of the Local Setpoint and Local Control passwords requires the Master Access level. If Overwrite Local Passwords is set to YES, Local passwords can be changed remotely only (over RS485 or Ethernet). If Overwrite Local Passwords is set to NO, Local passwords can be changed locally only (over USB or keypad). If changing Local Passwords is permitted locally, the keypad user can only change the Local Passwords if they have been changed from the initial NULL value to a valid one. Local Passwords must be 3 to 10 characters in length.



6. If any Remote password has never been set, that level will not be attainable except when logged in as the Master Level. The same logic applies to the Local passwords.
7. When passwords have been set, the user will be prompted to enter the appropriate password depending on the interface being used (remote or local), and the nature of the change being made (setpoint or control). If the correct password is entered, the user is now logged into that access level over that interface only. The access level turns off after a period of 5 minutes of inactivity, if control power is cycled, or if the user enters an incorrect password.

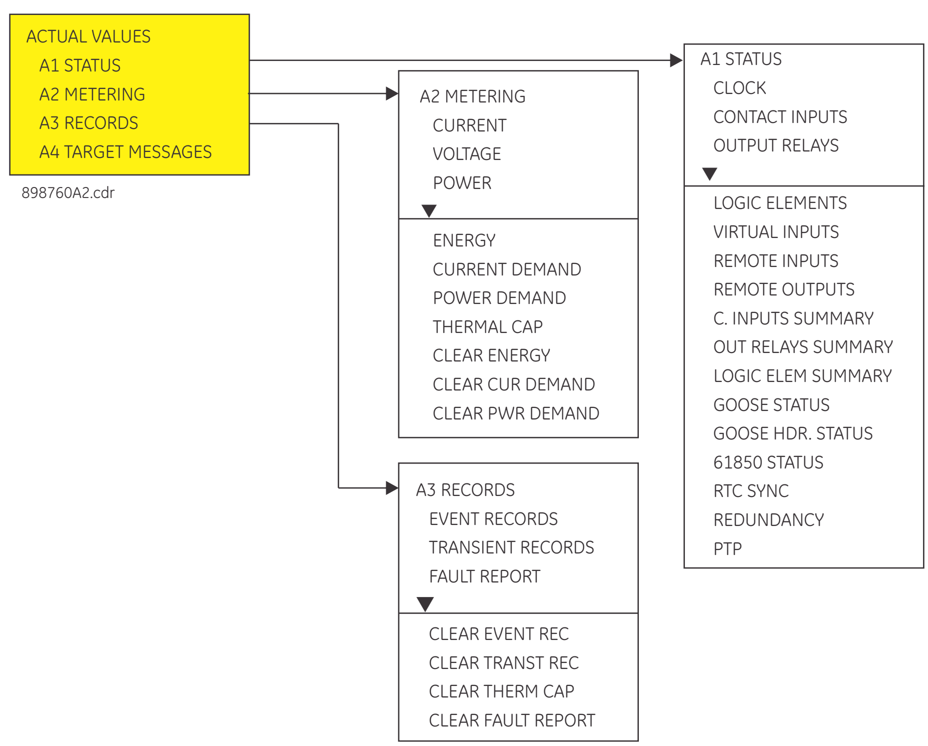
350 Feeder Protection System

Chapter 4: Actual values

Actual values overview

All measured values, the status of digital inputs and outputs, and fault analysis information are accessed in Actual Values mode. Actual value messages are organized into logical groups for easy reference as shown below.

Figure 4-1: Main Actual Values menu



A1 Status

Clock

PATH: ACTUAL VALUES > A1 STATUS > CLOCK

CURRENT DATE
Feb 23 2016

Range: Date in format shown

Indicates today's date.

CURRENT TIME
09:17:12

Range: Time in format shown

Indicates the current time of day.

Contact inputs

PATH: ACTUAL VALUES > A1 STATUS > CONTACT INPUTS

CI #1 (52a) (Contact Input 1)
OFF

Range: Off, On

The status of this contact shows the breaker close/open state, when wired to a 52a breaker auxiliary contact.

CI #2 (52b) (Contact Input 2)
OFF

Range: Off, On

The status of this contact shows the breaker close/open state, when wired to a 52b breaker auxiliary contact.

CONTACT INPUT 3 to 10
OFF

Range: Off, On

Message displays the state of the contact input. The message "ON" indicates that the contact input is energized, and message "OFF" indicates a de-energized contact.

Output relays

PATH: ACTUAL VALUES > A1 STATUS > OUTPUT RELAYS

TRIP (Output Relay #1)
OFF

Range: Off, On

The "ON" state of Output Relay #1 (TRIP) shows that a TRIP command has been sent to the breaker.

CLOSE (Output Relay #2)
OFF

Range: Off, On

The "ON" state of Output Relay #2 (CLOSE) shows that a close command has been sent to the breaker.

OUTPUT RELAY 3 to 6 (Auxiliary Output Relays)
OFF

Range: Off, On

OUTPUT RELAY 7 (Critical Failure Relay)

Range: Off, On

The "ON" state indicates that the relay is in-service.

Logic elements

PATH: ACTUAL VALUES > A1 STATUS > LOGIC ELEMENTS

LOGIC ELEMENT 1 to 16
OFF

Range: Off, On

The state "ON" or "OFF" for each logic element depends on its programmed logic: triggering inputs, blocking inputs, plus any pickup, and/or reset time delay.

Virtual inputs

The state of all active virtual inputs is displayed here.

PATH: ACTUAL VALUES > A1 STATUS > VIRTUAL INPUTS

VIRTUAL INPUTS 1 to 32
OFF

Range: Off, On

Remote inputs

The state of all active remote inputs is displayed here.

PATH: ACTUAL VALUES > A1 STATUS > REMOTE INPUTS

REMOTE INPUTS 1 to 32
OFF

Range: Off, On

Remote outputs

The state of all active remote outputs is displayed here.

PATH: ACTUAL VALUES > A1 STATUS > REMOTE OUTPUTS

REMOTE OUTPUTS 1 to 32
OFF

Range: Off, On

Contact inputs summary

PATH: ACTUAL VALUES > A1 STATUS > C. INPUTS SUMMARY

C. INPUTS SUMMARY

52a	OFF	CI#6	OFF
52b	OFF	CI#7	OFF
CI#3	OFF	CI#8	OFF
CI#4	OFF	CI#9	OFF
CI#5	OFF	CI#10	OFF

The display shows a summary of the states of all contact inputs.

Output relays summary

PATH: ACTUAL VALUES > A1 STATUS > OUT RELAYS SUMMARY

OUTPUT RELAYS SUMMARY

TRIP	OFF	RLY#5	OFF
CLOSE	OFF	RLY#6	OFF
RLY#3	OFF	RLY#7	ON
RLY#4	OFF		

This display shows a summary of the states of all output relays.

NOTE

Output relay #7 is the Critical Failure relay, used to indicate the correct functioning of the 350 relay. This output relay shows the status "ON" when the 350 relay is powered up and set to "Ready" and no self-test alarms are active, under **SETPOINTS > S1 RELAY SETUP > S1 INSTALLATION > RELAY STATUS.**

Logic elements summary

PATH: ACTUAL VALUES > A1 STATUS > LOGIC ELEM SUMMARY

LOGIC ELEM SUMMARY

LE#1	OFF	LE#9	OFF
LE#2	OFF	LE#10	OFF
LE#3	OFF	LE#11	OFF
LE#4	OFF	LE#12	OFF
LE#5	OFF	LE#13	OFF
LE#6	OFF	LE#14	OFF
LE#7	OFF	LE#15	OFF
LE#8	OFF	LE#16	OFF

This display shows a summary of the states of all logic elements.

GOOSE status

PATH: ACTUAL VALUES > A1 STATUS > GOOSE STATUS

GOOSE 1 TO 8 STATUS

Range: OFF, ON
Default: OFF

GOOSE HDR status

PATH: ACTUAL VALUES > A1 STATUS > GOOSE HDR STATUS

GOOSE 1 TO 8 H.STATUS

Range: OFF, ON

Default: OFF

61850 status

PATH: ACTUAL VALUES > A1 STATUS > 61850 STATUS

When a CID file is sent to the relay following a configuration change, it is temporarily placed in the SCL/notvalidated directory. Once the CID file is validated locally, it is transferred to the SCL/validated directory. The status of the validation process is indicated by the following 61850 status values.

61850 STATUS

Range: Not Ready, Ready, Default CID

Not Ready: there is an error in the CID file, with no 61850 services operative. A corrected CID file must be sent to the relay using the IEC 61850 Configurator.

Ready: there is a validated CID file in the SCL/validated directory, with all 61850 services operative.

Default CID: no CID file was found in either SCL/notvalidated or SCL/validated, so a default CID files was loaded. After the next reboot the default CID file will be treated as a regular CID file.

61850 NV STATUS

Range: Unknown, Header Error, Parse Error, Passed to Validated, Empty

Unknown: a default CID files has been created.

Header Error: the CID file in the SCL/notvalidated directory does not match the version of order code of the relay.

Parse Error: that the CID file in the SCL/notvalidated directory could not be validated.

Passed to Validated: a CID file was successfully validated and moved to the SCL/validated directory.

Empty: there is no CID file in the SCL/notvalidated directory.

RTC Sync Source

Path: ACTUAL VALUES > A1 STATUS > RTC SYNC SOURCE

The **RTC Sync Source** actual value is the time synchronizing source the relay is using at present. Possible sources are: PTP Clock, IRIG-B, SNTP and Internal.

Redundancy

The present values of the redundancy protocol are displayed here.

PATH: ACTUAL VALUES > A1 STATUS > REDUNDANCY>VERSIONS

- **PRP_HSR Version** -This is the current version of the PRP_HSR bitstream running in the redundancy FPGA.
- **Independent Version** -This is the current version of the Independent bitstream running in the redundancy FPGA.

PATH: ACTUAL VALUES > A1 STATUS > REDUNDANCY>PRP_HSR COUNTS

- **PRP_HSR A TX** - This is the number of correct messages transmitted over port A.

- **PRP_HSR B TX** - This is the number of correct messages transmitted over port B.
- **PRP_HSR A ERR** - This is the number of bad messages received over port A.
- **PRP_HSR B ERR** - This is the number of bad messages received over port B.

IEEE 1588 PTP (Precision Time Protocol)

PATH: **ACTUAL VALUES > A1 STATUS > PTP**

Grandmaster ID:

GRAND MAS HI + GRAND MAS LO 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 the grandmaster in a system with multiple grandmaster-capable clocks.

A2 Metering

The relay measures all RMS currents and voltages, frequency, and all auxiliary analog inputs. Other values like neutral current, symmetrical components, power factor, power (real, reactive, apparent), are derived. All quantities are recalculated every power system cycle 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.

By scrolling the Up/Down keys the relay shows one-by-one, all metered values as follows:

Current

Path: ACTUAL VALUES > A2 METERING > CURRENT

PH A CURRENT
0.0 A 0° lag
Range: 0.0 to 30000 A, 0 to 359° lag

PH B CURRENT
0.0 A 0° lag
Range: 0.0 to 30000 A, 0 to 359° lag

PH C CURRENT
0.0 A 0° lag
Range: 0.0 to 30000 A, 0 to 359° lag

NTRL CURRENT
0.0 A 0° lag
Range: 0.0 to 30000 A, 0 to 359° lag

GND CURRENT
0.0 A 0° lag
Range: 0.0 to 30000 A, 0 to 359° lag

SENS GND CURRENT
0.00 A 0° lag
Range: 0.00 to 15.00 A, 0 to 359° lag

POS SEQ CURRENT
0.0 A 0° lag
Range: 0.0 to 30000 A, 0 to 359° lag

NEG SEQ CURRENT
0.0 A 0° lag
Range: 0.0 to 30000 A, 0 to 359° lag

ZERO SEQ CURRENT
0.0 A 0° lag
Range: 0.0 to 30000 A, 0 to 359° lag

PH A CURRENT 2nd HRMC
0.0 %
Range: 0.0 to 100.0%

PH B CURRENT 2nd HRMC
0.0 %
Range: 0.0 to 100.0%

PH C CURRENT 2nd HRMC
0.0 %
Range: 0.0 to 100.0%

Voltage

Path: ACTUAL VALUES > A2 METERING > VOLTAGE

AN VOLTAGE
0 V 0° lag
Range: 0 to 65535 V

BN VOLTAGE
0 V 0° lag
Range: 0 to 65535 V

CN VOLTAGE
0 V 0° lag
Range: 0 to 65535 V

AB VOLTAGE
0 V 0° lag
Range: 0 to 65535 V

BC VOLTAGE
0 V 0° lag
Range: 0 to 65535 V

CA VOLTAGE
0 V 0° lag
Range: 0 to 65535 V

NTRL VOLTAGE
0 V 0° lag
Range: 0 to 65535 V

POS SEQ VOLTAGE
0 V 0° lag
Range: 0 to 65535 V

NEG SEQ VOLTAGE
0 V 0° lag
Range: 0 to 65535 V

ZERO SEQ VOLTAGE
0 V 0° lag
Range: 0 to 65535 V

AUX VOLTAGE
0 V 0° lag
Range: 0 to 65535 V

FREQUENCY
0.00 Hz
Range: 40 to 70 Hz

BUS FREQ
0.00 Hz
Range: 40 to 70 Hz

LINE FREQ
0.00 Hz
Range: 40 to 70 Hz

Path: ACTUAL VALUES > A2 METERING > VOLTAGE > VOLTS PER HERTZ
Display the value in x V/Hz.

Power

Path: ACTUAL VALUES > A2 METERING > POWER

3 ph REAL POWER
0.0 kW
Range: -100000.0 to 100000.0 kW

3 ph REACTIVE POWER
0.0 kVAR
Range: -100000.0 to 100000.0 kVAR

3 ph APPARENT POWER
0.0 kVA
Range: 0 to 3000.0 kVA

POWER FACTOR
0.00
Range: -0.99 to 1.00

DIRECTIONAL POWER 1
0.00 kW
Range: -100000.0 to 100000.0 kW

DIRECTIONAL POWER 2
0.00 kW
Range: -100000.0 to 100000.0 kW

WATTMETRIC POWER
0.000 W
Range: -1000000.0 to 1000000.0 W

Energy

NOTE

All negative values (-) represent lead and all positive values (+) represent lag.

Path: ACTUAL VALUES > A2 METERING > ENERGY

POSITIVE WATTHOUR
0.000 MWh
Range: 0.000 to 50000.000 MWh

NEGATIVE WATTHOUR
0.000 MWh
Range: 0.000 to 50000.000 MWh

POSITIVE VARHOUR
0.000 MVarh
Range: 0.000 to 50000.000 MVarh

NEGATIVE VARHOUR
0.000 MVarh
Range: 0.000 to 50000.000 MVarh

Current Demand

The relay measures Current Demand on each phase. 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 **S6 MONITORING > 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 with the **A3 RECORDS > CLEAR RECORDS** command.

Path: **A2 METERING > CURRENT DEMAND 1**

Path: **A2 METERING > CURRENT DEMAND 2**

LAST RESET
MM/DD/YY 00:00:00

CUR DEMAND 1 PH A
Range: 0.0 to 30000.0 A

MAX CUR DEMAND 1 PH A
Range: 0.0 to 30000.0 A

CUR DEMAND 1 PH B
Range: 0.0 to 30000.0 A

MAX CUR DEMAND 1 PH B
Range: 0.0 to 30000.0 A

CUR DEMAND 1 PH C
Range: 0.0 to 30000.0 A

MAX CUR DEMAND 1 PH C
Range: 0.0 to 30000.0 A

CUR DEMAND 1 PH A D/T
MM/DD/YY HH:MM:SS

CUR DEMAND 1 PH B D/T
MM/DD/YY HH:MM:SS

CUR DEMAND 1 PH C D/T
MM/DD/YY HH:MM:SS

Power Demand

The relay measures three phase Demand for real, reactive, and apparent power.

Path: **A2 METERING > POWER DEMAND**

LAST RESET
MM/DD/YY 00:00:00

REAL PWR DEMAND
Range: 0.0 to 100000.0 kW

MAX REAL PWR DMD
Range: 0.0 to 100000.0 kW

REACTIVE PWR DMD
Range: 0.0 to 100000.0 kVar

MAX REACTIVE PWR DMD
Range: 0.0 to 100000.0 kVar

APPARENT PWR DMD

Range: 0.0 to 100000.0 kVA

MAX APPARENT PWR DMD

Range: 0.0 to 100000.0 kVA

REAL PWR DMD D/T

MM/DD/YY HH:MM:SS

REACTIVE PWR DMD D/T

MM/DD/YY HH:MM:SS

APPARENT PWR DMD D/T

MM/DD/YY HH:MM:SS

Thermal capacity

Path: ACTUAL VALUES > A2 METERING > THERMAL CAPACITY

THERMAL CAP PH A
0%

THERMAL CAP PH B
0%

THERMAL CAP PH C
0%

Clear energy

Path: ACTUAL VALUES > A2 METERING > CLEAR ENERGY

CLEAR ENERGY
NO

Range: No, Yes

When set to "YES," pressing the ENTER key will clear all energy data.

Clear current demand

Path: ACTUAL VALUES > A2 METERING > CLEAR CURR DEMAND

CLEAR CURR DEMAND
NO

Range: No, Yes

When set to "YES," pressing the ENTER key will clear all current demand data.

Clear power demand

Path: ACTUAL VALUES > A2 METERING > CLEAR POWER DEMAND

CLEAR ENERGY
NO

Range: No, Yes

When set to "YES," pressing the ENTER key will clear all power data.

A3 Records

The 350 has an event recorder which runs continuously. All event records are stored in memory such that information is maintained for up to 3 days even after losing relay control power. 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.

Event records

The Event Recorder runs continuously, capturing and storing the last 256 events. All events are stored in non-volatile memory where the information is maintained, even in the case where relay control power is lost.

Shown below is an example of an event record caused by a Breaker Open operation, and the recorded information at the time of this record.

PATH: **ACTUAL VALUES > A3 RECORDS > EVENT RECORDS**

Table 4-1: Example of Event Record

A3 EVENT REC T:778 E778 Jan 30,2009 BKR Stat Open 16:30:23.324	►	E778, CONTROL BKR Stat Open PHASE A CURRENT: 0.0 A 0° Lag
		▼
		E778, CONTROL BKR Stat Open PHASE B CURRENT: 0.0 A 0° Lag
		▼
		E778, CONTROL BKR Stat Open PHASE C CURRENT: 0.0 A 0° Lag
		▼
		E778, CONTROL BKR Stat Open GROUND CURRENT: 0.0 A 0° Lag
		▼
		E778, CONTROL BKR Stat Open NTRL GND CURRENT: 0.0 A
		▼
		E778, CONTROL BKR Stat Open PHASE A-B VOLTAGE 0 V 0°
		▼
		E778, CONTROL BKR Stat Open PHASE B-C VOLTAGE 0 V 0°
		▼
		E778, CONTROL BKR Stat Open PHASE C-A VOLTAGE 0 V 0°
		▼
		E778, CONTROL BKR Stat Open FREQUENCY 0.00 Hz
		▼
		E778, CONTROL BKR Stat Open 3ph REAL POWER 0.0 kW
		▼
		E778, CONTROL BKR Stat Open 3ph REACTIVE POWER 0.0 kvar
		▼

		E778, CONTROL BKR Stat Open 3ph APPARENT POWER 0.0 kVA
		▼
		E778, CONTROL BKR Stat Open POWER FACTOR 0.00
		▼
		E778, CONTROL BKR Stat Open THERM CAP PH A 0.0%
		▼
		E778, CONTROL BKR Stat Open THERM CAP PH B 0.0%
		▼
		E778, CONTROL BKR Stat Open THERM CAP PH C 0.0%

Each event is saved with event number, date and time, and contains information such as per phase current, ground current, either phase-phase voltages (VTs connected in Delta), or phase-neutral voltages (VTs connected in Wye), and system frequency. The Event Recorder can be cleared from **ACTUAL VALUES > A3 RECORDS > CLEAR EVENT REC** setpoint. The following tables provide lists of the event types and event causes:

Table 4-2: Event type

Event Type	Display	Description
General Events	None	Events that occur when specific operation takes place
Pickup Events	PICKUP:	These are events that occur when a protection element picks up
Trip Events	TRIP:	These are events that occur when a breaker trip is initiated
Alarm and Latched Alarm Events	ALARM:	These are events that occur when an alarm is initiated
Control Events	CONTROL:	These are events that occur when a control element is activated
Dropout Events	DROPOUT:	These are events that occur when a protection element drops out after a corresponding pickup event
Contact Input Events	C. INPUT:	These are events that occur when a contact input changes its state
Virtual Input Events	V. INPUT	These are events that occur when a virtual input changes its state
Remote Input Events	R. INPUT	These are events that occur when a remote input changes its state
Logic Element Events	L. ELEMENT	These are events that occur when a logic element changes its state
Self-Test Warning Events	SELF-TEST WARNING	These are events that occur when a self-test warning is detected.
Block Events	BLOCK:	These are events that occur upon activation of any block signal.
Setting Date/Time Events	GENERAL:	These are events that occur upon changing the date or time in the relay.

For a complete list of Event Causes, see Format Code FC134 in the *3 Series Communications Guide*. Note that the format codes differ for each relay model.

Transient records

PATH: ACTUAL VALUES > A3 RECORDS > TRANSIENT RECORDS

FORCE TRIGGER?
No
Range: No, Yes

TOTAL RECORDS
1
Range: N/A

AVAILABLE RECORDS
1
Range: N/A

LAST CLEARED
Feb 08 2009
Range: N/A

Fault report

PATH: ACTUAL VALUES > A3 RECORDS > FAULT REPORT

PH IOC1 TRIP OP
PHASE: A C
04/01/2016 16:30:23.324

MODEL: 350-EP5G5HSECP2EDN
NAME: FEEDER 1
F/W REVISION: 2.20

PH A CURRENT
0.0 A 0° lag

PH B CURRENT
0.0 A 0° lag

PH C CURRENT
0.0 A 0° lag

NTRL CURRENT
0.0 A 0° lag

GND CURRENT
0.0 A 0° lag

SENS GND CURRENT
0.00 A 0° lag

AN VOLTAGE
0 V 0° lag

BN VOLTAGE
0 V 0° lag

CN VOLTAGE
0 V 0° lag

AB VOLTAGE
0 V 0° lag

BC VOLTAGE
0 V 0° lag

CA VOLTAGE
0 V 0° lag

NTRL VOLTAGE
0 V 0° lag

AUX VOLTAGE
0 V 0° lag

FREQUENCY
60.00 Hz

Clear event record

PATH: **ACTUAL VALUES > A3 RECORDS > CLEAR EVENT REC**

CLEAR
No

Range: No, Yes

When set to "Yes," pressing the ENTER key will clear all event records.

Clear transient record

PATH: **ACTUAL VALUES > A3 RECORDS > CLEAR TRANST REC**

CLEAR
No

Range: No, Yes

When set to "Yes," pressing the ENTER key will clear all transient records.

Clear thermal capacity record

PATH: **ACTUAL VALUES > A3 RECORDS > CLEAR THERM CAP**

CLEAR
No

Range: No, Yes

When set to "Yes," pressing the ENTER key will clear all thermal capacity records.

Clear fault report

PATH: **ACTUAL VALUES > A3 RECORDS > CLEAR FAULT REPORT**

CLEAR
No

Range: No, Yes

When set to "Yes," pressing the ENTER key will clear all fault reports.

A4 Target messages

Target messages are automatically displayed for any active condition on the relay such as pickups, trips, alarms, or asserted input. The target messages shown in the table below are displayed as necessary.

The relay displays the most recent event first, and after 5 seconds starts rolling up the other target messages, until the Reset command is initiated. If the Reset command is not performed, but any of the other faceplate pushbuttons is pressed, the display will not show the target messages, unless the user navigates to **ACTUAL VALUES > A4 TARGET MESSAGES**, where they can be reviewed.

The target messages can be reviewed by pressing **Up** and **Down** message pushbuttons from the relay keypad.

For a complete list of Active Targets, see Format Code FC134A in the *3 Series Communications Guide*. Note that the format codes differ for each relay model.

- The PKP messages will appear on the relay display as long as their respective flags are active. The messages will disappear from the display, when either the protection element drops out before operation, such as when the condition clears before reaching operation, or when the protection element operates.
- The OP and BKR Status messages will appear on the relay display, when the respective element operates, with the element function set to "TRIP", or "LATCHED ALARM". The message will stay on the display after the condition clears, and will disappear upon Reset command. If the element function is selected to "ALARM", or "CONTROL", the message will disappear from the display, when the condition causing operation clears.
- The Breaker Open and Breaker Close messages will appear on the display and stay for 5 seconds only, unless the reset command is initiated, or the element changes its state. For example, if the breaker is detected "Open", the message "Breaker Open OK" will appear on the display and will stay for 5 seconds, unless the breaker status changes to "Close". If the breaker status changes to "Close" within 5 seconds after the breaker has been detected open, the message "Breaker Open OK" will disappear, and the message "Breaker Close OK" will appear and stay for 5 seconds.
- The Contact Input ON/OFF, Virtual Input ON/OFF, and Remote Input ON/OFF messages will not appear as target messages upon change of state. The state change, however, will be logged in the Event recorder.

Autoreclose target messages

AR Ready	Appears on the display when the AR is Ready, i.e. breaker closed, AR function enabled, and no AR initiation.	The message appears on the display for 5 seconds, when the AR is detected Ready.
AR IN-PROGRESS	Appears on the display when the AR is in progress	Self-Reset message
AR LOCKOUT	Appears on the display when the AR is in lockout mode	Latched message. The message disappears upon Reset command

Examples of how the messages appear on the display:

Example 1:

Phase IOC1 Settings:

- PH IOC1 FUNCTION = Trip
- PH IOC1 PICKUP = 1.00 x CT
- PH IOC1 DELAY = 0.20 s

When current greater than the IOC1 pickup level is applied, the 3350 50 display shows the following target message:

A4 TARGET MESSAGES
Ph IOC1 Trip
STATE: PKP

After the 200 ms time delay expires, the display shows the following message only:

A4 TARGET MESSAGES
Ph IOC1 Trip
STATE: OP

Example 2:

Phase IOC1 Settings:

- PH IOC1 FUNCTION = Latched Alarm
- PH IOC1 PICKUP = 1.00 x CT
- PH IOC1 DELAY = 0.20 s

When current greater than the IOC1 pickup level is applied, the 350 display shows the following target message:

A4 TARGET MESSAGES
Ph IOC1 Alarm
STATE: PKP

After the 200 ms time delay expires, the display shows the following message only:

A4 TARGET MESSAGES
Ph IOC1 Alarm
STATE: OP

Example 3:

Phase IOC1 Settings:

- PH IOC1 FUNCTION = Alarm
- PH IOC1 PICKUP = 1.00 x CT
- PH IOC1 DELAY = 0.20 s

When current greater than the IOC1 pickup level is applied, the 350 display shows the following target message:

A4 TARGET MESSAGES
Ph IOC1 Alarm
STATE: PKP

After the 200 ms time delay expires, the display shows the following message only:

A4 TARGET MESSAGES
Ph IOC1 Alarm
STATE: OP

NOTE

Once the condition clears, the target message will disappear.

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350 Feeder Protection System

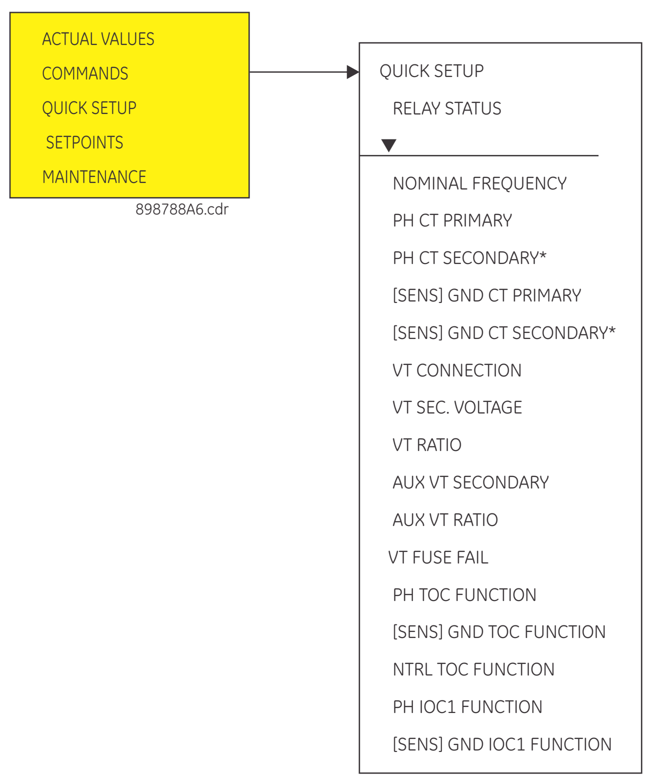
Chapter 5: Quick setup - Front control panel

The “Quick Setup” utility is part of the 350 relay main menu, and can be used for quick and easy programming. Power system parameters, and settings for some simple over-current elements can be easily set.

NOTE

Ensure the relay is in "Relay Ready" state before using Quick Setup.

Figure 5-1: Quick Setup menu



* Present only for universal CT

Quick Setup settings

The setpoints below can be programmed under the "Quick Setup" menu.

Note that monitoring of Breaker Status via 52a, 52b, or both of these contacts,, should be programmed under **SETPOINTS > S2 SYSTEM SETUP > BREAKER**.

PATH: **QUICK SETUP >**

PH CT PRIMARY

Range: 1 A to 6000 A in steps of 1
Default: 500 A

GND CT PRIMARY

Range: 1 A to 6000 A in steps of 1
Default: 50 A

VT CONNECTION

Range: Wye, Delta
Default: Wye

VT SEC VOLTAGE

Range: 50 V to 240 V in steps of 1
Default: 120 V

VT RATIO

Range: 1.0:1 to 5000.0:1 in steps of 0.1
Default: 1:1

AUX VT SECONDARY

Range: 50 V to 240 V in steps of 1
Default: 110 V

AUX VT RATIO

Range: 1.0:1 to 5000.0:1 in steps of 0.1
Default: 1:1

VT FUSE FAIL

Range: Trip, Disabled, Alarm
Default: Disabled

PH TOC FUNCTION

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

↳

PH TOC PICKUP

Range: 0.05 to 20.00 x CT
Default: 1.00 x CT

PH TOC CURVE

Range: ANSI Extremely/Very/Moderately/Normally Inverse, Definite Time, IEC Curve A/B/C and Short, IAC Extreme/Very/Inverse/Short, User Curve, FlexCurve™ A/B (programmable curves)
Default: Extremely Inverse

PH TOC TDM

Range: 0.05 to 50.00
Default: 1.00

GND TOC FUNCTION

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

↳

GND TOC PICKUP

Range: 0.05 to 20.00 x CT
Default: 1.00 x CT

GND TOC CURVE

Range: ANSI Extremely/Very/Moderately/Normally Inverse; Definite Time; IEC Curve A/B/C /Short Inverse; IAC Extreme/Very/Inverse/Short Inverse; User Curve, FlexCurve™ A/B (programmable curves)
Default: Extremely Inverse

GND TOC TDM

Range: 0.05 to 50.00
Default: 1.00

SENS GND TOC FUNCTION [WHEN SPECIFICALLY ORDERED]

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

↳

SENS GND TOC PICKUP

Range: 0.005 to 3.000 x CT
Default: 1.000 x CT

SENS GND TOC CURVE

Range: ANSI Extremely/Very/Moderately/Normally Inverse; Definite Time; IEC Curve A/B/C /Short Inverse; IAC Extreme/Very/Inverse/Short Inverse; User Curve, FlexCurve™ A/B (programmable curves)
Default: Extremely Inverse

SENS GND TOC TDM

Range: 0.05 to 50.00
Default: 1.0

NTRL TOC FUNCTION

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

↳

NTRL TOC PICKUP

Range: 0.05 to 20.00 x CT
Default: 1.00 x CT

NTRL TOC CURVE

Range: ANSI Extremely/Very/Moderately/Normally Inverse, Definite Time, IEC Curve A/B/C and Short, IAC Extreme/Very/Inverse/Short, User Curve, FlexCurve™ A/B (programmable curves)
Default: Extremely Inverse

NTRL TOC TDM

Range: 0.05 to 50.00
Default: 1.00

PH IOC1 FUNCTION
Range: Disabled, Trip, Latched Alarm, Alarm
Default: Disabled
↳

PH IOC1 PICKUP
Range: 0.05 to 20.00 x CT
Default: 1.00 x CT

GND IOC1 FUNCTION
Range: Disabled, Trip, Latched Alarm, Alarm
Default: Disabled
↳

GND IOC1 PICKUP
Range: 0.05 to 20.00 x CT
Default: 1.00 x CT

SENS GND IOC1 FUNCTION [WHEN SPECIFICALLY ORDERED]
Range: Disabled, Trip, Latched Alarm, Alarm
Default: Disabled
↳

SENS GND IOC1 PICKUP
Range: 0.005 to 3.000 x CT
Default: 1.000 x CT

NTRL IOC1 FUNCTION
Range: Disabled, Trip, Latched Alarm, Alarm
Default: Disabled
↳

NTRL IOC1 PICKUP
Range: 0.05 to 20.00 x CT
Default: 1.00 x CT

NOTE

The settings changed using the Quick Setup menu, are available for review and modification by navigating through **S1 RELAY SETUP**, **S2 SYSTEM SETUP** and **S3 PROTECTION** in the **SETPOINTS** main menu.

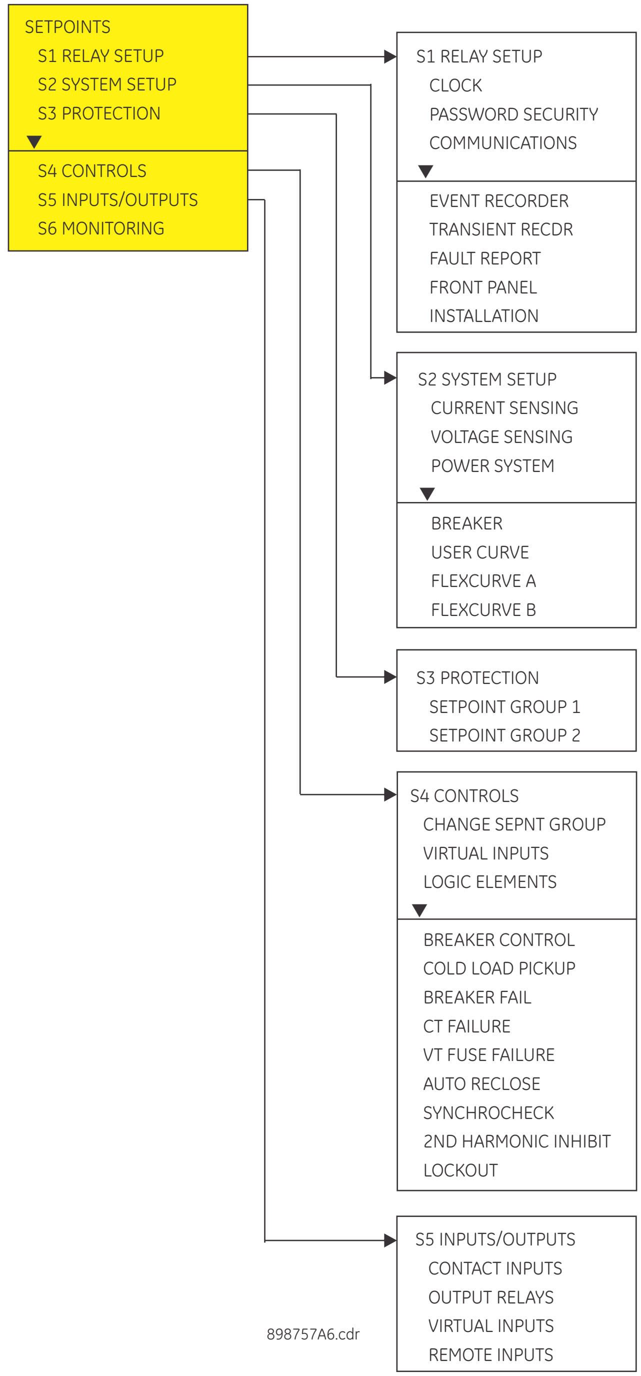
350 Feeder Protection System

Chapter 6: Setpoints

Setpoints Main Menu

The 350 has a considerable number of programmable setpoints, all of which make the relay extremely flexible. These setpoints have been grouped into a variety of pages and subpages as shown below. Each setpoints menu has a section that describes in detail the setpoints found on that menu.

Figure 6-1: Setpoints main menu



Setpoint entry methods

Before placing the relay into "**IN SERVICE**" mode, 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, or rear RS485, Ethernet 100 FX, Ethernet 10/100 BaseT (optional) port, and a computer running the EnerVista 3 Series Setup software supplied with the relay.
- Rear serial RS485, 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 3 Series Setup software is supplied with the relay.

The relay leaves the factory with setpoints programmed to default values, and these values are shown throughout the setpoint message illustrations. Some of these factory default values can be left unchanged whenever they satisfy the application.

At a minimum, the **S2 SYSTEM SETUP** setpoints must be entered for the system to function correctly. To safeguard against the installation of a relay into which setpoints have not been entered, the **Relay Not Ready** self-test warning is displayed. In addition, the critical failure relay will be de-energized. Once the relay has been programmed for the intended application, the **S1 RELAY SETUP/ INSTALLATION/ RELAY STATUS** setpoint should be changed from "**Not Ready**" (the default) to "**Ready**".

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 these setpoints is two or more of: "Disabled", "Enabled", "Trip", "Alarm", "Latched Alarm", and "Control".

  If **<ELEMENT_NAME > FUNCTION**: "Disabled", the feature is not operational.

  If **<ELEMENT_NAME > FUNCTION**: "Enabled", the feature is operational.

  If **<ELEMENT_NAME > FUNCTION**: "Trip", then the feature is operational. When an output is generated, the feature declares a Trip condition, and operates the Trip relay (output relay 1), any other selected auxiliary output relays, and displays the appropriate trip message. The "ALARM" LED will not turn on.

  If **<ELEMENT_NAME> FUNCTION**: "Alarm", the feature is operational. When an output is generated, the feature declares an Alarm condition which operates any selected auxiliary output relays and displays the appropriate alarm message. The ALARM LED will flash upon operation. The Alarm condition will self-reset when the operating condition clears, turning off the Alarm LED.

  If **<ELEMENT_NAME> FUNCTION**: "Latched Alarm", the feature is operational. When an output is generated, the feature declares an Alarm condition which operates any selected auxiliary output relays and displays the appropriate alarm message. The ALARM LED will flash upon operation. The Alarm condition and Alarm LED will stay "ON" after the operating condition clears, until the reset command is initiated.

If **<ELEMENT_NAME> FUNCTION**: "Control" the feature is operational. When an output is generated, the feature operates any selected output relays. The "Trip", "Alarm", and "Control" function setpoint values are also used to select those operations that will be stored in the Event Recorder.

- **OUTPUT RELAY setpoint**: The **<ELEMENT_NAME> OUTPUT 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 are output relays 3 to 6.
- **PICKUP setpoint**: The **<ELEMENT_NAME> PICKUP** setpoint selects the threshold above which the measured parameter causes an output from the measuring element.
- **BLOCK setpoint**: The **<ELEMENT_NAME> BLOCK** setpoint applies the selected input to block the function. More than one BLOCK setpoint may be available for a given element; a single high input always blocks the function..

  The range depends on order code, and can include Contact Input 1 to 10, Virtual Input 1 to 32, Remote Input 1 to 32, Logic Elements 1 to 16, 2nd Harmonic Alarm, 2nd Harmonic, CT Fail Alarm PKP, and CT Fail Alarm OP. The default setting is "Off".
- **DELAY setpoint**: The **<ELEMENT_NAME> DELAY** setpoint selects a fixed time interval to delay an input signal from appearing at the output. The time from a contact input change of state or an AC parameter input level change to a contact closure of the 1 Trip relay, is the time selected as time delay in this setpoint plus approximately up to 2 power frequency periods.
- **DIRECTION setpoint**: 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 element is allowed to operate for current flow in the forward direction only, as determined by the directional element. If set to "Reverse", the element is allowed to operate for current flow in the reverse direction only, as determined by the directional element.

Logic diagrams

The logic diagrams provide a complete comprehensive understanding of the operation of each feature. These sequential logic diagrams illustrate how each setpoint, input parameter, and internal logic is used in the feature to obtain an output. In addition to these logic diagrams, written descriptions are provided in the setpoints chapter which includes 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.
- **Compensator 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 setpoint and input parameter is indicated by the following symbols: "**<**" (less than) " **>**" (greater than), etc.
- **Time Delays**: Shown as a block with either pickup, drop-out, or both; times in milliseconds or seconds. If the delay is adjustable, associated delay setpoint is shown with block **SETPOINT** on the top of the delay block.
- **LED Indicators**: Shown as the following schematic symbol, □. The exact wording of the front panel label identifies the indicator.

- **Logic**: Described with basic logic gates (**AND, OR, XOR, NAND, NOR**). The inverter (**logical NOT**), is shown as a circle: ○.

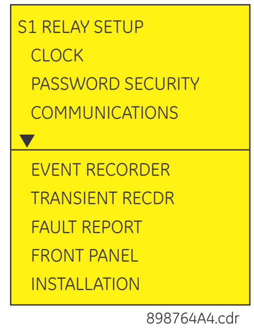
Setting text abbreviations

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

S1 Relay setup

Figure 6-2: Relay Setup menu



Clock

The 350 relay has an internal real time clock that performs time stamping via IRIG-B for various features such as the event and transient recorders. This time stamping is available with the IRIG-B signal connected to the relay terminals and set to “Enabled”. When an IRIG-B device is connected to the relay terminals, the relay detects the DC shift or the Amplitude Modulated signal automatically. Time stamping on multiple relays can be synchronized to ± 1.0 ms with the use of IRIG-B input. Time stamping is also optionally available using SNTP.

Time synchronization priority uses the IRIG-B and SNTP protocols - via Modbus, IEC60870-5-103, IEC60870-5-104, or DNP commands - as follows:

IRIG-B has the highest priority, so any other source of synchronization should be rejected if IRIG-B is the synchronization source and an IRIG-B signal is available.

PTP (V2) has the second highest priority, so if IRIG-B is not the synchronization source but PTP is, then any other source of synchronization should be rejected. SNTP has the third highest priority.

Synchronization commands are all eventually translated into a MODBUS function, and as such are blocked from the MODBUS layer as required.

Any synchronization commands other than Modbus, IEC60870-5-103, IEC60870-5-104, or DNP will be accepted only if IRIG-B, PTP, and SNTP are not the synchronization sources. There is no prioritization amongst synchronization commands. A synchronization command issued from DNP for example, can be directly followed by another from MODBUS, for example.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S1 RELAY SETUP > CLOCK**

DATE: (MM/DD/YYYY)

Range: Month: Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec Day: 1 to 31 Year: 2009 to 2099

Default: Jan 15 2009

This setting sets the date in the specified format.

TIME: (HH:MM:SS)

Range: 0 to 23: 0 to 59: 0 to59

Default: 03:15:50

This setting sets the time in the specified format.

DLS ENABLE

Range: Disabled, Enabled
Default: Disabled

PATH: **SETPOINTS > S1 RELAY SETUP > CLOCK > DLS ENABLE [ENABLED]**

DLS START MONTH:

Range: Not Set, January, February, March, April, May, June, July, August, September, October, November, December
Default: Not Set

This setting sets the month for the DLS start time.

DLS START WEEK:

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

This setting sets the week of the month for the DLS start time.

DLS START WEEKDAY:

Range: Not Set, Mon, Tue, Wed, Thu, Fri, Sat, Sun
Default: Not Set

This setting sets the weekday for the DLS start time.

DLS END MONTH:

Range: Not Set, January, February, March, April, May, June, July, August, September, October, November, December
Default: Not Set

This setting sets the month for the end of the DLS time.

DLS END WEEK:

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

This setting sets the week of the month for the end of the DLS time.

DLS END WEEKDAY:

Range: Not Set, Mon, Tue, Wed, Thu, Fri, Sat, Sun
Default: Not Set

This setting sets the weekday for the end of the DLS time.

PATH: **SETPOINTS > S1 RELAY SETUP > CLOCK**

IRIG-B:

Range: Disabled, Enabled
Default: Disabled

This setting enables the IRIG-B signal for time stamp synchronization.

1. Set the IRIG-B to “Enabled” if the IRIG-B device is connected to the relay IRIG-B terminals. The relay will display the message “IRIG-B failure” in the case of either no IRIG-B signal from the connected IRIG-B device, or when the signal cannot be decoded.
2. Set the date and time per the specified date and time format.
3. Set the start time of the Daylight Saving (DLS) time, by selecting the Month, the Week of the month, and the Weekday defining the beginning of the Daylight Saving time.
4. Set the end of the Daylight Saving time, by selecting the Month, the Week of the month, and the Weekday defining the end of the Daylight Saving time.

The clock has a super-capacitor back-up, so that time, date, and events will be kept for up to 3 days in cases of loss of relay control power.

SNTP MODE:

Range: Disabled, Unicast, Anycast, Broadcast

Default: Disabled

When "Disabled" is selected for this setting, SNTP time synchronization is disabled.

SNTP PORT:

Range: 0 to 65535

Default: 0

This setting configures the port that 350 .is using.

SNTP SERVER IP ADR:

Range: Standard IP Address format

Default: 000.000.000.000

This setting must be set to the SNTP/NTP server IP address.

UTC OFFSET:

Range: -24.00 to 24.00

Default: 0.00

If this setting is different to zero, this value will be used to convert from UTC to local time for SNTP synchronization.

NOTE

Refer to the *3 Series Communications Guide* for details on SNTP MODE, SNTP PORT, and SNTP SERVER IP ADR.

350 Real Time Clock

PATH: **SETPOINTS > S1 RELAY SETUP > CLOCK**

PTP FUNCTION

Range: Enabled, Disabled

Default: Disabled

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

PTP STRICT POWER PROFILE

Range: Enabled, Disabled

Default: Disabled

Power profile (IEEE Std C37.238™ 2011) requires that the relay selects as a grandmaster:

- only power profile compliant clocks
- that the delivered time has a worst-case error of ±1 µs
- and, that the peer delay mechanism be implemented.

With the **Strict Power Profile** setting set to "Enabled", the relay selects as the 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 set to "Disabled", the relay uses clocks without the power profile identification when no power profile clocks are present, and uses ports even if the peer delay mechanism is non-operational. This setting applies to all of the relay's PTP-capable ports.

PTP DOMAIN NUMBER

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 can support multiple time distribution domains, each distinguished with a unique domain number. More commonly, there is a single domain using the default domain number zero. 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 EPOCH

Range: UTC since 1995, UTC since 1900, UTC since 1970, TAI since 1970

Default: UTC since 1995

The setting selects the origin of the time scale.

Password security

Password security features are designed into the relay to provide protection against unauthorized setpoint changes and control. The relay has programmable passwords for both Local and Remote access, which can be used to allow setpoint changes and command execution from both the front panel and the communications ports. The remote user may choose to allow the local user to change the local passwords, or enforce use of the same passwords locally and remotely. The Local and the Remote passwords can be set only after password security is enabled by entering a Master Password. The Master Password is set to "NULL" when the relay is shipped from the factory; setting the Master Password enables password security.

Each interface (RS485, Ethernet, USB, and front panel keypad) is independent of one another, meaning that enabling setpoint access on one interface does not enable access for any of the other interfaces. The password must be explicitly entered via the active interface in order to change setpoints and execute commands. The Master Password cannot be set from the keypad, and must instead be accessed from one of the other interfaces.

The EnerVista 3 Series Setup software includes and interface for programming the relay's passwords as well as enabling/disabling setpoint access. For example, when an attempt is made to modify a setpoint but access is restricted, the program will prompt the user to enter the password and send it to the relay before the setpoint can be written to the relay. If a SCADA system is used for relay programming, it is up to the programmer to incorporate appropriate security for the application.

As well as being logged out of security, which allows the user to read setpoints and actual values only, three levels of security access are provided: Setpoint Level, Control Level, and Master Level. The Setpoint and Control Levels can be attained either locally using the Local passwords (USB port and keypad), or remotely using the Remote passwords (RS485 and Ethernet ports). The user can have either Setpoint or Control Level access active, but not both simultaneously from the same interface. Setpoint and Control passwords must be 3 to 10 alphanumeric characters in length. The Master Level is used for setting and resetting of passwords, and includes all Setpoint and Control Level access rights. The Master Password must be 8 to 10 characters in length, containing at least 2 letters and 2 numbers. The Master Level can define whether the local user is permitted to change Local Passwords without having to enter the Master Level. The Master Password is encrypted, and is not viewable from the keypad. If the Master Password is lost, the user should contact the factory.

After password entry, the access level is maintained until a period of 5 minutes of inactivity has elapsed, after which the password must be re-entered. A power loss or entering in the wrong password logs the user out.

Further definition of the access levels is described as follows:

SETPOINT LEVEL

- Changing settings under QUICK SETUP menu
- Changing settings under the SETPOINTS menu except the features requiring control access listed below
- Changing any setting under MAINTENANCE such as trip and close coil monitoring and breaker maintenance settings, except the features requiring control access listed below
- Changing the Local or Remote Setpoint Password, depending on the interface being accessed

CONTROL LEVEL

- Open and Close Breaker commands
- Virtual Input commands
- Clearing of event records, transient records, and other data
- Changing the Local or Remote Control Password, depending on the interface being accessed

MASTER LEVEL

- Setting and changing of all passwords including the Master Password
- Disabling password security
- All Setpoint and Control Level access rights
- Enabling the Password for Reset Key feature (when enabled, Trip and Alarm resets require a password)

For details on Password Security setup and handling using the EnerVista Setup software, refer to Chapter 3.

Access passwords

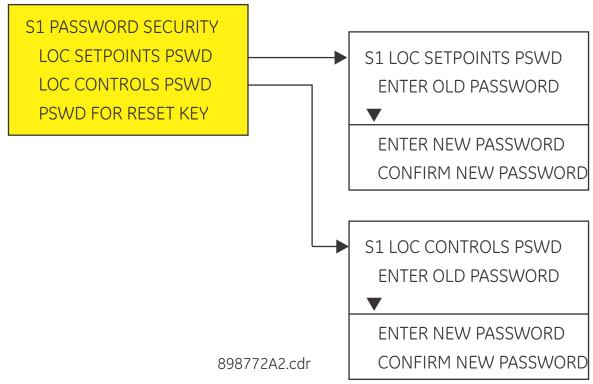
This section allows the user to change the Local Setpoint and Local Control Passwords, and to enable the Password for Reset Key feature (requires the Master Password).

The local user may change a local password from the keypad if all of the following are true:

- Security is enabled
- A valid local setpoint (or local control) password has initially been set
- The remote user has the Overwrite Local Passwords setpoint set to **NO**
- The local user knows the current local password.

For more details on the Password Security feature, refer to Chapter 3.

Figure 6-3: Menu for handling password security using keypad



The following steps describe how to change the Local Setpoints Password from the keypad. Similar steps are followed to change the Local Control Password.

ENTER OLD PASSWORD

The user is prompted to enter the current Local Setpoints Password. User the value up/down keys to select characters, and use the message left/right keys to move the cursor. Press the Enter key when done. An INVALID PASSWORD message will appear if a wrong password is entered, security is disabled, the password has not been originally set, or the local user does not have the rights to change the password. In addition, the user will be automatically logged out of security from the keypad. If the correct password was entered, the user is now logged in to the Setpoints Level from the keypad, and will be prompted to enter a new password.

ENTER NEW PASSWORD

The user is prompted to enter a new Local Setpoints Password. A valid password is alphanumeric, and is 3 to 10 characters in length. An INVALID PASSWORD message will appear if the new password does not meet the password requirements. If a valid password was entered, the user will be prompted to re-enter the new password.

CONFIRM PASSWORD

The user is prompted to re-enter the new Local Setpoints Password. If the passwords do not match, an ENTRY MISMATCH message will appear, the password will remain unchanged, and the user will be returned to the Enter New Password page. If the passwords match, a PASSWORD CHANGED message will appear indicating the Local Setpoints Password has successfully been updated.

PASSWORD FOR RESET KEY

Range: Disabled, Enabled

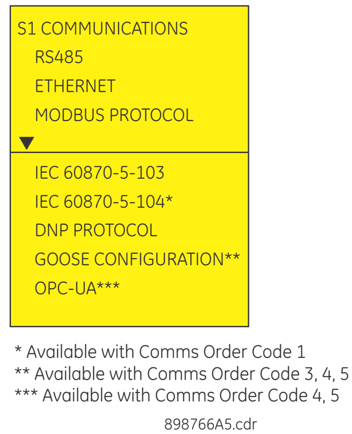
Default: Disabled

If set to Enabled, a PASSWORD is required to reset Trip/Alarm LEDs and events when pressing the Reset key. If set to Disabled, no password will be required.

When password security is enabled, the PSWD FOR RESET KEY is available, and set to Disabled by default. Changing the value of "PSWD FOR RESET KEY" requires the Master Password. If the Master Password has already been provided by the current user, further password confirmation is not required for this setpoint (the 5 minutes of inactivity rule does not apply).

Communications

Figure 6-4: Main communications menu



RS485 interface

The 350 is equipped with one serial RS485 communication port. The RS485 port has settings for baud rate and parity. It is important that these parameters agree with the settings used on the computer or other equipment that is connected to these ports. This port may be connected to a computer running the EnerVista 3 Series Setup software. This software can download and upload setting files, view measured parameters, and upgrade the device firmware. A maximum of 32 3-series devices can be daisy-chained and connected to a DCS, PLC, or PC using the RS485 port.

Select the **Settings > Communications > Serial Ports** menu item in the EnerVista 3 Series Setup program, or the **SETPOINTS > S1 RELAY SETUP > COMMUNICATIONS > RS485** path on the display, to configure the serial port.

The following settings are available to configure the RS485 port.

BAUD RATE

Range: 9600, 19200, 38400, 57600, 115200

Default: 115200

This setting specifies the baud rate (bits per second) for the RS485 port.

PARITY

Range: None, Odd, Even

Default: None

This setting specifies the parity for the RS485 port.

REAR RS485 PROTOCOL

Range: Modbus, IEC60870-5-103, DNP 3.0

Default: Modbus

This setting specifies the protocol to be used for the rear RS485 port.

Ethernet

Select the **SETPOINTS > S1 RELAY SETUP > COMMUNICATIONS > ETHERNET** path on the display or EnerVista 3 Series Setup program, to configure the Ethernet port.

The following settings are available to configure the Ethernet port.

IP ADDRESS

Range: Standard IP Address format

Default: 000.000.000.000

This setting specifies the IP Address for the Ethernet port.

SUBNET IP MASK

Range: Standard IP Address format

Default: 255.255.252.0

This setting specifies the Subnet IP Mask setting for the Ethernet port.

GATEWAY IP ADDRESS

Range: Standard IP Address format

Default: 000.000.000.000

This setting specifies the Gateway IP Address for the Ethernet port.

CONNECTION TYPE

Range: Copper, fiber

Default: Copper

This setting specifies the connection type (Copper or Fiber) used for Ethernet communication.

HIGH ETHERNET MSG ENABLE/DISABLE

Range: Enabled, Disabled

Default: Enabled

This setting enables or disables the High Ethernet traffic message from appearing under high Ethernet traffic conditions.

NOTE

When changing Ethernet settings, power to the relay must be cycled in order for the new settings to become active.

Redundancy mode

The redundancy mode settings select the mode in which the Ethernet ports will work, and optionally configure the Link Loss Alert (LLA) settings with redundancy set to LLA.

Path: **SETPOINTS > S1 RELAY SETUP > COMMUNICATIONS > ETHERNET > REDUNDANCY > REDUNDANCY MODE**

REDUNDANCY MODE

Range: None, LLA, PRP, HSR, Daisy Chain

Default: None

The REDUNDANCY MODE setting determines if ports A and B operate in redundant or independent mode.

In non-redundant mode (REDUNDANCY set to NONE), port A operates independently with their own MAC, IP address, mask and gateway and no communication on Port B.

If REDUNDANCY is set to LLA, the operation of port A and B depends on the LLA settings LLA PRIORITY and LLA TIMEOUT.

If REDUNDANCY is set to PRP, HSR, or Daisy Chain, the operation of port A and B will be as follows:

– Port A and B will use port A MAC address, mask and gateway.
– Port A MCST ADDRESS field will be visible.

For this setting change to take effect, a reboot is required.

For more information about the different redundancy mode options, see the *3 Series Communications Guide*.

LLA PRIORITY

Range: Enabled, Disabled

Default: Enabled

This setting is only used when REDUNDANCY is set to LLA.

If this setting is set to ENABLED, Port A has priority. If the Port A LLA detects a problem with the link, communication is switched to Port B.

If this setting is set to DISABLED, there is no priority, and therefore there is no primary port. Communications switch to the other port whenever the link fails.

With LLA enabled, the primary port is Port A while the secondary (redundant) port is Port B. Ports A and B use the Port A MAC and IP address settings, with Port B in standby mode such that it does not actively communicate on the Ethernet network but does monitor the link. If a problem is detected with the Port A link, communications switch to Port B temporarily. Once the Port A link has been regained and monitored for the duration of the LLA TIMEOUT, communications automatically switch back to Port A, the primary port.

LLA TIMEOUT

Range: 0 to 65535 s in steps of 1 s

Default: 300 s

This setting is only used when REDUNDANCY is set to LLA and LLA PRIORITY is set to ENABLED. When the link on the primary port is detected after it fails, the LLA TIMEOUT setting is the network health monitoring time. During this time, the secondary port remains active.

If primary network remains healthy for the duration of the LLA TIMEOUT value, communications switch back to the primary port automatically.

Modbus

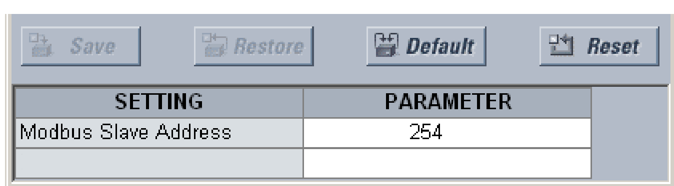
The Modicon Modbus protocol is supported by the 350 . Modbus is available via the RS485 serial link (Modbus RTU). The 350 always acts as a slave device, meaning that it never initiates communications; it only listens and responds to requests issued by a master device. A subset of the Modbus protocol format is supported that allows extensive monitoring, programming, and control functions using read and write register commands. Refer to the *3 Series Communications Guide* for additional details on the Modbus protocol and the Modbus memory map.

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

The 350 operates as a Modbus slave device only

Select the **Settings > Communications > Modbus > Protocol** menu item in EnerVista 3 Series Setup software, or the **SETPOINTS > S1 RELAY SETUP > COMMUNICATIONS > MODBUS PROTOCOL** path to set up the modbus protocol as shown below.

Figure 6-5: Modbus protocol configuration settings



The following Modbus settings are available:

MODBUS SLAVE ADDRESS

Range: 1 to 254 in steps of 1

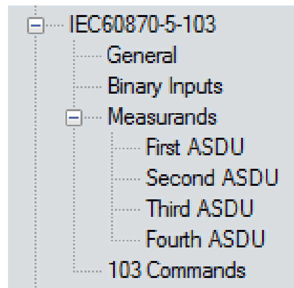
Default: 254

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

Please refer to the *3 Series Communications Guide* for details on how to set up the Modbus communications protocol.

IEC 60870-5-103 serial communication

Figure 6-6: IEC 60870-5-103 serial communications settings



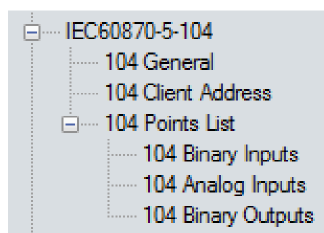
PATH: **SETPOINTS > S1 RELAY SETUP > COMMUNICATIONS > IEC61870-5-103**

Please refer to the *3 Series Communications Guide* for details on how to set up the IEC 60870-5-103 serial communications protocol.

For a complete list of Binary inputs, see Format Code FC134B in the *3 Series Communications Guide*. Note that the format codes differ for each relay model.

IEC60870-5-104 protocol

Figure 6-7: IEC 60870-5-104 protocol settings



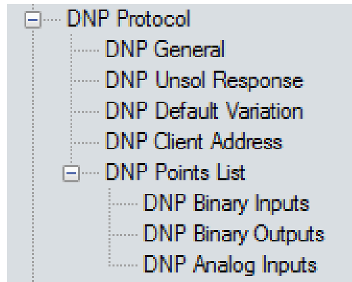
PATH: **SETPOINTS > S1 RELAY SETUP > COMMUNICATIONS > IEC61870-5-104**

Please refer to the *3 Series Communications Guide* for details on how to set up the IEC 60870-5-104 protocol.

For a complete list of Binary inputs, see Format Code FC134B in the *3 Series Communications Guide*. Note that the format codes differ for each relay model.

DNP communication

Figure 6-8: DNP communication settings



PATH: **SETPOINTS > RELAY SETUP > COMMUNICATIONS > DNP PROTOCOL > DNP GENERAL**

Please refer to the *3 Series Communications Guide* for details on how to set up the DNP protocol.

For a complete list of Binary inputs, see Format Code FC134B in the *3 Series Communications Guide*. Note that the format codes differ for each relay model.

3 Series IEC 61850 GOOSE details

The 350 firmware supports IEC61850 GOOSE communications on the optional communications daughter board.

Portions of the IEC61850 standard not pertaining to GOOSE, are not implemented in the 350 .

Manufacturing Message Specification (MMS) standard ISO/IEC 9506 is only supported when GOOSE type is set to “Advanced” (under **S1 RELAY SETUP > COMMUNICATIONS > GOOSE CONFIGURATION > TRANSMISSION**) and the Communications order code option includes IEC 61850.

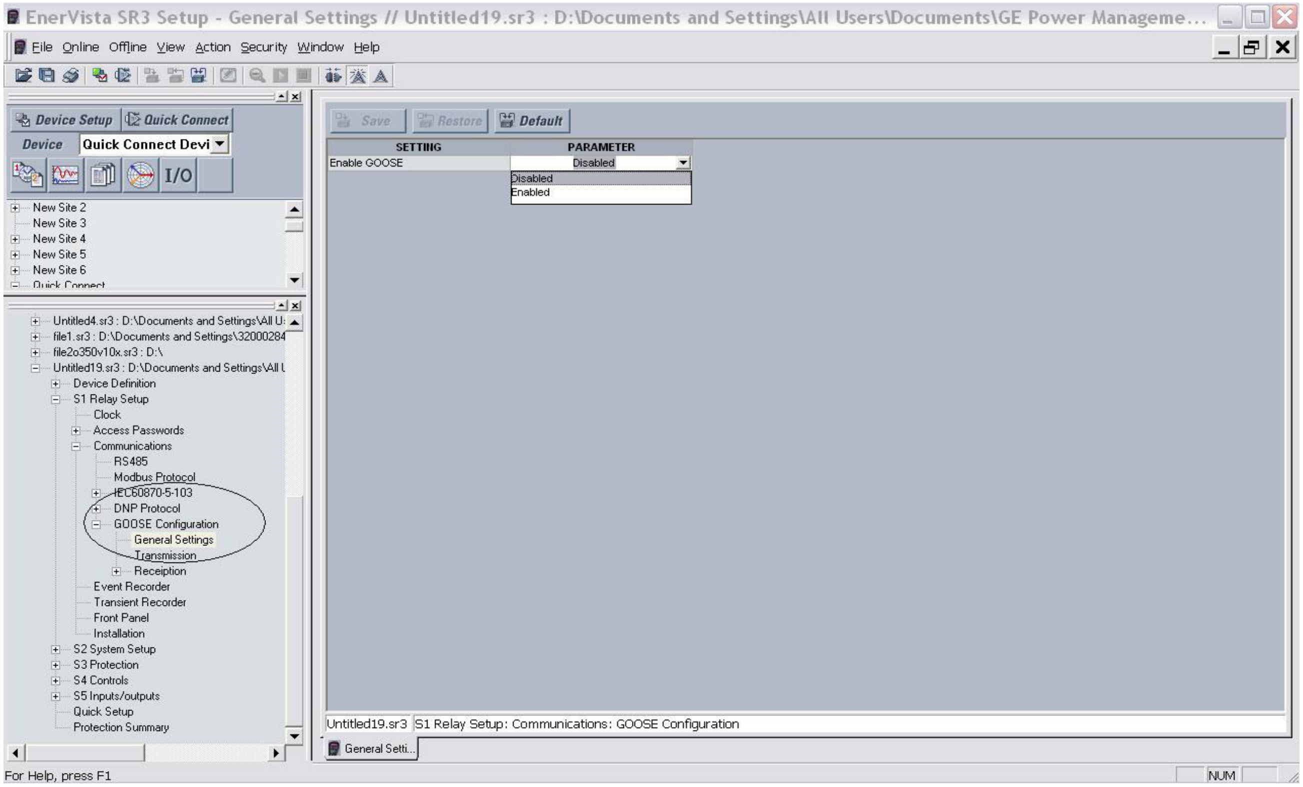
Configuration of transmission and reception settings for the GOOSE feature are performed using EnerVista 3 Series Setup software.

The 350 firmware accepts GOOSE messages from 8 Series, UR, F650 and UR Plus. The interoperability with other manufacturers will be guaranteed in almost all cases, by implementing the reception side with nested structures (one level of nesting) and all the standard data types.

GOOSE settings changes will take effect only after the 350 is re-booted. One setting is available to Enable/Disable both Transmission and Reception. It is possible to change this setting from the Front Panel of the relay.

Refer to the *3 Series Communications Guide* for details on how to set up the IEC 61850 communications protocol.

Figure 6-9: EnerVista 3 Series GOOSE General Settings



OPC-UA Settings

OPCUA Enable

Range: Disabled, Enabled

Default: Disabled

The OPCUA Enable setting is only for a 350 relay with a communications Order Code 4.

In this case only, the OPC-UA and the IEC61850 protocol do not run simultaneously. If IEC61850 is running by default but it is desired to use OPC-UA instead, the user must put the OPCUA Enable setting to Enabled. Then, the relay must be rebooted. This will run the OPC-UA instead of the IEC61850.

In the 350 relay with communications Order Code 5, this setting is not visible and both protocols run simultaneously.

Event recorder

The Event Recorder runs continuously, capturing and storing the last 256 events. All events are stored in a non-volatile memory where the information is maintained for up to 3 days in case of lost relay control power.

PATH: SETPOINTS > S1 RELAY SETUP > EVENT RECORDER

PICKUP EVENTS

Range: Disabled, Enabled

Default: Disabled

When set to “Enabled”, the event recorder records the events that occur when a protection element picks up.

DROPOUT EVENTS

Range: Disabled, Enabled

Default: Disabled

When set to “Enabled” the event recorder records the dropout state of a protection element.

TRIP EVENTS

Range: Disabled, Enabled

Default: Enabled

The trip events include all programmed relay elements set to trip the breaker. The text “TRIP” followed by the name of the operated element is recorded.

ALARM EVENTS

Range: Disabled, Enabled

Default: Enabled

These events include the elements programmed as an “ALARM” or “LATCHED ALARM” function, which detect power system conditions considered as an alarm.

CONTROL EVENTS

Range: Disabled, Enabled

Default: Enabled

If set to “Enabled”, the event recorder records events caused by the performance of the programmed control elements.

BLOCK EVENTS

Range: Disabled, Enabled

Default: Enabled

When set to “Enabled”, an event will be triggered upon activation of any block signal.

CONTACT INPUTS

Range: Disabled, Enabled

Default: Enabled

When set to “Enabled”, the event recorder will record the event, when a contact input changes its state.

LOGIC ELEMENT

Range: Disabled, Enabled

Default: Enabled

When set to “Enabled”, the event recorder records the events, which occur upon state change of any programmed remote input.

VIRTUAL INPUTS

Range: Disabled, Enabled

Default: Enabled

When set to “Enabled”, the event recorder records the events, which occur upon state changes of any logic element.

REMOTE INPUTS

Range: Disabled, Enabled

Default: Enabled

When set to “Enabled”, the event recorder records the events, which occur upon state change of any programmed remote input.

SETTING DATE/TIME

Range: Disabled, Enabled

Default: Disabled

When set to “Enabled”, the event recorder records the event of the changing of the date and time.

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 the analog current and voltage inputs - Ia, Ib, Ic, Ig, Va, Vb, Vc, and Vx when relay is ordered with CTs and VTs, or only analog current inputs Ia, Ib, Ic, and Ig when relay is ordered without VTs. Triggering of the transient recorder occurs, when an event is detected, causing a pickup, trip, dropout, or alarm, any one of which has been "Enabled" to activate the trigger. The transient recorder trigger may also be activated when any of the selected trigger inputs 1 to 3 is detected as having “On” status.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S1 RELAY SETUP > TRANSIENT RECDR**

NUM OF RECORDS

Range: 1, 3, 6

Default: 1

This setpoint selects the desired number of records to be saved in the memory.

SAMPLING RATE

Range: 4, 8, 16, 32

Default: 4

This setpoint defines the sampling rate at which transient records will be recorded.

TRIGGER MODE

Range: Overwrite, Protected

Default: Overwrite

When the “Overwrite” setting is selected, the new records overwrite the old ones, meaning the relay will always keep the newest records. In “Protected” mode, the relay will keep the number of records corresponding to the selected number, only without overwriting.

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 ON PKP

Range: Off, On

Default: Off

Selection of "Yes" setting enables triggering for the recorder upon Pickup condition detected from any protection or control element.

TRIGGER ON DPO

Range: Off, On

Default: Off

Selection of "Yes" setting enables triggering for the recorder upon a Dropout condition detected from any protection or control element.

TRIGGER ON TRIP

Range: Off, On

Default: Off

Selection of "Yes" setting enables triggering for the recorder upon Trip condition detected from any protection or control element.

TRIGGER ON ALARM

Range: Off, On

Default: Off

Selection of "Yes" setting enables triggering for the recorder upon Alarm condition detected from any protection or control element.

TRIGGER ON INPUT 1 to 3

Range: Off, Contact Input 1 to 10, Virtual Input 1 to 32, Remote Input 1 to 32, Logic Element 1 to 16

Default: Off

Selection of input or logic element from the settings range enables triggering input for the recorder. A record will be triggered if the status of the selected input changes to "On".

TRIGGER ON INPUT 1 to 3

Range: Off, Contact Input 1 to 10, Virtual Input 1 to 32, Remote Input 1 to 32, Logic Element 1 to 16, CT Fail Alarm PKP, CT Fail Alarm OP, 2nd Harmonic Alarm, 2nd Harmonic

Default: Off

Selection of input or logic element from the settings range enables triggering input for the recorder. A record will be triggered if the status of the selected input changes to "On".

Fault report

The 350 relay has a Fault Report which captures measured analog signals at the time of the trip. The Fault Report stores only the last recorded values in relay's non-volatile memory. The Fault Report has two configurable setpoints, "FAULT TRIGGER" and "DELAY OTHER TRIGGERS". The high state of the selected Fault Trigger operand will trigger the Fault Report. The default setting is ANY TRIP. The time delay setting is provided for selection of time to override any subsequent triggers following the first trigger and prevent losing information from the record. When this time delay elapses, the fault record can be updated if new trip exists. The recorded values from the Fault Report can be seen in: **ACTUAL VALUES > A3 RECORDS > FAULT REPORT**.

The Fault Report header includes the following information:

- Relay model
- Device name
- Firmware revision
- Date and time of trigger
- Name of the trip trigger
- Active setting group at the time of trigger
- All measured analog signals - currents, voltages

The Fault Report runs continuously, capturing and storing the last trip in non-volatile memory, where the information is maintained even if relay control power is lost. This record is updated when the fault record delay has elapsed and a new trips occur.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S1 RELAY SETUP > FAULT REPORT**

FAULT RECORD TRIGGER

Range: Off, Any Trip, Contact Input 1 to 10, Virtual Input 1 to 32, Remote Input 1 to 32, Logic Element 1 to 16

Default: Any Trip

This setting selects an operand for triggering the report. The report is triggered at the rising edge of the selected trigger operand. To avoid inaccuracies during the fault transient period, data from one cycle after the trigger is collected.

FAULT RECORD DELAY

Range: 0.00 to 600.00 s in steps of 0.01 s

Default: 0.00 s

This setting specifies the time delay after the first trip trigger for the Fault Report, during which the record is not updated with any subsequent trip triggers.

Front panel with non-programmable LEDs

The user can send a message to the display, that will override any normal message by sending text through Modbus. Refer to the *3 Series Communications Guide* for register details.

PATH: **SETPOINTS > S1 RELAY SETUP > FRONT PANEL**

FLASH MESSAGE TIME

Range: 1 s to 65535 s

Default: 5 s

Flash messages are status, warning, error, or information messages displayed for several seconds in response to certain key presses during setting programming. These messages override any normal messages. The duration of a flash message on the display can be changed to accommodate different reading rates.

MESSAGE TIMEOUT

Range: 1 s to 65535 s

Default: 30 s

If the keypad is inactive for a period of time, the relay automatically reverts to a default message. The inactivity time is modified via this setting to ensure messages remain on the screen long enough during programming or reading of actual values.

SCREEN SAVER

Range: Off, 1 min to 10000 min

Default: Off

The life of the LCD backlight can be prolonged by enabling the Screen Saver mode.

If the keypad is inactive for the selected period of time, the relay automatically shuts off the LCD screen. Any activity (keypress, alarm, trip, or target message) will restore screen messages.

LED BKR OPEN COLOR

Range: Red, Green, Orange, Off

Default: Green

Allows the user to select the color of the LED indicator under Breaker Open conditions.

LED BKR CLSD COLOR

Range: Red, Green, Orange, Off

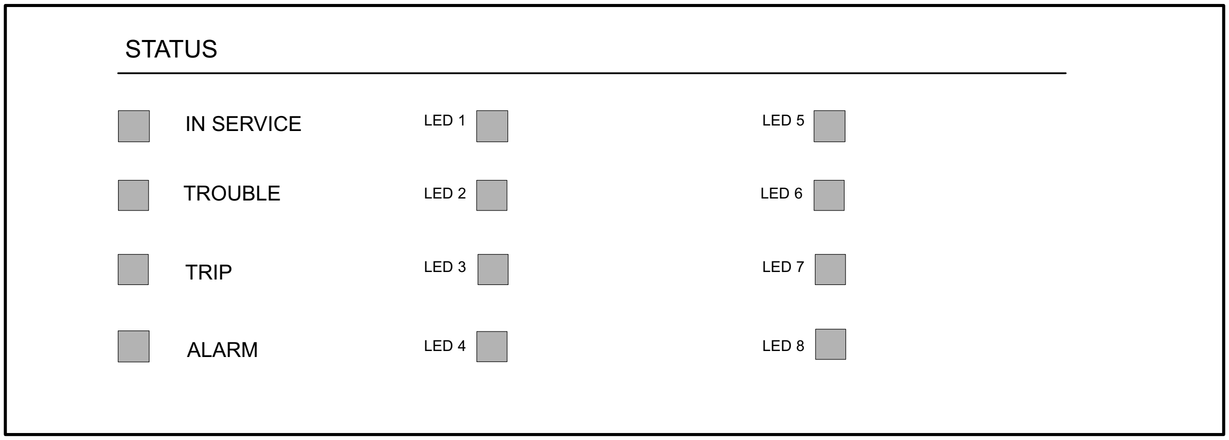
Default: Green

Allows the user to select the color of the LED indicator under Breaker Closed conditions.

Front panel with programmable LEDs

The front panel ordered with programmable LEDs (option L) provides 4 non-programmable and 8 programmable LEDs. The first column of four LEDs (on the left) are non-programmable LEDs. The next two columns of LEDs are programmable; they can be triggered by a selected operand from a list of logic operands, and can be programmed to be either Self-Reset or Latched. The LED color for LED5 to LED8 can also be programmed. By default the programmable LEDs are all Off, with no source selected.

The LEDs on the relay front panel are ordered as shown:



898862A1.CDR

Programmable LEDs can be configured using the keypad or the EnerVista 3 Series Setup software as described in *Chapter 3 - Software Setup*.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S1 RELAY SETUP > FRONT PANEL**

FLASH MESSAGE TIME

Range: 1 s to 65535 s

Default: 5 s

Flash messages are status, warning, error, or information messages displayed for several seconds in response to certain key presses during setting programming. These messages override any normal messages. The duration of a flash message on the display can be changed to accommodate different reading rates.

MESSAGE TIMEOUT

Range: 1 s to 65535 s

Default: 30 s

If the keypad is inactive for a period of time, the relay automatically reverts to a default message. The inactivity time is modified via this setting to ensure messages remain on the screen long enough during programming or reading of actual values.

SCREEN SAVER

Range: Off, 1 min to 10000 min

Default: Off

The life of the LCD backlight can be prolonged by enabling the Screen Saver mode.

If the keypad is inactive for the selected period of time, the relay automatically shuts off the LCD screen. Any activity (keypress, alarm, trip, or target message) will restore screen messages.

LED1(8) SOURCE

Range: Any operand from the list of logic operands

Default: Off

Selects the signal source of programmable LED 1 through 8.

LED1(8) TYPE

Range: Self-reset, Latched

Default: Self-reset

Selects the type of programmable LED 1 through 8.

LED5(8) COLOR

Range: Off, Red, Orange, Green

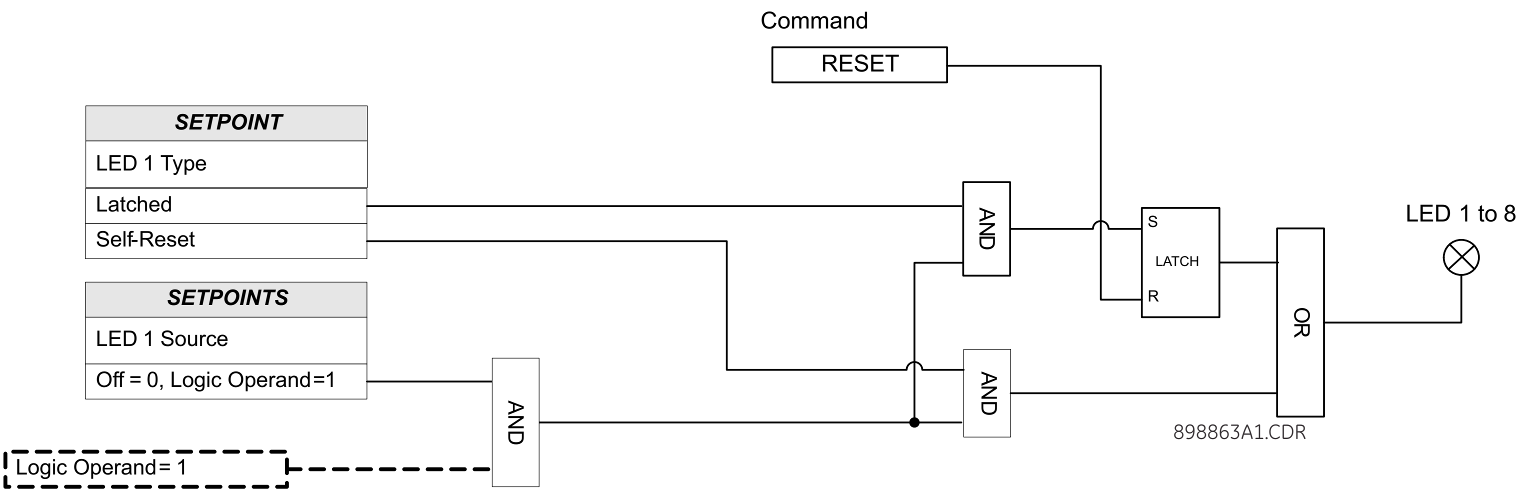
Default: Orange

Selects the color of programmable LED 5 through 8.

NOTE

Note that programmable LEDs 1 through 4 have fixed colors: LED1 (Red), LED2 (Orange), LED3 (Orange), LED4 (Orange).

Figure 6-10: Programmable LED with Trigger SOURCE and Self-reset or Latched TYPE



When the LED TYPE is Latched, the LED stays lit even after the value of the operand (flag) selected as a trigger drops down (resets). The LED can be turned off by either pressing the RESET pushbutton, or by executing a reset command via communications. When the LED TYPE is Self-reset, the LED resets after the logic operand value drops down (resets).

Installation

PATH: SETPOINTS > S1 RELAY SETUP > INSTALLATION

RELAY NAME

Range: Feeder Name, Alpha-numeric (14 characters)

Default: Feeder Name

The RELAY NAME setting allows the user to uniquely identify a relay. This name will appear on generated reports. This name is also used to identify specific devices which are engaged in automatically sending/receiving data over the communications channel.

RELAY STATUS

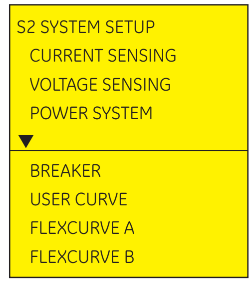
Range: Not Ready, Ready

Default: Not Ready

Allows the user to activate/deactivate the relay. The relay is not operational when set to "Not Ready."

S2 System Setup

Figure 6-11: Main system setup menu



898765A3.cdr

Current sensing

PATH: **SETPOINTS > S2 SYSTEM SETUP > CURRENT SENSING**

PHASE CT PRIMARY

Range: 1 A to 6000 A

Default: 500 A

Enter the primary rating of the three-phase feeder CTs wired to the relay phase CT terminals (see above). For correct operation, the relay CT tap must match the feeder CT tap (5 A or 1 A).

As the phase CTs are connected in wye (star), the calculated phasor sum of the three phase currents (Ia + Ib + Ic = Neutral Current = $3I_0$) is used as the input for the neutral overcurrent. In addition, a zero-sequence (core balance) CT which senses current in all of the circuit primary conductors, or a CT in a neutral grounding conductor may also be used.

PHASE CT SECONDARY

Range: 1 A or 5 A

Default: 5 A

Configurable 1 A or 5 A secondary, available with Phase Current option 'P0' installed. Enter the rated phase CT secondary current of the three-phase current transformers.

GROUND [SENS GND] CT PRIMARY

Range: [1 A to 600 A] 1 A to 6000 A

Default: 50 A

For the above configuration, the ground CT primary rating must be entered. To detect low level ground fault currents, the sensitive ground input may be used. In this case, the sensitive ground CT primary rating must be entered. The Sens GND CT primary range is 1 A to 600 A

The relay phase and ground CT types (5 A, 1 A) must match the feeder phase and ground CT taps.

GROUND [SENS GND] CT TYPE

Range: 1 A or 5 A

Default: 5 A

Configurable 1 A or 5 A secondary, available with Ground Current option 'G0' or 'S0' installed. Enter the rated ground CT secondary current of the ground current transformer.

Voltage sensing

PATH: **SETPOINTS > S2 SYSTEM SETUP > VOLTAGE SENSING**

VT CONNECTION

Range: Wye, Delta

Default: Wye

The 350 provides three-phase VT inputs, that can be wired to either bus VTs or feeder VTs. Select the "Wye" connection, if phase-neutral voltages are wired to the relay VT terminals. Select "Delta" connection, if phase-phase voltages from either Delta or Open Delta VTs are connected to the three-phase VT terminals. See the VT connections per the Typical Wiring Diagram in Chapter 2.

VT SECONDARY

Range: 50 V to 240 V

Default: 120 V

This setting defines the voltage across the VT secondary winding when nominal voltage is applied to the primary. On a source of 13.8kV line-line voltage, with a VT ratio of 14400:120 V delta connection, the voltage to be entered is "115 V". For a Wye connection, the voltage to be entered is $115/\sqrt{3} = 66$ V.

VT RATIO

Range: 1.0:1 to 5000.0:1

Default: 1.0:1

This setting defines the VT primary to secondary turns ratio. For a 14400: 120 VT, the entry would be "120.0:1" (14400/120 = 120).

AUX VT INPUT

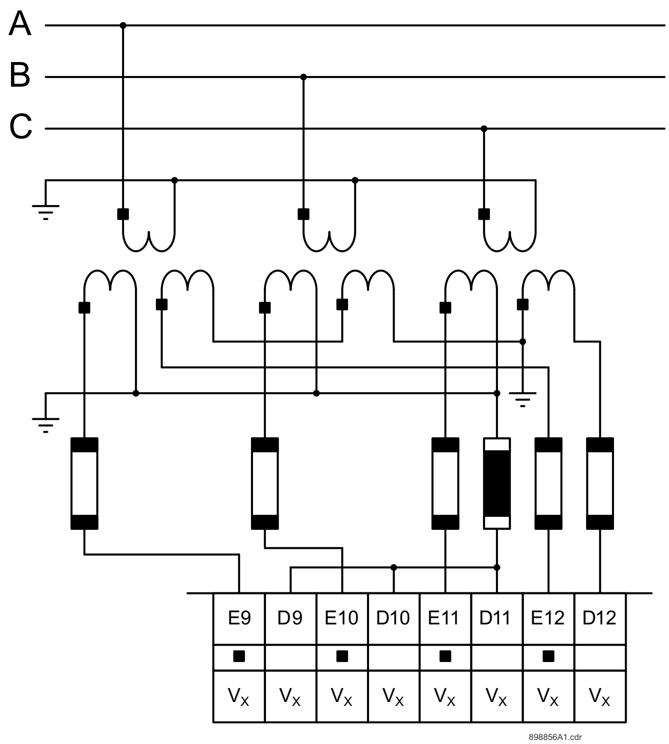
Range: V_{ab} *VT,* V_{bc} *VT,* V_{ca} *VT,* V_{an} *VT,* V_{bn} *VT,* V_{cn} *VT, V*

Default: V_{ab} *VT*

The 350 relay provides a voltage input (AUX VT INPUT), where a single feeder/line VT can be connected. The aux. VT voltage can be used for setting up auxiliary under- and over-voltage feeder protection, as well as one of the voltage inputs for the synchrocheck function. Select the phase-neutral, or the phase-phase voltage connected to the Aux VT input terminals.

The auxiliary voltage input can also be connected to an open corner delta VT arrangement for the Wattmetric ground fault protection. This arrangement is also known as a broken delta. Connection should be as shown in the following figure, where polarity is critical.

Figure 6-12: Broken delta connection



AUX VT SECONDARY

Range: 50 V to 240 V

Default: 110 V

This setting defines the voltage across the VT secondary winding when nominal voltage is applied to the primary. On a source of 13.8kV line-line voltage, with a VT ratio of 14400:120 V delta connection, the voltage to be entered is "115 V". For a Wye connection, the voltage to be entered is $115/\sqrt{3} = 66$ V.

AUX VT RATIO

Range: 1.0:1 to 5000.0:1

Default: 1.0:1

This setting defines the VT primary to secondary turns ratio. For a 14400: 120 VT, the entry would be "120.0:1" (14400/120 = 120).

NOTE

The 350 relay can be applied to both metering and protection feeders with up to 550 kV phase-to-phase voltage. Please ensure that the selected VT ratio and VT secondary do not result in a primary voltage exceeding 550 kV.

Power system

PATH: **SETPOINTS > S2 SYSTEM SETUP > POWER SYSTEM**

NOMINAL FREQUENCY

Range: 60 Hz, 50 Hz

Default: 60 Hz

Enter the nominal power system frequency. This value is used as a default to set the optimal digital sampling rate.

SYSTEM ROTATION

Range: ABC, ACB,

Default: ABC

Enter the phase sequence of the power system.

Breaker

The status of the feeder breaker is monitored by the 350 relay using the status of either one or two contact inputs named 52a (CI#1) and 52b (CI#2) wired to the breaker auxiliary contacts 52a and 52b respectively (see below).

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S2 SYSTEM SETUP > BREAKER**

52a CONTACT

Range: Disabled, 52a (CI#1)

Default: Disabled

Select contact input 52a (CI#1) if connected to breaker auxiliary contact 52a.

52b CONTACT

Range: Disabled, 52b (CI#2)

Default: Disabled

Select contact input 52b (CI#2) if connected to breaker auxiliary contact 52b.

BKR CONNECTED

Range: Contact Input 3 to 10, Disabled

Default: Disabled

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) to the system.

NOTE

It is highly recommended to monitor the status of the feeder breaker using both breaker auxiliary contacts 52a, and 52b, however using only one of them is also acceptable.

The 350 can detect the breaker status by using only one contact: either 52a or 52b. However, one should be aware that in such cases, it would be impossible to distinguish between a breaker open state and breaker racked out state, unless another contact from the breaker is wired to the relay.To clarify this ambiguity, the BKR CONNECTED function under SETPOINTS/S2 SYSTEM SETUP/S2 BREAKER should be programmed to an additional contact input. When this additional input is closed, a single 52a or 52b contact will show both breaker states. When the breaker is racked out, this additional breaker connected input should be open. In this case, both breaker status indicators will be off.

The logic for Breaker Open, and Breaker Close status is shown in the table below:

Table 6-1: Breaker open / Breaker closed status logic

52a contact configured	52b contact configured	Breaker status	
		Open	**Close**
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	Status unknown	

If the contact input selected under BKR CONNECTED setting 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.

Table 6-2: Breaker status with both contacts configured

52a contact status	52b contact status	Breaker status
Off	On	open
On	Off	closed
On	On	BKR status failure
Off	Off	BKR status failure

User curve

There is one user-programmable User Curve available with the 350 system. Refer to the *S3 Protection/Current Elements/TOC Curves* section for details on how to set the User Curve. Due to the complexity of the configuration, the User Curve is available only through the EnerVista 3 Series Setup program.

FlexCurves

There are two user-programmable FlexCurves™ available with the 350 system, labeled A and B.

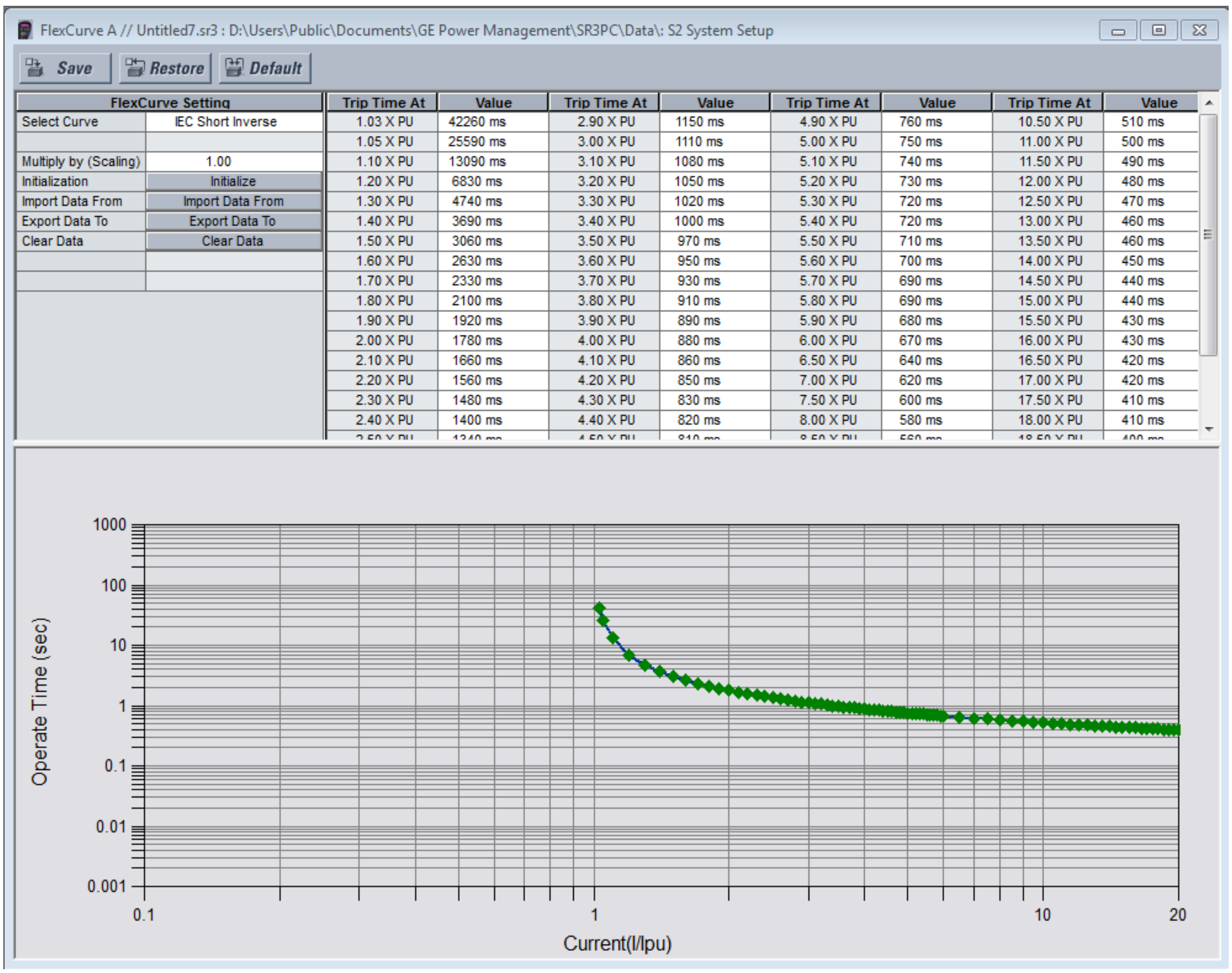
For details on FlexCurves please refer to *S3 Protection/TOC Curves* in this manual.

NOTE

The **User Curve** and **Flexcurves A and B** are available for programming under EnerVista 3 Series Setup software.

The following Flexcurve A diagram: *Example user-programmed curve* shows a user-programmed IEC Short Inverse curve. The curve in this example was obtained by choosing the IEC Short Inverse option from the Select Curve setting in the FlexCurve A screen. The resulting curve can be modified if desired by moving the graph plot points.

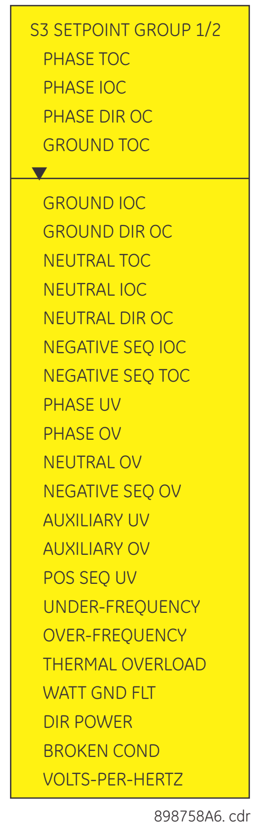
Figure 6-13: Example user-programmed curve



S3 Protection

The 350 protection elements are organized in two identical setpoint groups: Setpoint Group 1 and Setpoint Group 2.

Figure 6-14: Main Protection menu



Time overcurrent curves

The relay has a total of two phase, two neutral, and two ground/sensitive ground time overcurrent elements. The programming of the time-current characteristics of these elements is identical in all cases and will only be covered in this section. The required curve is established by programming a Pickup Current, Curve Shape, Curve Multiplier, and Reset Time. The Curve Shape can be either a standard shape or a user-defined shape programmed with the FlexCurve™ feature.

Accurate coordination may require changing the time overcurrent characteristics of particular elements under different conditions. For picking up a cold load, a different time-current characteristic can be produced by increasing the pickup current value. The following setpoints are used to program the time-current characteristics.

NOTE

If the injected current is more than 20 x PKP, the trip time will be the same as 20 x PKP.

- **<Element_Name> PICKUP**: The pickup current is the threshold current at which the time overcurrent element starts timing. There is no intentional 'dead band' when the current is above the pickup level. However, accuracy is only guaranteed above a 1.5 per unit pickup level. The dropout threshold is 98% of the pickup threshold. Enter the pickup current corresponding to 1 per unit on the time overcurrent curves as a multiple of the source CT. For example, if 100: 5 CTs are used and a pickup of 90 amps is required for the time overcurrent element, enter "0.9 x CT".

- **<Element_Name> CURVE**: Select the desired curve shape. If none of the standard curve shapes is appropriate, a custom FlexCurve™ can be created by entering the trip times at 80 different current values; see S2 SYSTEM SETUP > FLEXCURVE A. Curve formulas are given for use with computer based coordination programs. Calculated trip time values are only valid for I / Ipu > 1. Select the appropriate curve shape and multiplier, thus matching the appropriate curve with the protection requirements. The available curves are shown in the table below.

ANSI	GE TYPE IAC	IEC	OTHER
Extremely Inverse	Extremely Inverse	Curve A (BS142)	Definite Time
Very Inverse	Very Inverse	Curve B (BS142)	Flexcurve A™
Normally Inverse	Inverse	Curve C (BS142)	Flexcurve B™
Moderately Inverse	Short Inverse	IEC Short Inverse	User Curve

- **<Element_Name> MULTIPLIER**: A multiplier setpoint allows shifting of the selected base curve in the vertical time direction. Unlike the electromechanical time dial equivalent, trip times are directly proportional to the value of the time multiplier setpoint. For example, all trip times for a multiplier of 10 are 10 times the multiplier 1 or base curve values.

  When Timed Over-Current is programmed with Definite time, the operating time is obtained after multiplication of the selected Multiplier (TDM) by a 0.1 s base line. For example, selection of TDM = 5 would lead to a 0.5 s operating time.

- **<Element_Name> RESET**: Time overcurrent tripping 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 trip is generated. If less than 100% is accumulated in this variable and the current falls below the dropout threshold of 97 to 99% of the pickup value, the variable must be reduced. Two methods of this resetting operation are available, Instantaneous and Linear. The Instantaneous selection is intended for applications with other relays, such as most static units, which set the energy capacity directly to zero when the current falls below the reset threshold. The Linear selection can be used where the relay must coordinate with electromechanical units. With this setpoint, the energy capacity variable is decremented according to the following equation.

$$T_{RESET} = E \times M \times C_R$$

where: T_{RESET} = reset time in seconds; E = energy capacity reached (per unit); M = curve multiplier; CR = characteristic constant (5 for ANSI, IAC, Definite Time, and FlexCurves™; 8 for IEC)

ANSI Curves

The ANSI time overcurrent curve shapes conform to industry standards and the ANSI C37.90 curve classifications for extremely, very, normally, and moderately inverse. The ANSI curves are derived from the following formula:

$$T = M \times \left(A + \frac{B}{(I/I_{pu}) - C} + \frac{D}{((I/I_{pu}) - C)^2} + \frac{E}{((I/I_{pu}) - C)^3} \right)$$

where:T = trip time (seconds); M = multiplier value; I = input current; I_{pu} = pickup current setpoint; A, B, C, D, E = constants

Table 6-3: ANSI Curve Constants

ANSI Curve Shape	A	B	C	D	E
ANSI Extremely Inverse	0.0399	0.2294	0.5000	3.0094	0.7222
ANSI Very Inverse	0.0615	0.7989	0.3400	–0.2840	4.0505
ANSI Normally Inverse	0.0274	2.2614	0.3000	–4.1899	9.1272
ANSI Moderately Inverse	0.1735	0.6791	0.8000	–0.0800	0.1271

Table 6-4: 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 the four standard curves defined in IEC 255-4 and British standard BS142. These are defined as IEC Curve A, IEC Curve B, IEC Curve C, and Short Inverse. The formulae for these curves are:

$$T = M \times \left(\frac{K}{(I/I_{pu})^{E} - 1} \right)$$

where: T = trip time (seconds), M = multiplier setpoint, I = input current, I_{pu} = pickup current setpoint, K, E = constants.

Table 6-5: IEC (BS) Inverse Time Curve Constants

IEC (BS) Curve Shape	K	E
IEC Curve A (BS142)	0.140	0.020
IEC Curve B (BS142)	13.500	1.000
IEC Curve C (BS142)	80.000	2.000
IEC Short Inverse	0.050	0.040

Table 6-6: IEC 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
IEC Curve A										
0.05	0.860	0.501	0.315	0.249	0.214	0.192	0.176	0.165	0.156	0.149
0.10	1.719	1.003	0.630	0.498	0.428	0.384	0.353	0.330	0.312	0.297
0.20	3.439	2.006	1.260	0.996	0.856	0.767	0.706	0.659	0.623	0.594
0.40	6.878	4.012	2.521	1.992	1.712	1.535	1.411	1.319	1.247	1.188
0.60	10.317	6.017	3.781	2.988	2.568	2.302	2.117	1.978	1.870	1.782
0.80	13.755	8.023	5.042	3.984	3.424	3.070	2.822	2.637	2.493	2.376
1.00	17.194	10.029	6.302	4.980	4.280	3.837	3.528	3.297	3.116	2.971
IEC Curve B										
0.05	1.350	0.675	0.338	0.225	0.169	0.135	0.113	0.096	0.084	0.075
0.10	2.700	1.350	0.675	0.450	0.338	0.270	0.225	0.193	0.169	0.150
0.20	5.400	2.700	1.350	0.900	0.675	0.540	0.450	0.386	0.338	0.300
0.40	10.800	5.400	2.700	1.800	1.350	1.080	0.900	0.771	0.675	0.600
0.60	16.200	8.100	4.050	2.700	2.025	1.620	1.350	1.157	1.013	0.900
0.80	21.600	10.800	5.400	3.600	2.700	2.160	1.800	1.543	1.350	1.200
1.00	27.000	13.500	6.750	4.500	3.375	2.700	2.250	1.929	1.688	1.500
IEC Curve C										
0.05	3.200	1.333	0.500	0.267	0.167	0.114	0.083	0.063	0.050	0.040
0.10	6.400	2.667	1.000	0.533	0.333	0.229	0.167	0.127	0.100	0.081
0.20	12.800	5.333	2.000	1.067	0.667	0.457	0.333	0.254	0.200	0.162
0.40	25.600	10.667	4.000	2.133	1.333	0.914	0.667	0.508	0.400	0.323
0.60	38.400	16.000	6.000	3.200	2.000	1.371	1.000	0.762	0.600	0.485
0.80	51.200	21.333	8.000	4.267	2.667	1.829	1.333	1.016	0.800	0.646
1.00	64.000	26.667	10.000	5.333	3.333	2.286	1.667	1.270	1.000	0.808
IEC Short Time										
0.05	0.153	0.089	0.056	0.044	0.038	0.034	0.031	0.029	0.027	0.026
0.10	0.306	0.178	0.111	0.088	0.075	0.067	0.062	0.058	0.054	0.052
0.20	0.612	0.356	0.223	0.175	0.150	0.135	0.124	0.115	0.109	0.104
0.40	1.223	0.711	0.445	0.351	0.301	0.269	0.247	0.231	0.218	0.207

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
0.60	1.835	1.067	0.668	0.526	0.451	0.404	0.371	0.346	0.327	0.311
0.80	2.446	1.423	0.890	0.702	0.602	0.538	0.494	0.461	0.435	0.415
1.00	3.058	1.778	1.113	0.877	0.752	0.673	0.618	0.576	0.544	0.518

IAC Curves

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

$$T = M \times \left(A + \frac{B}{(I/I_{pu}) - C} + \frac{D}{((I/I_{pu}) - C)^2} + \frac{E}{((I/I_{pu}) - C)^3} \right)$$

where: T = trip time (seconds), M = multiplier setpoint, I = input current, I_{pu} = pickup current setpoint, A to E = constants.

Table 6-7: GE Type IAC Inverse Curve Constants

IAC Curve Shape	A	B	C	D	E
IAC Extreme Inverse	0.0040	0.6379	0.6200	1.7872	0.2461
IAC Very Inverse	0.0900	0.7955	0.1000	–1.2885	7.9586
IAC Inverse	0.2078	0.8630	0.8000	–0.4180	0.1947
IAC Short Inverse	0.0428	0.0609	0.6200	–0.0010	0.0221

Table 6-8: IAC Curve Trip Times

Multiplier (TDM)										
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
IAC Extremely Inverse										
0.5	1.699	0.749	0.303	0.178	0.123	0.093	0.074	0.062	0.053	0.046
1.0	3.398	1.498	0.606	0.356	0.246	0.186	0.149	0.124	0.106	0.093
2.0	6.796	2.997	1.212	0.711	0.491	0.372	0.298	0.248	0.212	0.185
4.0	13.591	5.993	2.423	1.422	0.983	0.744	0.595	0.495	0.424	0.370
6.0	20.387	8.990	3.635	2.133	1.474	1.115	0.893	0.743	0.636	0.556
8.0	27.183	11.987	4.846	2.844	1.966	1.487	1.191	0.991	0.848	0.741
10.0	33.979	14.983	6.058	3.555	2.457	1.859	1.488	1.239	1.060	0.926
IAC Very Inverse										
0.5	1.451	0.656	0.269	0.172	0.133	0.113	0.101	0.093	0.087	0.083
1.0	2.901	1.312	0.537	0.343	0.266	0.227	0.202	0.186	0.174	0.165
2.0	5.802	2.624	1.075	0.687	0.533	0.453	0.405	0.372	0.349	0.331
4.0	11.605	5.248	2.150	1.374	1.065	0.906	0.810	0.745	0.698	0.662
6.0	17.407	7.872	3.225	2.061	1.598	1.359	1.215	1.117	1.046	0.992
8.0	23.209	10.497	4.299	2.747	2.131	1.813	1.620	1.490	1.395	1.323
10.0	29.012	13.121	5.374	3.434	2.663	2.266	2.025	1.862	1.744	1.654
IAC Inverse										
0.5	0.578	0.375	0.266	0.221	0.196	0.180	0.168	0.160	0.154	0.148
1.0	1.155	0.749	0.532	0.443	0.392	0.360	0.337	0.320	0.307	0.297
2.0	2.310	1.499	1.064	0.885	0.784	0.719	0.674	0.640	0.614	0.594
4.0	4.621	2.997	2.128	1.770	1.569	1.439	1.348	1.280	1.229	1.188
6.0	6.931	4.496	3.192	2.656	2.353	2.158	2.022	1.921	1.843	1.781
8.0	9.242	5.995	4.256	3.541	3.138	2.878	2.695	2.561	2.457	2.375
10.0	11.552	7.494	5.320	4.426	3.922	3.597	3.369	3.201	3.072	2.969
IAC Short Inverse										

Multiplier (TDM)										
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
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

USER Curves

The relay provides a selection of user definable curve shapes used by the time overcurrent protection. The User curve is programmed by selecting the proper parameters in the formula:

$$T = \frac{A * D}{(V^P - Q)} + B * D + K$$

A, P, Q, B, K - selectable curve parameters within the ranges from the table: D is the Time Dial Multiplier.

User Curve can be used on multiple elements only if the time dial multiplier is the same for each element.

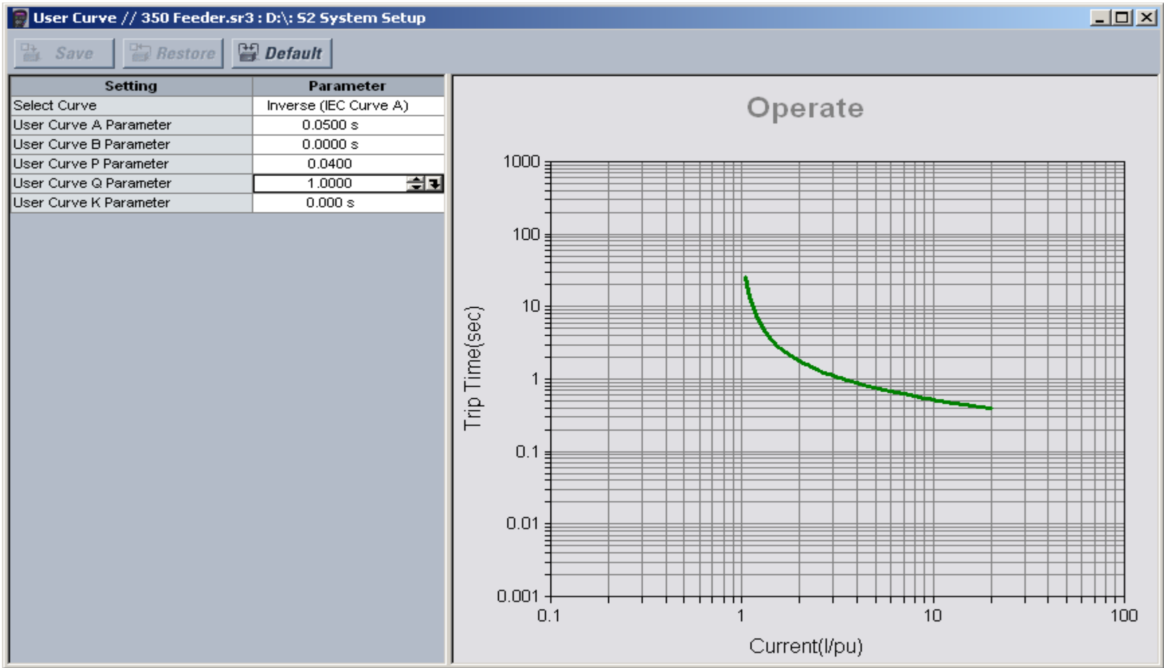
$V = I/I_{PICKUP}$ (TOC setting) is the ratio between the measured current and the pickup setting.

NOTE

The maximum trip time for the User Curve is limited to 65.535 seconds. The User Curve can be used for one protection situation only.

Parameters	A	B	P	Q	K
Range	0 to 125	0 to 3	0 to 3	0 to 2	0 to 1.999
Step	0.0001	0.0001	0.0001	0.0001	0.001
Unit	sec	sec	NA	NA	sec
Default Value	0.05	0	0.04	1.0	0

Figure 6-15: USER curve configuration settings



Flexcurves

Prospective FlexCurves™ can be configured from a selection of standard curves to provide the best approximate fit, then specific data points can be edited afterwards. Click the **Initialize** button to populate the pickup values with the points from the curve specified by the "Select Curve" setting and the "Multiply" value. These values can then be edited to create a custom curve. Click on the **Clear FlexCurve Data** button to reset all pickup values to zero.

Curve data can be imported from CSV (comma-separated values) files by clicking on the **Open** button. Likewise, curve data can be saved in CSV format by clicking the **Save** button. CSV is a delimited data format with fields separated by the comma character and records separated by new lines. Refer to IETF RFC 4180 for additional details.

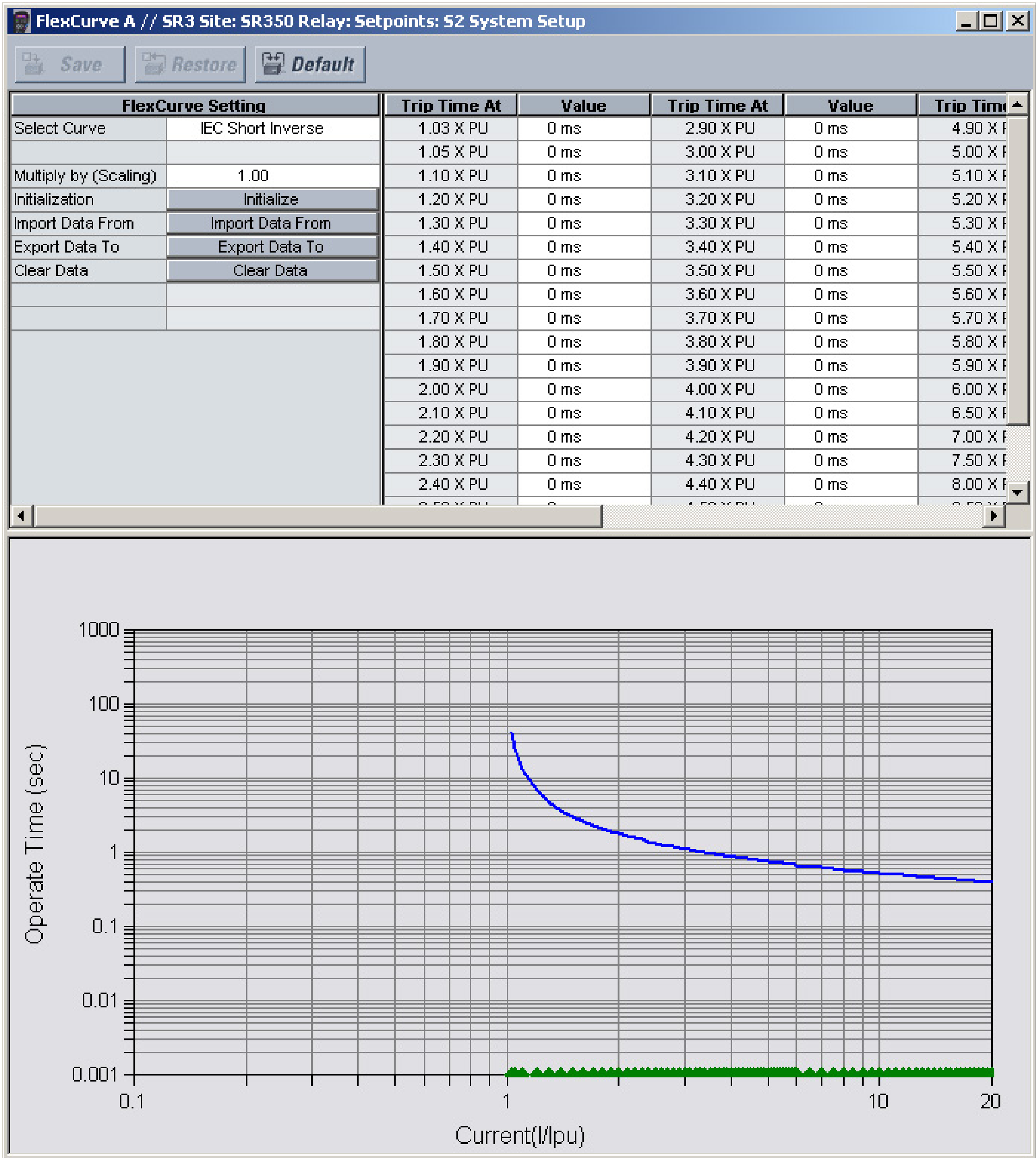
The curve shapes for the two FlexCurves are derived from the following equations.

Eq. 1

$$T_{operate} = TDM \times \left(T_{flex} \text{ at } \frac{I}{I_{pickup}} \right), \text{ when } \frac{I}{I_{pickup}} \geq 1.00$$

In the above equations, $T_{operate}$ represents the operate time in seconds, TDM represents the multiplier setting, I represents the input current, I_{pickup} represents the value of the pickup current setting, T_{flex} represents the FlexCurve™ time in seconds.

Figure 6-16: Flexcurve™ configuration settings



The following settings are available for each custom Flexcurve™.

Select Curve

Range: ANSI Moderately Inverse, ANSI Very Inverse, ANSI Extremely Inverse, IEEE Normally Inverse, IEC Curve A, IEC Curve B, IEC Curve C, IEC Short Inverse, IAC Extreme Inv, IAC Very Inverse, IAC Inverse, IAC Short Inverse, User Curve, FlexCurve B (Note: For FlexCurve A, you can select FlexCurve B as the setpoint, and vice versa for FlexCurve B.)

Default: Extremely Inverse

This setting specifies a curve to use as a base for a custom FlexCurve™. Must be used before Initialization is implemented (see **Initialization** below).

Multiply

Range: 0.01 to 30.00 in steps of 0.01

Default: 1.00

This setting provides selection for 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 was 5 times bigger than the PKP level, the operation of the element will not occur before a time elapse of 495 ms from pickup.

Initialization

Used after specifying a curve to use as a base for a custom FlexCurve™ (see **Select Curve** and **Multiply** above). When the **Initialize FlexCurve** button is clicked, the pickup settings will be populated with values specified by the curve selected in this setting.

1.03 × Pickup, ..., 20.00 × Pickup

Range: 0 to 65535 ms in steps of 1

Default: 0 ms

These settings specify the time to operate at the following pickup levels 1.03 to 20.00. This data is converted into a continuous curve by linear interpolation between data points. To enter a custom FlexCurve™, enter the operate time for each selected pickup point.

NOTE

Each FlexCurve can be configured to provide inverse time characteristic to more than one Time Overcurrent Element. However, for computation of the curve operating times, one must take into account the setting of the Time Delay Multiplier from the FlexCurve menu, and the Time Delay Multiplier setting from TOC menu. The true TDM applied to the TOC element when FlexCurve is selected is the result from the multiplication of both TDM settings. For example, for FlexCurve Multiplier = 5, and Phase TOC Multiplier = 2, the total Time Dial Multiplier will be equal to 10. To avoid confusion, it is suggested to keep the multiplier from the TOC menu equal to 1, and change only the multiplier from the selected FlexCurve. This way, one can see from the FlexCurve setup, the curve operating times as related to the multiples of pickup.

Phase timed overcurrent (51P)

The relay has one Phase Time Overcurrent protection element per protection group. The settings of this function are applied to each of the three phases to produce trip or pickup per phase. 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 operation, if the measured current drops below 97-98% of the pickup value, before the time for operation is reached. The selection of Definite Time has a base time delay of 0.1 s, multiplied by the selected TD multiplier. For example the operating time for TOC set to Definite Time and a TDM set to 5 will result in 5*0.1 = 0.5 s.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S3 PROTECTION > SETPOINT GROUP 1(2) > PHASE TOC**

PH TOC FUNCTION

Range: Disabled, Latched Alarm, Alarm, Trip

Default: Disabled

For details see Common setpoints.

PH TOC PKP

Range: 0.05 to 20.00 x CT in steps of 0.01 x CT

Default: 1.00 x CT

This setting sets the time overcurrent pickup level. For example, a PKP setting of 0.9 x CT with 300:5 CT translates into 270A primary current.

PH TOC CURVE

Range: ANSI Extremely/Very/Moderately/Normally Inverse, Definite Time, IEC Curve A/B/C and Short Inverse, IAC Extremely/Very/Inverse/Short, User Curve, FlexCurve A, FlexCurve B

Default: Extremely Inverse

This setting sets the shape of the selected TOC inverse curve. If none of the standard curve shapes is appropriate, a custom User curve, or FlexCurve can be created. Refer to the User curve and the FlexCurve setup for more detail on their configurations and usage.

PH TOC TDM

Range: 0.05 to 50.00 in steps of 0.01

Default: 1.00

This setting provides selection for 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 was 5 times bigger than the PKP level, the operation of the element will not occur before an elapsed time from pickup, of 495 ms.

PH TOC RESET

Range: Instantaneous, Linear

Default: Instantaneous

The “Instantaneous” reset method is intended for applications with other relays, such as most static relays, which set the energy capacity directly to zero when the current falls below the reset threshold. The “Timed” reset method can be used where the relay must coordinate with electromechanical relays.

PH TOC DIRECTION

Range: Disabled, Forward, Reverse

Default: Disabled

This setting provides control to the Phase TOC function in terms of permitting operation upon fault conditions in the selected current flow direction, and blocking it when faults occur in the opposite direction.

A special case is considered when fault direction is undefined. Then "BLK OC DIR UN" setting in Neutral Directional defines the fault direction.

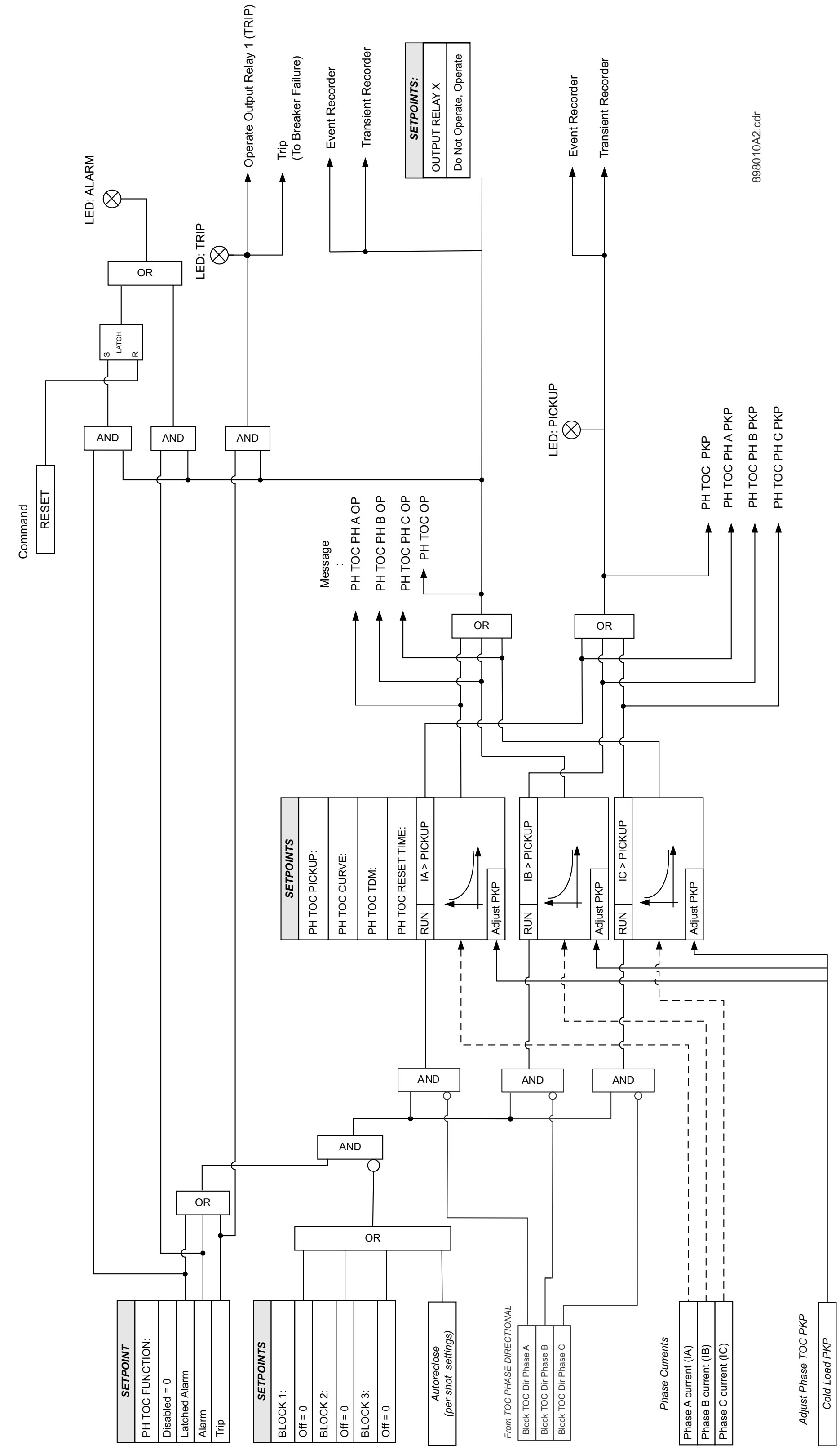
OUTPUT RELAY X

For details see Common setpoints.

BLOCK 1/2/3

For details see Common setpoints.

Figure 6-17: Phase time overcurrent protection logic diagram



Phase instantaneous overcurrent protection (50P)

The 350 relay has two identical phase instantaneous overcurrent protection types per Setpoint Group: Phase IOC1, and Phase IOC2. Each consists of three separate instantaneous overcurrent elements; one per phase, with identical settings.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S3 PROTECTION > SETPOINT GROUP 1(2) > PHASE IOC1(2)**

PH IOC1/2 FUNCTION

Range: Disabled, Latched Alarm, Alarm, Trip

Default: Disabled

For details see Common setpoints.

PH IOC1/2 PKP

Range: 0.05 to 20.00 x CT in steps of 0.01 x CT

Default: 1.00 x CT

This setting sets the instantaneous overcurrent pickup level. For example, a PKP setting of 0.9 x CT with 300:5 CT translates into 270A primary current.

PH IOC1/2 DELAY

Range: 0.00 to 300.00 sec in steps of 0.01 sec

Default: 0.00 sec

This setting provides selection for the time used to delay the protection operation.

PH IOC DIRECTION

Range: Disabled, Forward, Reverse

Default: Disabled

This setting provides control to the Phase IOC1(2) function in terms of permitting operation upon fault conditions in the selected current flow direction, and blocking it, when faults occur in the opposite direction.

A special case is considered when fault direction is undefined. Then “BLK OC DIR UN” setting in Phase Directional defines the fault direction.

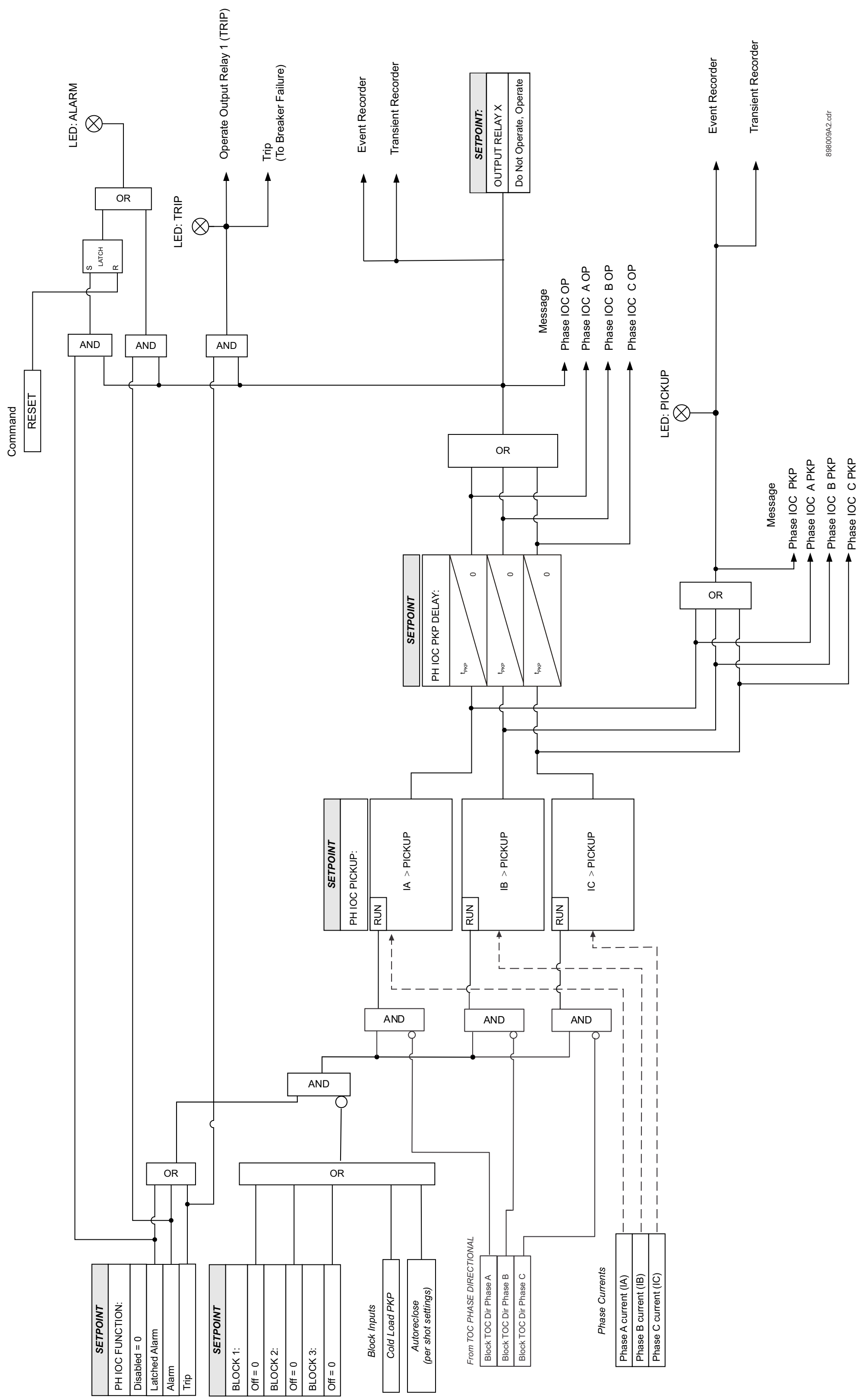
OUTPUT RELAY X

For details see Common setpoints.

BLOCK 1/2/3

For details see Common setpoints.

Figure 6-18: Phase instantaneous overcurrent protection logic diagram



Phase directional (67P)

The Phase Directional element (one for each of phases A, B and C) is used to discriminate between faults that occur in the forward direction, and faults that occur in the reverse direction. The Phase Directional element can be used either individually for control or alarm by energizing the auxiliary output relays, or as a part of the Phase Time, or Instantaneous, over-current elements to define the tripping direction. (See the setup for Phase TOC and Phase IOC elements.)

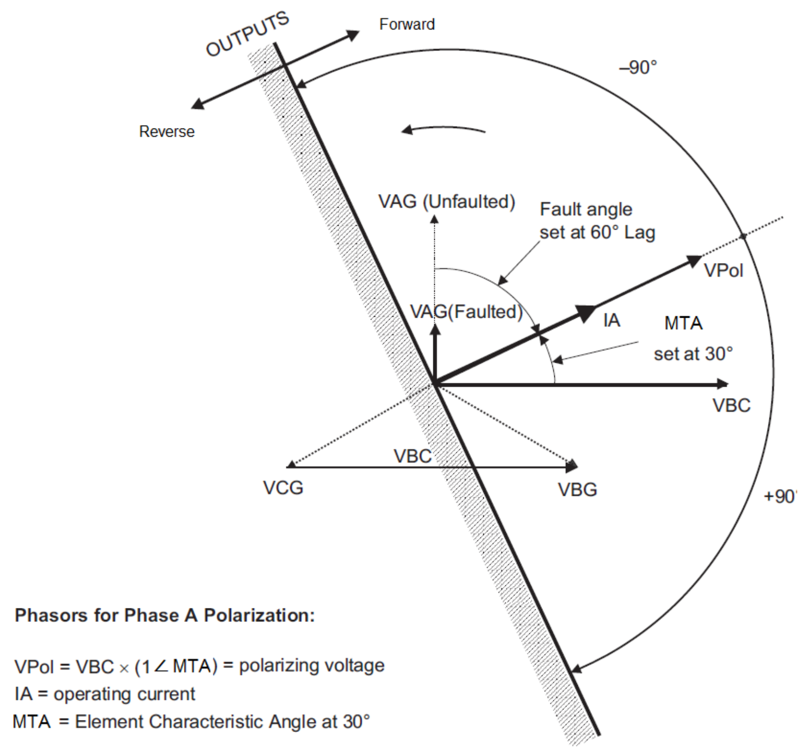
The polarizing signal for the Phase Directional element is determined by comparing the phase angle between the current from the phase CTs and the line-line voltage from the VTs, and the set MTA angle.

The following table shows the operating and polarizing signals used for phase directional control:

PHASE	OPERATING SIGNAL	POLARIZING SIGNAL Vpol	
		ABC PHASE SEQUENCE	ACB PHASE SEQUENCE
A	Angle of Ia	Angle of Vbc × (Angle of MTA)	Angle of Vcb × (Angle of MTA)
B	Angle of Ib	Angle of Vca × (Angle of MTA)	Angle of Vac × (Angle of MTA)
C	Angle of Ic	Angle of Vab × (Angle of MTA)	Angle of Vba × (Angle of MTA)

When line voltage is below the minimum polarizing voltage threshold (MIN POL VOLTAGE), the direction is undefined. In this case, phase overcurrent protection elements are blocked if “BLK OC DIR UN” setting is enabled and directional is not disabled.

Figure 6-19: Phase A polarization



The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S3 PROTECTION > SETPOINT GROUP 1(2) > PHASE DIR**

NOTE

In situations where a current inversion is produced during a fault, the phase directional element requires a period of time to establish the blocking signal. This time is approximately 20 ms. Certain instantaneous overcurrent elements can be activated before receiving the blocking signal from the directional element. In cases where these situations can be expected, we recommend to add a 50ms delay to IOC, TOC elements.

PH DIR FUNCTION

Range: Disabled, Alarm, Latched Alarm, Control

Default: Disabled

When Alarm function is selected, the alarm LED will flash upon detection of Reverse direction for any phase, and will drop out when the direction changes to Forward for all phases. When Latched Alarm is selected, the alarm LED will flash upon detection of Reverse direction, and will stay lit (latched) after the direction for all phases is Forward. The alarm LED can be reset by issuing the reset command. Detection of Reverse direction when Control function is selected does not trigger the alarm LED.

PH DIR MTA

Range: 0° to 359° Lead in steps of 1

Default: 30°

This setting sets the Maximum Torque Angle (MTA) for the Phase Directional element to define the regions of Forward and Reverse directions. This is the angle of maximum sensitivity, i.e. maximum torque angle by which the operating current leads the polarizing voltage.

MIN POL VOLTAGE

Range: 0.00 to 1.25 x VT in steps of 0.01

Default: 0.05 x VT

This setting is used to establish the minimum level of voltage for which the phase angle measurement is reliable. The setting is based on VT accuracy.

BLOC OC DIR UN

Range: Disabled, Enabled

Default: Enabled

This setting establishes the procedure under undefined direction (voltage below threshold). If enabled, OC elements with “Forward” or “Reverse” setting are blocked; otherwise, they are not.

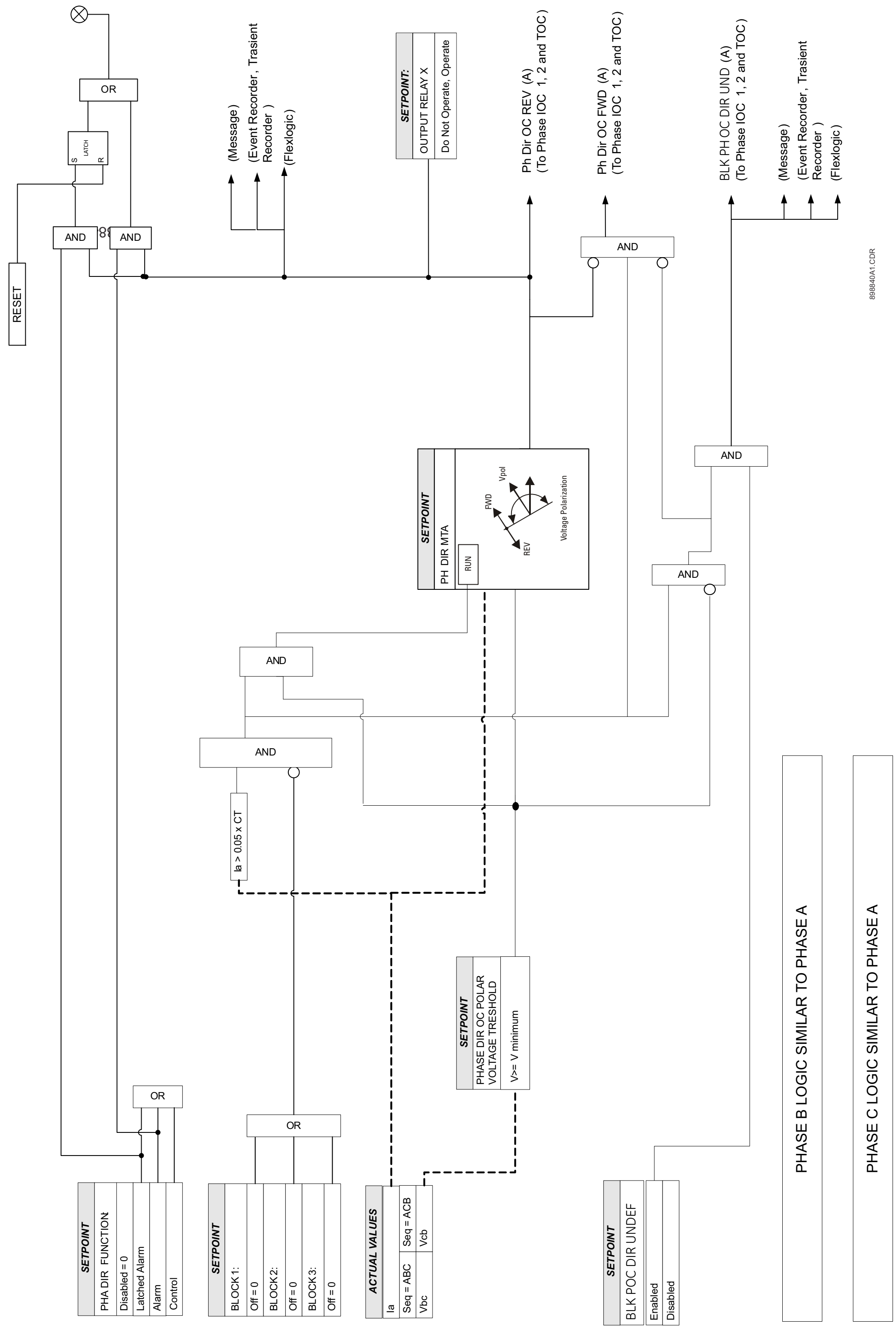
OUTPUT RELAY X

For details see Common setpoints.

BLOCK 1/2/3

For details see Common setpoints.

Figure 6-20: Phase directional logic diagram



Ground/Sensitive Ground timed overcurrent protection (51G/SG)

The relay has one Ground Time Overcurrent protection per setpoint group. 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 operate 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 to operate is reached. The selection of Definite Time has a base time delay of 0.1 s, multiplied by the selected TD multiplier. For example the operating time for TOC set to Definite Time and a TDM set to 5 will result in 5*0.1 = 0.5 s.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S3 PROTECTION > SETPOINT GROUP 1(2) > GROUND TOC**

NOTE

The settings from the menu for Sensitive Ground TOC, appears only upon selection of the Sensitive Ground CT when ordering the relay. Otherwise, the relay displays the menu for Ground TOC protection.

Sensitive ground CTs are used in cases where the fault current is limited by a grounding resistor.

GND TOC FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm

Default: Disabled

For details see Common setpoints.

GND TOC PKP

Range: 0.05 to 20.00 x CT in steps of 0.01 x CT

Default: 1.00 x CT

SENS.GND TOC PKP

Range: 0.005 to 3.00 x CT in steps of 0.001 x CT

Default: 1.00 x CT

This setting sets the time overcurrent pickup level. For example, a PKP setting of 0.9 x CT with 300:5 CT translates into 270A primary current.

GND TOC CURVE

Range: ANSI Extremely/Very/Moderately/Normally Inverse, Definite Time, IEC Curve A/B/C and Short Inverse, IAC Extremely/Very/Inverse/Short, User Curve, FlexCurve A, FlexCurve B

Default: Extremely Inverse

This setting sets the shape of the selected over-current inverse curve. If none of the standard curve shapes is appropriate, a custom User curve, or FlexCurve can be created. Refer to the User curve and the FlexCurve setup for more detail on their configurations and usage.

GND TOC TDM

Range: 0.05 to 50.00 in steps of 0.01

Default: 1.0

This setting provides selection for 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 was 5 times bigger than the PKP level, the operation of the element will not occur before an elapsed time from pickup, of 495 ms.

GND TOC RESET

Range: Instantaneous, Linear

Default: Instantaneous

The "Instantaneous" reset method is intended for applications with other relays, such as most static relays, which set the energy capacity directly to zero when the current falls below the reset threshold. The "Timed" reset method can be used where the relay must coordinate with electromechanical relays.

GND TOC DIRECTION

Range: Disabled, Forward, Reverse

Default: Disabled

This setting provides control to the Ground TOC function in terms of permitting operation upon fault conditions in the selected current flow direction, and blocking it, when faults occur in the opposite direction.

A special case is considered when fault direction is undefined. Then "BLK OC DIR UN" setting in Ground Directional defines the fault direction.

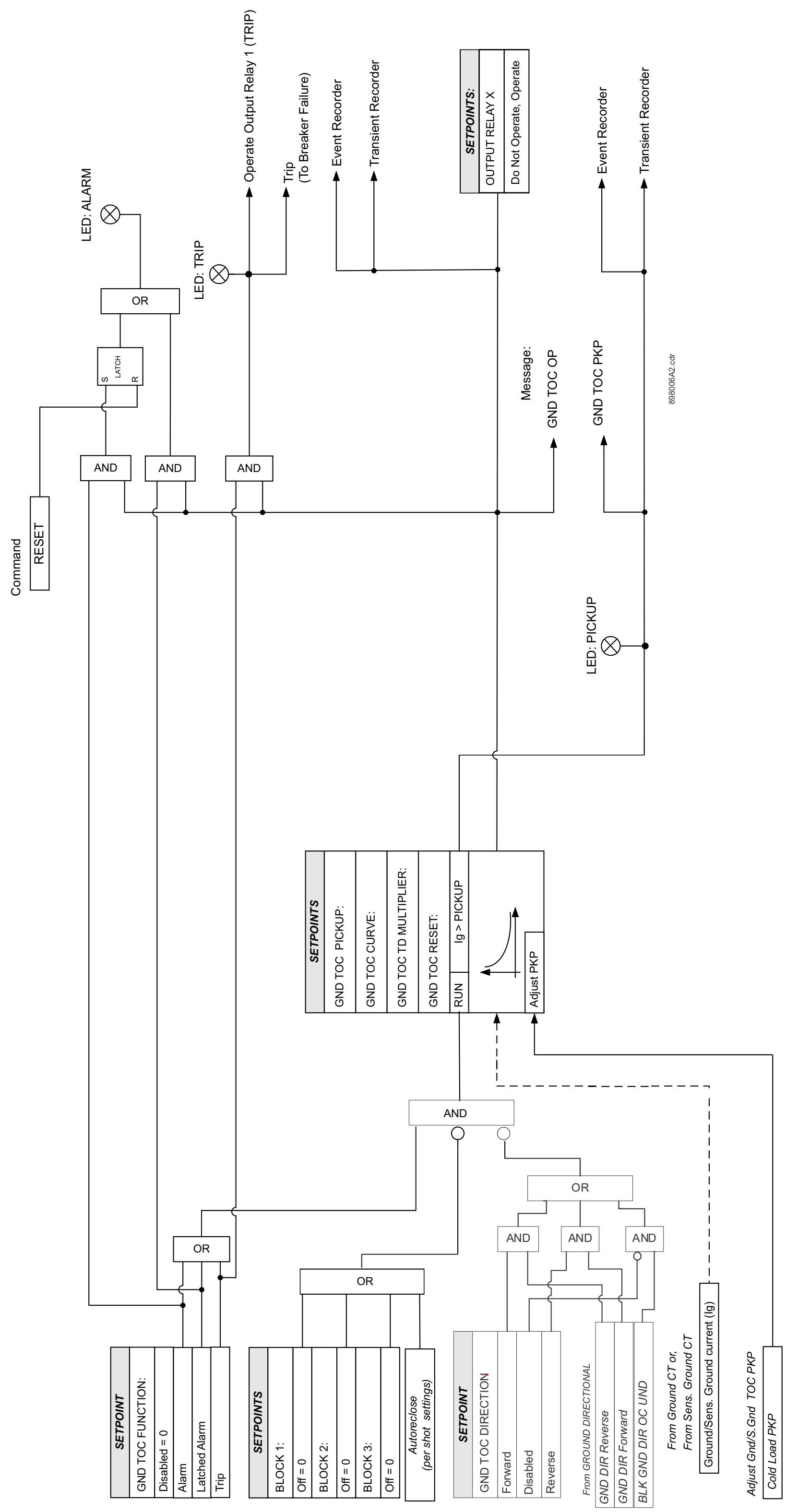
OUTPUT RELAY X

For details see Common setpoints.

BLOCK 1/2/3

For details see Common setpoints.

Figure 6-21: Ground/Sensitive Ground timed overcurrent protection: Logic Diagram



Ground/Sensitive Ground instantaneous overcurrent protection (50G/SG)

The relay has one Ground/Sensitive Ground Instantaneous Overcurrent protection element per setpoint group. The settings of these functions are applied to the gound/sensitive ground current for 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 0.00 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 97-99% of the pickup value.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S3 PROTECTION > SETPOINT GROUP 1(2) > GROUND IOC1(2)**

GND IOC FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm

Default: Disabled

For details see Common setpoints.

GND IOC PKP

Range: Disabled, 0.05 to 20.00 x CT in steps of 0.01 x CT

Default: 1.00 x CT

SENS.GND IOC PKP

Range: 0.005 to 3.00 x CT in steps of 0.001 x CT

Default: 1.00 x CT

This setting sets the ground overcurrent pickup level specified per times CT. For example, a PKP setting of 0.9 x CT with 300:5 CT translates into 270A primary current.

GND IOC DELAY

Range: 0.00 to 300.00 sec in steps of 0.01 sec

Default: 0.00 sec

This setting provides selection for pickup time delay used to delay the operation of the protection.

GND IOC DIRECTION

Range: Disabled, Forward, Reverse

Default: Disabled

This setting provides control to the Ground IOC1(2) function in terms of permitting operation upon fault conditions in the selected current flow direction, and blocking it, when faults occur in the opposite direction.

A special case is considered when fault direction is undefined. Then “BLK OC DIR UN” setting in Ground Directional defines the fault direction.

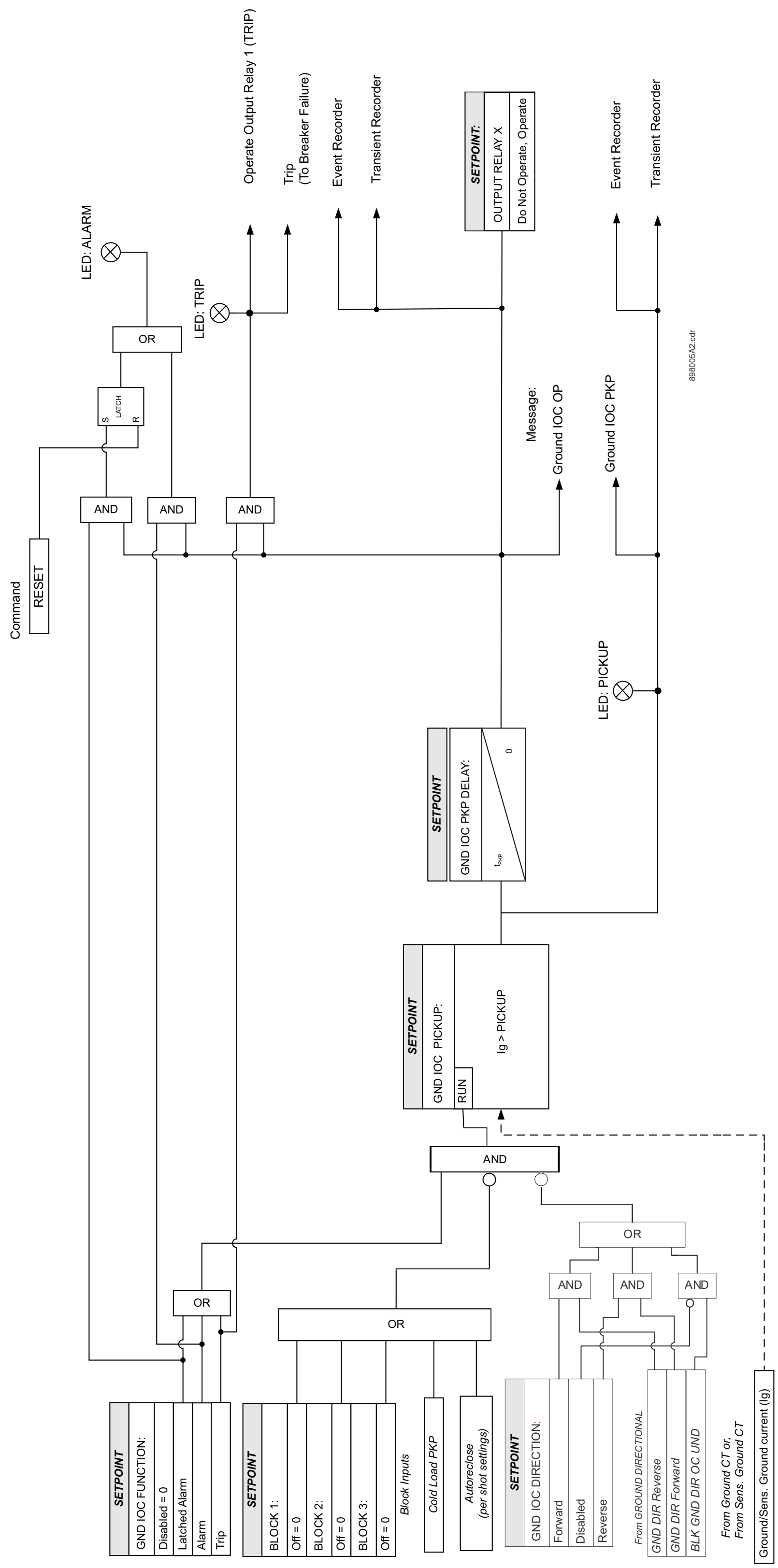
OUTPUT RELAY X

For details see Common setpoints.

BLOCK 1/2/3

For details see Common setpoints.

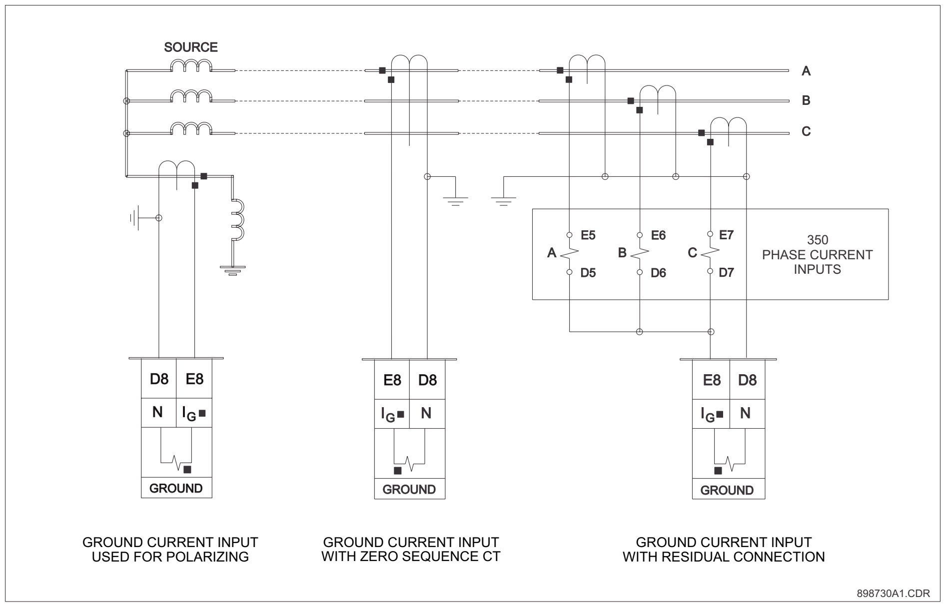
Figure 6-22: Ground/Sensitive Ground instantaneous overcurrent protection logic diagram



Ground directional (67G/SG)

The Ground Directional element is used to discriminate whether a fault occurs in a forward or in a reverse direction, and it can be used either individually or as a part of the Ground Time, or Instantaneous over-current elements. (See the setup for Ground TOC, and Ground IOC elements.)

The operating current for the Ground directional element is the measured current from the ground CT input terminals. Depending on the ground CT connection, the measured current from the CT terminals can be either the current from a zero sequence CT, or the zero sequence current from a residual CT connection (see figure below).



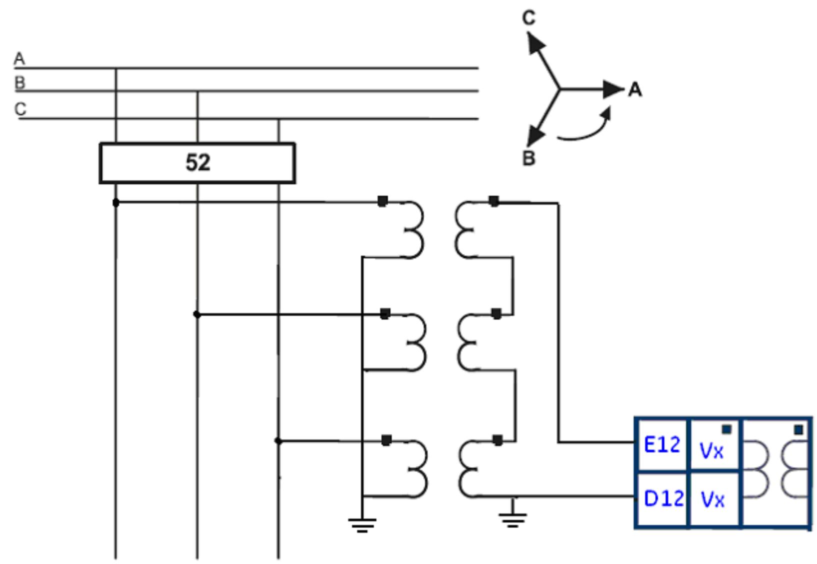
The polarizing signal for the Ground Directional element is based on the zero sequence voltage. Depending on the relay's order code, the zero sequence voltage used for the polarizing voltage, is either calculated, when three-phase voltages are available, or is measured from the auxiliary voltage input Vx when the three-phase voltages are not available. For those relays with available phase VTs, the polarizing voltage for the Neutral directional element is calculated as follows:

$$-V_0 = \frac{-(V_a + V_b + V_c)}{3} \quad \text{Eq. 2}$$

Please note, that the phase VT inputs must be connected in Wye.

For those relays with available Vx auxiliary voltage input only, the polarizing voltage for the Ground directional element is three times the zero sequence voltage measured at the Vx terminals. The Vx input should be connected to measure $3V_0$ from an broken delta VT configuration as shown on the figure below.

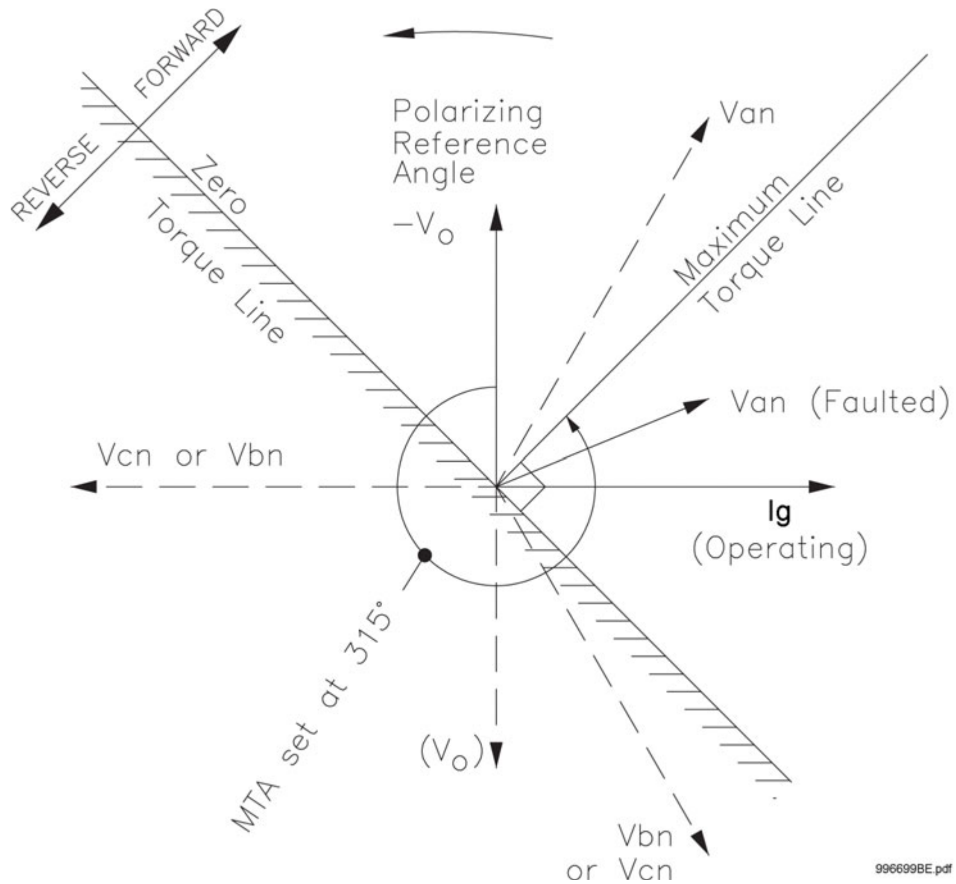
Figure 6-23: Open Delta VT connection



The fault is detected in the Forward direction when the direction of the operating current Ig is within ± 90° of the polarizing signal. Otherwise the direction is detected as Reverse.

In the case where the voltage drops below the setting of the minimum polarizing voltage, the ground directional element is undefined. In this case, ground overcurrent protection elements are blocked if “BLK OC DIR UN” setting is enabled and directional is not disabled.

The diagram below shows the regions for detection of ground current Forward and Reverse directions with respect to the zero sequence voltage and the selected Maximum Torque Angle (MTA).



The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S3 PROTECTION > SETPOINT GROUP 1(2) > GND DIR**

GND (S.GND) DIR FUNCTION

Range: Disabled, Latched Alarm, Alarm, Control

Default: Disabled

When the **Alarm** function is selected, the alarm LED will flash upon detection of Reverse direction, and will drop out when the direction changes to Forward. When **Latched Alarm** is selected, the alarm LED will flash upon detection of Reverse direction, and will stay lit (latched) after the direction changes to Forward. The alarm LED can be reset by issuing a Reset command. Detection of Reverse direction when the **Control** function is selected, does not trigger the alarm LED.

GND (S.GND) DIR MTA

Range: 0° to 359° lead in steps of 1°

Default: 315°

This setting sets the Maximum Torque Angle (MTA), for the Ground Directional element to define the regions of Forward and Reverse directions. For Voltage polarizing, enter the maximum torque angle by which the operating current leads the polarizing voltage. This is the angle of maximum sensitivity.

MIN POL VOLTAGE

Range: 0.05 to 1.25 x VT in steps of 0.01

Default: 0.05 x VT

The minimum zero sequence voltage level must be selected to prevent operation due to normal system unbalances, or voltage transformer errors. Set the minimum zero sequence voltage level to 2% of VT for well balanced systems, and 1% of VT accuracy. For systems with high resistance grounding or floating neutrals, this setting can be as high as 20%. The default of 5% of VT is appropriate for most solidly grounded systems. The following table shows the operating current, and the polarizing signals used for directional control:

Table 6-9: Ground Directional characteristics

Quantity	Operating Current	Polarizing Voltage
Ground	Ig	-Vo/-3Vo*

* Polarizing voltage will be 3Vo when voltage is measured from the auxiliary voltage channel.

BLOCK OC DIR UN

Range: Disabled, Enabled

Default: Enabled

This setting establishes the procedure under undefined direction. If enabled, ground OC elements with “Forward” or “Reverse” setting are blocked; otherwise, they are not.

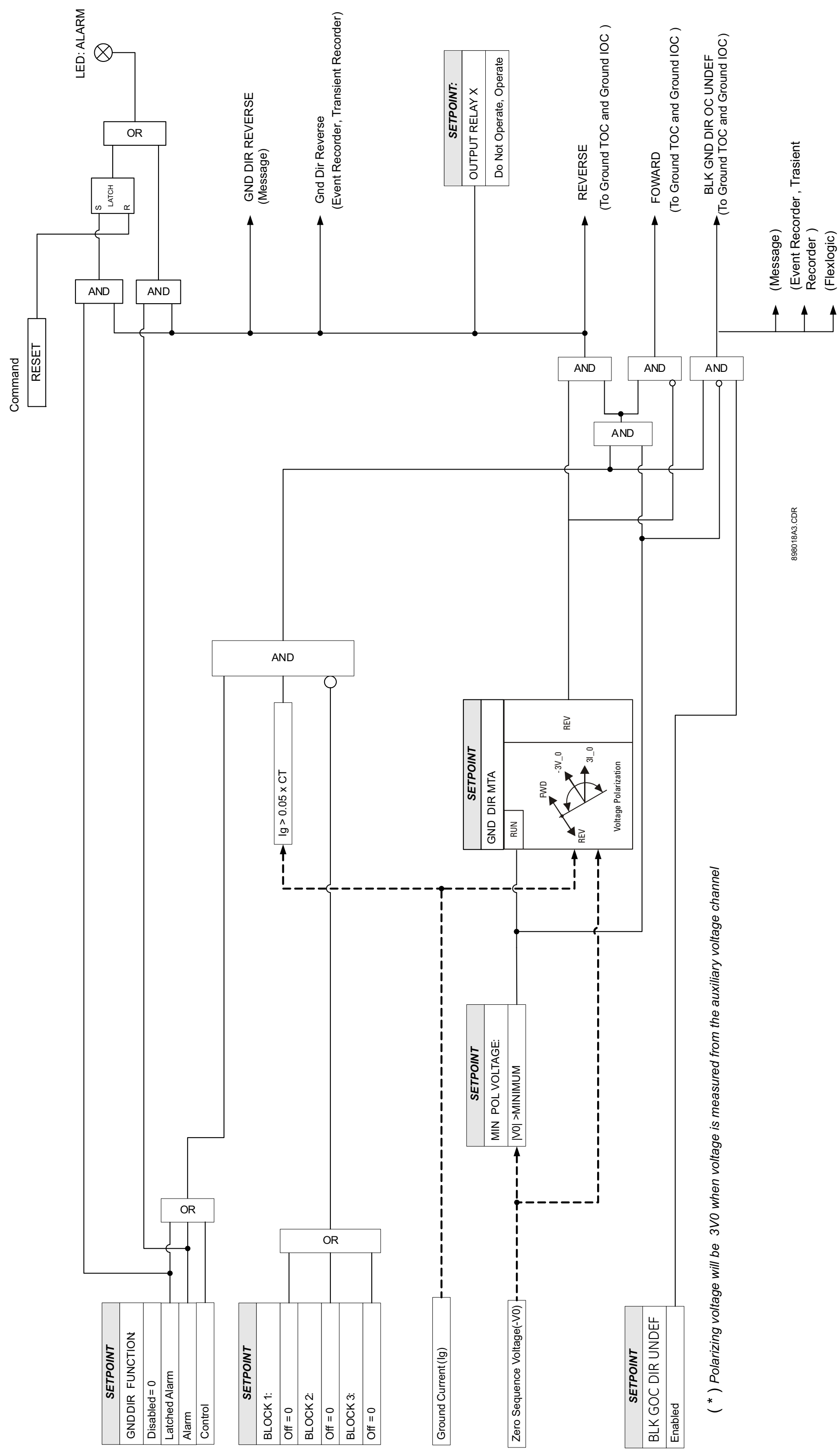
OUTPUT RELAY X

For details see Common setpoints.

BLOCK 1/2/3

For details see Common setpoints.

Figure 6-24: Ground directional logic diagram



Neutral timed overcurrent (51N)

The relay has one Neutral Time Overcurrent protection element per setpoint group. The settings of this function are applied to the calculated neutral current to produce pickup and trip flags. The Neutral TOC pickup flag is asserted, when the neutral current is above the PKP value. The Neutral TOC operate 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 neutral current drops below 97-99% of the pickup value, before the time for operation is reached. The selection of Definite Time has a base time delay of 0.1 s, multiplied by the selected TD multiplier. For example the operating time for TOC set to Definite Time and a TDM set to 5 will result in 5*0.1 = 0.5 s.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S3 PROTECTION > SETPOINT GROUP 1(2) > NEUTRAL TOC**

NTRL TOC FUNCTION

Range: Disabled, Latched Alarm, Alarm, Trip

Default: Disabled

For details see Common setpoints.

NTRL TOC PKP

Range: 0.05 to 20.00 x CT in steps of 0.01 x CT

Default: 1.00 x CT

This setting sets the time overcurrent pickup level. For example, a PKP setting of 0.9 x CT with 300:5 CT translates into 270A neutral current.

NTRL TOC CURVE

Range: ANSI Extremely/Very/Moderately/Normally Inverse, Definite Time, IEC Curve A/B/C and Short Inverse, IAC Extremely/Very/Inverse/Short, User Curve, FlexCurve A, FlexCurve B

Default: Extremely Inverse

This setting sets the shape of the selected over-current inverse curve. If none of the standard curve shapes is appropriate, a custom User curve, or FlexCurve can be created. Refer to the User curve and the FlexCurve setup for more detail on their configurations and usage.

NTRL TOC TDM

Range: 0.05 to 50.00 in steps of 0.01

Default: 1.00

This setting provides selection for Time Dial Multiplier by which the times from the selected inverse curve are modified. For example if an ANSI Extremely Inverse curve is selected with TDM = 2, and the fault current was 5 times bigger than the PKP level, operation of the element will not occur before an elapse of 495 ms from pickup.

NTRL TOC RESET

Range: Instantaneous, Linear

Default: Instantaneous

The “Instantaneous” reset method is intended for applications with other relays, such as most static relays, which set the energy capacity directly to zero when the current falls below the reset threshold. The “Timed” reset method can be used where the relay must coordinate with electromechanical relays.

NTRL TOC DIRECTION

Range: Disabled, Forward, Reverse
Default: Disabled

This setting provides control to the Neutral TOC function in terms of permitting operation under fault conditions in the selected current flow direction, and blocking it when faults occur in the opposite direction.

A special case is considered when fault direction is undefined. Then “BLK OC DIR UN” setting in Neutral Directional defines the fault direction.

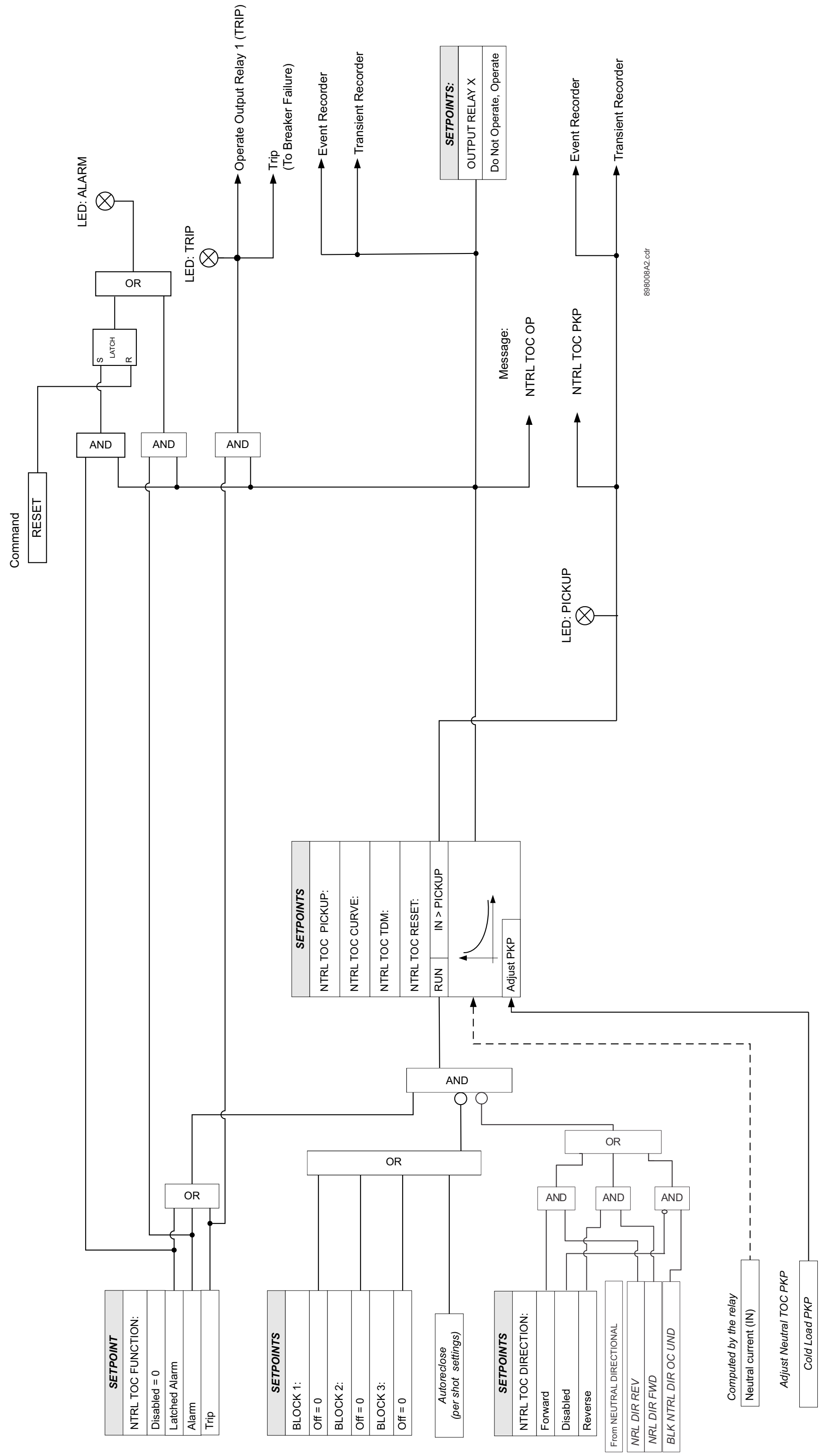
OUTPUT RELAY X

For details see Common setpoints.

BLOCK 1/2/3

For details see Common setpoints.

Figure 6-25: Neutral Timed Overcurrent Protection: Logic Diagram



Negative sequence timed overcurrent protection (51_2)

The 3 Series relay has one Negative Sequence Overcurrent element per setpoint group. The negative sequence overcurrent protection responds to negative sequence $|I_2|$current, where it is calculated as .

$$|I_2| = \frac{1}{3}.|I_A + I_B.(1\angle 240) + I_C.(1\angle 120)|$$

The negative sequence overcurrent elements are uniquely suited to detect phase-phase faults and are not sensitive to balanced loads. While negative sequence elements do not respond to a balanced load, they do detect the negative sequence current present in an unbalanced load. For this reason, select an element pickup setting above the maximum expected I_2 current due to load unbalance.

The Negative Sequence TOC1(2) Trip (Alarm) Pickup flag is asserted when the negative sequence current is above the PKP value. The Negative Sequence TOC1(2) Trip (Alarm) operate 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 97-99% of the pickup value, before the time for operation is reached. When Definite Time is selected, the time for Negative Sequence TOC operation is defined only by the TDM setting. The selection of Definite Time has a base time delay of 0.1s, multiplied by the selected TD multiplier. For example, the operating time for TOC set to Definite Time and a TDM set to 5 will result in 5*0.1 = 0.5s.

PATH: **SETPOINTS > S3 PROTECTION > SETPOINT GROUP 1(2) > NEG SEQ TOC1(2)**

NEG SEQ TOC FUNC

Range: Disabled, Latched Alarm, Alarm, Trip

Default: Disabled

For details see Common setpoints.

NEG SEQ TOC PKP

Range: 0.05 to 20.00 x CT in steps of 0.01 x CT

Default: 1.00 x CT

This setting defines the negative sequence TOC pickup level associated with the ratings of the CTs selected under NEG SEQ CT INPUT.

NEG SEQ TOC CURVE

Range: - ANSI Extremely/Very/Moderately/Normally Inverse- Definite Time- IEC Curve A/B/C and Short Inverse- IAC Extremely/Very/Inverse/Short, User Curve, FlexCurve™ A/B

Default: Ext Inverse

This setting defines the shape of the selected overcurrent inverse curve.

NEG SEQ TOC TDM

Range: 0.05 to 50.00 in steps of 0.01

Default: 1.00

This setting provides a selection for Time Dial Multiplier, which modifies the time response of the selected curve. For example if an ANSI Extremely Inverse curve is selected with TDM = 2, and the fault current was 5 times bigger than the PKP level, the operation of the element will not occur before the elapse of 2.59 seconds from pickup.

NEG SEQ TOC RESET

Range: Instantaneous, Linear

Default: Instantaneous

The reset of the negative sequence timed overcurrent can be selected as either "Instantaneous" or "Linear". If Instantaneous reset is selected, the Negative Sequence TOC element will reset instantaneously providing that the current drops below 97-98% of the Neg. Seq. TOC PKP level, before the time for operation is reached. When Linear reset is selected, the time to reset is calculated based on the following linear equation:

$$T_{RESET} = E.M.C_R \qquad \textbf{Eq. 3}$$

where: T_{RESET} - reset time in seconds; E - energy capacity reached (per unit); M - curve multiplier; C_R - characteristic constant (5 for ANSI, IAC, Definite Time, and Flexcurves^{TM}; 8 for IEC).

The 100% "energy capacity" for the TOC element is defined by the selection of PKP, TDM and points from the inverse curve. A memory variable based on actual values currents is monitored for accumulation of energy capacity, where if it reaches a level of 100% of the set energy capacity level, the element operates, and if it goes below 97-98% of this level, the element will tend to reset. The accumulated energy capacity is used as an input for computation of the reset time, when the "Linear" reset is selected as a setting.

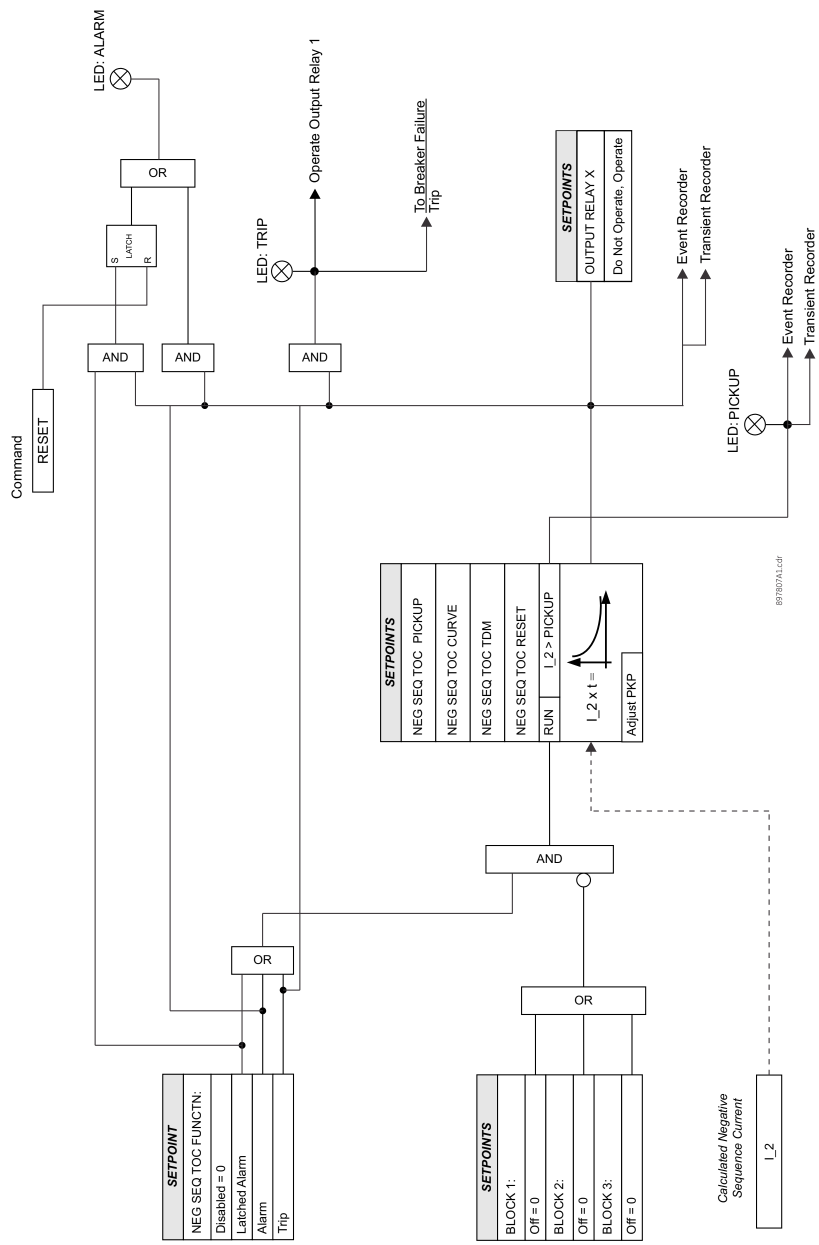
OUTPUT RELAY X

For details see Common setpoints.

BLOCK 1/2/3

For details see Common setpoints.

Figure 6-26: Negative Sequence Timed Overcurrent logic diagram



Neutral instantaneous overcurrent protection (50N)

The relay has two Instantaneous Overcurrent protection elements per setpoint group. The settings of this function are applied to the calculated neutral current for 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 Delay setting. If the pickup time delay is set to 0.00 seconds, the pickup and operate flags will be asserted at the same time. The element drops from pickup without operation, if the neutral current drops below 97-99% of the pickup value before the time for operation is reached.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > PROTECTION > ETPOINT GROUP 1 (2) > NEUTRAL IOC1(2)**

NTRL IOC1(2) FUNCTION

Range: Disabled, Latched Alarm, Alarm, Trip

Default: Disabled

For details see Common setpoints.

NTRL IOC PKP

Range: 0.05 to 20 x CT in steps of 0.01 x CT

Default: 1.00 x CT

This setting sets the neutral instantaneous overcurrent pickup level.

NTRL IOC DELAY

Range: 0.00 to 300 sec in steps of 0.01 sec

Default: 0.00 sec

This setting sets the neutral instantaneous overcurrent delay.

NTRL IOC DIRECTION

Range: Disabled, Forward, Reverse

Default: Disabled

This setting provides control to the Neutral IOC1(2) function in terms of permitting operation upon fault conditions in the selected current flow direction, and blocking it when faults occur in the opposite direction.

A special case is considered when fault direction is undefined. Then “BLK OC DIR UN” setting in Neutral Directional defines the fault direction.

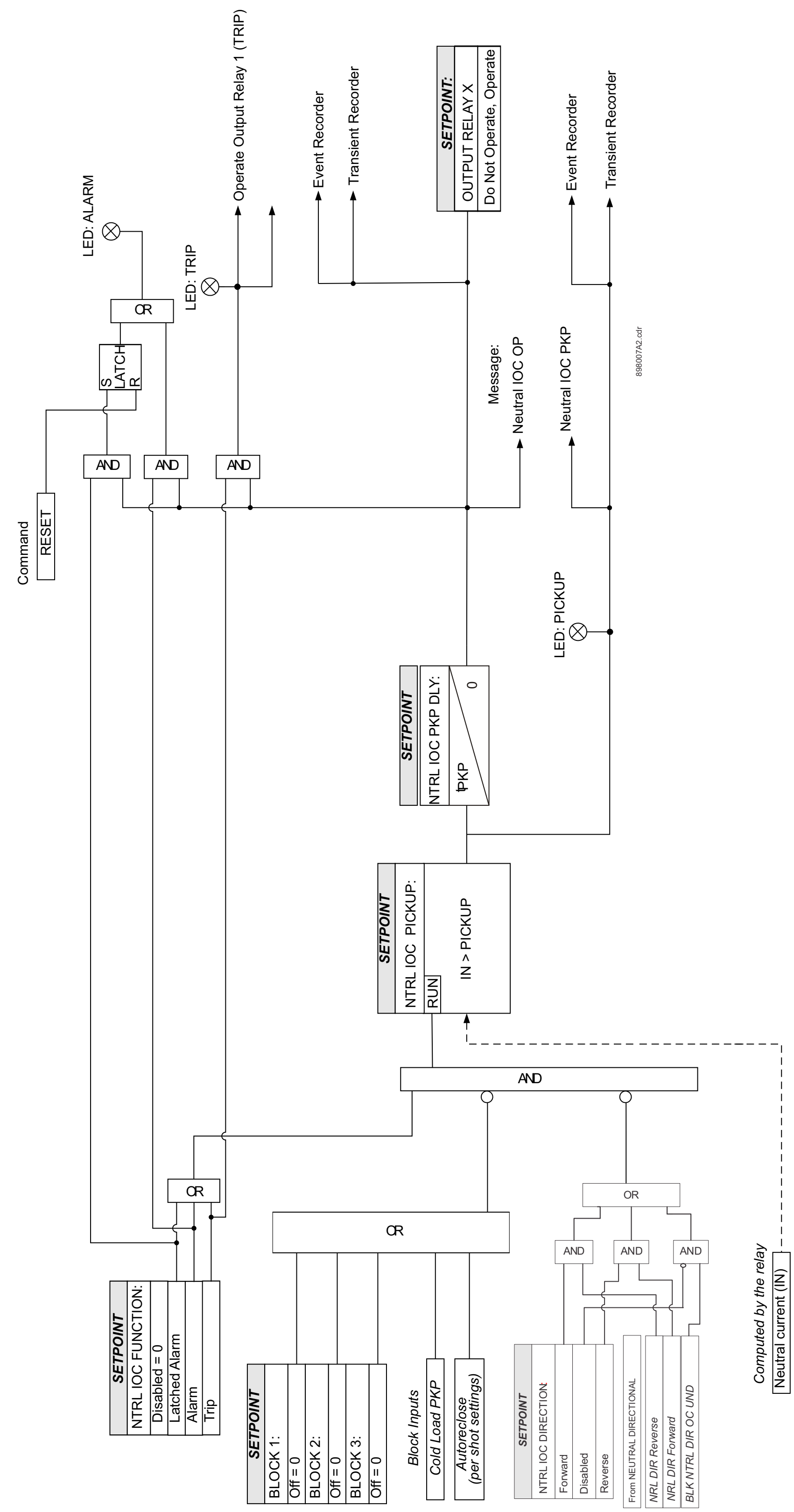
OUTPUT RELAY X

For details see Common setpoints.

BLOCK 1/2/3

For details see Common setpoints.

Figure 6-27: Neutral Instantaneous Overcurrent Protection: Logic Diagram



Neutral directional (67N)

The Neutral Directional element is used to discriminate between faults that occur in the forward direction, and faults that occur in the reverse direction. The Neutral Directional element can be used either individually for control or alarm by energizing the auxiliary output relays, or as a part of the Neutral, Instantaneous, or Time over-current elements to define the tripping direction. (See the setup for Neutral TOC, and Neutral IOC elements.)

The polarizing signal for the Neutral Directional element can be set to be either voltage (zero sequence voltage), current (measured ground current), or dual (both).

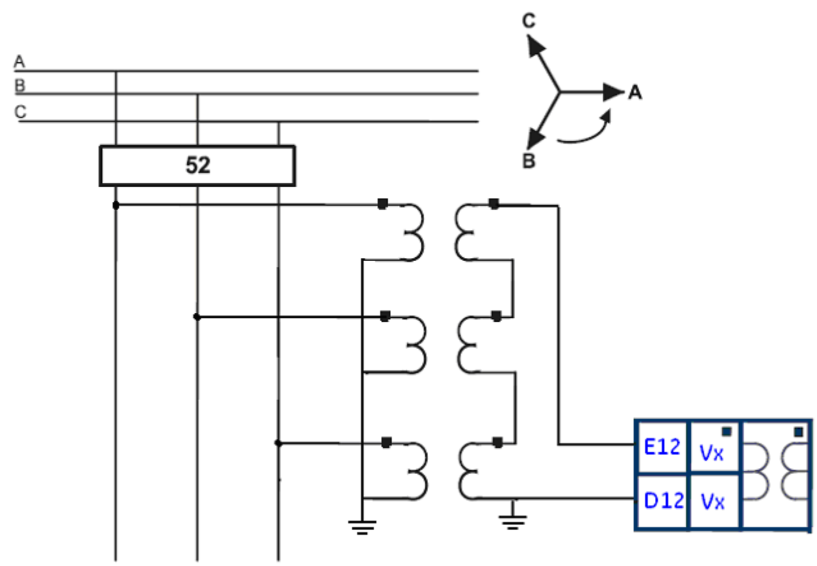
Depending on the relay's order code, the zero sequence voltage used for the Neutral Directional polarizing voltage, is calculated either when three-phase voltages are available, or is the measured voltage from the auxiliary Vx voltage input when the three-phase voltages are not available. For those relays with available phase VTs, the polarizing voltage for the Neutral directional element is calculated as follows:

$$-V_0 = \frac{-(V_a + V_b + V_c)}{3} \qquad \textbf{Eq. 4}$$

Please note that the phase VT inputs must be connected in Wye.

For those relays with available Vx auxiliary voltage input only, the polarizing voltage for the Neutral directional element is three times the zero sequence voltage measured at the Vx terminals. The Vx input should be connected to measure $3V_0$ from a Broken Delta VT configuration as shown in the figure below.

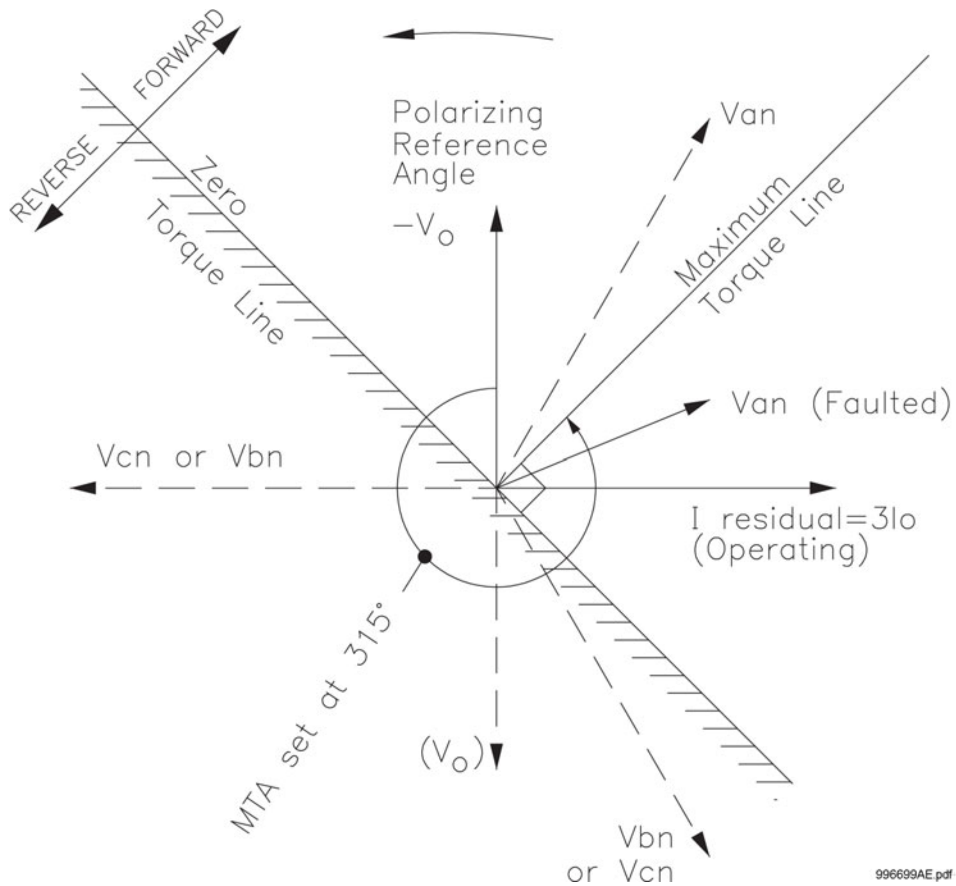
Figure 6-28: Broken Delta VT connection



When "Voltage" polarization is selected, the direction is determined by comparing the angle between the operating current and the voltage, and the set MTA angle. In cases where the voltage drops below the setting of the minimum polarizing voltage, the neutral directional element is undefined (see following table).

When "Current" polarizing is selected, the direction of the neutral current is determined with reference to the direction of the measured ground current . The fault is detected in the Forward direction when the ground current typically flowing from the ground point into the neutral current is within ± 90° of the polarizing current. Otherwise the direction is detected as Reverse. The neutral directional element is undefined (see following table) if the polarizing ground current drops below 5% of the ground CT.

The diagram below shows the regions for detection of neutral current Forward and Reverse directions with respect to the zero sequence voltage and the selected Maximum Torque Angle (MTA).



When “Dual” polarizing is selected, the Reverse direction is declared if both directional comparators - the one based on the zero sequence polarizing voltage, and the other based on measured ground polarizing current - declare Reverse direction. If the direction from one of the comparators declares Forward direction and the other declares Reverse direction, the neutral directional element is undefined (see following table). If the polarizing voltage falls below the set minimum voltage, the direction declared depends on the polarizing ground current, assuming the measured ground current is above some 5% CTg. The same rule applies if the ground current falls below 5% CTg. In this case the direction is determined using the polarizing zero sequence voltage, assuming it is above the set minimum voltage from the settings menu.

When direction is undefined, the “BLK NOC DIR UNDEF” setting determines whether neutral overcurrent protection must be blocked (setting = Enabled) or enabled (setting= Disabled).

Table 6-10: Neutral directional element directions

Directional type	Current direction	Voltage direction	Result
Current	Undefined	-	Undefined
	FW		FW
	RV		RV
Voltage	-	Undefined	Undefined
		FW	FW
		RV	RV

Directional type	Current direction	Voltage direction	Result
Dual	Undefined	Undefined	Undefined
	FW	RV	Undefined
	RV	FW	Undefined
	Undefined	FW	FW
	Undefined	RV	RV
	FW	Undefined	FW
	RV	Undefined	RV

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S3 PROTECTION > S3 SETPOINT GROUP 1(2) > NTRL DIR**

NTRL DIR FUNCTION

Range: Disabled, Latched Alarm, Alarm, Control

Default: Disabled

When an **Alarm** function is selected, the alarm LED will flash upon detection of Reverse direction, and will drop out when the direction changes to Forward. When **Latched Alarm** is selected, the alarm LED will flash upon detection of Reverse direction, and will stay lit (latched) after the direction changes to Forward. The alarm LED can be reset, by issuing a Reset command. Detection of Reverse direction when the **Control** function is selected, does not trigger the alarm LED.

NTRL DIR POLARIZING

Range: Voltage, Current, Dual

Default: Voltage

This setting specifies the voltage polarizing signal for the detection of Forward and Reverse directions.

NTRL DIR MTA

Range: 0° to 359° Lead in steps of 1°

Default: 315°

This setting sets the Maximum Torque Angle (MTA), for the Neutral Directional element to define the regions of Forward and Reverse directions. For Voltage polarizing, enter the maximum torque angle by which the operating current leads the polarizing voltage. This is the angle of maximum sensitivity.

MIN POL VOLTAGE

Range: 0.05 to 1.25 x VT in steps of 0.01

Default: 0.05 x VT

This setting affects only cases where voltage or dual polarizing is selected. The minimum zero sequence voltage level must be selected to prevent operation due to normal system unbalances, or voltage transformer errors. Set the minimum zero sequence voltage level to 2% of VT for well balanced systems, and 1% of VT accuracy. For systems with high resistance grounding or floating neutrals, this setting can be as high as 20%. The default of 5% of VT is appropriate for most solidly grounded systems.

Table 6-11: Neutral directional characteristics

Quantity	Operating Current	Polarizing Voltage (VT connection: Wye)	Polarizing Current
Neutral	$3I_0 = I_a + I_b + I_c$	$-V_0 = -(V_a + V_b + V_c)/3$ $-3V_0$ (*)	I_g

* Polarizing voltage will be $3V_o$ when voltage is measured from the auxiliary voltage channel.

BLK OC DIR UN

Range: Disabled, Enabled

Default: Enabled

This setting establishes the procedure under undefined direction conditions. If enabled, OC elements with a “Forward” or “Reverse” setting are blocked; otherwise, they are not.

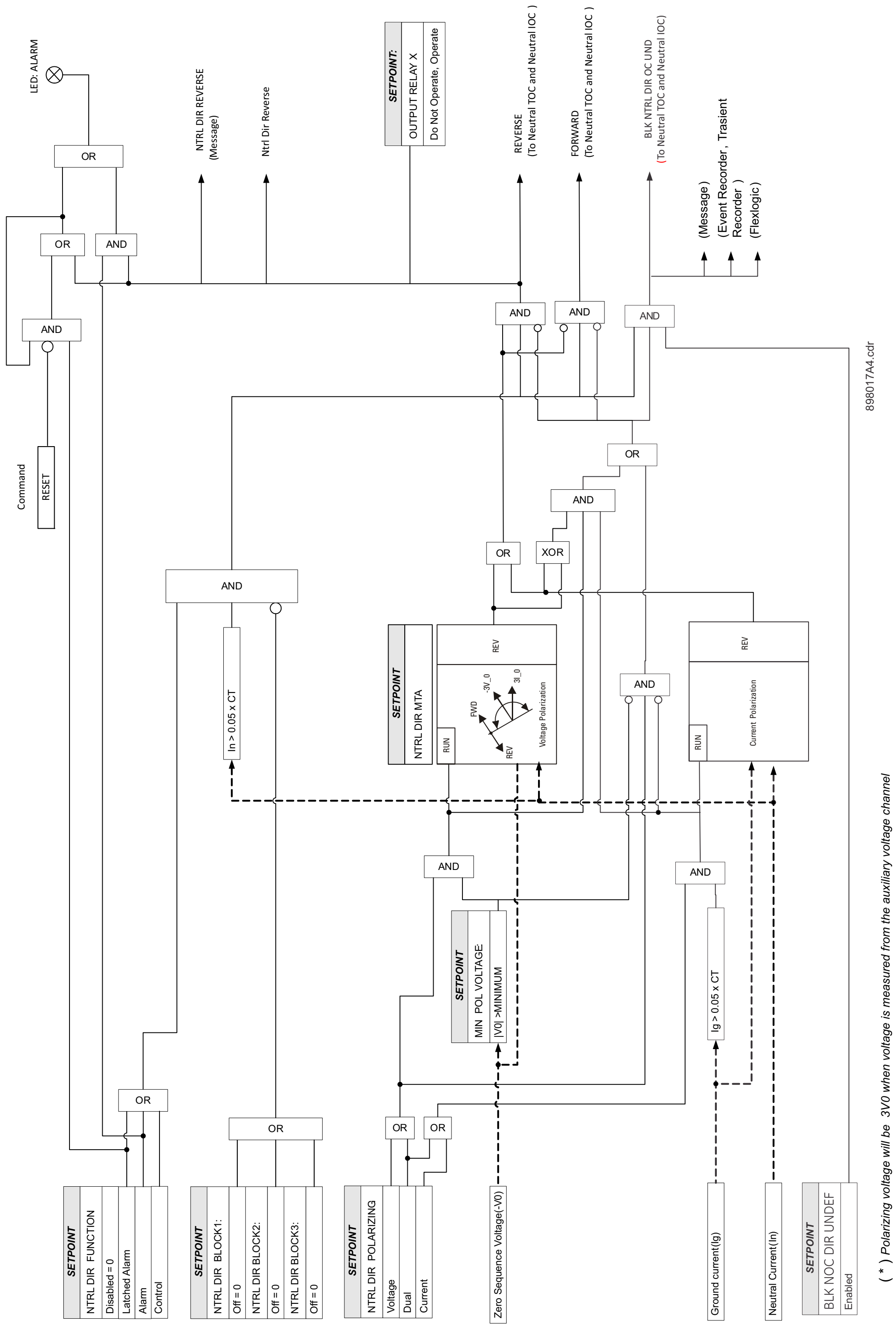
OUTPUT RELAY X

For details see Common setpoints.

BLOCK 1/2/3

For details see Common setpoints.

Figure 6-29: Neutral directional logic diagram



Negative sequence instantaneous overcurrent (50_2)

The 350 relay has one Negative Sequence Overcurrent element per protection group. The negative sequence over-current protection responds to negative sequence current, where it is calculated as .

$$|I_2| = \frac{1}{3}.|I_A + I_B.(1\angle 240) + I_C.(1\angle 120)|$$

The negative sequence over-current elements are uniquely suited to detect phase-phase faults and are not sensitive to balanced loads. While negative sequence elements do not respond to balanced load, they do detect the negative sequence current present in unbalanced load. For this reason, select an element pickup setting above the maximum expected current due to load unbalance.

PATH: **SETPOINTS > S3 PROTECTION > SETPOINT GROUP 1(2) > NEG SEQ IOC**

NEG SEQ IOC FUNCTION

Range: Disabled, Latched Alarm, Alarm, Trip

Default: Disabled

For details see Common setpoints.

NEG SEQ IOC PKP

Range: 0.05 to 20.00 x CT in steps of 0.01 x CT

Default: 1.00 x CT

This setting defines the negative sequence IOC pickup level.

NEG SEQ IOC DELAY

Range: 0.00 to 300.00 sec in steps of 0.01 sec

Default: 0.00 sec

This setting specifies the time delay before IOC operation. .

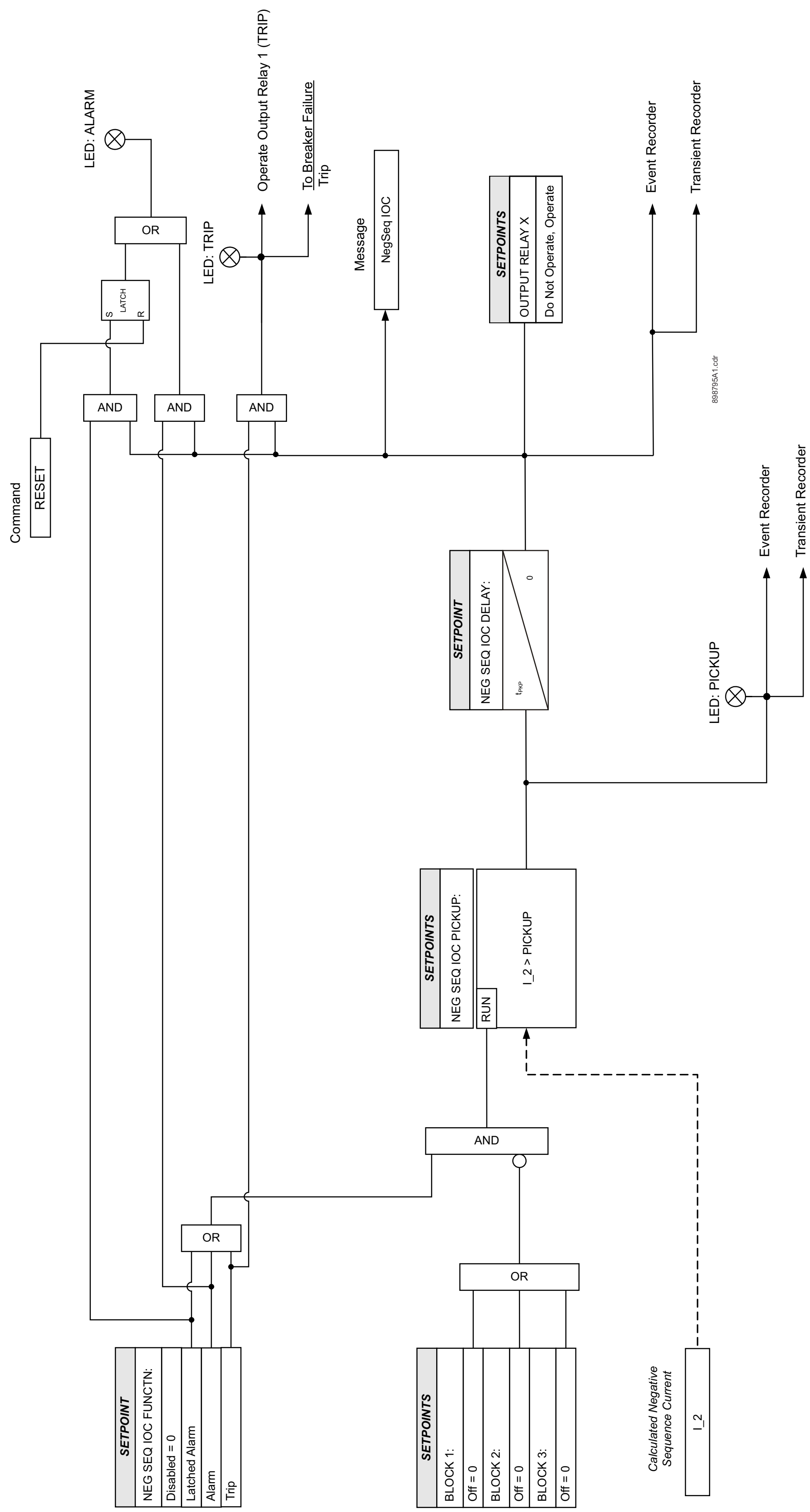
OUTPUT RELAY X

For details see Common setpoints.

BLOCK 1/2/3

For details see Common setpoints.

Figure 6-30: Negative sequence instantaneous overcurrent protection logic diagram



Phase undervoltage (27P)

- **Undervoltage Protection**: For voltage sensitive loads, such as induction motors, a drop in voltage will result in an increase in the drawn current, which may cause dangerous overheating in the motor. The undervoltage protection feature can be used to either cause a trip or generate an alarm when the voltage drops below a specified voltage setting for a specified time delay.
- **Permissive Functions**: The undervoltage feature may be used to block the functioning of external devices by operating an output relay, when the voltage falls below the specified voltage setting. Note that all internal features that are inhibited by an undervoltage condition, such as underfrequency and overfrequency, have their own inhibit functions independent of the undervoltage protection features.
- **Source Transfer Schemes**: In the event of an undervoltage, a transfer signal may be generated to transfer a load from its normal source to a standby or emergency power source.

The undervoltage elements can be programmed to have an inverse time delay characteristic. The undervoltage delay setpoint defines a family of curves as shown below. The operating time is given by:

$$T = \frac{D}{1 - V/V_{pu}} \quad \text{Eq. 5}$$

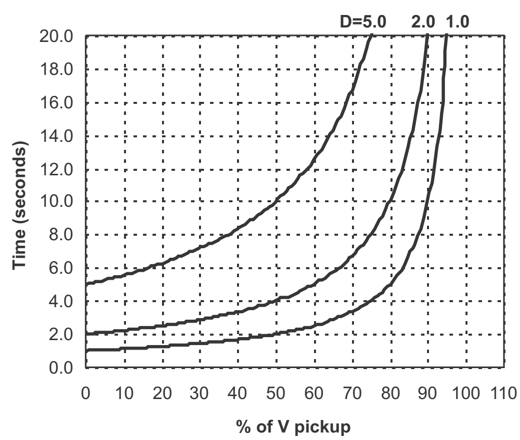
Where:

T = Operating Time
D = Undervoltage Delay setpoint
V = Voltage as a fraction of the nominal VT Secondary Voltage
V_{pu} = Pickup Level

NOTE

At 0% of pickup, the operating time equals the Undervoltage Delay setpoint.

Figure 6-31: Inverse time undervoltage curves



The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: SETPOINTS > S3 PROTECTION > SETPOINT GROUP 1(2) > PHASE UV

PH UV FUNCTION

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

For details see Common setpoints.

PH UV PKP

Range: 0.00 to 1.25 x VT in steps of 0.01

Default: 0.75 x VT

This setting defines the phase UV pickup level, and it is usually set to a level, below which the drawn current from voltage sensitive loads, such as induction motors may cause dangerous motor overheating conditions.

PH UV CURVE

Range: Definite Time, Inverse Time

Default: Inverse Time

This setting selects the type of timing-inverse time/definite time to define the time of undervoltage operation based on the selected UV time delay, and the actual undervoltage condition with respect to the selected UV pickup.

PH UV DELAY

Range: 0.00 to 600.00 sec in steps of 0.01 sec

Default: 2.0 s

This setting specifies the time delay used by the selected "PHASE UV CURVE" type of timing, to calculate the time before UV operation. When Inverse Time is selected, this setting is used in the formula for Inverse Time operating time.

PH UV PHASES

Range: Any One, Any Two, All Three

Default: Any One

This setting selects the combination of undervoltage conditions with respect to the number of phase voltages under the undervoltage pickup setting. Selection of the "Any Two", or "All Three" settings would effectively rule out the case of single VT fuse failure.

PH UV MIN VOLTAGE

Range: 0.00 to 1.25 x VT in steps of 0.01

Default: 0.30 x VT

The minimum operating voltage level is programmable to prevent undesired UV operation before voltage becomes available.

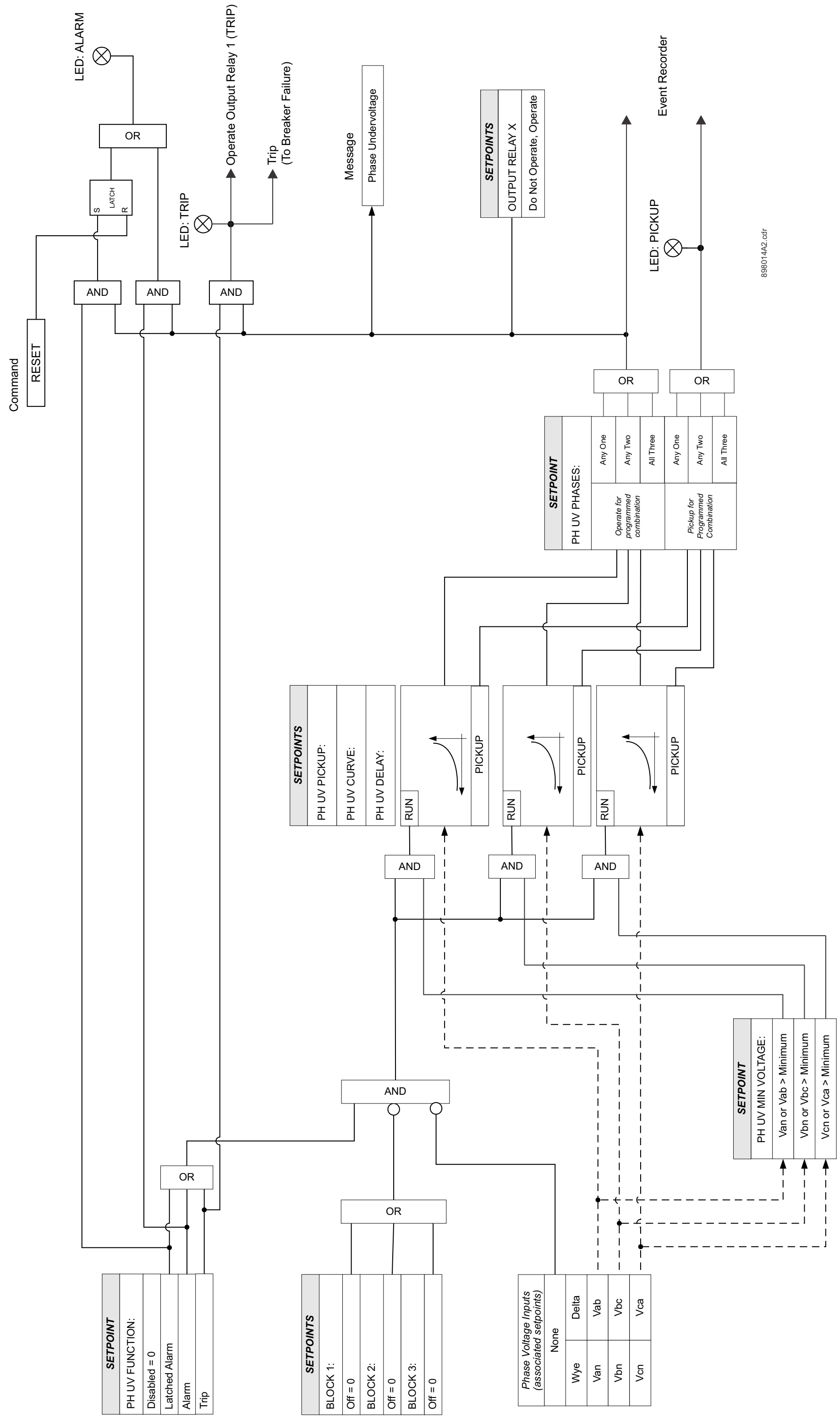
OUTPUT RELAY X

For details see Common setpoints.

BLOCK 1/2/3

For details see Common setpoints.

Figure 6-32: Phase undervoltage logic diagram



Phase overvoltage (59P)

The phase OV protection can be used to protect voltage sensitive feeder loads and circuits against sustained overvoltage conditions. The protection can be used to either cause a trip, or generate an alarm when the voltage exceeds a specified voltage value for the specified time delay.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S3 PROTECTION > SETPOINT GROUP 1(2) > PHASE OV**

PH OV FUNCTION

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

For details see Common setpoints.

PH OV PKP

Range: 0.00 to 1.25 x VT in steps of 0.01
Default: 1.25 x VT

This setting defines the Phase OV pickup level.

PH OV DELAY

Range: 0.00 to 600.00 sec in steps of 0.01
Default: 2.0 s

This setting specifies the time delay before OV operation.

PH OV PHASES

Range: Any One, Any Two, All Three
Default: Any One

This setting selects the combination of overvoltage conditions with respect to the number of phase voltages over the overvoltage pickup setting.

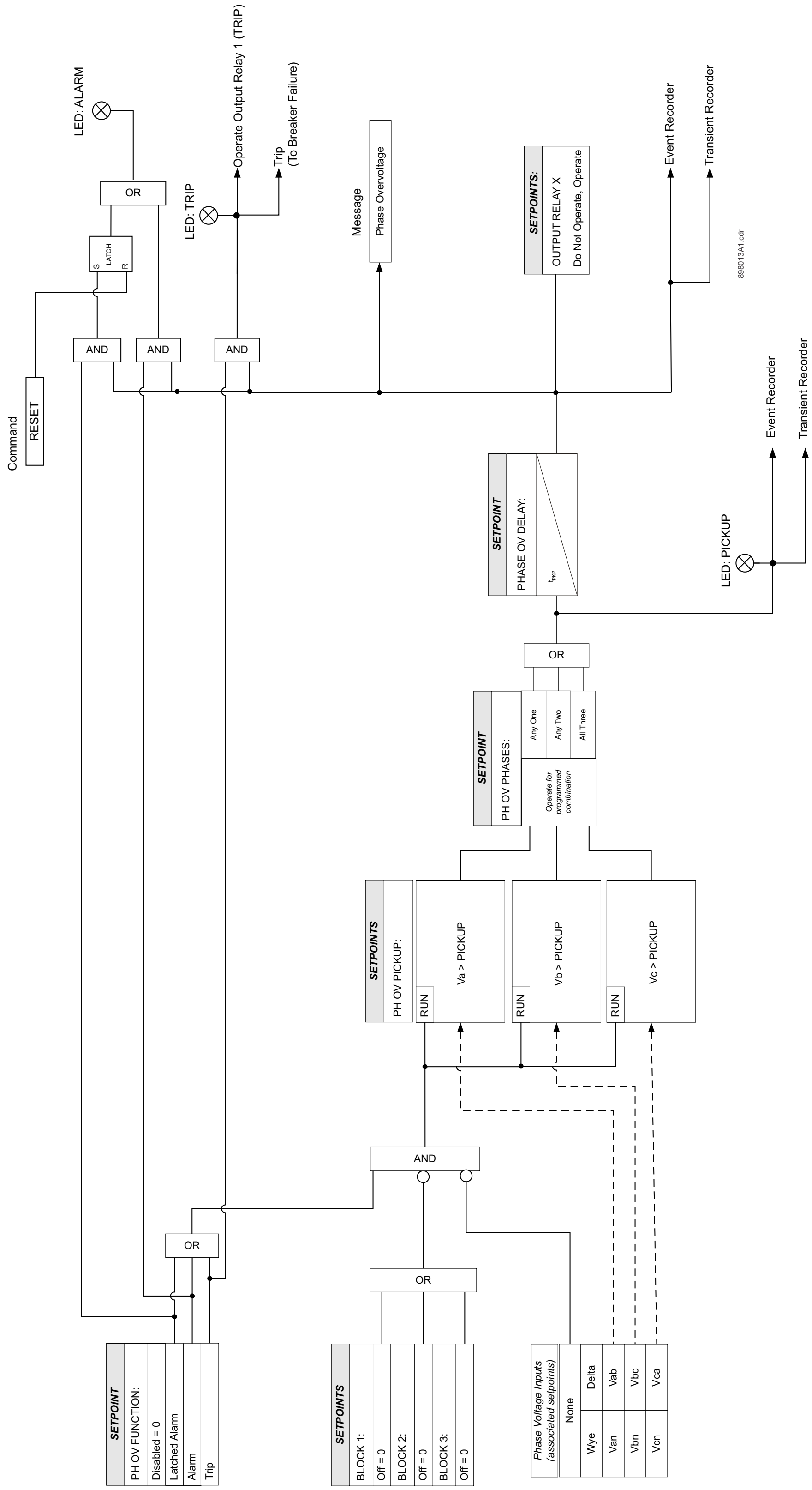
OUTPUT RELAY X

For details see Common setpoints.

BLOCK 1/2/3

For details see Common setpoints.

Figure 6-33: Phase Overvoltage logic diagram



Neutral overvoltage (59N)

The relay has one Neutral Overvoltage element per protection group. This element requires the three phase Bus VTs to be Wye connected. When setting the pickup for this element, it is important to consider the error in the VT ratio, as well as the normal voltage unbalance on the system.

NOTE

This element should be used 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 3V0 cannot discriminate between a faulted circuit and an adjacent healthy circuit. Use of a time delayed back-up or an alarm mode allow other protections an opportunity to isolate the faulted element first.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S3 PROTECTION > SETPOINT GROUP 1(2) > NEUTRAL OV**

NEUTRAL OV FUNCTION

Range: Disabled, Alarm, Latched Alarm,Trip

Default: Disabled

For details see Common setpoints.

NEUTRAL OV PKP

Range: 0.00 to 1.25 x VT in steps of 0.01

Default: 0.30 x VT

This setting defines the neutral OV pickup level.

NEUTRAL OV DELAY

Range: 0.00 to 600.00 sec in steps of 0.01 sec

Default: 2.0 s

This setting specifies the time delay before OV operation.

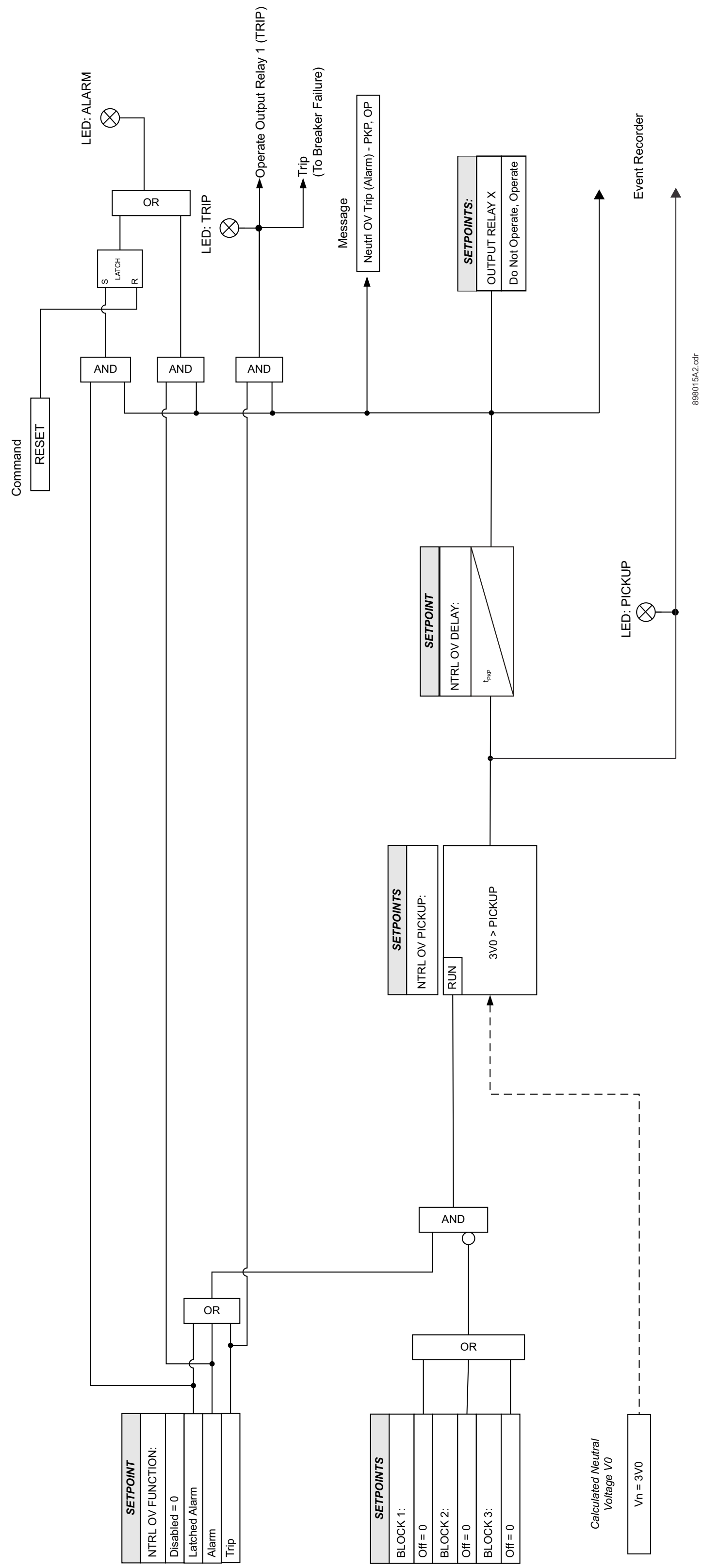
OUTPUT RELAY X

For details see Common setpoints.

BLOCK 1/2/3

For details see Common setpoints.

Figure 6-34: Neutral Overvoltage logic diagram



Negative sequence overvoltage (59_2)

The relay has one Negative Sequence Overvoltage element per protection group. The negative sequence overvoltage may be used to detect the loss of one or two phases of the source, a reversed voltage phase sequence, or non-system voltage conditions.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S3 PROTECTION > SETPOINT GROUP 1(2) > NEGATIVE SEQ. OV**

NEG SEQ OV FUNCTION

Range: Disabled, Alarm, Latched Alarm, Trip

Default: Disabled

For details see Common setpoints.

NEG SEQ OV PKP

Range: 0.00 to 1.25 x VT in steps of 0.01

Default: 0.30 x VT

This setting defines the negative sequence OV pickup level.

NEG SEQ OV DELAY

Range: 0.00 to 600.00 sec in steps of 0.01 sec

Default: 2.00 s

This setting specifies the time delay before OV operation.

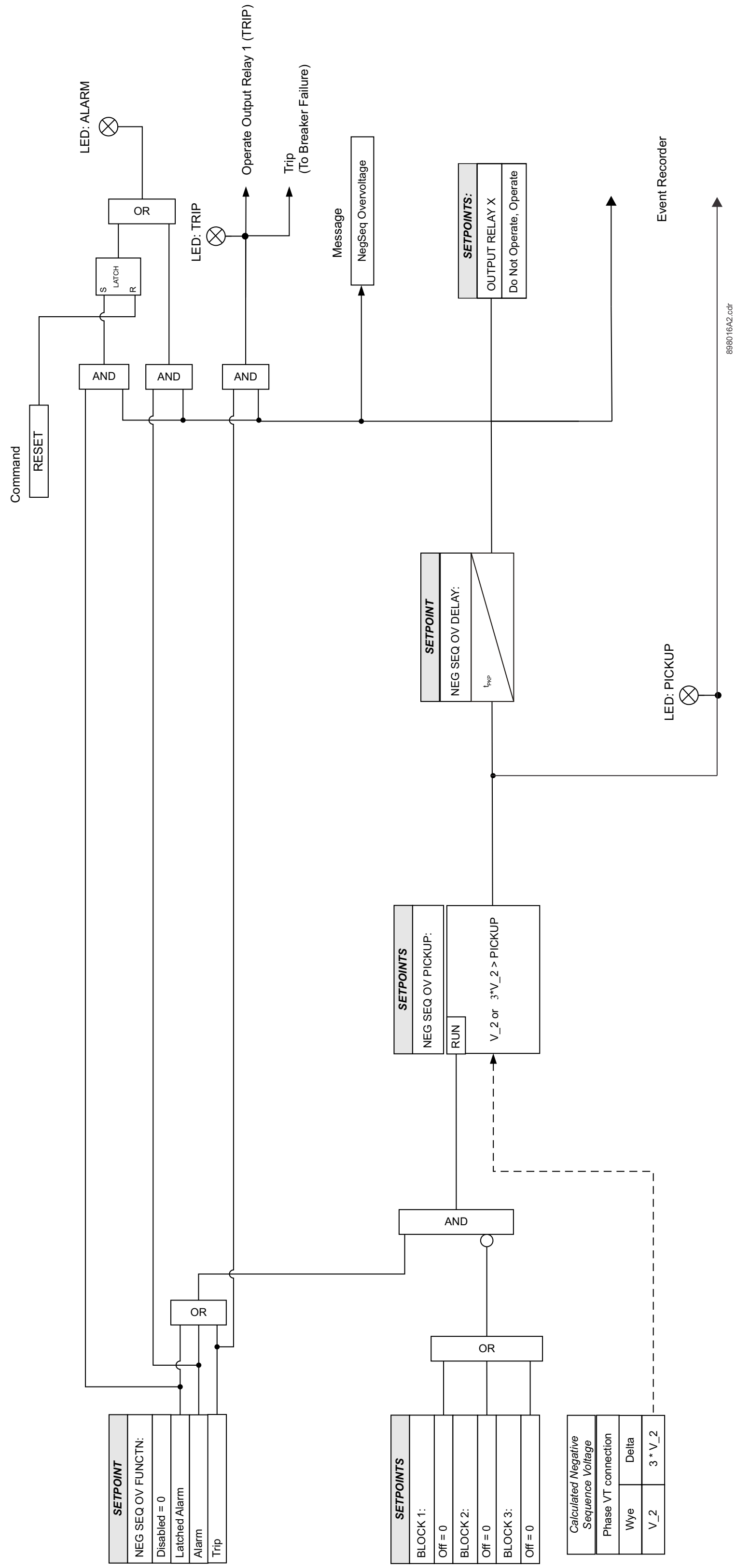
OUTPUT RELAY X

For details see Common setpoints.

BLOCK 1/2/3

For details see Common setpoints.

Figure 6-35: Negative Sequence Overvoltage logic diagram



Auxiliary undervoltage (27X)

The relay has one Auxiliary Undervoltage element per setpoint group. The input for this element is the voltage from the auxiliary VT relay terminals, where a single voltage from the line is connected. The time delay characteristic can be programmed as either definite time or inverse time. A minimum operating voltage level is programmable to prevent undesired operation before voltage becomes available.

- **Undervoltage Protection**: For voltage sensitive loads, such as induction motors, a drop in voltage will result in an increase in the drawn current, which may cause dangerous overheating in the motor. The undervoltage protection feature can be used to either cause a trip or generate an alarm when the voltage drops below a specified voltage setting for a specified time delay.
- **Permissive Functions**: The undervoltage feature may be used to block the functioning of external devices by operating an output relay, when the voltage falls below the specified voltage setting. Note that all internal features that are inhibited by an undervoltage condition, such as underfrequency and overfrequency, have their own inhibit functions independent of the undervoltage protection features.
- **Source Transfer Schemes**: In the event of an undervoltage, a transfer signal may be generated to transfer a load from its normal source to a standby or emergency power source.

The undervoltage elements can be programmed to have an inverse time delay characteristic. The undervoltage delay setpoint defines a family of curves as shown below. The operating time is given by:

$$T = \frac{D}{1 - V/V_{pu}} \quad \textbf{Eq. 6}$$

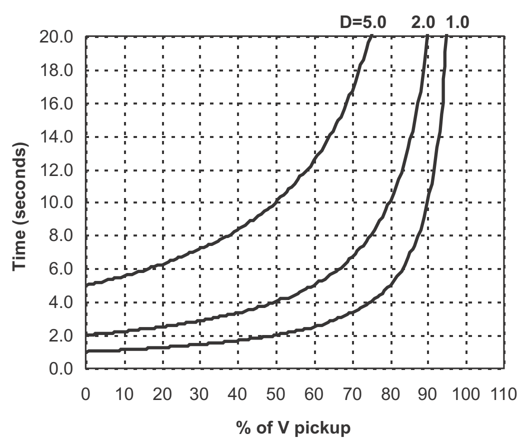
Where:

T = Operating Time
D = Undervoltage Delay setpoint
V = Voltage as a fraction of the nominal VT Secondary Voltage
V_{pu} = Pickup Level

NOTE

At 0% of pickup, the operating time equals the Undervoltage Delay setpoint.

Figure 6-36: Inverse time undervoltage curves



The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: SETPOINTS > S3 PROTECTION > SETPOINT GROUP 1(2) > AUXILIARY UV

AUX UV FUNCTION

Range: Disabled, Alarm, Latched Alarm, Trip

Default: Disabled

For details see Common setpoints.

AUX UV PKP

Range: 0.00 to 1.25 x VT in steps of 0,01

Default: 0.75 x VT

This setting defines the auxiliary UV pickup level.

AUX UV CURVE

Range: Definite Time, Inverse Time

Default: Inverse Time

This setting selects the type of timing-inverse time/definite time, to define the time of aux. undervoltage operation based on selected UV time delay, and the actual undervoltage condition with respect to the selected UV pickup.

AUX UV DELAY

Range: 0.00 to 600.00 sec in steps of 0.01 sec

Default: 2.0 s

This setting specifies the time delay before UV operation, when Definite Time is selected under the AUX UV CURVE setting. When Inverse Time is selected, this setting is used in the formula for Inverse Time operating time.

AUX UV MIN VOLTAGE

Range: 0.00 to 1.25 x VT in steps of 0,01

Default: 0.30 x VT

The minimum operating voltage level is programmable to prevent undesired UV operation before voltage becomes available.

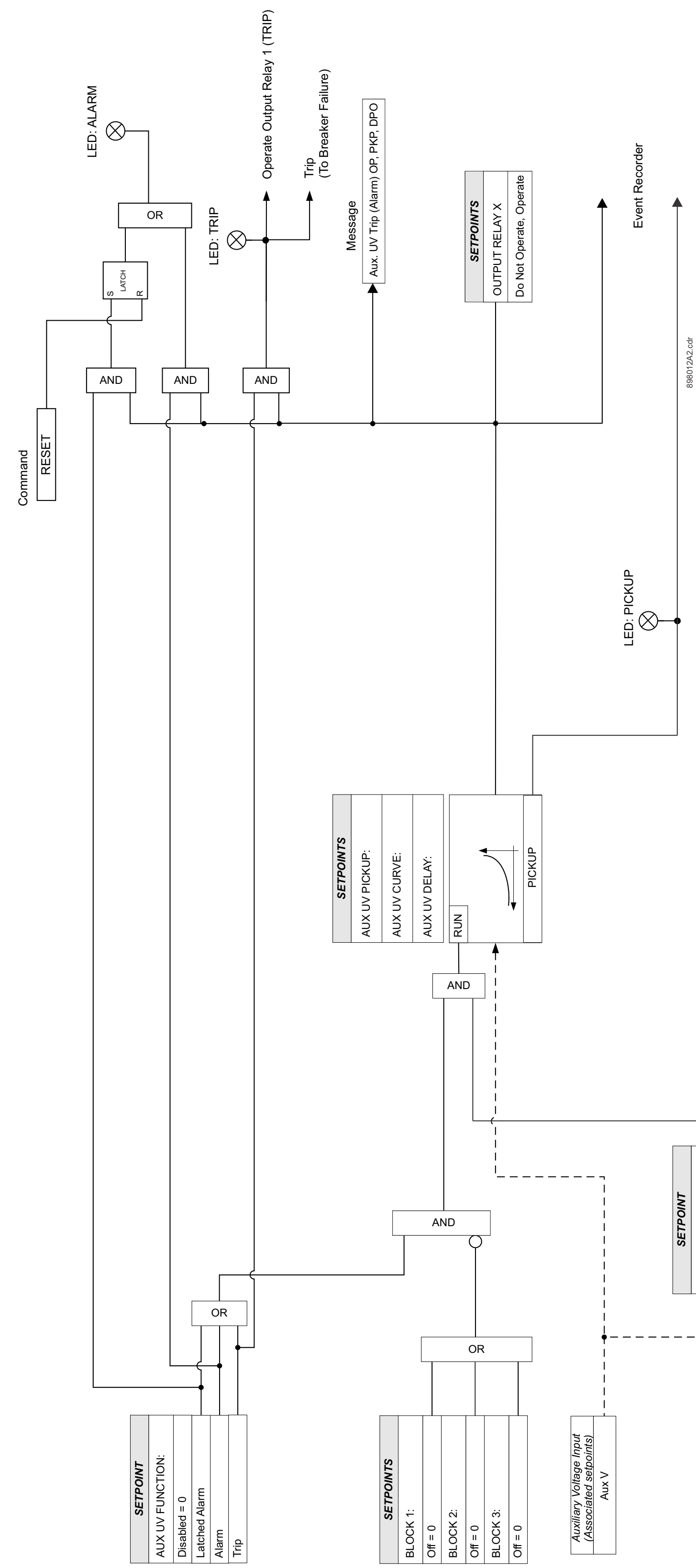
OUTUT RELAY X

For details see Common setpoints.

BLOCK 1/2/3

For details see Common setpoints.

Figure 6-37: Auxiliary Undervoltage logic diagram



Auxiliary overvoltage (59X)

The relay has one Auxiliary Overvoltage element per protection group. The element is intended for monitoring overvoltage conditions of the auxiliary voltage input. A typical application for this element is monitoring the zero sequence voltage (3V_0) from an open corner Delta VT connection. The nominal voltage for the auxiliary voltage input is set under **Setpoints > S2 System Setup > Voltage Sensing > Aux VT Secondary**.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S3 PROTECTION > SETPOINT GROUP 1(2) > AUXILIARY OV**

AUX OV FUNCTION

Range: Disabled, Alarm, Latched Alarm, Trip

Default: Disabled

For details see Common setpoints.

AUX OV PKP

Range: 0.00 to 1.25 x VT in steps of 0.01

Default: 0.3 x VT

This setting defines the auxiliary OV pickup level.

AUX OV DELAY

Range: 0.00 to 600.00 sec in steps of 0.01

Default: 2.0 s

This setting specifies the time delay before OV operation.

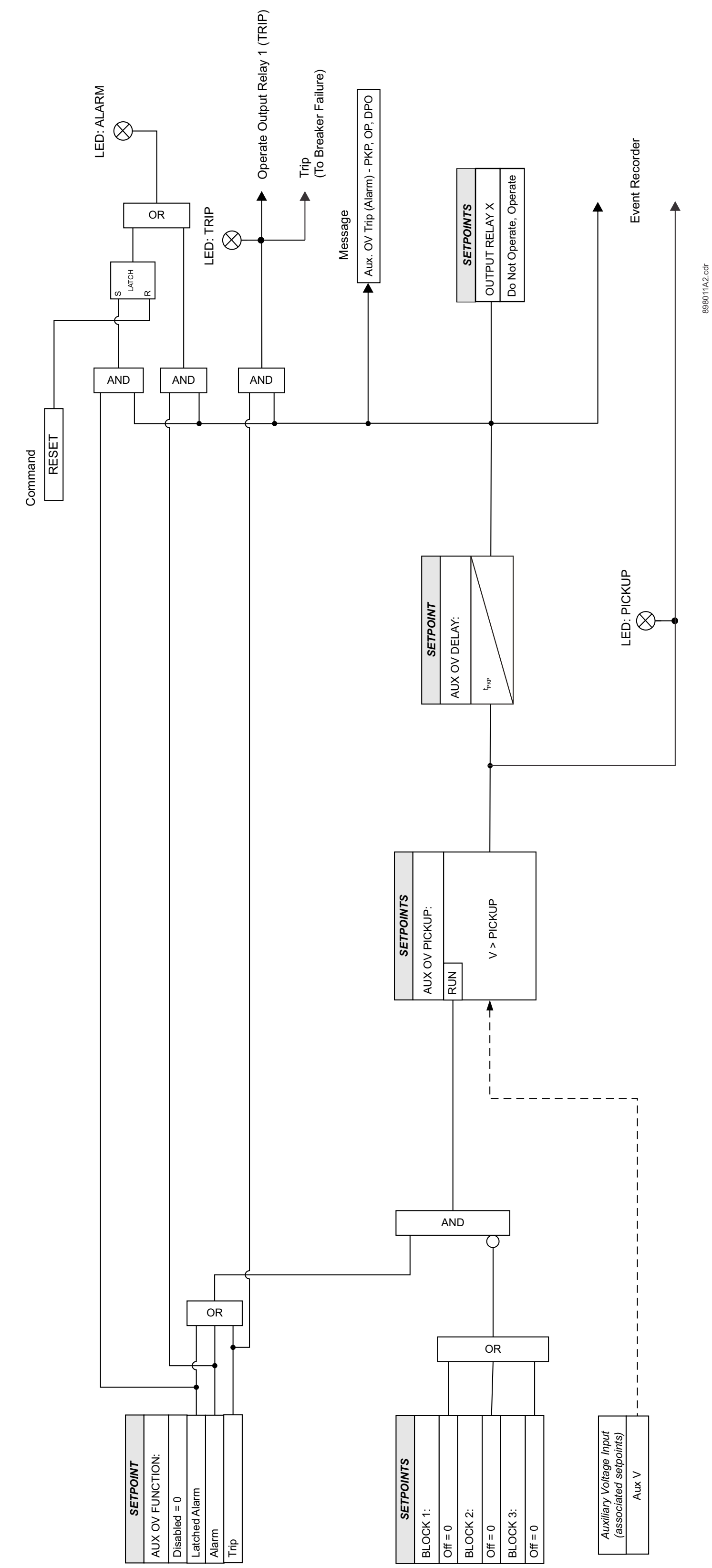
OUTPUT RELAY X

For details see Common setpoints.

BLOCK 1/2/3

For details see Common setpoints.

Figure 6-38: Auxiliary Overvoltage logic diagram



Underfrequency (81U)

The relay is equipped with two Underfrequency elements per setpoint group. These elements can be used for detecting system underfrequency conditions, and be part of an automatic load shedding scheme. The need for such protection 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 frequency will occur and may lead to a complete collapse. The 350 provides two underfrequency elements, which can automatically disconnect sufficient load to restore an acceptable balance between load and generation.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S3 PROTECTION > SETPOINT GROUP 1(2) > UNDER-FREQUENCY1(2)**

UNDERFREQ 1(2) FUNCTION

Range: Disabled, Alarm, Latched Alarm, Trip

Default: Disabled

For details see Common setpoints.

UNDERFREQ 1(2) PKP

Range: 40.00 to 70.00 Hz in steps of 0.01 Hz

Default: 59.00 Hz

This setting defines the Underfrequency pickup level, and it is usually set to a frequency level considered dangerous for the stability of the system.

UNDERFREQ 1(2) DELAY

Range: 0.1 to 600.0 sec in steps of 0.1 sec

Default: 2.0 s

This setting specifies the time delay before underfrequency operation.

MIN VOLTAGE

Range: 0.00 to 1.25 x VT in steps of 0.01

Default: 0.70 x VT

The minimum operating voltage level is programmable to prevent undesired underfrequency operation before voltage becomes available, such as on faults cleared by downstream protection or fuses.

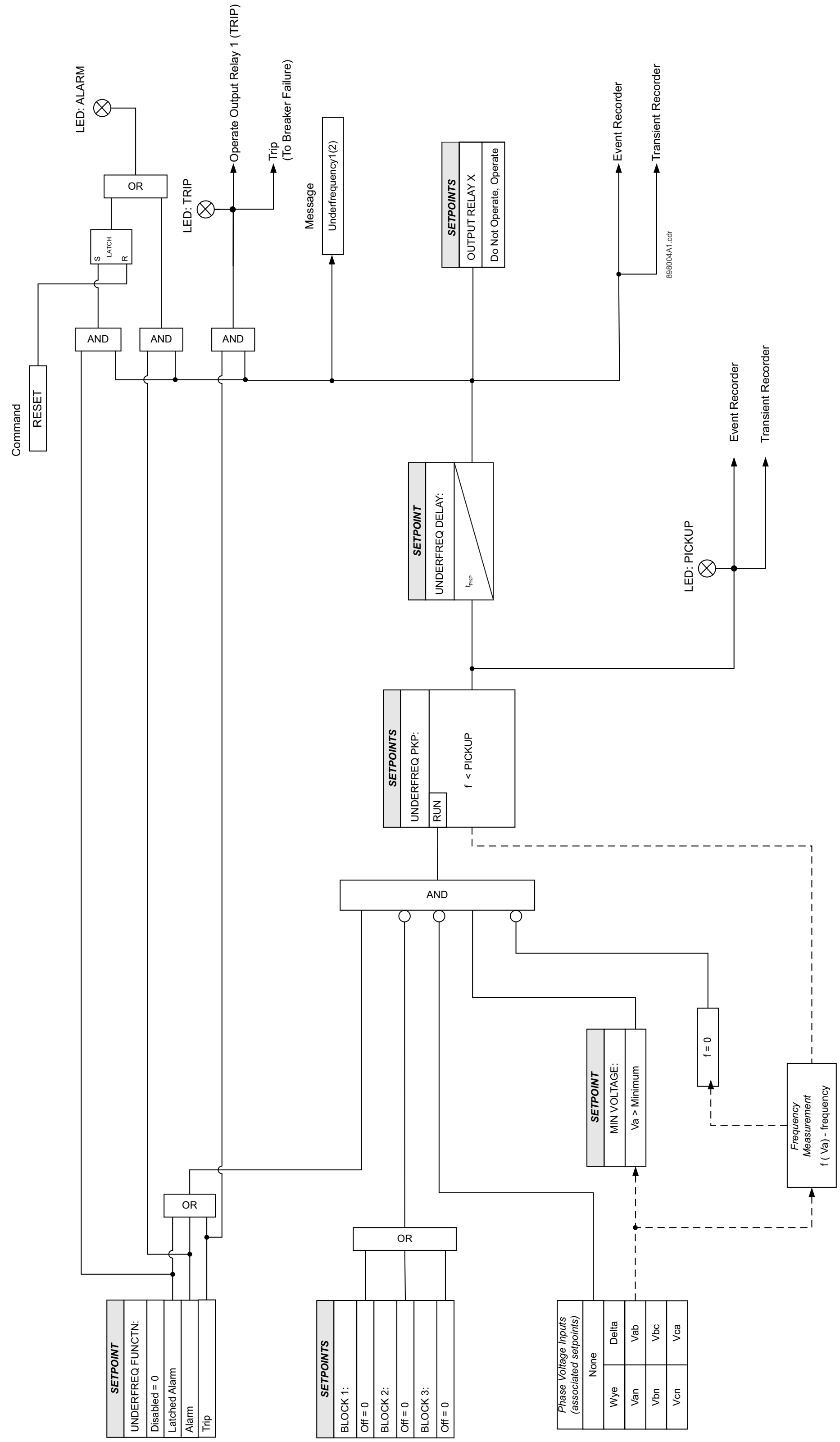
OUTPUT RELAY X

For details see Common setpoints.

BLOCK 1/2/3

For details see Common setpoints.

Figure 6-39: Underfrequency logic diagram



Overfrequency (81O)

The relay is equipped with two Overfrequency elements per setpoint group, ANSI device number 81O-1, and 81O-2. Voltage channel phase A is used for frequency measurement.

The steady-state frequency of a power system is an indicator of the existing balance between generated power and the load. Whenever this power is disrupted through disconnection of significant load or the isolation of a part of the system that has surplus of generation, it would result in increase of frequency. If the control system of the generators do not respond fast enough to quickly ramp the turbine frequency back to normal, the overspeed can lead to turbine trip. The overfrequency elements can be used to control the turbine frequency at a generating location. This element can also be used for feeder reclosing as part of the “after load shedding restoration”

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S3 PROTECTION > SETPOINT GROUP 1(2) > OVER-FREQUENCY1(2)**

OVERFREQ 1(2) FUNCTION

Range: Disabled, Alarm, Latched Alarm, Trip

Default: Disabled

For details see Common setpoints.

OVERFREQ 1(2) PKP

Range: 40.00 to 70.00 Hz in steps of 0.01

Default: 60.50 Hz

This setting defines the Overfrequency pickup level, and it is usually set to a frequency level considered dangerous for the stability of the system.

OVERFREQ 1(2) DELAY

Range: 0.1 to 600.0 s in steps of 0.1

Default: 2.0 s

This setting specifies the time delay before overfrequency operation.

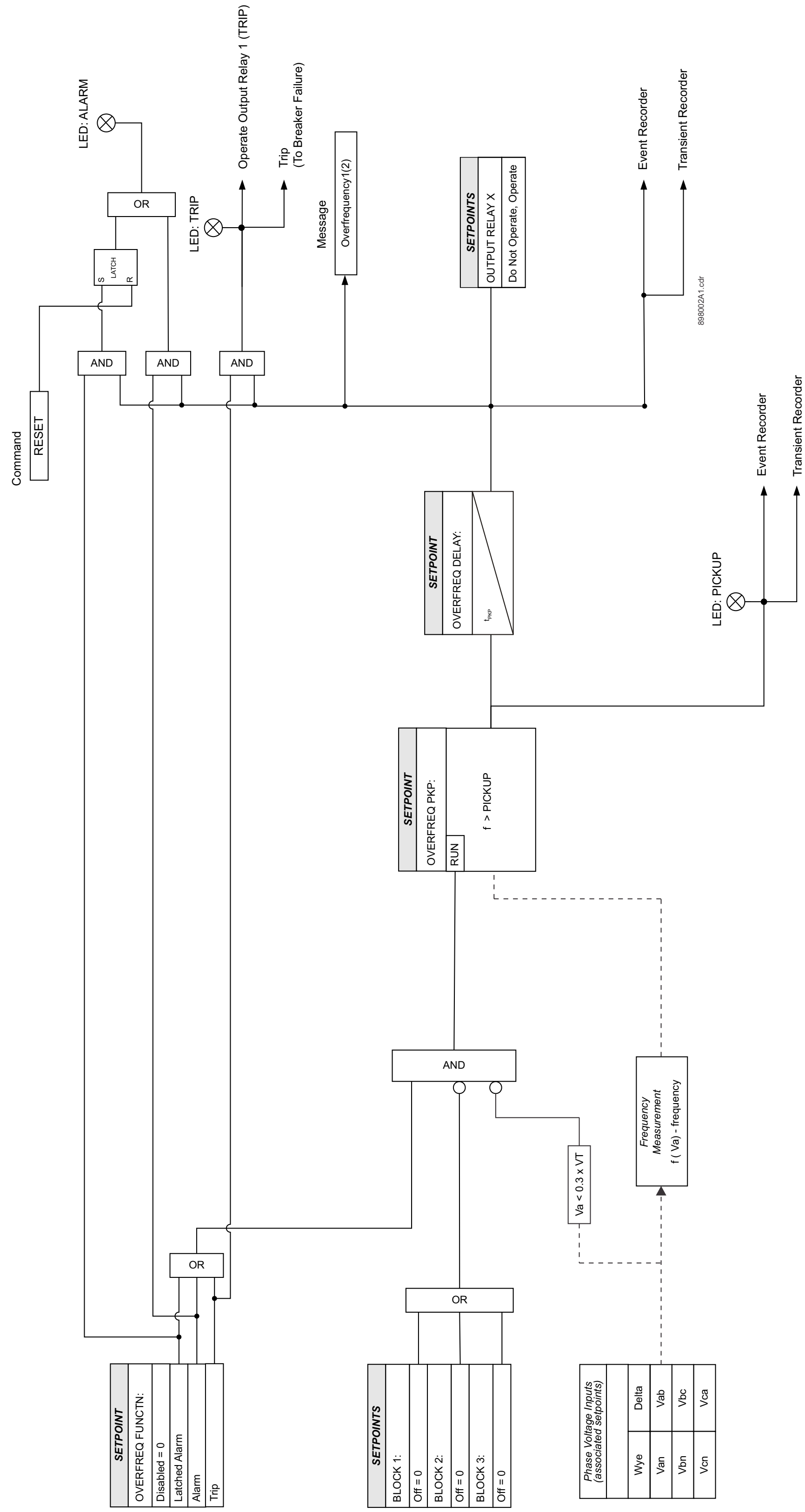
OUTPUT RELAY X

For details see Common setpoints.

BLOCK 1/2/3

For details see Common setpoints.

Figure 6-40: Overfrequency logic diagram



Thermal Overload (49)

The thermal overload protection can be applied to prevent damage to the protected cables, dry transformers, capacitor banks, or even overhead lines. Loads exceeding the load ratings of the protected equipment can, over time, degrade the insulation, and may in return lead to short circuit conditions. As the heating of plant equipment such as cables or transformers is resistive (I^2R), the generated heat is directly proportional to the square of the flowing current (I^2). The relay uses a thermal time characteristic based on current squared and integrated over time.

The relay will continuously calculate the thermal capacity as a percentage of the total thermal capacity. The thermal capacity is calculated as follows:

Eq. 7

$$\theta(t) = \theta(t-1) + \frac{\Delta t}{\tau}\left(\left(\frac{I_{phase}}{I_{pickup}}\right)^2 - \theta(t-1)\right)$$

Where:

$\theta(t)$ = Thermal capacity (%) at time t

$\theta(t-1)$ = Thermal capacity (%) at time $t-1$

$\Delta t/\tau$ = Time step Δt divided by the heating/cooling time constant τ

I_{phase}/I_{pickup} = Ratio between the actual load current and the pickup setting

τ = Heating and cooling time constant, usually provided by the manufacturer.

The heating time constant is used when the squared load/pickup ratio is greater than the thermal capacity $\theta(t-1)$ estimated in the previous time step. Otherwise the formula uses the cooling time constant.

The time to trip is estimated when the load current exceeds the PKP setting, and the 49 element picks up. At the same time, the thermal capacity will start to increase at a rate depending on the current amplitude and the prior loading condition of the cable. When the thermal capacity exceeds the alarm level, the element will generate an alarm signal. The thermal model alarm can be used as a warning for the start of dangerous overload conditions, and can prevent unnecessary tripping. When the thermal capacity exceeds the trip level, the element will generate a trip signal. As per the formula below, the operate time (time to trip) is determined from when the element picks up until it trips, and depends on both the measured load over time, and the equipment heating and cooling time constants.

The time to operate is defined by IEC60255-149 standard and based on the initial equipment state is expressed by the following formulas:

Hot Curve

The time to operate is calculated by the formula below. The formula includes the initial non-zero thermal capacity of the equipment corresponding to a certain load.

Eq. 8

$$T_{TRIP} = \tau \times \ln\left(\frac{(I_{phase}/I_{pickup})^2 - \theta_0}{(I_{phase}/I_{pickup})^2 - \theta}\right)$$

Where:

T_{TRIP} = Time to trip in seconds

θ_0 = Initial thermal capacity

θ = 1 = Thermal capacitystate set to 100%

τ = Heating and cooling time constant, usually provided by the manufacturer.

I_{phase}/I_{pickup} = Ratio of the actual phase current and the pickup setting.

Cold Curve

The time to operate calculated by the formula, starts from thermal level with no load before overload occurs, meaning the equipment temperature is considered as the ambient temperature and its thermal level is considered equal to zero.

Eq. 9

$$T_{TRIP} = \tau \times \ln\left(\frac{(I_{phase}/I_{pickup})^2}{(I_{phase}/I_{pickup})^2 - \theta}\right)$$

The time to trip will start timing out once the level of the computed thermal capacity (%) becomes higher than 100% thermal capacity ($\theta = 1$). The trip flag will dropout when the Thermal capacity falls below 97% of the pickup level.

Calculating the PICKUP setting

In some applications, it is required to apply overload factor (K-factor) to achieve the thermal rating of the protected equipment. In such cases the pickup level need to be calculated based on the K-factor and the base current (rated equipment current). The time to trip is then estimated when the ratio of actual current above the programmed pickup current is higher than 1. The pickup is calculated as follows:

Eq. 10

$$I_{pickup} = K * I_{base}$$

Where:

K = overload factor (usually provided by the equipment manufacturer)

I_{base} = base current (rated current of the equipment)

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S3 PROTECTION > SETPOINT GROUP 1(2) > THERMAL OVLD**

THERMAL OVLD FUNC

Range: Disabled, Latched Alarm, Alarm, Trip

Default: Disabled

The thermal capacity will be displayed on the relay even if the Thermal Overload Function is set to “Disabled. The output relay #1 “Trip” will operate only if the function is selected as a Trip and the thermal capacity value of any phase is over 100%. The LED “ALARM” will turn on when the function is selected as a Trip or Alarm if the thermal capacity value of any phase is over the THERMAL OVLD ALARM setting. This LED will turn off when the thermal capacity value of all phases is below 97% of the THERMAL OVLD ALARM setting. If Latched Alarm is selected as a function setting, the LED “ALARM” will flash if the thermal capacity value of any phase is over the THERMAL OVLD ALARM setting, and will stay “ON” when the thermal capacity value of all phases is below 97% of the THERMAL OVLD ALARM setting, until the reset command is initiated.

The thermal capacity values are stored in memory and can be cleared either by using the "Clear Thermal Capacity" command, or by cycling relay control power.

THERMAL OVLD PKP

Range: 0.05 to 20 x CT in steps of 0.01 x CT

Default: 1.00 x CT

This setting sets the level of phase current above which the thermal model starts timing out the time-to-trip per the logarithmic formula above.

THERMAL OVLD ALARM

Range: 70.0 to 110.0% in steps of 0.1%

Default: 80.0%

This setting sets the alarm level for the accumulated thermal capacity above which the element generates an alarm.

HEAT TIME CONSTANT (τ_H)

Range: 3.0 to 600.0 min in steps of 0.1 min

Default: 6.0 min

This time constant is used to compute the thermal capacity when the thermal capacity at each time-step is greater than the one computed in the previous time-step.

COOL TIME CONSTANT (τ_C)

Range: 1.00 to 6.00 × τ_H in steps of 0.01 × τ_H

Default: 2.00 × τ_H

This time constant is used to compute the thermal capacity when the thermal capacity at each time-step is less than the one computed in the previous time-step.

OUTPUT RELAY X

For details see Common setpoints.

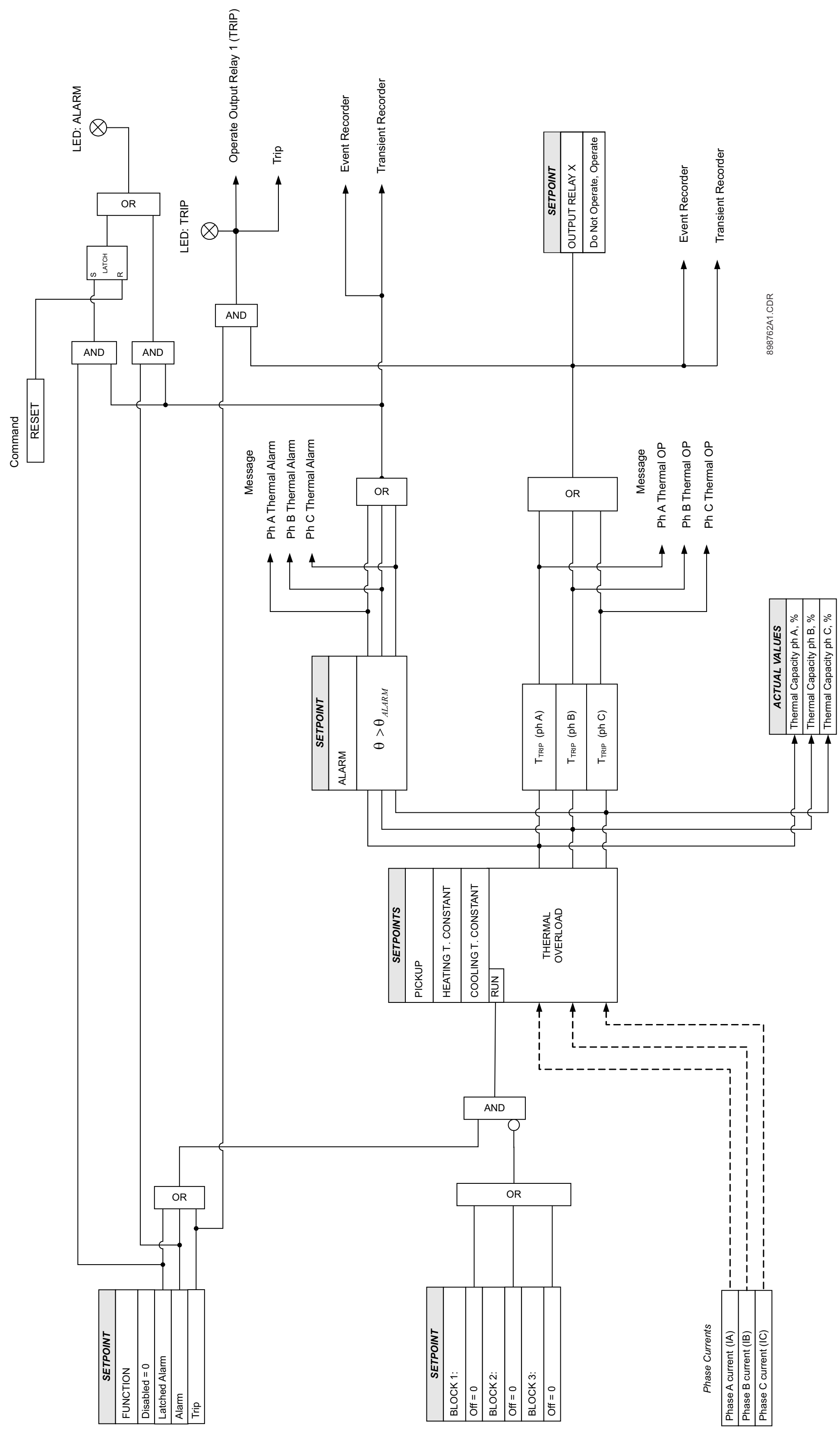
BLOCK 1/2/3

For details see Common setpoints.

NOTE

The thermal capacity is displayed on the relay even if the Thermal Overload Function is set to "Disabled".

Figure 6-41: Thermal Overload protection logic diagram



Wattmetric ground fault (32N)

The Wattmetric ground fault element, also called Wattmetric Zero-sequence Directional element, responds to power derived from zero-sequence voltage and zero-sequence current in a direction specified by the element characteristic angle. The angle can be set within all four quadrants, so the measured power can be active or reactive or some combination thereof. Therefore the element can be used to sense either forward or reverse ground faults in either inductively, capacitively, or resistively grounded networks. The inverse time characteristic allows time coordination of elements across the network.

Typical applications include ground fault protection in solidly grounded, ungrounded, resistor-grounded, or resonant-grounded networks, or for directionalizing other non-directional ground elements.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S3 PROTECTION > SETPOINT GROUP 1(2) > WATT GND FLT**

FUNCTION

Range: Disabled, Alarm, Latched Alarm, Trip, Control

Default: Disabled

For details see Common setpoints.

VOLTAGE

Range: Calculated Vn, Measured Vx

Default: Calculated Vn

This setting uses neutral voltage (that is, three times the zero-sequence voltage). The setpoint allows selecting the internally calculated neutral voltage, or externally supplied voltage (broken delta VT connected to the auxiliary channel of the relay).

NOTE

When Calculated Vn is selected, the VT CONNECTION setting must be set to wye for the element to run. When Measured Vx is selected, the AUX VT INPUT under **SETPOINTS > S2 SYSTEM SETUP > VOLTAGE SENSING** must be set to neutral voltage (Vn) under the VT bank setpoints for the element to run.

VOLTAGE PICKUP

Range: 0.02 to 1.00 x VT in steps of 0.01 x VT

Default: 0.20 x VT

This setpoint specifies the minimum neutral voltage for supervising the power measurement. This threshold is higher than possible unbalance during normal operation of the system. Typically, this setpoint is selected at 0.1 to 0.2 x VT for ungrounded or resonant grounded systems, and at 0.05 to 0.1 x VT for resistor grounded systems.

When the VOLTAGE setpoint value is Measured Vx, 1 x VT is the AUX VT SECONDARY setpoint value multiplied by the AUX VT RATIO setpoint value.

When the VOLTAGE setpoint value is Calculated Vn, 1 x VT is the VT SECONDARY setpoint value multiplied by the VT RATIO setpoint value.

CURRENT

Range: Calculated In, Measured Ig

Default: Calculated In

This setting corresponds to the neutral current (that is, three times the zero-sequence current), either calculated internally from the phase currents or supplied externally via the ground CT input from more accurate sources such as a core balance CT. This setpoint selects the source of the operating current.

CURRENT PICKUP

Range: 0.002 to 20.000 x CT in steps of 0.001 x CT
Default: 0.060 x CT

This setpoint specifies the neutral current supervision level for the measurement of zero sequence power.

When the CURRENT setpoint value is Measured Ig, 1 x CT is the GROUND [SENS GND] CT PRIMARY setpoint value. When the CURRENT setpoint value is Calculated In, 1 x CT is the PHASE CT PRIMARY setpoint value.

POWER PICKUP

Range: 0.001 to 1.200 CTxVT in steps of 0.001 CTxVT
Default: 0.100 CTxVT

This setpoint specifies the operating point of the element.

A value of 1 CTxVT is a product of the 1 x VT voltage as specified in the VOLTAGE PICKUP setpoint description of this element, and 1 x CT current as specified for the CURRENT PICKUP setpoint of this element.

REF POWER PICKUP

Range: 0.001 to 1.200 CTxVT in steps of 0.001 CTxVT
Default: 0.100 CTxVT

This setpoint is used to calculate the inverse time characteristic delay (defined by Sref in the equations below).

A value of 1 CTxVT is a product of the 1 VT voltage as specified in the VOLTAGE PICKUP setpoint description of this element, and 1 CT current as specified for the CURRENT PICKUP setpoint of this element.

ECA

Range: 0 to 359° in steps of 1°
Default: 0°

The setpoint adjusts the maximum torque angle of the element. The operating power is calculated as:

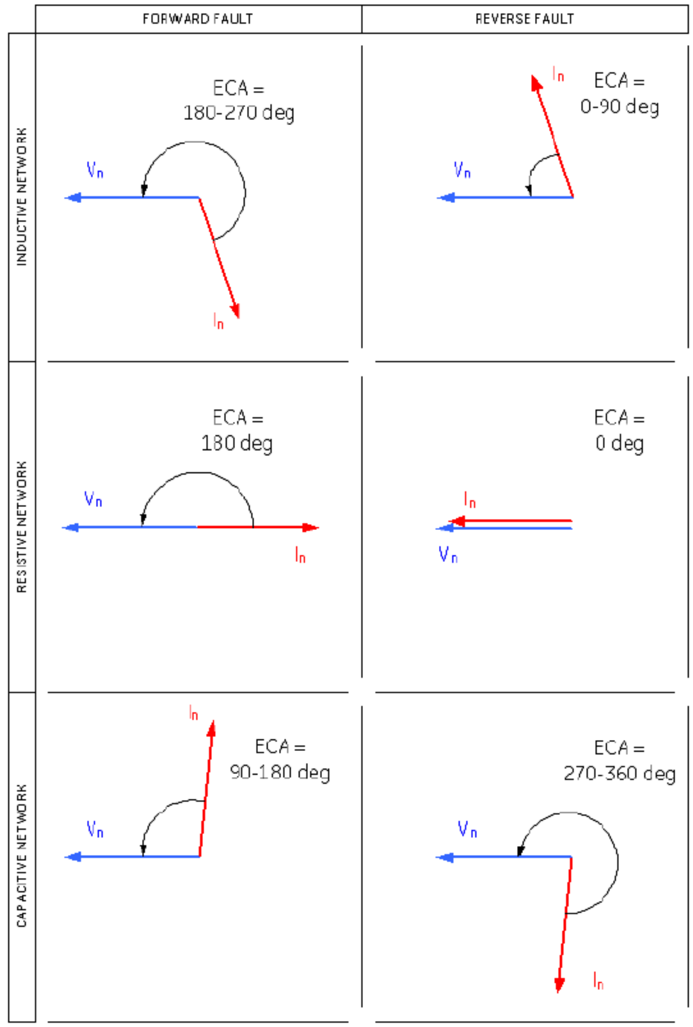
Eq. 11

$$S_{op} = \mathbf{Re}\{V_n \cdot (I_n \cdot 1\angle \mathbf{ECA}°)^*\}$$

Where * indicates complex conjugate and · indicates simple vector multiplication.

By varying the element characteristic angle (ECA), the element can be made to respond to forward or reverse direction in inductively, resistively, or capacitively grounded networks as shown in the Wattmetric characteristic angle response diagram below.

Figure 6-42: Wattmetric characteristic angle response



POWER PICKUP DELAY

Range: 0.00 to 300.00 s in steps of 0.01 s

Default: 0.20 s

This setpoint defines a definite time delay before the inverse time characteristic is activated. If the curve selection is set as "Definite Time" the element operates after this security time delay. If the curve selection is "Inverse" or one of the FlexCurves, the element uses both the definite and inverse time timers sequentially. The definite time timer specified by this setpoint, is used, and when it expires it releases the inverse time timer for operation.

CURVE

Range: Definite Time, Inverse, FlexCurve A, FlexCurve B

Default: Definite Time

This setpoint allows the choice of one of three methods to delay the operate signal once all the conditions are met to discriminate fault direction.

The "Definite Time" selection allows for a fixed time delay defined by the POWER PICKUP DELAY setpoint.

The "Inverse" selection allows for inverse time characteristics delay t defined by the following formula:

Eq. 12

$$t = m \times S_{ref}/S_{op}$$

where:m is a multiplier defined by the MULTIPLIER setpoint value

S_{ref} is the REF POWER PICKUP setpoint value

S_{op} is the operating power at the time. This timer starts after the definite time timer expires.

The "FlexCurve A" and "FlexCurve B" selections allow custom user-programmable time characteristics. When working with FlexCurves, the element uses the operate power to reference power ratio, and the multiplier setpoint is not applied:

Eq. 13

$$t = \text{FlexCurve}(S_{ref}/S_{op})$$

NOTE: The TDM for the Flexcurve in this equation is 1.00.

Again, the inverse time timer starts after the definite time timer expires. Inverse time reset is instantaneous whenever S_{op} is less than S_{ref}.

MULTIPLIER

Range: 0.01 to 2.00 s in steps of 0.01 s

Default: 1.00 s

This setting is applicable only if the CURVE setpoint above is selected to Inverse. It defines the multiplier factor m for the inverse time delay.

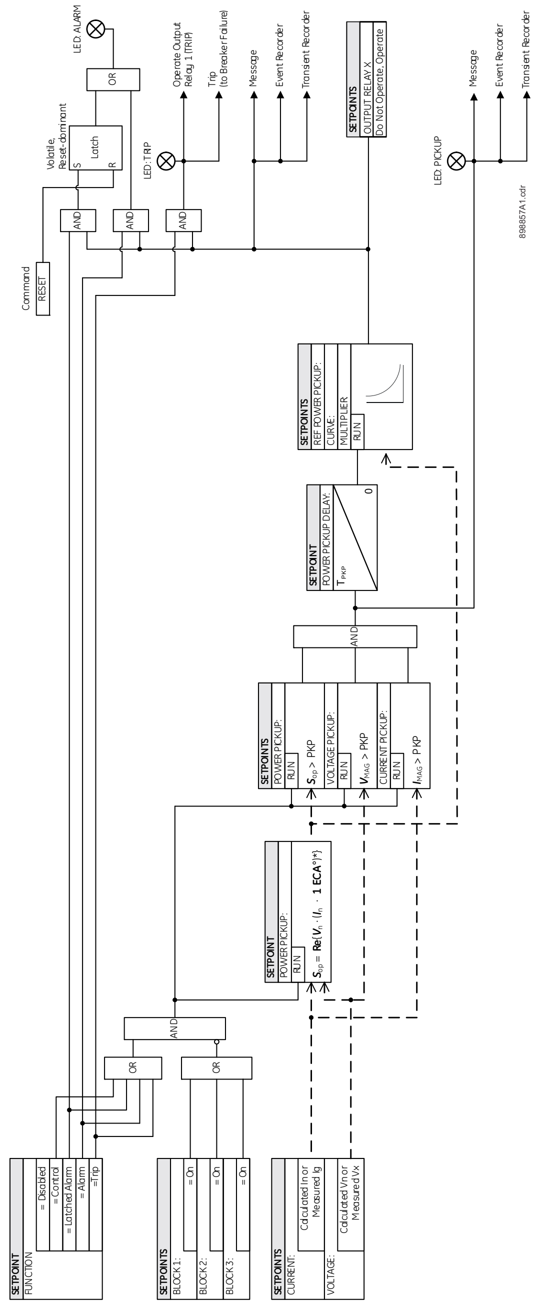
OUTPUT RELAY X

For details see Common setpoints.

BLOCK 1/2/3

For details see Common setpoints.

Figure 6-43: Wattmetric ground fault logic diagram



Directional power (32)

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 function has two independent elements; typically one element is used for alarming and the other stage for tripping.

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:

$$P \cos\theta + Q \sin\theta > SMIN$$

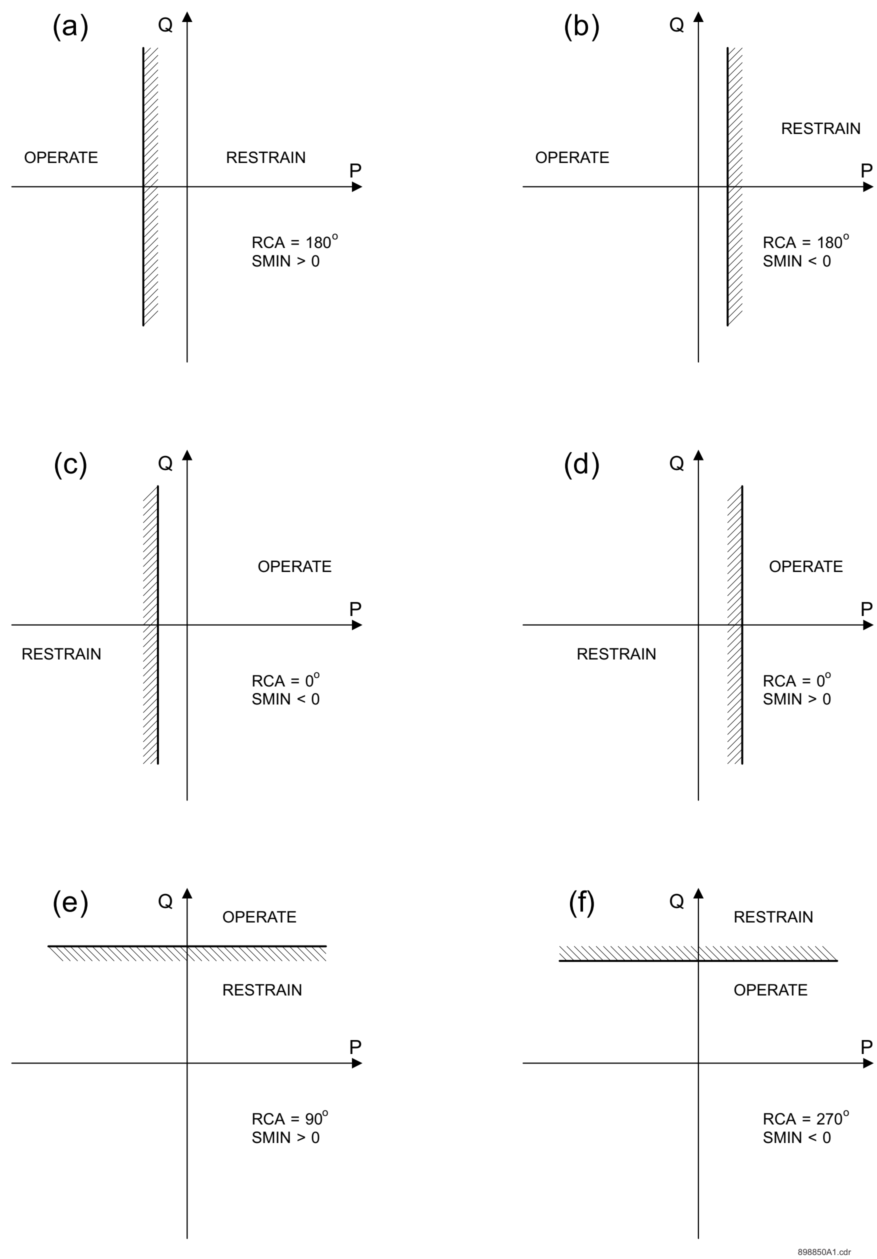
Where:

P and Q are active and reactive powers

angle theta is the element characteristic (RCA) angles

SMIN is the minimum operating power.

Figure 6-44: Sample applications of the directional power element



NOTE

The element drops out if the magnitude of the positive-sequence current becomes virtually zero, that is, it drops below 0.02 x CT. Such a condition is taken as an indication that the protected equipment is disconnected.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S3 PROTECTION > SETPOINT GROUP 1(2) > DIRECTIONAL POWER**

FUNCTION

Range: Disabled, Alarm, Latched Alarm, Trip, Control

Default: Disabled

For details see Common setpoints.

RCA

Range: 0 to 359° in steps of 1°

Default: 0°

This setting specifies the Relay Characteristic Angle (RCA) for the Directional Power function. Application of this setting is threefold:

- It allows the element to respond to active or reactive power in any direction (active overpower/underpower, etc.).
- It allows compensation for any CT and VT angular errors to permit more precise settings.
- It allows for the 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 RCA to "0°," reactive overpower by setting RCA to "90°," active underpower by setting RCA to "180°," and reactive underpower by setting RCA to "270°".

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 of the directional power element figure above for details. Together with the RCA, this setting enables a wide range of operating characteristics.

The setting is a multiple of rated power where:

When VT CONNECTION = Wye,

Rated Power= 3 x VT SECONDARY x VT RATIO x PHASE CT PRIMARY

When VT CONNECTION = Delta,

Rated Power = sqrt(3) x VT SECONDARY x VT RATIO x PHASE CT PRIMARY

PICKUP DELAY

Range: 0.0 to 600.0 s in steps of 0.1 s

Default: 0.50 s

This setting specifies the time delay for this function to operate after pickup.

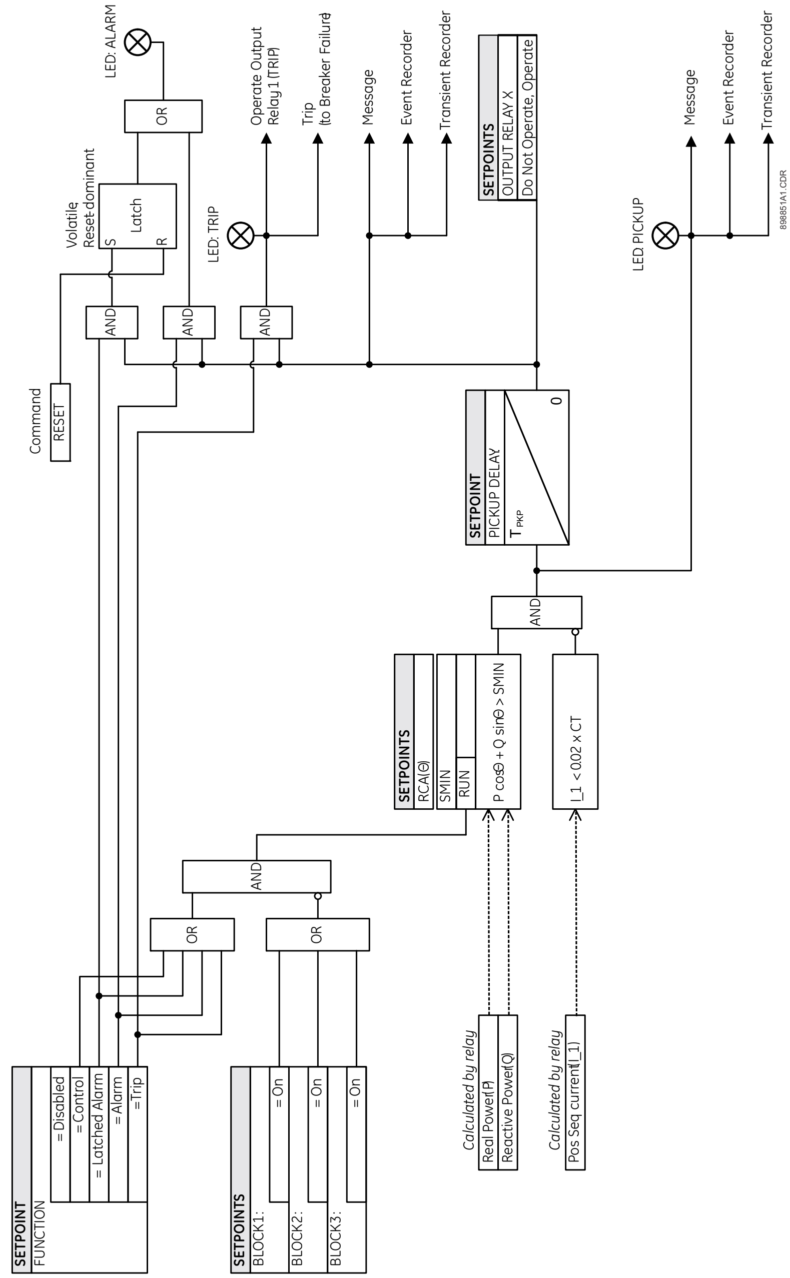
OUTPUT RELAY X

For details see Common setpoints.

BLOCK 1/2/3

For details see Common setpoints.

Figure 6-45: Directional power logic diagram



Broken conductor (I1/I2 or 46BC)

The Broken Conductor detection function detects a feeder broken conductor condition or a single-pole open breaker malfunction condition by checking the phase current input phasors and the I_2 / I_1 ratio. In normal and balanced load situations this ratio is zero, while in broken conductor conditions an unbalance is produced and this ratio increases. The intention of this function is to detect a single-phase broken conductor only. As such, two-phase or three-phase broken conductors cannot be detected.

The broken conductor element compares the I_2 / I_1 ratio against a programmed threshold, while I_1 is the normal range. To distinguish between a single-phase disappearance and a system disturbance in all three phases (such as load change, switching, etc.), the broken conductor element also monitors for a change in only a single phase current.

NOTE

Note that there are several broken conductor scenarios that this element cannot detect.

The broken conductor Pickup flag is asserted when the I_2 / I_1 ratio is above the I_2/I_1 RATIO setting's value, the positive sequence current is between I_1 MIN and I_1 MAX, and a single phase current changes by more than 0.05 x CT. The broken conductor Trip flag is asserted if the element stays picked up for the time defined by the PICKUP DELAY setting. The element instantaneously drops from pickup without operation if the I_2 / I_1 ratio decreases to below 97% to 98% of the pickup value before the time for operation is reached.

PATH: **SETPOINTS > S3 PROTECTION > SETPOINT GROUP 1(2) > BROKEN CONDUCTOR**

BROKEN CONDUCTOR FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Control

Default: Disabled

For details see Common setpoints.

I_2/I_1 RATIO

Range: 20.0% to 100.0% in steps of 0.1%

Default: 20.0%

This setting specifies the ratio of negative-sequence current to positive-sequence current for element operation. When one phase conductor is broken, the I_2 / I_1 ratio with balanced remaining phases is 50%. Thus, usually this setting should be set below 50% (for example, to 30%).

I_1 MIN

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

Default: 0.10 x CT

This setting specifies the minimum positive-sequence current supervision level. Ensure the setting is programmed to a level sufficient to prevent the I_2 / I_1 ratio from causing erratic pickup due to a low I_1 signal. However, this setting cannot be set too high since the broken conductor condition cannot be detected under light load conditions when I_1 is less than the value specified by this setting.

I_1 MAX

Range: 0.05 to 5.00 x CT in steps of 0.01 x CT

Default: 0.10 x CT

This setting specifies the maximum I_1 level allowed for the broken conductor function to operate. When I_1 exceeds this setting, it is considered a fault. This broken conductor function should not respond to any fault conditions so normally the setting is programmed to less than the maximum load current.

PICKUP DELAY

Range: 0.000 to 60.000 s in steps of 0.001 s

Default: 20.000 s

This setting specifies the pickup time delay for this function to operate after broken conductor pickup. The time delay should be programmed to a sufficient length to ensure coordination with external fault clearing and with the dead time of any single-phase reclosers.

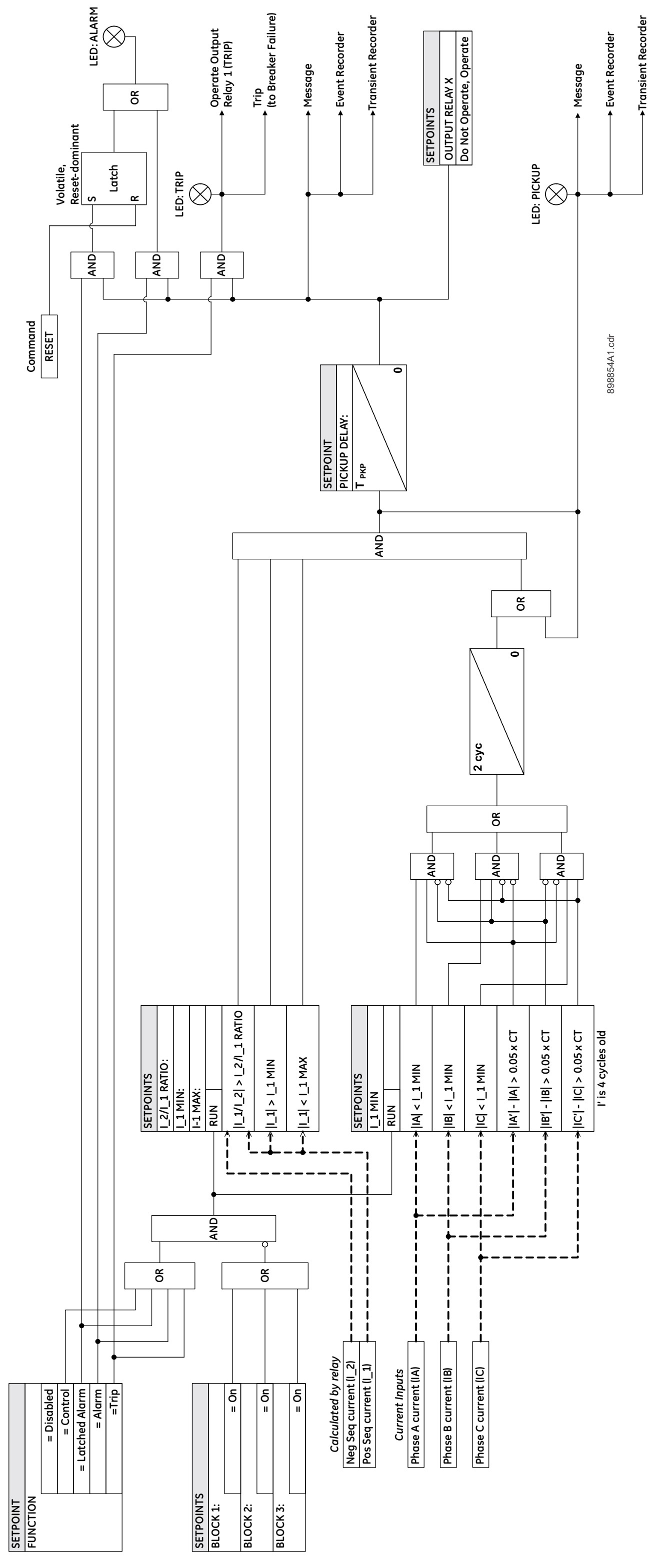
OUTPUT RELAY X

For details see Common setpoints.

BLOCK 1/2/3

For details see Common setpoints.

Figure 6-46: Broken conductor logic diagram



Positive sequence undervoltage (27_1)

The relay has one Positive Sequence Undervoltage element per protection group. The input for this element is the computed positive sequence voltage based on measured three-phase voltages at relay terminals. The time delay characteristic can be programmed as either definite time, or inverse time. A minimum operating voltage level is programmable to prevent undesired operation before voltage becomes available.

- **Undervoltage Protection**: For voltage sensitive loads, such as induction motors, a drop in voltage will result in an increase in the drawn current, which may cause dangerous overheating in the motor. The undervoltage protection feature can be used to either cause a trip or generate an alarm when the voltage drops below a specified voltage setting for a specified time delay.
- **Permissive Functions**: The undervoltage feature may be used to block the functioning of external devices by operating an output relay, when the voltage falls below the specified voltage setting. Note that all internal features that are inhibited by an undervoltage condition, such as underfrequency and overfrequency, have their own inhibit functions independent of the undervoltage protection features.
- **Source Transfer Schemes**: In the event of an undervoltage, a transfer signal may be generated to transfer a load from its normal source to a standby or emergency power source.

The undervoltage elements can be programmed to have an inverse time delay characteristic. The undervoltage delay setpoint defines a family of curves as shown below. The operating time is given by:

$$T = \frac{D}{1 - V/V_{pu}}$$ **Eq. 14**

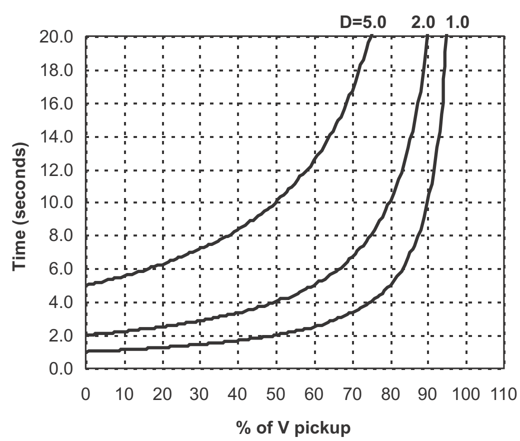
Where:

T = Operating Time
D = Undervoltage Delay setpoint
V = Voltage as a fraction of the nominal VT Secondary Voltage
V_{pu} = Pickup Level

NOTE

At 0% of pickup, the operating time equals the Undervoltage Delay setpoint.

Figure 6-47: Inverse time undervoltage curves



The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: SETPOINTS > S3 PROTECTION > S3 SETPOINT GROUP 1(2) > POSITIVE SEQ UV 1(2)

POS SEQ UV FUNCTION

Range: Disabled, Alarm, Latched Alarm, Trip

Default: Disabled

For details see Common setpoints.

POS SEQ UV PKP

Range: 0.00 to 1.25 x VT in steps of 0,01

Default: 0.75 x VT

This setting defines the positive sequence UV pickup level.

POS SEQ UV CURVE

Range: Definite Time, Inverse Time

Default: Inverse Time

This setting selects the type of timing-inverse time/definite time, to define the time of positive sequence undervoltage operation based on selected UV time delay, and the actual undervoltage condition with respect to the selected UV pickup.

POS SEQ UV DELAY

Range: 0.00 to 600.00 sec in steps of 0.01 sec

Default: 2.0 s

This setting specifies the time delay before UV operation, when Definite Time is selected under the POS SEQ UV CURVE setting.

POS SEQ UV MIN VOLTAGE

Range: 0.00 to 1.25 x VT in steps of 0,01

Default: 0.30 x VT

The minimum operating voltage level is programmable to prevent undesired UV operation before voltage becomes available.

NOTE

The minimum voltage setting follows a different criteria from the pickup setting. The pickup setting accounts for the rated VT secondary value connection being either WYE or DELTA depending on the connection setting, however, the minimum voltage setting assumes the rated VT secondary value connection is WYE. As a result, when the connection is instead DELTA, the user must set the Min Voltage value SQRT(3) times higher than expected in order to compensate.

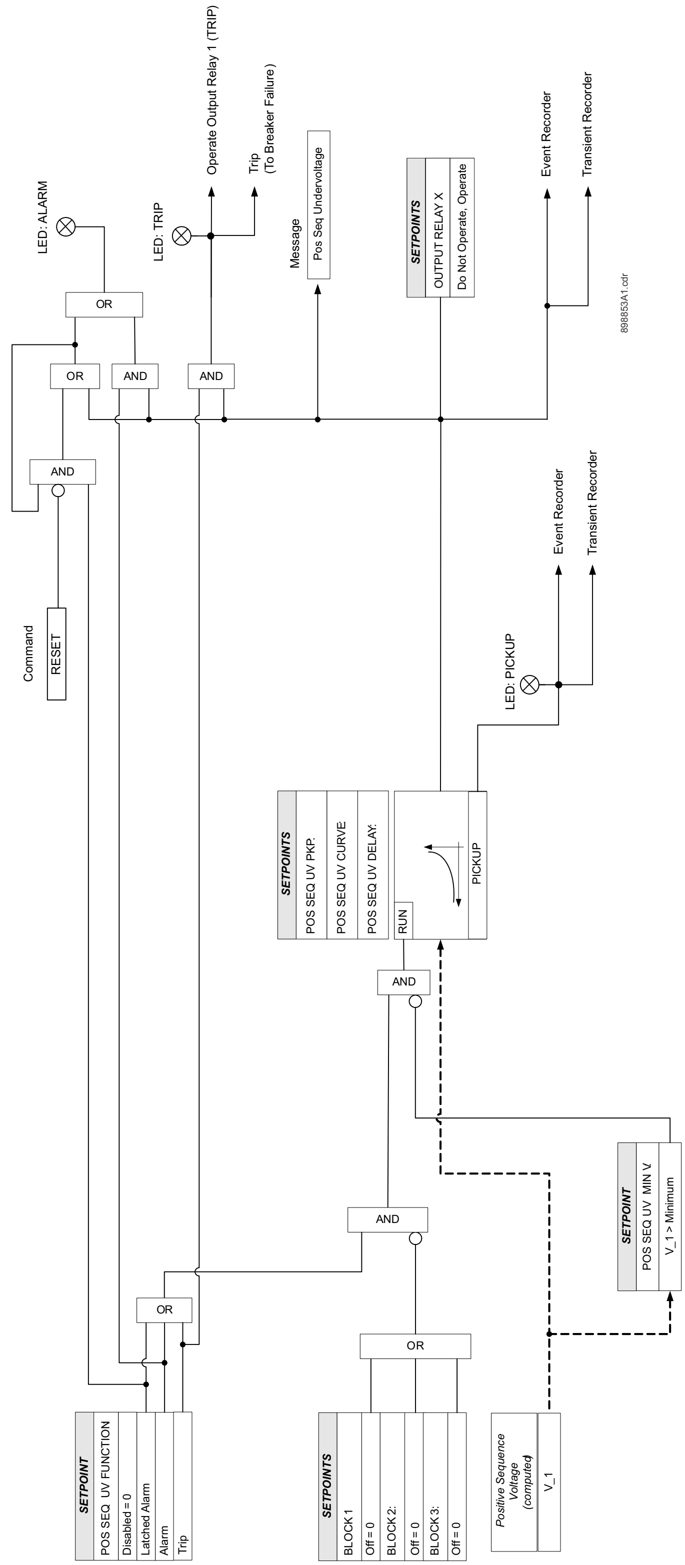
OUTPUT RELAY X

For details see Common setpoints.

BLOCK 1/2/3

For details see Common setpoints.

Figure 6-48: Positive sequence undervoltage logic diagram



Volts per Hertz (24)

Volts-per-hertz (V/Hz) protection can be applied to transformer feeders to detect overexcitation that can be dangerous for the transformer. The flux in the transformer core is directly proportional to the voltage and inversely proportional to the frequency. When V/Hz ratios are exceeded, saturation of the magnetic core of the transformer occurs. This causes saturation of the normal iron path designed to carry that flux, which instead follows leakage paths, causing damage as well as iron burning from the interlamination iron core.

This can happen in the following cases:

- In an islanded power system operating condition, where the sudden loss of load causes a voltage rise. Unsuccessful reduction of the voltage in such disturbances.
- When a generator voltage runaway condition causes the Generator Step-up Unit and the auxiliary transformer to encounter high voltages.
- At low frequencies where overfluxing typically occurs, full protection is especially important. Consider a generator coasting down with full excitation applied. If the exciter does not have a V/Hz limiter, the voltage regulator attempts to maintain rated voltage as speed decreases. To avoid transformer (and generator) damage, the V/Hz protection must remove the transformer from service, and also trip the generator exciter breaker.

The volts-per-hertz (V/Hz) value is derived from the maximum of the three-phase voltage inputs. If there is no voltage on the relay terminals, the V/Hz value is automatically set to 0. The measured voltage from the V/Hz ratio is expressed with reference to the nominal voltage entered under Voltage Sensing setup. The measured frequency is expressed with respect to the nominal frequency entered under Power System setup. These setpoints can be found at the following paths:

Voltage: **PATH**: **SETPOINTS > S2 SYSTEM SETUP > VOLTAGE SENSING > VT SECONDARY**

Frequency: **PATH**: **SETPOINTS > S2 SYSTEM SETUP > POWER SYSTEM > NOMINAL FREQUENCY**

For example, if the Phase VT Secondary and Nominal Frequency are set to 120 V and 60 Hz, respectively, these 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), this means 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. 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).

The element has a linear reset characteristic, and the reset time can be programmed to match the cooling characteristics of the protected equipment. The element will fully reset from the trip threshold once the set reset time has elapsed. The V/Hz element may 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 below.

PATH: **SETPOINTS > S3 PROTECTION > SETPOINT GROUP 1(2) > VOLTS PER HERTZ**

FUNCTION

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

For details see Common setpoints.

VOLTAGE MODE

Range: Phase-ground, Phase-phase

Default: Phase-ground

If the Phase VT Connection is set to "Wye", then the Voltage Mode setting further defines the operating quantity and per-unit value for this element.

When "Phase-ground" is selected, the relay applies the phase-to-ground nominal voltage programmed as VT Secondary from Voltage Sensing menu.

When "Phase-phase" voltage mode is selected, then the computed phase-phase voltage as an operating quantity is referenced with respect to the phase-to-phase nominal voltage, that the relay calculates when multiplying the programmed phase-ground nominal voltage and the square root of 3.

If the Phase VT Connection (set under **SETPOINTS > S2 SYSTEM SETUP > VOLTAGE SENSING > VT CONNECTION** is set to "Delta", then the programmed 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 V/Hz

Default: 1.05 x V/Hz

Enter the pickup value (multiple of V/Hz), above which the volts-per-hertz element will pickup. For example, if Phase VT Secondary and Nominal Frequency are set to 120 V and 60 Hz respectively, and Pickup is set to 1.05 x (V/Hz) then the volts-per-hertz element will pickup, when the actual division of the measured volts by the detected frequency is above 2.1.

CURVE

Range: Definite Time, Inverse A, Inverse B, Inverse C, FlexCurve A, FlexCurve B

Default: Definite TIme

Definite Time:

For the definite time curve, T(s) = TD multiplier. For example, setting the TD multiplier to 20 results a time delay of 20 seconds to operate when above the Volts/Hz pickup setting.

Inverse Curve A:

The curve for the Volts/Hertz Inverse Curve A shape is derived from the formula:

$$T = \frac{TDM}{\left[\left(\frac{V}{Hz}\right)\Big/ Pickup\right]^2 - 1} \quad \text{when} \quad \frac{V}{F} > Pickup$$

where:

T = Operating Time

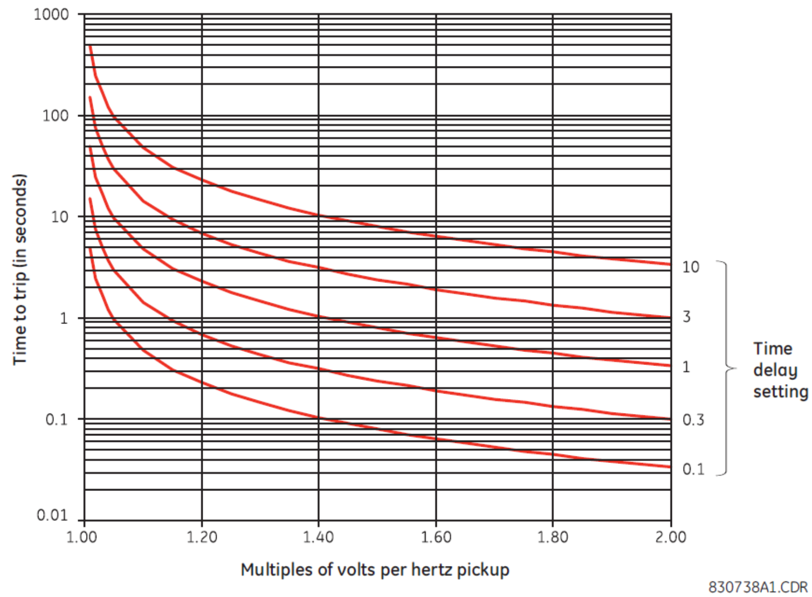
TDM = Time Delay Multiplier (delay in seconds)

V = fundamental RMS value of voltage

F = frequency of voltage signal

Pickup = volts-per-hertz pickup setpoint

Figure 6-49: Volts-per-hertz curves, inverse curve A



Inverse Curve B:

The curve for the Volts/Hertz Inverse Curve B shape is derived from the formula:

$$T = \frac{TDM}{\left[\left(\frac{V}{Hz}\right)/Pickup\right] - 1} \quad when \quad \frac{V}{F} > Pickup$$

where:

T = Operating Time

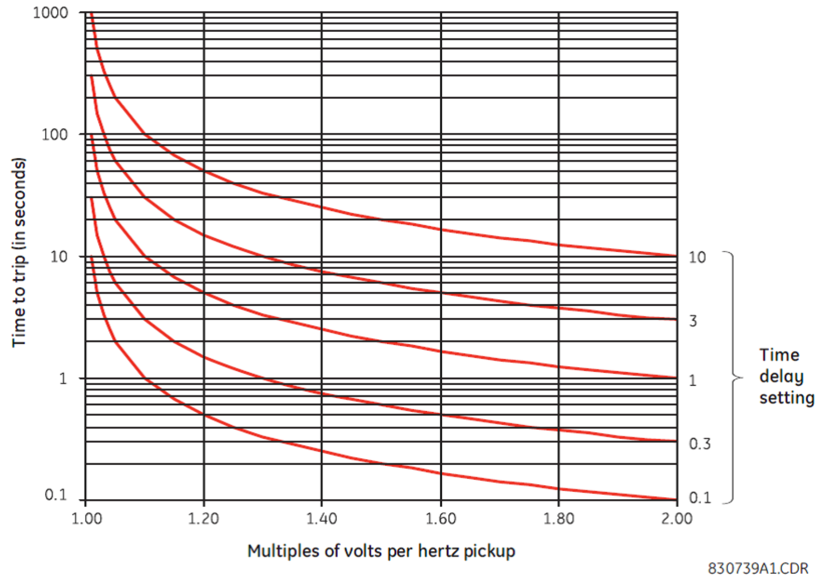
TDM = Time Delay Multiplier (delay in seconds)

V = fundamental RMS value of voltage

F = frequency of voltage signal

Pickup = volts-per-hertz pickup setpoint

Figure 6-50: Volts-per-hertz curves, inverse curve B



Inverse Curve C:

The curve for the Volts/Hertz Inverse Curve C shape is derived from the formula:

$$T = \frac{TDM}{\left[\left(\frac{V}{Hz}\right)/Pickup\right]^{1/2} - 1} \quad when \ \frac{V}{F} > Pickup$$

where:

T = Operating Time

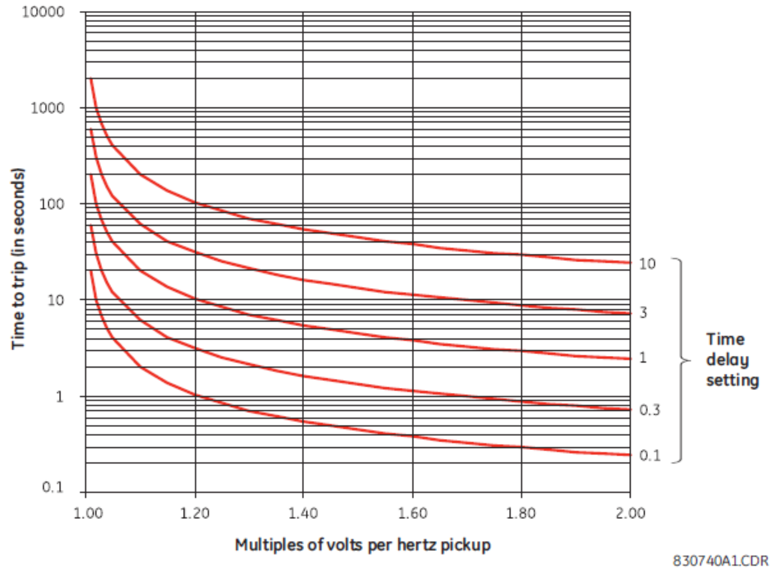
TDM = Time Delay Multiplier (delay in seconds)

V = fundamental RMS value of voltage

F = frequency of voltage signal

Pickup = volts-per-hertz pickup setpoint

Figure 6-51: Volts-per-hertz curves, inverse curve C



TD MULTIPLIER

Range: 0.05 to 600.00 in steps of 0.01

Default: 1.000

This setting provides a selection for Time Dial Multiplier which modifies the operating times per the selected inverse curve. When the curve is set Definite Time T(s) = TD multiplier. For example, setting the TD multiplier to 20 results a time delay of 20 seconds to operate when above the Volts/Hz pickup setting..

RESET TIME

Range: 0.00 to 6000.00 s in steps of 0.01 s

Default: 1.00 s

The time that the volts per hertz value must remain below the pickup level before the element resets.

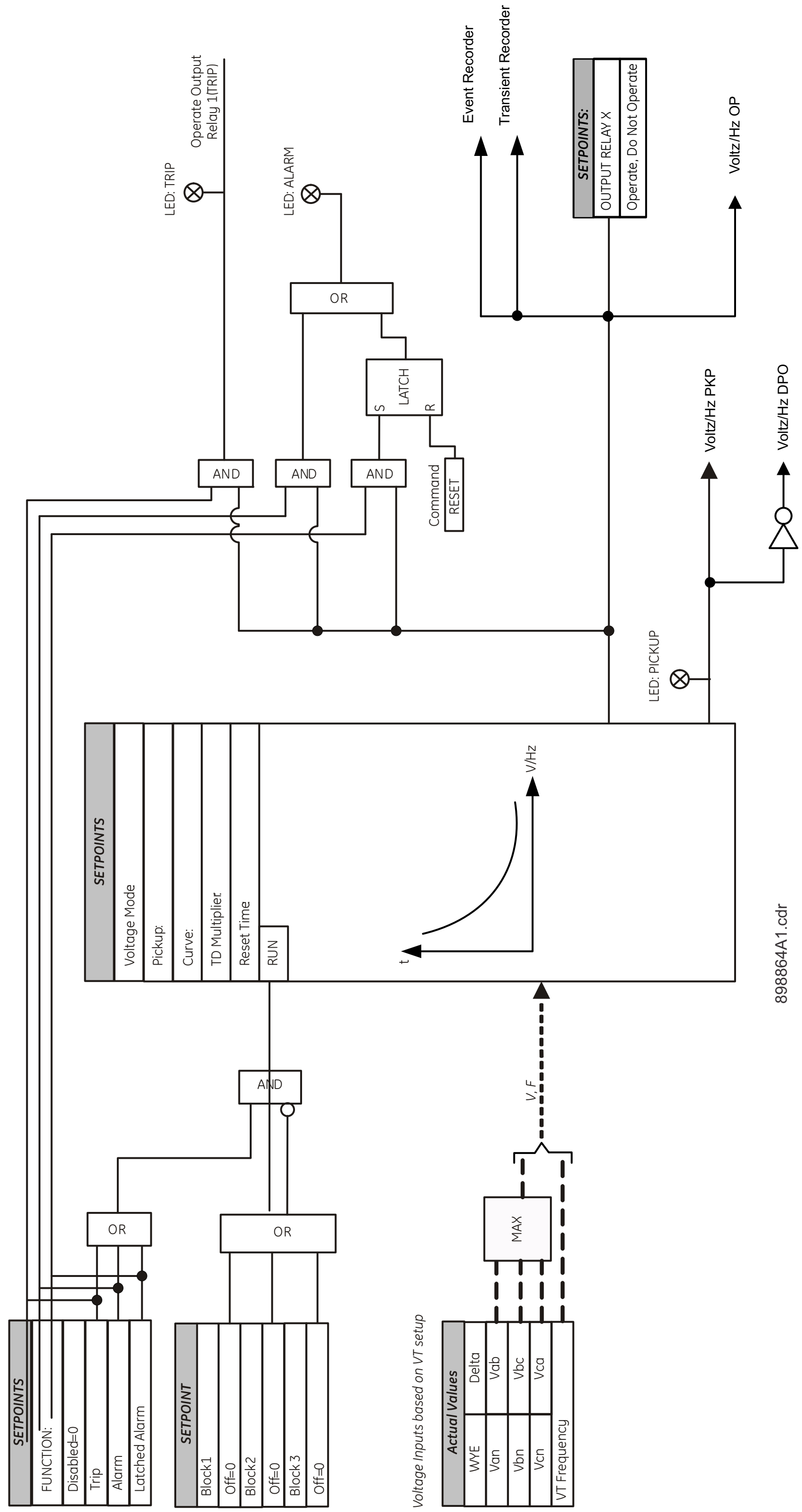
OUTPUT RELAY X

For details see Common setpoints.

BLOCK 1/2/3

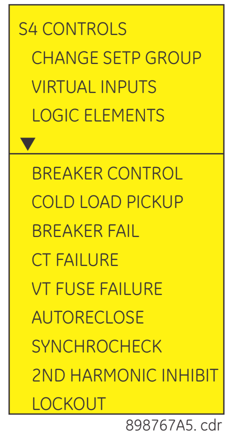
For details see Common setpoints.

Figure 6-52: Volts-per-hertz logic diagram



S4 Controls

Figure 6-53: Main controls menu



Change setpoint group

The 350 relay has two identical setpoint groups- Group 1 and Group 2 for all protection elements. Switching between these two groups is available automatically by assigning an input (contact, virtual, remote, logic element), or via communications.

Group 1 is the default setpoint group. The relay can automatically switch from Group 1 protections to Group 2 protections, and vice versa, by setting up the switching conditions under "Change Setpoint Group". Under some application conditions, such as an overcurrent element pick up, it may not be desirable to change setpoint groups. A setpoint change can also be prevented if the breaker is open, so that a fault detected before a reclosure will not cause a group change while the breaker is open. In such cases, the user can set a condition under "BLK GROUP CHANGE", where if asserted, the active setpoint group will stay active, even if the input configured to switch to the other setpoint group is asserted. For example if the active group was Group 1 at the time of a trip, the breaker opens, and the input configured under "BLK GROUP CHANGE" is asserted, the relay will maintain Setpoint Group 1, even if the input "SET GROUP 2 ACTIVE" is asserted. Vice versa, if the "BLK GROUP CHANGE" input is asserted; the relay will not switch from Group 2 to Group 1, even if the input under "SET GROUP 2 ACTIVE" is de-asserted.

The relay will default to Setpoint Group 1, if both the input "SET GROUP 2 ACTIVE" and the blocking input "BLK GROUP CHANGE" are de-asserted.

Switching from Group 1 to Group 2 can be also initiated by the Autoreclose, or the Cold Load Pickup functions. If the setpoint group selected in the Autoreclosure menu is different from the active setpoint group, then the Autoreclosure function will force the relay to apply the Autoreclosure selected setpoint group. The Autoreclosure function will then apply the AR shot settings to the corresponding protections. The relay will revert to the previous setpoint group after detecting the Autoreclosure resets.

Similarly, if "Enabled" and not blocked by the Autoreclosure, the Cold Load Pickup function will force the relay to apply the protections of the other setpoint group, if the one selected under the CLP menu is different from this, being in-service. The relay will revert to the setpoint group used originally, after the CLP blocking function resets.

PATH: **SETPOINTS > S4 CONTROLS > CHANGE SPNT GROUP**

SET GROUP 2 ACTIVE

Range: Off, Contact Input 1 to 10, Virtual Input 1 to 32, Remote Input 1 to 32, Logic Elements 1 to 16, CT Fail Alarm PKP, CT Fail Alarm OP, 2nd Harmonic Alarm, 2nd Harmonic

Default: Off

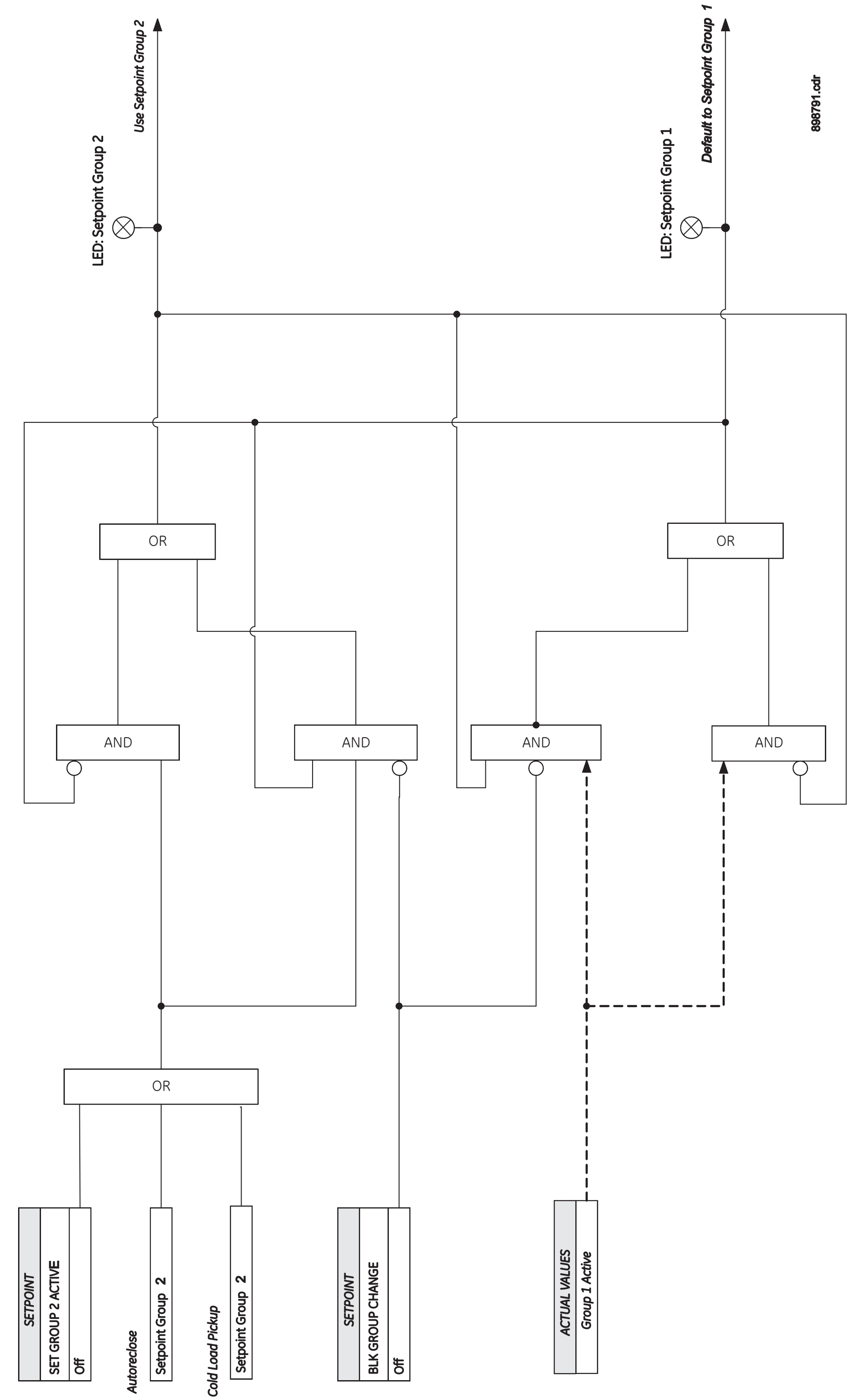
This setting selects an input used to change from Setpoint Group 1 to Setpoint Group 2, when asserted. If no group change supervision is selected, Setpoint group 2 will stay active as long as the "SET GROUP 2 ACTIVE" input is asserted, and will revert to Group 1, when this input is de-asserted.

BLOCK GROUP CHANGE

For details see Common setpoints.

This setting defines an input that can be used to block changing setpoint groups. When the assigned input is asserted, changing from one setpoint group to the other one is blocked.

Figure 6-54: Switching setpoint groups - Logic diagram



Virtual inputs

There are 32 virtual inputs that can be individually programmed to respond to input commands entered via the relay keypad, or by using communication protocols.

PATH: **SETPOINTS > S4 CONTROLS > VIRTUAL INPUTS**.

VIRTUAL INPUT 1

Range: Off, On

Default: Off

The state of each virtual input can be controlled under **SETPOINTS > S4 CONTROL > VIRTUAL INPUTS** menu. For this purpose, each of the virtual inputs selected for control need be "Enabled" under **SETPOINTS > S5 INPUTS/OUTPUTS > VIRTUAL INPUTS**, and its type "Self-Reset" or "Latched" specified.

If Self-Reset type was selected, entering "On" command will lead to a pulse of one protection pass. To prolong the time of the virtual input pulse, one can assign it as a trigger source to a Logic Element with a dropout timer set to the desired pulse time. If "Latched" type is selected, the state of the virtual input will be latched, upon entering "On" command.

Refer to the logic diagram in the **S5 INPUTS/OUTPUTS > VIRTUAL INPUTS** section for more details.

Logic elements

The 350 relay has 16 Logic Elements available to build simple logic using the state of any programmed contact, virtual, or remote input, or from the output operand of a protection, or control element. Changing the state of any of the assigned inputs used as trigger sources, will change the state of the Logic Element, unless a blocking input is present. The logic provides for assigning up to eight triggering inputs in a programmable gate for Logic Element operation, and up to four blocking inputs in a programmable gate for defining the block signal. Pickup and dropout timers are available for delaying Logic Element operation and drop-out respectively. In addition, the user can define whether to use the "ON", or "OFF" state of the programmed element by selecting ASSERTED: "On" or "Off".

Referring to the Logic Element logic diagram below, the Logic Element can be set to one of four functions: **Control**, **Alarm**, **Latched Alarm**, or **Trip**. When **Alarm** or **Latched Alarm** is selected, the output relay #1 (Trip) is not triggered during Logic Element operation. The Trip output relay will be triggered when **Trip** is selected as the function, and the Logic Element operates. The Logic Element function can be also selected as **Control**, and used with other relay elements without turning on the "ALARM" and "TRIP" LEDs.

The "PICKUP" LED will turn on upon a Logic Element pickup condition except when the Logic Element function is selected as **Control**.

The "ALARM" LED will turn on upon Logic Element operation if the Logic Element function selected is either **Alarm**, or **Latched Alarm**.

The "TRIP" LED will turn on upon Logic Element operation if the Logic Element function is selected as **Trip**.

The option to trigger auxiliary output relays is provided for any of the selected Logic Element functions.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S4 CONTROLS > LOGIC ELEMENTS**

LE1(16) FUNCTION

Range: Disabled, Control, Alarm, Latched Alarm, Trip

Default: Disabled

For details see Common setpoints.

LE1(16) ASSERTED

Range: On, Off

Default: Off

This setting defines the Logic Element state “On” or “Off” to be used as an output. The asserted “On” selection provides an output “high” when the LE is "On". If asserted “Off” is selected, then the LE output will be “high”, when the LE is “Off”.

TRIGGER INPUTS

Range: 2 to 8

Default: 3

This setting defines the number of trigger sources to be used in the menu of the Logic Element. Up to eight trigger sources (inputs) can be selected.

TRIGGER SOURCE 1 (8)

Range: Off, Any input from the list of inputs

Default: Off

Each of the trigger sources is configurable by allowing the assigning of an input selected from a list of inputs. This input can be a contact input, a virtual input, a remote input, or an output flag from a protection, or control element. See the list of available inputs from the table below.

TRIGGER LOGIC

Range: OR, AND, NOR, NAND, XOR, XNOR

Default: OR

This setting defines the gate types for the trigger sources (inputs).

NOTE

Note that the XOR functionality is as follows: XOR output is triggered only when ONLY ONE of the inputs is triggered.

PKP TIME DELAY

Range: 0 to 60000 ms in steps of 1 ms

Default: 0 ms

This setting specifies the pickup time delay before Logic Element operation.

DPO TIME DELAY

Range: 0 to 60000 ms in steps of 1 ms

Default: 0 ms

This setting specifies the time delay from a reset timer that starts upon expiry of the pickup time delay and prolongs the operation of the Logic Element until this time expires.

OUTPUT RELAY X

For details see Common setpoints.

NUMBER OF BLOCKS

Range: 2 to 4

Default: 3

This setting defines the number of blocks to be used in the menu of the Logic Element. Up to four blocks can be selected.

BLOCK 1 (4)

Range: Off, Any input from the list of inputs

Default: Off

Each of the blocks is configurable by allowing the assigning of an input selected from a list of inputs. This input can be a contact input, a virtual input, a remote input, or an output flag from a protection, or control element, as well as an input from any of the other seven logic inputs. See the list of available inputs from the table below

BLOCK LOGIC

Range: OR, AND, NOR, NAND, XOR, XNOR

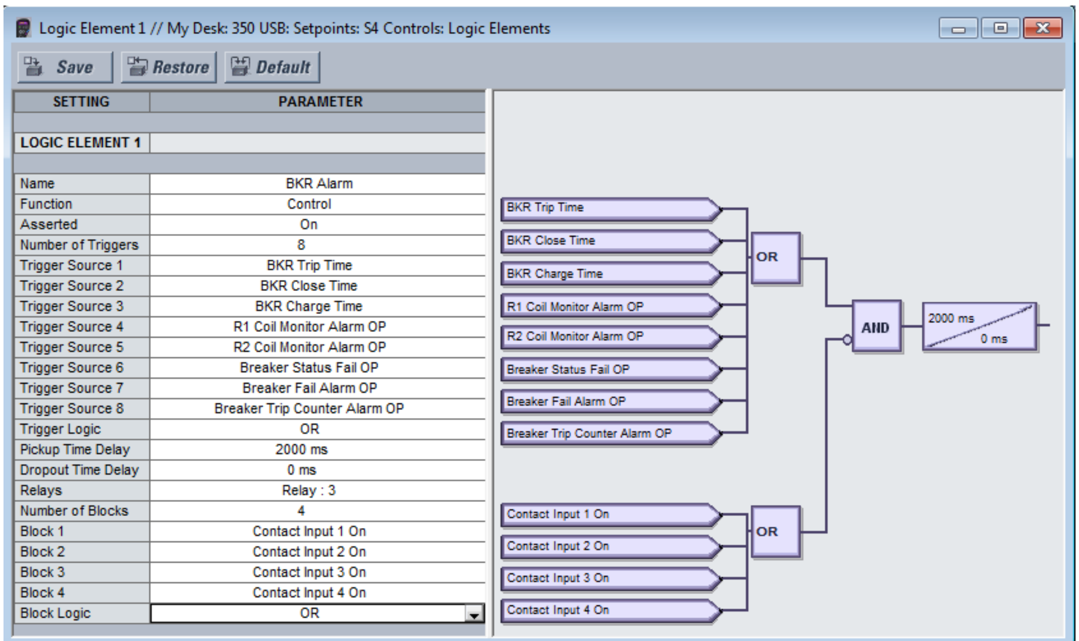
Default: OR

This setting defines the gate type for the block inputs.

A Logic Element can be used to provide under-voltage supervision when overcurrent conditions are detected. The logic from the Logic Element below, see figure: *Example of Block Logic setting from EnerVista*, shows that overcurrent trip will not be initiated unless the relay detects either auxiliary or phase under-voltage conditions. In any other cases, with both under-voltage elements dropped out, Overcurrent trip will not be initiated. Each Logic Element can include output from another logic element.

Example: Programing an overall breaker alarm using Logic Elements

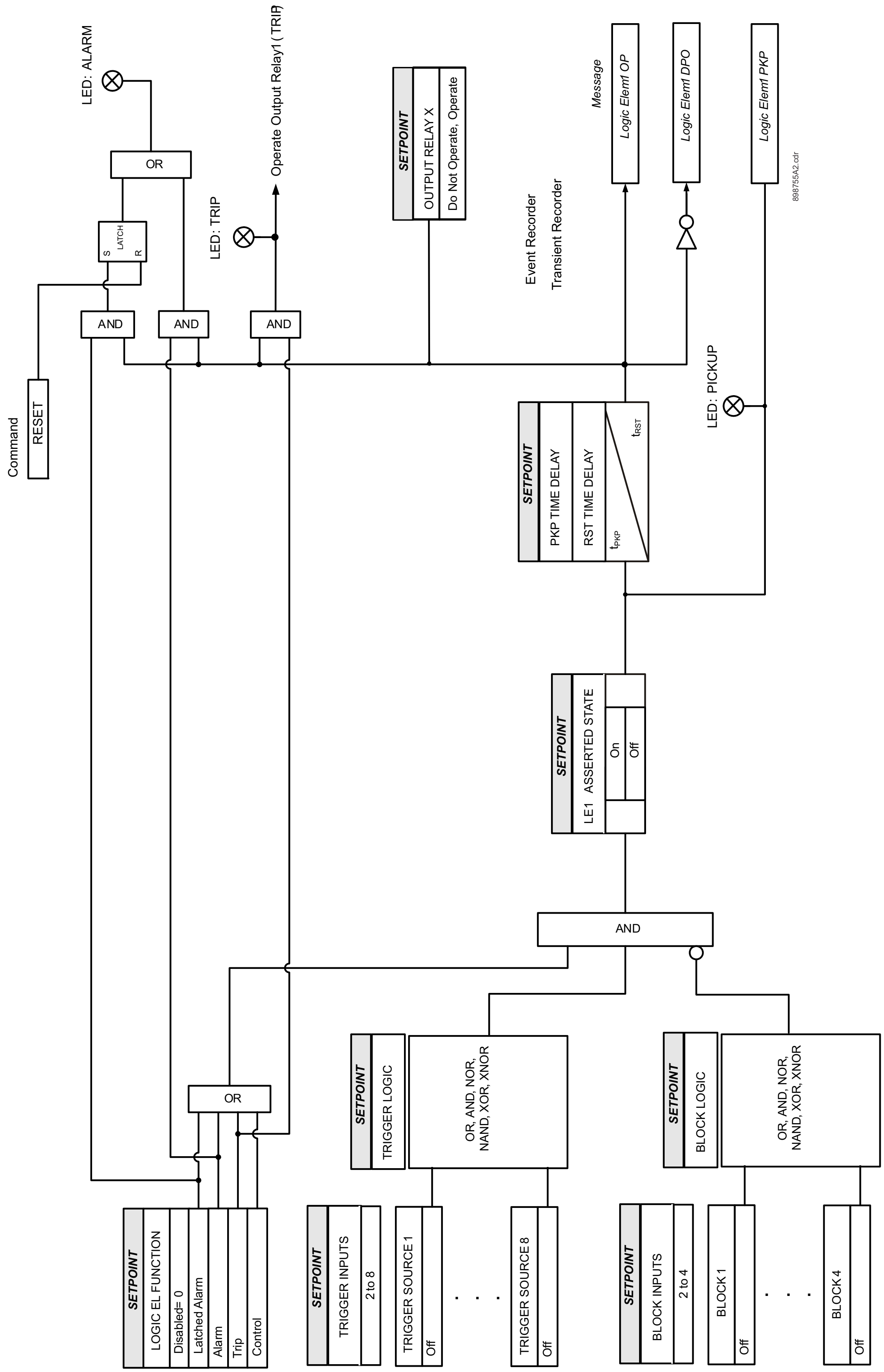
Figure 6-55: Example of an overall breaker alarm from EnerVista



In this example, all eight trigger sources from Logic Element 1 are programmed into an OR gate, with operands originating from breaker functions such as Breaker Status, Breaker Health, Trip Counter, Breaker Coil Monitoring, and Breaker Failure. The Trigger Logic setpoint is selectable to any boolean operator such as OR, AND, NAND, NOR, XOR, or XNOR. All four block inputs are programmed with contact inputs 1 to 4, and the Block logic setpoint is programmed into an OR gate. These inputs may include Maintenance input, Breaker disconnected input, Protection disabled input, etc.

Output Relay # 3 is selected to energize upon operation of Logic Element 1, to denote a Breaker Alarm. With pickup time delay set to 2000ms, Logic Element 1 (BKR Alarm) operation will occur 2 seconds after the operation of any of the trigger sources when no block is applied.

Figure 6-56: Logic Element logic diagram



Operand types and descriptions

The following tables of Logic Operands, taken from Function Code FC134B in the *3 Series Communications Guide*, show the list of available Logic Inputs. Where specific event descriptions are not given, a general description applies as follows:

General descriptions of operands originating from protection, control, and monitoring elements:

"..operand name..Trip PKP"	The function setpoint of the element has been programmed as "Trip" and the element picked up
"..operand name.. Trip OP"	The function setpoint of the element has been programmed as "Trip" and the element operated
"..operand name.. Trip DPO"	The function setpoint of the element has been programmed as "Trip" and the element operation dropped out
"..operand name..Alarm PKP"	The function setpoint of the element has been programmed as "Alarm" and the element picked up
"..operand name.. Alarm OP"	The function setpoint of the element has been programmed as "Alarm" and the element operated
"..operand name.. Alarm DPO"	The function setpoint of the element has been programmed as "Alarm" and the element operation dropped out
"..operand name.. Block"	The operation of the element has been blocked

General descriptions of operands originating from digital elements such as contact, virtual and Remote inputs, Output Relays, and Virtual Outputs:

"..operand name.. Off	"The status of the selected input or output is OFF
"..operand name.. On	"The status of the selected input or output is ON

Element	Operands	Event Description
Contact Inputs	Contact IN 1..10 On	
	Contact IN 1..10 Off	
Virtual Inputs	Virtual IN 1..32 On	
	Virtual IN 1..32 Off	
Remote Inputs	Remote IN 1..32 On	
	Remote IN 1..32 Off	

Element	Operands	Event Description
General	Off	
	On	
	Any Trip	Generated upon operation of any element with function setpoint set to "Trip"
	Any Alarm	Generated upon operation of any element with function setpoint set to "Alarm"
	Any Pkp OP	Generated upon detection of pickup status from any element
	Any Block	Generated when the operation of any element is blocked
	Output Relay 1 On	
	Output Relay 2 On	
	Output Relay 3 On	
	Output Relay 4 On	
	Output Relay 5 On	
	Output Relay 6 On	
	Output Relay 1 Blk	
	Output Relay 2 Blk	
	BKR Connected	Defines the status of the breaker in the power system. BKR Connected means breaker racked in the system
	Setpoint Group2 On	Setpoint Group 2 is active
	Open Breaker	Defines a command to open the breaker
	Close Breaker	Defines a command to close the breaker
	Maint. Req.	
	52a Contact OP	
	52b Contact OP	
	Reset OK	Reset command has been executed
	BKR Stat Open	Breaker status open detected
	BKR Stat Clsd	Breaker status closed detected
	Setpoint Group1 On	Setpoint Group 1 is active
	Group Change Blk	Changing of Setpoint Groups is blocked
	Clock Not Set	
	Relay Not Ready	
	IRIG-B Failure	
	Ethernet Link Fail	
	Ambient Temp. >80C	
	Eth Link A Fail	
	Eth Link B Fail	
	Order Code Error	Device order code is invalid
	RTC Error	
	Cal Error	Last calibration date is invalid
	EEPROM Error	
	System Health Error	Self-test checks indicate a problem with the system
	CPU 33V Error	
	Analog V Rail Fail	

Element	Operands	Event Description
Arc Flash	Arc Flash OP	
	Arc Flash Trip OP	
	Arc Flash Alarm OP	
	Arc Flash Block	
	Light Sensor 1..4 OP	Light above threshold detected by light sensor 1..4
	LightSns1..4 Trbl	Trouble detected in light sensor 1..4
	LightSns Trbl	Trouble detected in one of the light sensors or corresponding fiber
	HS IOC OP	High speed IOC has operated
	HS Ph A IOC OP	High speed IOC for phase A has operated
	HS Ph B IOC OP	High speed IOC for phase B has operated
	HS Ph C IOC OP	High speed IOC for phase C has operated
	HS GND IOC OP	High speed IOC for ground has operated
Autorecloser	AR Close	Autoreclose close command is issued
	AR N/Ready	Autoreclose not ready
	AR In Progress	Autoreclose is in progress
	AR Disabled	Autoreclose is disabled
	AR Ext. Init	External Initiation is detected by the Autoreclosure
	AR Ready	Autoreclosure is ready
	AR Block	
Breaker Health	BKR Alarm	Breaker health alarm has picked up
	BKR Trip Time	Breaker trip time is exceeded
	BKR Close Time	Breaker closing time is exceeded
	BKR Charge Time	Breaker spring charging time is exceeded
	BKR Trp/Cls Fail	Breaker did not open or close upon the respective command
	BKR Charge Fail	Breaker spring for tripping did not charge
Synchrocheck	Sync Operation	Syncheck element operated
	Sync Close OP	Syncheck close breaker command has been generated to the breaker
	Sync Condition	Defines the presence of syncheck conditions.
Testing	Testing ON	Testing feature is Enabled
	Testing OFF	Testing feature is Disabled

Element	Operands		
Ambient Temperature	HI Amb Temp PKP	LO Amb Temp PKP	HI Amb Temp DPO
	HI Amb Temp OP	LO Amb Temp OP	LO Amb Temp DPO
Auxiliary Overvoltage	Aux OV Trip PKP	Aux OV Alarm OP	Aux OV Alarm PKP
	Aux OV Trip OP	Aux OV Alarm DPO	
	Aux OV Trip DPO	Aux OV Block	
Auxiliary Undervoltage	Aux UV Trip PKP	Aux UV Alarm OP	Aux UV Trip DPO
	Aux UV Alarm PKP	Aux UV Alarm DPO	
	Aux UV Trip OP	Aux UV Block	
Breaker Failure	BKR Fail Alrm PKP	BKR Fail Alrm DPO	
	BKR Fail Alrm OP	BKR Stat Fail OP	
Broken Conductor	Brkn Cond Trip PKP	Brkn Cond Alrm DPO	Brkn Cond Alarm OP
	Brkn Cond Trip OP	Brkn Cond PKP	Brkn Cond Block
	Brkn Cond Trip DPO	Brkn Cond OP	
	Brkn Cond Alrm PKP	Brkn Cond DPO	

Element	Operands		
Cold Load Pickup	CLP Alarm PKP	CLP Alarm OP	
CT Failure	CTFail 1 Alrm PKP	CTFail 1 Alrm DPO	
	CTFail 1 Alrm OP	CTFail 1 Block	
Demand	Curr Dmd1 Alrm OP	Curr Dmd1 Block	AppP Dmd Alrm OP
	RealP Dmd Alrm OP	RealP Dmd Block	AppP Dmd Block
	ReacP Dmd Alrm OP	ReacP Dmd Block	
	Curr Dmd1 PhA Alrm OP	Curr Dmd2 PhA Alrm OP	Curr Dmd3 PhA Alrm OP
Directional Power	Dir Pwr 1 Trip PKP	Dir Pwr 1 PKP	Dir Pwr 2 Alrm PKP
	Dir Pwr 1 Trip OP	Dir Pwr 1 OP	Dir Pwr 2 Alarm OP
	Dir Pwr 2 Trip PKP	Dir Pwr 2 PKP	Dir Pwr 1 Alrm PKP
	Dir Pwr 2 Trip OP	Dir Pwr 2 OP	Dir Pwr 1 Alarm OP
	Dir Pwr 1 Block	Dir Pwr 2 Block	
Ground Directional	GndDirRev Alm OP	GndDir Und OP	GndDir UndAlm DPO
	GndDirRev Alm DPO	GndDir Und DPO	Gnd Dir Rev DPO
	GndDir UndAlm OP	Gnd Dir Rev OP	GndDirRev Block
Ground Instantaneous Overcurrent	Gnd IOC1 Trip PKP	Gnd IOC2 Trip PKP	Gnd IOC1 Alarm DPO
	Gnd IOC1 Trip OP	Gnd IOC2 Trip OP	Gnd IOC1 Block
	Gnd IOC1 Trip DPO	Gnd IOC2 Trip DPO	Gnd IOC2 Alarm DPO
	Gnd IOC1 Alarm PKP	Gnd IOC2 Alarm PKP	Gnd IOC2 Block
	Gnd IOC1 Alarm OP	Gnd IOC2 Alarm OP	
Ground Timed Overcurrent	Gnd TOC1 Trip PKP	Gnd TOC1 Alarm PKP	Gnd TOC1 Block
	Gnd TOC1 Trip OP	Gnd TOC1 Alarm OP	
	Gnd TOC1 Trip DPO	Gnd TOC1 Alarm DPO	
Lockout	Lockout OP	L/O Rst Closed OP	
	Lockout DPO	Lockout Block	
Logic Elements	LE 1..16 Alarm DPO	LE 1..16 PKP	LE 1..16 DPO
	LE 1..16 Alarm OP	LE 1..16 Trip DPO	LE 1..16 OP
	LE 1..16 Alarm PKP	LE 1..16 Trip OP	LE 1..16 Trip PKP
Negative Sequence Instantaneous Overcurrent	NSeq IOC Trp PKP	NSeq IOC Alrm OP	NSeq IOC Trp DPO
	NSeq IOC Trp OP	NSeq IOC Alrm DPO	NSeq IOC Alrm PKP
	NSeq IOC Block		
Negative Sequence Overvoltage	NSeq OV Trp PKP	NegSeq OV2 Trp PKP	NSeq OV Alrm DPO
	NSeq OV Trp OP	NegSeq OV2 Trp OP	NSeq OV Block
	NSeq OV Trp DPO	NegSeq OV2 Trp DPO	NSeq OV2 Alrm DPO
	NSeq OV Alrm PKP	NSeq OV2 Alrm PKP	NSeq OV2 Block
	NSeq OV Alrm OP	NSeq OV2 Alrm OP	
Negative Sequence Timed Overcurrent	NSeq TOC1 Trip PKP	NSeq TOC1 Alrm OP	NSeq TOC1 Alrm PKP
	NSeq TOC1 Trip OP	NSeq TOC1 Alrm DPO	
	NSeq TOC1 Trip DPO	NSeq TOC1 Blk	
Neutral Directional	NtrlDir RevAlm OP	Ntrl Dir Rev DPO	Ntrl Dir Rev OP
	NtrlDir RevAlmDPO	NtrlDir Und OP	NtrlDir UndAlm DPO
	NtrlDir UndAlm OP	NtrlDir Und DPO	NTRL DIR Rev Block
Neutral Instantaneous Overcurrent	Ntrl IOC1 Trip PKP	Ntrl IOC1 Alrm PKP	Ntrl IOC2 Alrm DPO
	Ntrl IOC1 Trip OP	Ntrl IOC1 Alrm OP	Ntrl IOC2 Block
	Ntrl IOC1 Trip DPO	Ntrl IOC1 Alrm DPO	Ntrl IOC2 Trip DPO
	Ntrl IOC2 Trip PKP	Ntrl IOC1 Block	Ntrl IOC2 Alrm OP
	Ntrl IOC2 Trip OP	Ntrl IOC2 Alrm PKP	

Element	Operands		
Neutral Overvoltage	Ntrl OV Trip PKP	Ntrl OV2 Alrm PKP	Ntrl OV3 Trip PKP
	Ntrl OV Trp OP	Ntrl OV2 Alrm OP	Ntrl OV3 Trip OP
	Ntrl OV Trip DPO	Ntrl OV2 Alrm DPO	Ntrl OV3 Trip DPO
	Ntrl OV Alrm PKP	Ntrl OV3 Alrm PKP	Ntrl OV4 Trip PKP
	Ntrl OV Alrm OP	Ntrl OV3 Alrm OP	Ntrl OV4 Trip OP
	Ntrl OV Alrm DPO	Ntrl OV3 Alrm DPO	Ntrl OV4 Trip DPO
	Ntrl OV2 Trip PKP	Ntrl OV4 Alrm PKP	Ntrl OV Block
	Ntrl OV2 Trip OP	Ntrl OV4 Alrm OP	Ntrl OV2 Block
	Ntrl OV2 Trip DPO	Ntrl OV4 Alrm DPO	Ntrl OV3 Block
			Ntrl OV4 Block
Neutral Timed Overcurrent	Ntrl TOC1 Trip PKP	Ntrl TOC1 Alrm OP	Ntrl TOC1 Alrm PKP
	Ntrl TOC1 Trip OP	Ntrl TOC1 Alrm DPO	
	Ntrl TOC1 Trip DPO	Ntrl TOC1 Block	
Overfrequency	OverFreq1 Trip PKP	OverFreq1 Alrm PKP	OverFreq3 Trip PKP
	OverFreq1 Trip OP	OverFreq1 Alrm OP	OverFreq3 Trip OP
	OverFreq1 Trip DPO	OverFreq1 Alrm DPO	OverFreq3 Trip DPO
	OverFreq2 Trip PKP	OverFreq2 Alrm PKP	OverFreq4 Trip PKP
	OverFreq2 Trip OP	OverFreq2 Alrm OP	OverFreq4 Trip OP
	OverFreq2 Trip DPO	OverFreq2 Alrm DPO	OverFreq4 Trip DPO
	OverFreq1 Block	OverFreq3 Alrm PKP	OverFreq4 Alrm PKP
	OverFreq2 Block	OverFreq3 Alrm OP	OverFreq4 Alrm OP
	OverFreq3 Block	OverFreq3 Alrm DPO	OverFreq4 Alrm DPO
	OverFreq4 Block		
Phase Directional	PhDir RevAlm OP	PhDir Rev OP	PhDir UndAlm OP
	PhDir RevAlm DPO	PhDir Rev DPO	PhDir UndAlm DPO
	PhADir RevAlm OP	PhADir Rev OP	PhADir UndAlm OP
	PhADir RevAlm DPO	PhADir Rev DPO	PhADir UndAlm DPO
	PhBDir RevAlm OP	PhBDir Rev OP	PhBDir UndAlm OP
	PhBDir RevAlm DPO	PhBDir Rev DPO	PhBDir UndAlm DPO
	PhCDir RevAlm OP	PhCDir Rev OP	PhCDir UndAlm OP
	PhCDir RevAlm DPO	PhCDir Rev DPO	PhCDir UndAlm DPO
	PhDir Und OP	PhBDir Und OP	PhDir Block
	PhDir Und DPO	PhBDir Und DPO	
	PhADir Und OP	PhCDir Und OP	
	PhADir Und DPO	PhCDir Und DPO	

Element	Operands		
Phase Instantaneous Overcurrent	Ph IOC1 Trip PKP	Ph IOC1 Alarm PKP	Ph IOC2 Trip DPO
	Ph IOC1 Trip OP	Ph IOC1 Alarm OP	Ph IOC1 Block
	Ph IOC1 Trip DPO	Ph IOC1 Alarm DPO	Ph IOC2 Alarm DPO
	Ph IOC2 Trip PKP	Ph IOC2 Alarm PKP	Ph IOC2 Block
	Ph IOC2 Trip OP	Ph IOC2 Alarm OP	
	Ph A IOC1 Alrm PKP	Ph A IOC1 Trip PKP	Ph A IOC2 Alrm PKP
	Ph A IOC1 Alrm OP	Ph A IOC1 Trip OP	Ph A IOC2 Alrm OP
	Ph A IOC1 Alrm DPO	Ph A IOC1 Trip DPO	Ph A IOC2 Alrm DPO
	Ph B IOC1 Alrm PKP	Ph B IOC1 Trip PKP	Ph B IOC2 Alrm PKP
	Ph B IOC1 Alrm OP	Ph B IOC1 Trip OP	Ph B IOC2 Alrm OP
	Ph B IOC1 Alrm DPO	Ph B IOC1 Trip DPO	Ph B IOC2 Alrm DPO
	Ph C IOC1 Alrm PKP	Ph C IOC1 Trip PKP	Ph C IOC2 Alrm PKP
	Ph C IOC1 Alrm OP	Ph C IOC1 Trip OP	Ph C IOC2 Alrm OP
	Ph C IOC1 Alrm DPO	Ph C IOC1 Trip DPO	Ph C IOC2 Alrm DPO
	Ph A IOC2 Trip PKP	Ph B IOC2 Trip PKP	Ph C IOC2 Trip PKP
	Ph A IOC2 Trip OP	Ph B IOC2 Trip OP	Ph C IOC2 Trip OP
	Ph A IOC2 Trip DPO	Ph B IOC2 Trip DPO	Ph C IOC2 Trip DPO

Element	Operands		
Phase Overvoltage	Ph OV1 Trip PKP	Ph OV2 Alarm PKP	Ph OV3 Trip PKP
	Ph OV1 Trip OP	Ph OV2 Alarm OP	Ph OV3 Trip OP
	Ph OV1 Trip DPO	Ph OV2 Alarm DPO	Ph OV3 Trip DPO
	Ph OV1 Alarm PKP	Ph OV2 Trip PKP	Ph OV3 Alarm PKP
	Ph OV1 Alarm OP	Ph OV2 Trip OP	Ph OV3 Alarm OP
	Ph OV1 Alarm DPO	Ph OV2 Trip DPO	Ph OV3 Alarm DPO
	Ph OV4 Alarm PKP	Ph OV4 Trip PKP	Ph OV1 Block
	Ph OV4 Alarm OP	Ph OV4 Trip OP	Ph OV2 Block
	Ph OV4 Alarm DPO	Ph OV4 Trip DPO	Ph OV3 Block
	Ph A OV1 Trip PKP	Ph A OV3 Trip PKP	Ph OV4 Block
	Ph A OV1 Trip OP	Ph A OV3 Trip OP	Ph A OV3 Alarm PKP
	Ph A OV1 Trip DPO	Ph A OV3 Trip DPO	Ph A OV3 Alarm OP
	Ph B OV1 Trip PKP	Ph B OV3 Trip PKP	Ph A OV3 Alarm DPO
	Ph B OV1 Trip OP	Ph B OV3 Trip OP	Ph B OV3 Alarm PKP
	Ph B OV1 Trip DPO	Ph B OV3 Trip DPO	Ph B OV3 Alarm OP
	Ph C OV1 Trip PKP	Ph C OV3Trip PKP	Ph B OV3 Alarm DPO
	Ph C OV1 Trip OP	Ph C OV3 Trip OP	Ph C OV3 Alarm PKP
	Ph C OV1 Trip DPO	Ph C OV3 Trip DPO	Ph C OV3 Alarm OP
	Ph A OV2 Trip PKP	Ph A OV4 Trip PKP	Ph C OV3 Alarm DPO
	Ph A OV2 Trip OP	Ph A OV4 Trip OP	Ph A OV3 Alarm PKP
	Ph A OV2 Trip DPO	Ph A OV4 Trip DPO	Ph A OV4 Alarm PKP
	Ph B OV2 Trip PKP	Ph B OV4 Trip PKP	Ph A OV4 Alarm OP
	Ph B OV2 Trip OP	Ph B OV4 Trip OP	Ph A OV4 Alarm DPO
	Ph B OV2 Trip DPO	Ph B OV4 Trip DPO	Ph B OV4 Alarm PKP
	Ph C OV2 Trip PKP	Ph C OV4 Trip PKP	Ph B OV4 Alarm OP
	Ph C OV2 Trip OP	Ph C OV4 Trip OP	Ph B OV4 Alarm DPO
	Ph C OV2 Trip DPO	Ph C OV4 Trip DPO	Ph C OV4 Alarm PKP
	Ph A OV1 Alarm PKP	Ph A OV2 Alarm PKP	Ph C OV4 Alarm OP
	Ph A OV1 Alarm OP	Ph A OV2 Alarm OP	Ph C OV4 Alarm DPO
	Ph A OV1 Alarm DPO	Ph A OV2 Alarm DPO	Ph C OV1 Alarm OP
	Ph B OV1 Alarm PKP	Ph B OV2 Alarm PKP	Ph C OV1 Alarm DPO
	Ph B OV1 Alarm OP	Ph B OV2 Alarm OP	Ph C OV2 Alarm OP
	Ph B OV1 Alarm DPO	Ph B OV2 Alarm DPO	Ph C OV2 Alarm DPO
	Ph C OV1 Alarm PKP	Ph C OV2 Alarm PKP	
Phase Timed Overcurrent	Ph TOC1 Trip PKP	Ph TOC1 Alarm PKP	Ph TOC1 Block
	Ph TOC1 Trip OP	Ph TOC1 Alarm OP	
	Ph TOC1 Trip DPO	Ph TOC1 Alarm DPO	
	Ph A TOC1 Alrm PKP	Ph A TOC1 Trip PKP	Ph C TOC1 Alrm PKP
	Ph A TOC1 Alrm OP	Ph A TOC1 Trip OP	Ph C TOC1 Alrm OP
	Ph A TOC1 Alrm DPO	Ph A TOC1 Trip DPO	Ph C TOC1 Alrm DPO
	Ph B TOC1 Alrm PKP	Ph B TOC1 Trip PKP	Ph C TOC1 Trip PKP
	Ph B TOC1 Alrm OP	Ph B TOC1 Trip OP	Ph C TOC1 Trip OP
	Ph B TOC1 Alrm DPO	Ph B TOC1 Trip DPO	Ph C TOC1 Trip DPO

Element	Operands		
Phase Undervoltage	Ph UV1 Trip PKP	Ph UV1 Alarm PKP	Ph UV3 Alrm PKP
	Ph UV1 Trip OP	Ph UV1 Alarm OP	Ph UV3 Alrm OP
	Ph UV1 Trip DPO	Ph UV1 Alarm DPO	Ph UV3 Alrm DPO
	Ph UV2 Trip PKP	Ph UV2 Alrm PKP	Ph UV3 Trip PKP
	Ph UV2 Trip OP	Ph UV2 Alrm OP	Ph UV3 Trip OP
	Ph UV2 Trip DPO	Ph UV2 Alrm DPO	Ph UV3 Trip DPO
	Ph UV4 Trip PKP	Ph UV4 Alrm PKP	Ph UV1 Block
	Ph UV4 Trip OP	Ph UV4 Alrm OP	Ph UV2 Block
	Ph UV4 Trip DPO	Ph UV4 Alrm DPO	Ph UV3 Block
	Ph A UV1 Trip PKP	Ph A UV3 Trip PKP	Ph UV4 Block
	Ph A UV1 Trip OP	Ph A UV3 Trip OP	Ph A UV3 Alarm PKP
	Ph A UV1 Trip DPO	Ph A UV3 Trip DPO	Ph A UV3 Alarm OP
	Ph B UV1 Trip PKP	Ph B UV3 Trip PKP	Ph A UV3 Alarm DPO
	Ph B UV1 Trip OP	Ph B UV3 Trip OP	Ph B UV3 Alarm PKP
	Ph B UV1 Trip DPO	Ph B UV3 Trip DPO	Ph B UV3 Alarm OP
	Ph C UV1 Trip PKP	Ph C UV3Trip PKP	Ph B UV3 Alarm DPO
	Ph C UV1 Trip OP	Ph C UV3 Trip OP	Ph C UV3 Alarm PKP
	Ph C UV1 Trip DPO	Ph C UV3 Trip DPO	Ph C UV3 Alarm OP
	Ph A UV2 Trip PKP	Ph A UV4 Trip PKP	Ph C UV3 Alarm DPO
	Ph A UV2 Trip OP	Ph A UV4 Trip OP	Ph A UV3 Alarm PKP
	Ph A UV2 Trip DPO	Ph A UV4 Trip DPO	Ph A UV4 Alarm PKP
	Ph B UV2 Trip PKP	Ph B UV4 Trip PKP	Ph A UV4 Alarm OP
	Ph B UV2 Trip OP	Ph B UV4 Trip OP	Ph A UV4 Alarm DPO
	Ph B UV2 Trip DPO	Ph B UV4 Trip DPO	Ph B UV4 Alarm PKP
	Ph C UV2 Trip PKP	Ph C UV4 Trip PKP	Ph B UV4 Alarm OP
	Ph C UV2 Trip OP	Ph C UV4 Trip OP	Ph B UV4 Alarm DPO
	Ph C UV2 Trip DPO	Ph C UV4 Trip DPO	Ph C UV4 Alarm PKP
	Ph A UV1 Alarm PKP	Ph A UV2 Alarm PKP	Ph C UV4 Alarm OP
	Ph A UV1 Alarm OP	Ph A UV2 Alarm OP	Ph C UV4 Alarm DPO
	Ph A UV1 Alarm DPO	Ph A UV2 Alarm DPO	Ph C UV1 Alarm OP
	Ph B UV1 Alarm PKP	Ph B UV2 Alarm PKP	Ph C UV1 Alarm DPO
	Ph B UV1 Alarm OP	Ph B UV2 Alarm OP	Ph C UV2 Alarm OP
	Ph B UV1 Alarm DPO	Ph B UV2 Alarm DPO	Ph C UV2 Alarm DPO
	Ph C UV1 Alarm PKP	Ph C UV2 Alarm PKP	
Positive Sequence UV	PosSeq UV1 Trp PKP	PosSeq UV1 AlrmPKP	PosSeq UV1 Block
	PosSeq UV1 Trip OP	PosSeq UV1 Alrm OP	
	PosSeq UV1 Trp DPO	PosSeq UV1 AlrmDPO	
Second Harmonic Inhibit	2nd Hrmc Alarm PKP	2nd Hrmc PKP	2nd Hrmc Alarm DPO
	2nd Hrmc Alarm OP	2nd Hrmc OP	2nd Hrmc DPO
Sensitive Ground Instantaneous Overcurrent	SGnd IOC1 Trip PKP	SGnd IOC1 Alrm PKP	SGnd IOC2 Trip DPO
	SGnd IOC1 Trip OP	SGnd IOC1 Alrm OP	SGnd IOC1 Block
	SGnd IOC1 Trip DPO	SGnd IOC1 Alrm DPO	SGnd IOC2 Alrm DPO
	SGnd IOC2 Trip PKP	SGnd IOC2 Alrm PKP	SGnd IOC2 Block
	SGnd IOC2 Trip OP	SGnd IOC2 Alrm OP	
Sensitive Ground Timed Overcurrent	SGnd TOC1 Trip PKP	SGnd TOC1 Alrm PKP	SGnd TOC1 Block
	SGnd TOC1 Trip OP	SGnd TOC1 Alrm OP	
	SGnd TOC1 Trip DPO	SGnd TOC1 Alrm DPO	

Element	Operands		
Thermal Overload	Therm O/L Trip OP	Therm Lvl Alrm OP	Therm O/L Block
	Therm O/L Trip DPO	Therm Lvl Alrm DPO	
	Therm PhA Alrm OP	Therm PhB Alrm OP	Therm PhC Alrm OP
	Therm PhA Alrm DPO	Therm PhB Alrm DPO	Therm PhC Alrm DPO
Trip Counter	BKRTrpCntrAlrm OP		
Underfrequency	UndrFreq1 Trip PKP	UndrFreq1 Alrm PKP	UndFreq4 Trip PKP
	UndrFreq1 Trip OP	UndrFreq1 Alrm OP	UndFreq4 Trip OP
	UndrFreq1 Trip DPO	UndrFreq1 Alrm DPO	UndFreq4 Trip DPO
	UndrFreq2 Trip PKP	UndrFreq2 Alrm PKP	UndFreq4 Alarm PKP
	UndrFreq2 Trip OP	UndrFreq2 Alrm OP	UndFreq4 Alarm OP
	UndrFreq2 Trip DPO	UndrFreq2 Alrm DPO	UndFreq4 Alarm DPO
	UndFreq3 Trip PKP	UndFreq3 Alrm PKP	UndrFreq1 Block
	UndFreq3 Trip OP	UndFreq3 Alarm OP	UndrFreq2 Block
	UndFreq3 Trip DPO	UndFreq3 Alrm DPO	UndFreq3 Block
			UndFreq4 Block
Volts per Hertz	Volt Hertz Trip PKP	Volt Hertz Alarm PKP	Volt Hertz PKP
	Volt Hertz Trip OP	Volt Hertz Alarm OP	Volt Hertz OP
	Volt Hertz Trip DPO	Volt Hertz Alarm DPO	Volt Hertz DPO
	Volt Hertz Block OP		
VT Fuse Fail	Fuse Fail Trip PKP	Fuse Fail Alrm PKP	
	Fuse Fail Trip OP	Fuse Fail Alrm OP	
	Fuse Fail Trip DPO	Fuse Fail Alrm DPO	
Wattmetric Ground Fault	WGF 1 Trip PKP	WGF 1 PKP	WGF 1 Alarm PKP
	WGF 1 Trip OP	WGF 1 OP	WGF 1 Alarm OP
	WGF 1 Trip DPO	WGF 1 DPO	WGF 1 Alarm DPO
	WGF 2 Trip PKP	WGF 2 PKP	WGF 2 Alarm PKP
	WGF 2 Trip OP	WGF 2 OP	WGF 2 Alarm OP
	WGF 2 Trip DPO	WGF 2 DPO	WGF 2 Alarm DPO
		WGF 1 Block	WGF 2 Block
Self-Test Error	Self-Test Rly 7 On	Self Test Alarm OP	
Trip Coil Monitoring	R1 CoilMonAlrm OP	R2 CoilMonAlrm OP	

Breaker control

The Breaker Control menu is designed to trip and close the breaker from the relay either remotely (LOCAL MODE setting set to "OFF," or the selected contact input deselected) or locally (the input from the LOCAL MODE setpoint asserted). While in LOCAL MODE, the REMOTE OPEN and CLOSE setpoints are not active.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S4 CONTROLS > BREAKER CONTROL**

LOCAL MODE

Range: Off, Contact Input 1 to 10, Virtual Input 1 to 32, Remote Input 1 to 32, Logic Elements1 to 16, CT Fail Alarm PKP, CT Fail Alarm OP, 2nd Harmonic Alarm, 2nd Harmonic

Default: 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 "OFF," or the selected input de-asserted).

RESET

Range: Off, Contact Input 1 to 10, Virtual Input 1 to 32, Remote Input 1 to 32, Logic Elements1 to 16, CT Fail Alarm PKP, CT Fail Alarm OP, 2nd Harmonic Alarm, 2nd Harmonic

Default: Off

The RESET setting resets the latched alarm or Trip LEDs, and the latched relays.

REMOTE OPEN

Range: Off, Contact Input 1 to 10, Virtual Input 1 to 32, Remote Input 1 to 32, Logic Elements1 to 16, CT Fail Alarm PKP, CT Fail Alarm OP, 2nd Harmonic Alarm, 2nd Harmonic

Default: Off

This setting specifies the input which when asserted, initiates a trip (output relay #1 TRIP energized) and opens the breaker.

REMOTE CLOSE

Range: Off, Contact Input 1 to 10, Virtual Input 1 to 32, Remote Input 1 to 32, Logic Elements 1 to 16, CT Fail Alarm PKP, CT Fail Alarm OP, 2nd Harmonic Alarm, 2nd Harmonic

Default: Off

This setting specifies the input which when asserted initiates a close (output relay #2 CLOSE energized) and closes the breaker.

KEYPAD BKR OPEN

Range: Yes, No

Default: No

This setting provides flexibility to the user to open the breaker from the keypad. Selecting “Yes” will introduce a pulse of 100ms to the "trip" output relay. The setting is active, when the selected input under LOCAL MODE setpoint is asserted

KEYPAD BKR CLOSE

Range: Yes, No

Default: No

This setting provides flexibility to the user to close the breaker from the keypad. Selecting “Yes” will introduce a pulse of 100ms to the "close" output relay. The setting is active, when the selected input under LOCAL MODE setpoint is asserted

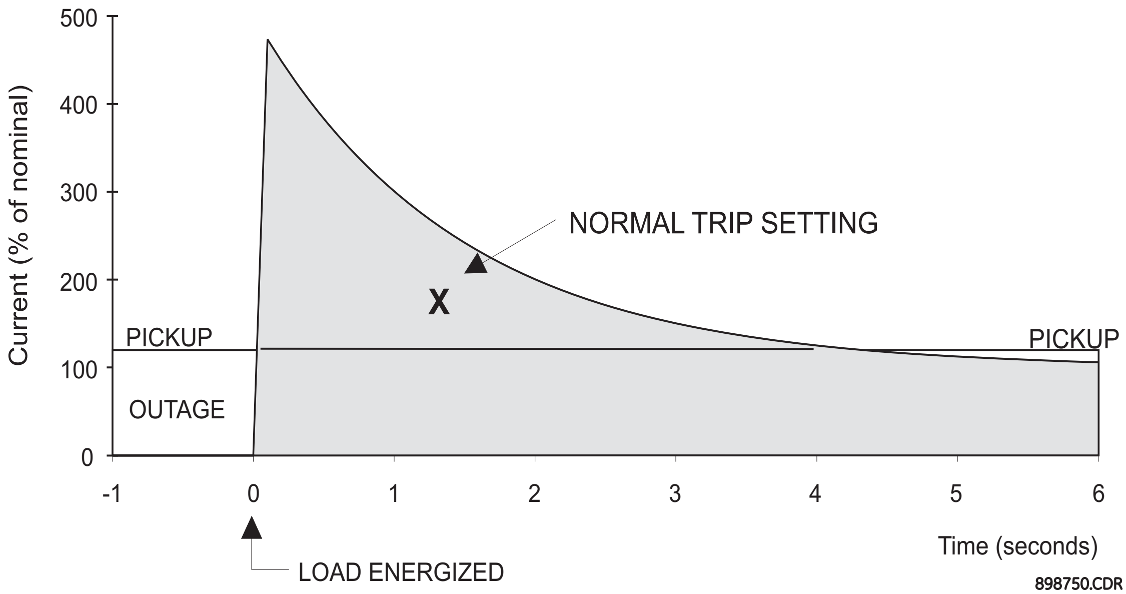
By default, the breaker control mode is set to "Remote" (LOCAL MODE set to "OFF"). In this mode, only the REMOTE OPEN and REMOTE CLOSE setpoints are active. The rest of the setpoints with exception of the RESET setpoint are deactivated, regardless of the status of their selected inputs.

Local Mode is set if the input for the LOCAL MODE setpoint is asserted. In this mode, the REMOTE OPEN and REMOTE CLOSE setpoints are deactivated, regardless of the status of their selected inputs. **Breaker Open** and **Breaker Close** commands from the KEYPAD BKR OPEN and KEYPAD BKR CLOSE setpoints will be active, if the breaker operation is set to Local Mode (i.e. the selected input under the LOCAL MODE setpoint asserted).

Cold load pickup (CLP)

The 350 can be programmed to block the instantaneous over-current elements, and raise the pickup level of the time over-current elements, when a cold load condition is detected. The cold load condition is detected during closing of the breaker on a feeder that has been de-energized for a long time. The feeder inrush current and the motor accelerating current during breaker closing may be above some over-current protection settings. The diagram shows the slow decaying of the cold load current starting at about 500% of the nominal current at the time of breaker closing, decaying down to 300% after 1 second, 200% after 2 seconds, and 150% after 3 seconds.

Figure 6-57: Cold load pickup



The relay detects Cold Load condition (Cold Load Pickup armed), if the currents on all three phases drop below 3% of the CT nominal rating for the period of time greater, than the Outage Time Before Cold Load setting. The Cold Load condition can be immediately initiated (Outage Time Before Cold Load timer bypassed), by asserting a contact input selected for External CLP Initiate.

The second timer Cold Load Pickup Block is used to specify the time of blocking the instantaneous over-current elements, and the time of raised pickup levels of the time over-current elements, after breaker closing. The timer starts when at least one of the three phase currents is above 10% of CT nominal. Upon timer expiration, the settings return to normal.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S4 CONTROLS > COLD LOAD PICKUP**

CLP BLK FUNCTION

Range: Disabled, Alarm, Latched Alarm

Default: Disabled

For details see Common setpoints.

The Alarm LED turns OFF upon manual or remote reset command.

OUTAGE TIME

Range: 1 to 1000 min in steps of 1 min

Default: 20 min

This timer starts when the feeder is de-energized (currents drop below 3% of CT nominal). The Cold Load Pickup is armed after its time expiration.

CLP BLOCKING TIME

Range: 1 to 1000 sec in steps of 1 sec

Default: 5 s

This setting sets the time of blocking for the selected instantaneous overcurrent elements, and the time of raised pickup level of the time overcurrent elements. This timer starts when currents bigger than 10% of CT nominal are detected.

CLP EXT INITIATE

Range: Off, Contact Input 1 to 10, Virtual Input 1 to 32, Remote Input 1 to 32, Logic Input 1 to 16, CT Fail Alarm PKP, CT Fail Alarm OP, 2nd Harmonic Alarm, 2nd Harmonic

Default: Off

This setting allows the user to select Contact Input, Virtual Input, Remote Input, or Logic Element, and force the CLP element into the Cold Load Pickup armed state, bypassing the timer **Outage Time Before Pickup**.

BLOCK PH IOC1(2)/ BLOCK GND [S.GND] IOC1(2)/ BLOCK NTRL IOC1(2) / BLOCK NEG SEQ IOC

Range: No, Yes

Default: No

Each instantaneous over-current element from the list can be selected for block or not, upon cold load pickup condition.

RAISE PH TOC PKP/ RAISE GND [S.GND] TOC PKP/ RAISE NTRL TOC PKP/RAISE NSEQ TOC PKP

Range: 0 to 100% in steps of 1%

Default: 0%

The pickup level of each time over-current element from the list can be raised by 0 to 100%, upon cold load pickup condition.

OUTPUT RELAY X

For details see Common setpoints.

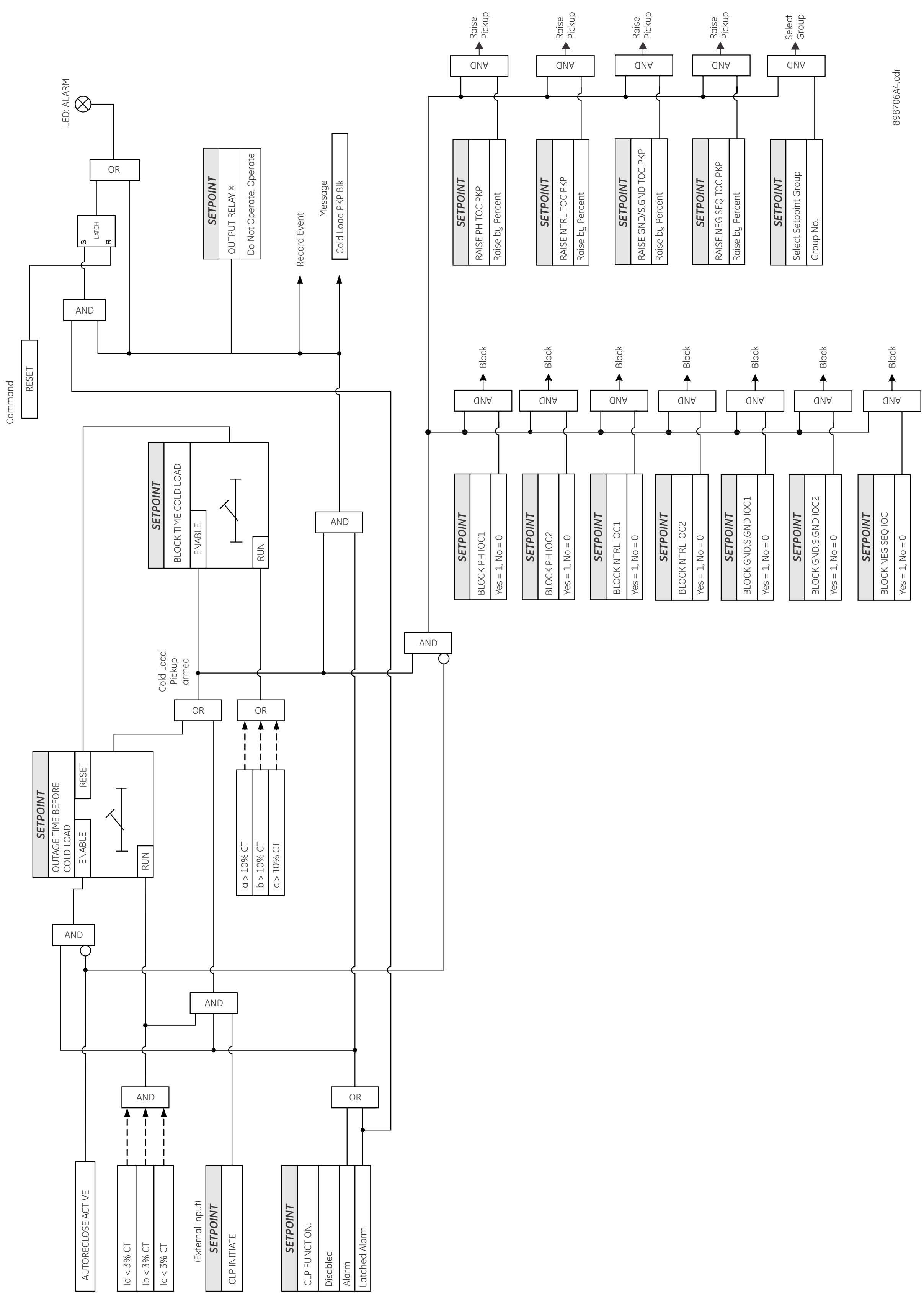
SELECT SETP GROUP

Range: Active Group, SP Group 1 Active, SP Group 2 Active

Default: Active Group

The CLP blocking function will block the IOC, and adjust the TOC pickup levels for the over-current elements from whichever Setting Group is active, if the setting Active Group is selected.

Figure 6-58: Cold load pickup logic diagram



Breaker failure (50BF)

The Breaker Failure function monitors the phase currents, after a trip command from the protection elements is initiated. If any phase current is above the set current level after the BF DELAY time expires, a breaker failure will be declared, and will operate the selected output relays. The Breaker failure scheme provides also an external input to initiate breaker failure via Contact Input, Virtual Input, Remote Input, or Logic Element.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S4 CONTROLS > BREAKER FAIL**

BF FUNCTION

Range: Disabled, Alarm, Latched Alarm

Default: Disabled

For details see Common setpoints.

BF CURRENT

Range: 0.05 to 20.00 x CT in steps of 0.01

Default: 1.00 x CT

This setting selects the current level to be monitored by the BF logic, after the programmed time delays.

BF EXT INITIATE

Range: Off, Contact Input 1 to 10, Virtual Input 1 to 32, Remote Input 1 to 32, Logic Element 1 to 16, CT Fail Alarm PKP, CT Fail Alarm OP, 2nd Harmonic Alarm, 2nd Harmonic

Default: Off

This setting allows the user to select Contact Input, Virtual or Remote Input, Logic Element to initiate the Breaker Failure logic.

BF TIME DELAY 1

Range: 0.03 to 1.00 s in steps of 0.01 s

Default: 0.10 s

This timer starts when breaker trip command is issued from any of the protection elements.

BF TIME DELAY 2

Range: 0.00 to 1.00 s in steps of 0.01 s

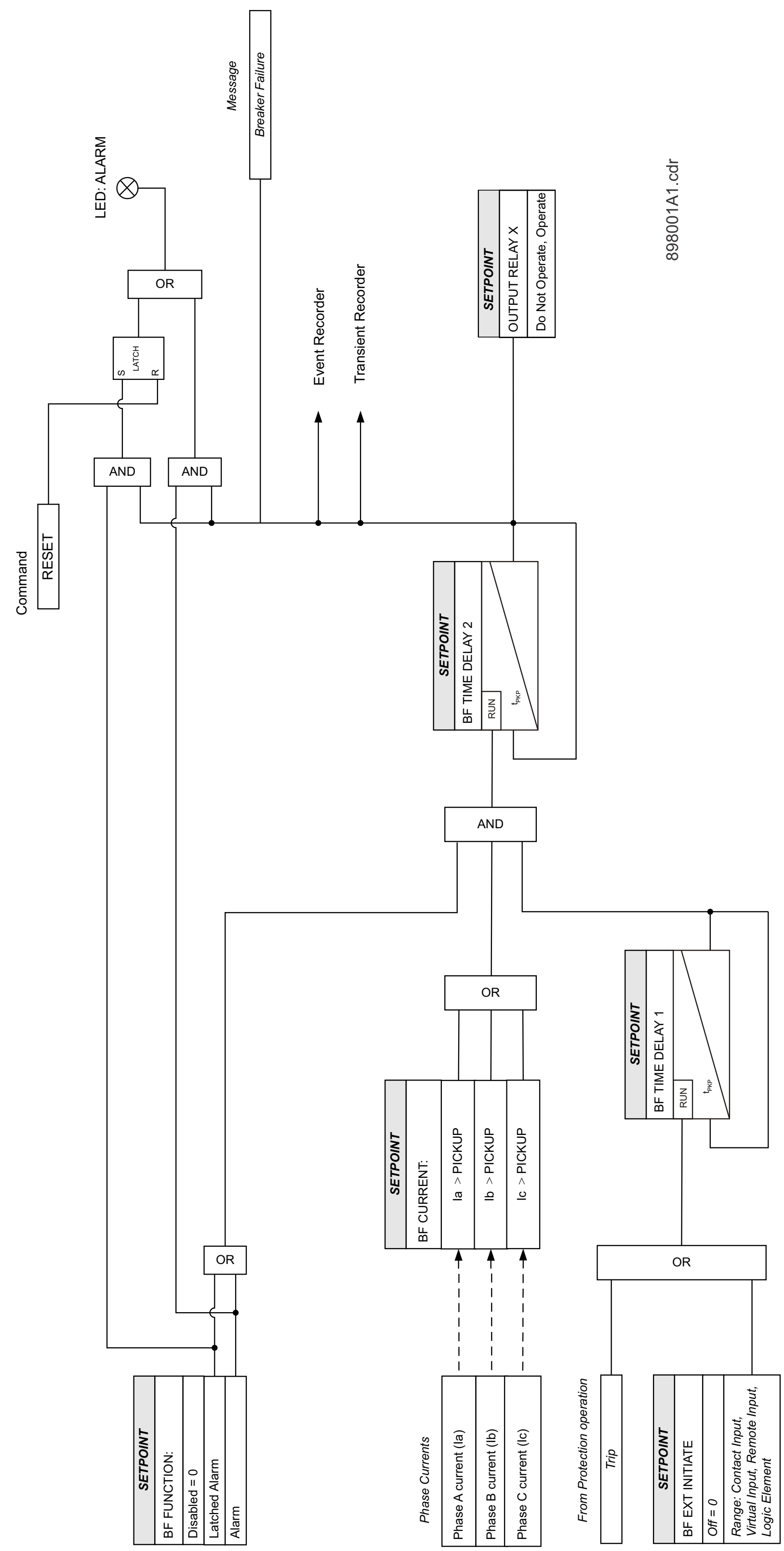
Default: 0.00 s

This timer does not start until a trip condition is recognized, BF TIMER DELAY 1 has expired, and at least one of the phase currents is above the BF CURRENT setting.

OUTPUT RELAY X

For details see Common setpoints.

Figure 6-59: Breaker failure logic diagram



CT failure (60CTS)

Failure of a CT secondary wiring that is open (one phase or two phases), can lead to undesired operation by some of the enabled protection elements. These include the differential protection, restricted ground fault, and sensitive overcurrent protection elements operating based on sequence components such as neutral and negative sequence instantaneous and timed over-current elements. The CT failure function is designed to detect problems with system current transformers (CTs) used to supply currents to the relay. The logic detects the presence of zero sequence current at the supervised source without the presence of zero sequence voltage, or ground current.

NOTE

The CT Failure element shows in the S4 CONTROLS menu only if the relay was ordered with phase current and phase voltage inputs.

NOTE

The voltage transformers connection used must be able to refer zero sequence voltage from the primary to the secondary side. Therefore, this element should only be enabled where the VT is of a five-limb construction, or comprises three single-phase units with the primary star point grounded.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S4 CONTROLS > CT FAILURE**

CT FAILURE FUNCTION

Range: Disabled, Alarm, Latched Alarm

Default: Disabled

For details see Common setpoints.

OUTPUT RELAY X

For details see Common setpoints.

CT BLOCK 1 (3)

For details see Common setpoints.

CT FAIL 3I0 CURRENT PKP

Range: 0.03 to 2.00 x CT in steps of 0.01

Default: 0.10 x CT

This setting defines the level of neutral current, above which CT failure picks up. The neutral current pickup level is expressed in the times phase CT rating set under the **S2 SYSTEM SETUP > CURRENT SENSING** menu. Refer to the CT failure detection logic diagram for more detail.

CT FAIL 3V0 VOLTAGE INHIBIT

Range: 0.05 to 2.00 x VT in steps of 0.01

Default: 0.20 x VT

This setting defines the level of neutral voltage (3V0) above which CT failure detection is inhibited. The inhibit level is expressed in the times VT rating set under the **S2 SYSTEM SETUP > VOLTAGE SENSING** menu.

CT FAIL GND CURRENT INHIBIT

Range: 0.02 to 2.00 x CT in steps of 0.01

Default: 0.20 x CT

This setting defines the level of ground current above which CT failure detection is inhibited. The inhibit level is expressed in the times ground CT rating set under the **S2 SYSTEM SETUP > CURRENT SENSING** menu.

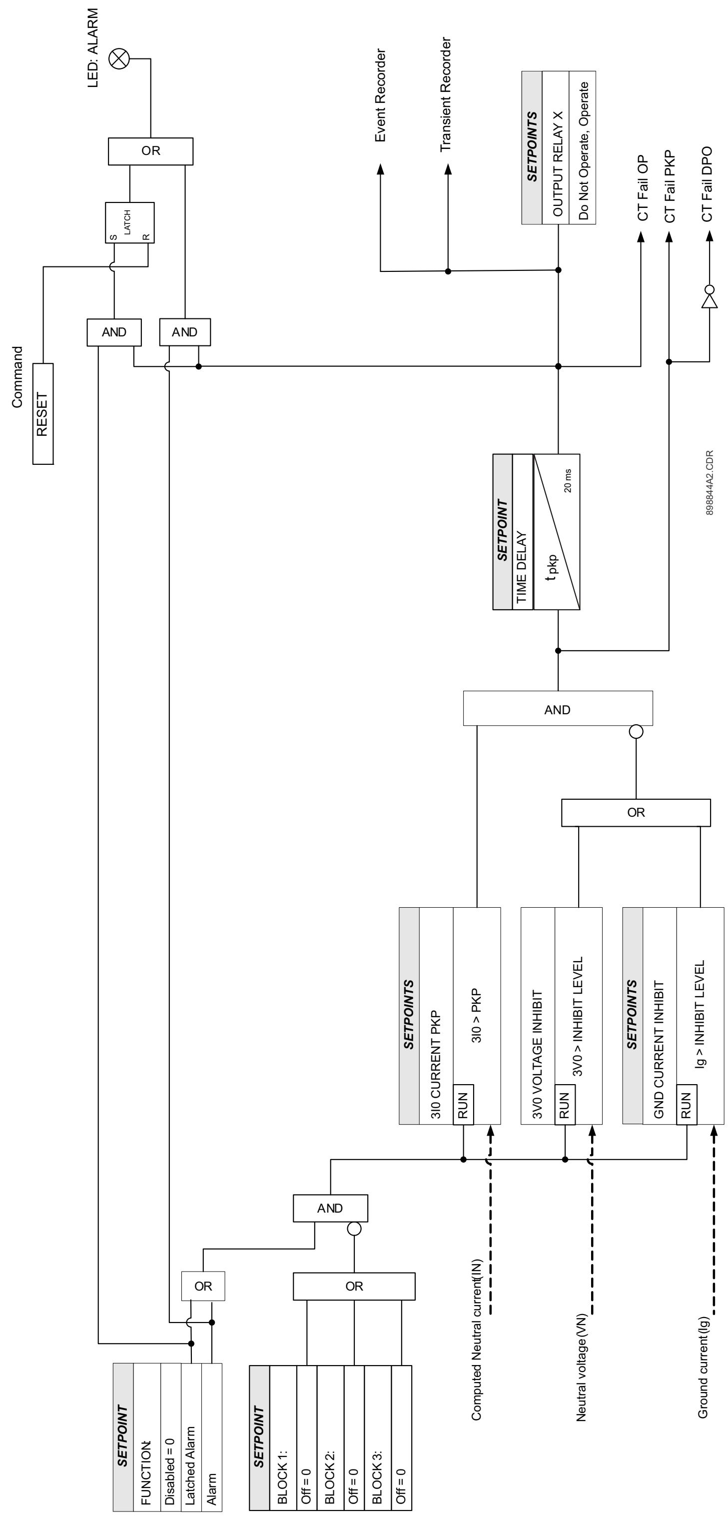
CT FAIL TIME DELAY

Range: 0.00 to 60.00 s in steps of 0.01 s

Default: 0.10 s

This setting defines the time for CT failure to operate.

Figure 6-60: CT failure detection logic diagram



Autorecloser (79)

The automatic recloser is intended for use on single three-pole tripping breaker applications. Up to four reclosing "shots" can be programmed with independent set of protection elements for initiation, and individual dead time prior to each subsequent shot. A typical example for selection of individual set of overcurrent protection elements for initiation is the selection of instantaneous overcurrent protections for the first AR initiation, and selection of time overcurrent protections after the first reclose. This would provide longer time before the breaker opens, and allow the fuses to burn off, if the fault is still present.

NOTE

To synchronize the Reclose function with the breaker status feedback, it is recommended that a debounce of 2 cycles is used, regardless of whether the breaker status is detected using one or both contacts.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S4 CONTROLS > AUTORECLOSE > AR SETUP**

AR FUNCTION

Range: Disabled, Enabled

Default: Disabled

For details see Common setpoints.

NUMBER OF SHOTS

Range: 1 to 4, step 1

Default: 1

The maximum number of reclosures that will be attempted before AR Not Ready.

DEAD TIME SHOT 1 to 4

Range: 0.1 to 600.0 s, step 0.1 s

Default: 1.0 s

This setting specifies the dead time delay before each reclosure. Four time delay settings are to be configured and used to time out before the first, second, third, or fourth breaker reclosure.

RST N/READY TIME

Range: 0.1 to 600.0 s, step 0.1 s

Default: 10 s

This setting specifies the reset AR Not Ready time. Upon breaker close, the timer times out, and resets the AR lockout.

INCOMP SEQ TIME

Range: 0.1 to 600.0 s, step 0.1 s

Default: 5.0 s

This timer is used to set the maximum time interval allowed for single reclosure shot. The timer starts timing out for both situations: upon AR initiate to open the breaker, where the breaker doesn't open, or whenever breaker reclose command is issued, where the breaker doesn't close. Upon incomplete sequence time expiry, the AR goes into AR Not Ready mode.

RESET TIME

Range: 0.1 to 600.0 s, step 0.1 s

Default: 5.0 s

This time is used to reset the AR into AR ready mode after successful reclosure. If no breaker tripping occurs within the reset time, the AR shot counter is reset.

BLOCK AR

For details see Common setpoints.

EXT INITIATE

Range: Off, Contact Input 1 to 10, Virtual Input 1 to 32, Remote Input 1 to 32, Logic Elements 1 to 16, CT Fail Alarm PKP, CT Fail Alarm OP, 2nd Harmonic Alarm, 2nd Harmonic
Default: Off

This setting provides selection for contact input, virtual input, remote input, or logic element to initiate the AR scheme.

PH IOC1/2 INITIATE

Range: Off/On
Default: Off

When set to “On,” the operation of this element initiates the AR sequence.

GND [S.GND] IOC1/2 INITIATE

Range: Off/On
Default: Off

When set to “On,” the operation of this element initiates the AR sequence.

NTRL IOC1/2 INITIATE

Range: Off/On
Default: Off

When set to “On,” the operation of this element initiates the AR sequence.

PHASE TOC INITIATE

Range: Off/On
Default: Off

When set to “On,” the operation of this element initiates the AR sequence.

NTRL TOC INITIATE

Range: Off/On
Default: Off

When set to “On,” the operation of this element initiates the AR sequence.

GND [S.GND] TOC INITIATE

Range: Off/On
Default: Off

When set to “On,” the operation of this element initiates the AR sequence.

NSEQ TOC INITIATE

Range: Off/On
Default: Off

When set to “ON,” the operation of this element initiates the AR sequence.

AR READY - RELAY X

Range: Do not operate, Operate
Default: Do not operate

Any or all of the output relays can be selected to operate upon Autoreclose Status detected as “AR READY”.

AR IN-PROGR - RELAY X

Range: Do not operate, Operate
Default: Do Not Operate

Any or all of the output relays can be selected to operate upon Autoreclose Status detected as “AR IN-PROGRESS”.

AR N/READY - RELAY X

Range: Do not operate, Operate

Default: Do Not Operate

Any or all of the output relays can be selected to operate upon Autoreclose Status detected as "AR LOCKOUT".

SELECT SETP GROUP

Range: Active group, SP Group 1 Active, SP Group 2 Active

Default: SP Group 1 Active

The Autoreclose function will be executed in the setpoint group selected as a setting in "SELECT SETP GROUP", or in the active setpoint group if the setting "Active Group" is selected.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S4 CONTROLS > AUTORECLOSE > AR SHOT 1(4)**

BLOCK PH IOC1/2 Shot 1 to 4

Range: Off/On

Default: Off

If set to "On" for the selected shot, the operation of the element will initiate breaker trip after the corresponding breaker reclosing shot.

BLOCK NTRL IOC1/2 Shot 1 to 4

Range: Off/On

Default: Off

If set to "On" for the selected shot, the operation of the element will initiate breaker trip after the corresponding breaker reclosing shot.

BLOCK GND/S.GND IOC1/2 Shot 1 to 4

Range: Off/On

Default: Off

If set to "On" for the selected shot, the operation of the element will initiate breaker trip after the corresponding breaker reclosing shot.

BLOCK PH TOC Shot 1 to 4

Range: Off/On

Default: Off

If set to "On" for the selected shot, the operation of the element will initiate a breaker trip after the corresponding breaker reclosing shot.

BLOCK GND TOC Shot 1 to 4

Range: Off/On

Default: Off

If set to "On" for the selected shot, the operation of the element will initiate a breaker trip after the corresponding breaker reclosing shot.

BLOCK NSEQ TOC Shot 1 to 4

Range: Off/On

Default: Off

If set to "ON" for the selected shot, the operation of the element will initiate a breaker trip after the corresponding breaker reclosing shot.

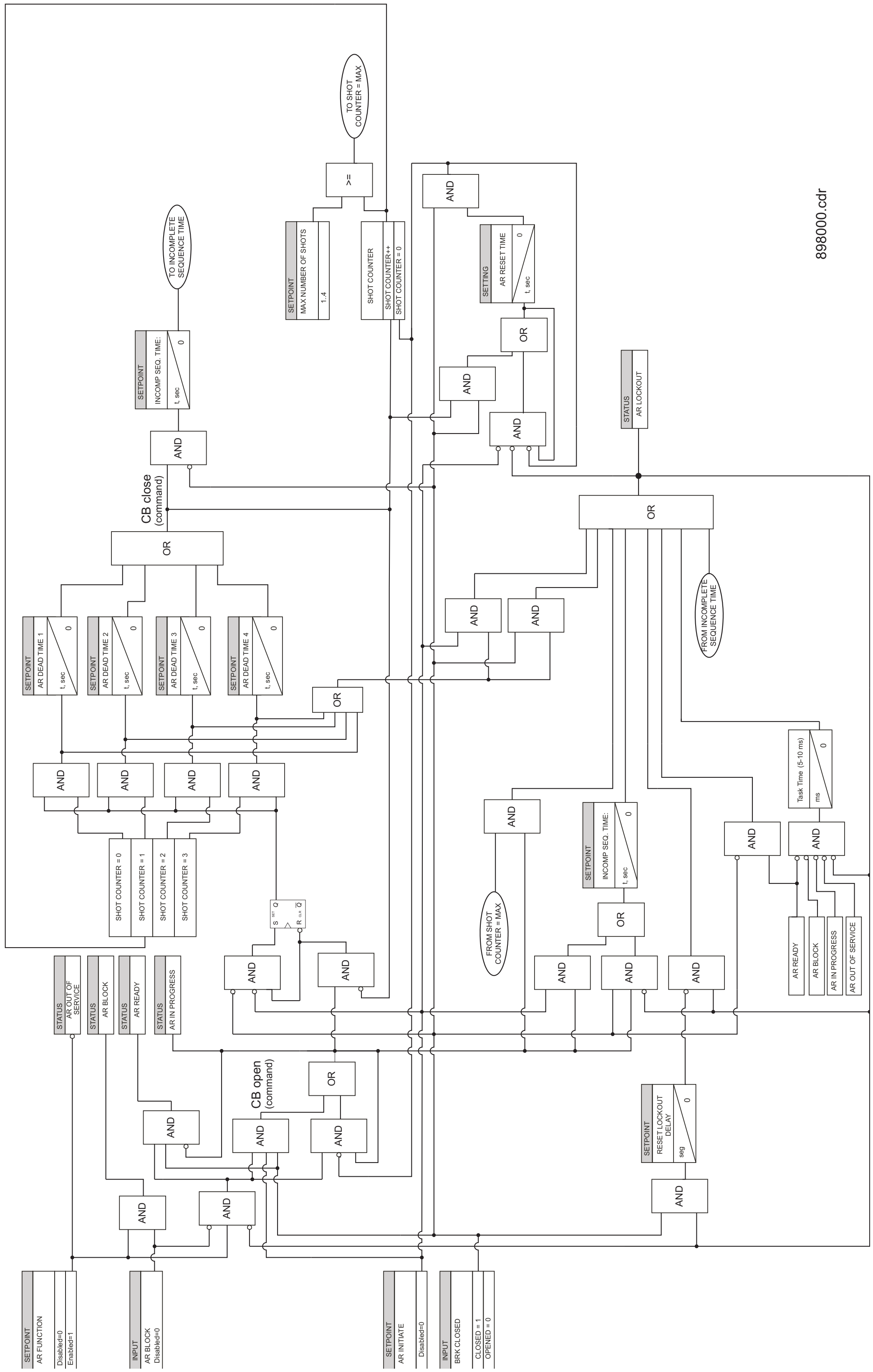
BLOCK NTRL TOC Shot 1 to 4

Range: Off/On

Default: Off

If set to “On” for the selected shot, the operation of the element will initiate a breaker trip after the corresponding breaker reclosing shot.

Figure 6-61: Autoreclose logic diagram



The Automatic Reclosure function is designed to perform up to four breaker autoreclosings, with a configurable dead time before each reclosing shot. Upon AR function enabled, and breaker status “closed”, the AR is set into “AR Ready” state. If an intermittent feeder fault occurs such as overhead conductor touching tree branch, one or more of the overcurrent protection elements enabled under AR initiate menu will operate and issue a breaker trip command. If the breaker opens, the dead time configured under the first AR shot will start timing out. After this time expires, the AR scheme will produce the first breaker reclosing shot. Upon breaker close and no fault conditions, the overcurrent elements set for initiation on the first AR shot will not operate, and the reclosing is declared successful. The remaining of the configured AR sequence will be executed. The AR Reset time will start timing out, where upon time expiry resets the AR counter. The AR sequence is reset with AR function into “AR Ready” state.

If the fault is permanent, the configured AR sequence will be executed in full, where the breaker opens after the last reclosing shot and the AR function goes into lockout.

The reclosure scheme passes through the following states during operation:

AR NOT READY: When in this state, the AR is blocked. The AR NOT READY occurs if any of the following conditions are present:

- The maximum shot number was reached.
- The incomplete sequence AR INCOM SEQ TIME timer times out.
- The AR BLOCK INPUT is set

AR READY: To reach this state the AR RESET NOT READY timer times out from NOT READY state or the AR RESET TIME timer times out from WAIT RST TIME state. In this state the autorecloser is waiting for reclose Initiation (RI) event to start the reclosure process.

WAIT FOR 52 OPEN: Once a Reclose Initiation event occurs the autorecloser is waiting for breaker status OPEN or otherwise the AR INCOM SEQ TIME timer will time out. If the AR INCOM SEQ TIME expires, the autorecloser will go into NOT READY state. However if the breaker opens, the AR scheme will start the configured DEAD TIME timer, and will be put into WAIT DEAD TIME state.

WAIT DEAD TIME: In this state the autorecloser is waiting for the relevant AR DEAD TIME SHOT timer to time out. If during this time out the breaker status changes to CLOSE, a Reclose Initiation or an AR BLOCK input occurs the autorecloser process ends in a NOT READY state. If not, the WAIT FOR 52 CLOSE state is reached.

WAIT FOR 52 CLOSE: In this state upon reclosing command, the autorecloser is waiting for the breaker to CLOSE. If the AR INCOM SEQ TIME timer times out or a new Reclose Initiation occurs and it’s the last shot then the autorecloser ends in a NOT READY state. If a new Reclose Initiation occurs and it is not the last from the programmed sequence, the autorecloser goes into the WAIT FOR 52 OPEN status.

WAIT RESET TIME: In this state, when the AR RST TIME timer times out the number of shots is reset and the autorecloser goes into AR READY state waiting for a new AR execution.If the breaker status changes to OPEN or an AR BLOCK input occurs, or a new *Reclose Initiation* happens and it’s the last shot then the autorecloser ends in a NOT READY state.

If a new *Reclose Initiation* different from the last shot occurs the autorecloser goes into the WAIT FOR 52 OPEN status for the next shot.

Reclose Initiation is produced by a trip with the relevant permission enabled.

Synchrocheck (25)

The Synchrocheck element is used for monitoring the connection of two parts of the circuit by the close of a breaker. This element verifies that voltages (VL and VB) at both sides of the breaker are within the magnitude, angle and frequency limits set by the user. VL and VB are the Line and Busdbar voltage values measured by the device.

WARNING

Calculated voltages are not suitable for synchrocheck. Under the following conditions, the Synchrocheck function is disabled:

- **Wye is selected under "VT Connection" and a Delta voltage input (V_{ab} VT, V_{bc} VT, V_{ca} VT) is selected under "Auxiliary VT input"**
- **Delta is selected under "VT Connection" and a Wye voltage input (V_{an} VT, V_{bn} VT, V_{cn} VT) is selected under "Auxiliary VT input"**

WARNING

Due to the discrete computation of the analog incoming data measurements, fixed at a frequency rate of a quarter of power cycle, the next constraint between settings must be taken into account:

- **At 50 Hz: 1.8 x ΔF_{max} <Max Angle Diff**
- **At 60 Hz: 1.5 x ΔF_{max} Angle Diff The non-compliance of this requirement could cause a synchrocheck close condition out of the limits set by settings.**

The non-compliance of this requirement could cause a synchrocheck close condition out of the limits set by settings.

Synchrocheck, or Synchronism Check (25), is defined as the comparison of the voltage difference of two circuits with different sources to be either linked through an impedance element (transmission line, feeder, etc.), or connected through parallel circuits of defined impedance. The voltage comparison between both sides of a breaker is performed before closing the breaker, in order to minimize internal damage that could occur due to the voltage difference, both in magnitude and angle. This is extremely important in steam generating plants, where reclosing output lines with angle differences could lead to severe damage to the turbine axis.

The difference in voltage level and phase angle in a given moment is the result of the existing load between remote resources connected through parallel circuits (load flux), as well as a consequence of the impedance of those elements connecting them (even if there is no load flux in parallel circuits, or because sources to be connected are completely independent and isolated from one another).

In interconnected systems, the angle difference between both ends of an open breaker is usually negligible, as its sources are remotely connected through other elements (equivalent or parallel circuits). However, in isolated circuits as in the case of an independent generator, the difference in angle, voltage levels and relative slip of voltage phasors can be very important. It can also be that the relative slip of voltage values is very low or null so that they will be rarely in phase. Luckily, due to the changing conditions of a power system (connection-disconnection of loads, sources, and new inductive-capacitive elements) the relative slip between phasors is not null and they can be synchronized.

In the first case, even if we must take into consideration the length of the line whose ends (sources) will be connected for determining the angle difference between them, this is not enough to fix the synchronism conditions before closing the breaker. Experience tells us that the window of angle difference between voltage phasors must be fixed to a value of 15° to 20°.

VOLTAGE INPUTS

In order to perform the synchrocheck function, the device uses only one voltage from each end of the breaker. Voltage values to be compared must be on the same basis, either phase-to-phase or phase-to-ground voltage. Also, they must be the same at both ends of the breaker. It is not possible to compare a phase-to-ground voltage at one end with a phase-to-phase voltage at the other end.

Additionally, if on one end, three voltages have been connected, the necessary voltage on the other end for synchrocheck will only be single-phase voltage. If there is only one voltage (either phase-to-phase or phase-to-ground) at both ends of the breaker, this must be the same phase in both cases.

CLOSING PERMISSION LOGIC

If the voltage at one or both ends of the breaker is null, the synchrocheck function cannot establish the necessary parameters to give conditions for closing, and therefore does not issue synchrocheck permission. If the user wants to enable the closing permission for cases where there is a of loss of one or both voltages at both ends of the breaker, the synchrocheck function incorporates closing permission logic for the following cases.

- Dead Line-Dead Bus,
- Live Line-Dead Bus,
- Dead Line-Live Bus,
- Any Line-Dead Bus,
- Dead Line-Any Bus,
- One Live-Other Dead,
- Not Both Live

LIVE LINE-LIVE BUS CONDITION

In the Live Line-Live Bus case, once the Voltage difference has been successfully verified in magnitude, the relative frequency slip between phasors is calculated. From the information obtained from the relay, the algorithm will kow the slip (mHz) of both phasors, and it will take as reference (VRef) the lowest frequency phasor. The behavior of the algorithm depends on the slip frequency and the breaker close time as follows:

1. If the relative slip, Δf, is equal to or lower than 20 mHz, the algorithm gives permission to close as soon as the angle difference is lower than the **Max Angle Difference**, because at such a low speed, the hold time for getting an “in-phase” closing permission would be too long.
2. If the relative slip is higher than 30 mHz, the element performs an anticipative algorithm, determining the right moment to give the closing command to the breaker, so that the breaker closes when the line and busbar voltages are in phase. When the difference between the voltage values equals two times the set angle as maximum angle difference (ΔV = ΔVset), the anticipative algorithm starts running and uses the set **Breaker Closing Time** to establish the initiation of permission, so that it is executed in the moment when both voltage phasors are completely in phase, thus minimizing the voltage difference in the breaker chamber to negligible values. The main benefit is that after a considerable number of breaker operations, damage to internal connection elements, as well as to the chamber isolating element, is drastically reduced, ensuring a longer life for the breaker, and reducing costly maintenance operations.
3. The algorithm ensures that the difference between voltages in the real closing moment it not higher than the set value (**Max Volt Diff**).

PATH: **SETPOINTS > S4 CONTROLS > SYNCHROCHECK**

SYNCHROCHECK FUNCTION:

Range: Disabled, Enabled

Default: Disabled

For details see Common setpoints.

DEAD BUS LEVEL

Range: 0.00 to 1.25 x VT in steps of 0.01 x VT
Default: 0.10 x VT

This setting specifies the voltage level considered as the dead Bus.

LIVE BUS LEVEL

Range: 0.03 to 1.25 x VT in steps of 0.01 x VT
Default: 0.50 x VT

This setting specifies the voltage level considered as the live Bus.

DEAD LINE LEVEL

Range: 0.00 to 1.25 x VT in steps of 0.01 x VT
Default: 0.10 x VT

This setting specifies the voltage level considered as the dead Line.

LIVE LINE LEVEL

Range: 0.03 to 1.25 x VT in steps of 0.01 x VT
Default: 0.50 x VT

This setting specifies the voltage level considered as the live Line.

MAX VOLT DIFF

Range: 10 to 10000 V in steps of 1 V
Default: 1000 V

This setting specifies the maximum difference between the line and busbar voltage to allow the synchrocheck element to close.

MAX ANGLE DIFFERENCE

Range: 2 to 80 degrees in steps of 1
Default: 10 degrees

This setting specifies the maximum difference in angle between the line and busbar voltage to allow the synchrocheck element to close.

MAX FREQ SLIP

Range: 0.05 to 5.00 Hz in steps of 0.01
Default: 0.05 Hz

This setting specifies the maximum difference in frequency (slip) between the line and busbar voltage to allow the synchrocheck element to close.

BKR CLOSING TIME

Range: 0.00 to 1.00 s in steps of 0.01 s
Default: 0.10 s

This setting specifies the estimated breaker Closing and is used for establishing the Closing order in a moment that allows the busbar and line voltages to be in phase.

DEAD SOURCE

Range: None, DL-DB (Dead Line-Dead Bus), LL-DB (Live Line-Dead Bus), DL-LB (Dead Line-Live Bus), AL-DB (Any Line-Dead Bus), DL-AB (Dead Line-Any Bus), OL-OD (One Live-Other Dead), NBL (Not Both Live)
Default: None

For each setpoint value in the Range, this setting enables the Closing permission signal to be issued as follows:

- Dead Line-Dead Bus: the Closing permission signal is issued for a dead line and dead bus Condition (without voltage at both sides of the breaker).
- Live Line-Dead Bus: the Closing permission signal is issued for a live line and dead bus Condition (without voltage at the side of the breaker that correspond to the busbar voltage).

- Dead Line-Live Bus: the Closing permission signal is issued for a dead line and live bus Condition (without voltage at the side of the breaker that correspond to the line voltage).
- Any Line-Dead Bus: the Closing permission signal is issued for any line but dead bus Condition (without voltage at the side of the breaker that correspond to the bus voltage).
- Dead Line-Any Bus: the Closing permission signal is issued for any bus but a dead line Condition (without voltage at the side of the breaker that correspond to the line voltage).
- One Live-Other Dead: the Closing permission signal is issued if bus and line Condition are different.
- Not Both Live: for if bus and line Condition are not both live.

BYPASS

Range: Off, On, Contact Input 1 to 10, Virtual Input 1 to 32, Remote Input 1 to 32, Logic Element 1 to 16
Default: Off

This setting allows the user to bypass the Synchrocheck function by force by selecting On, Contact Input, Virtual Input, or Remote Input.

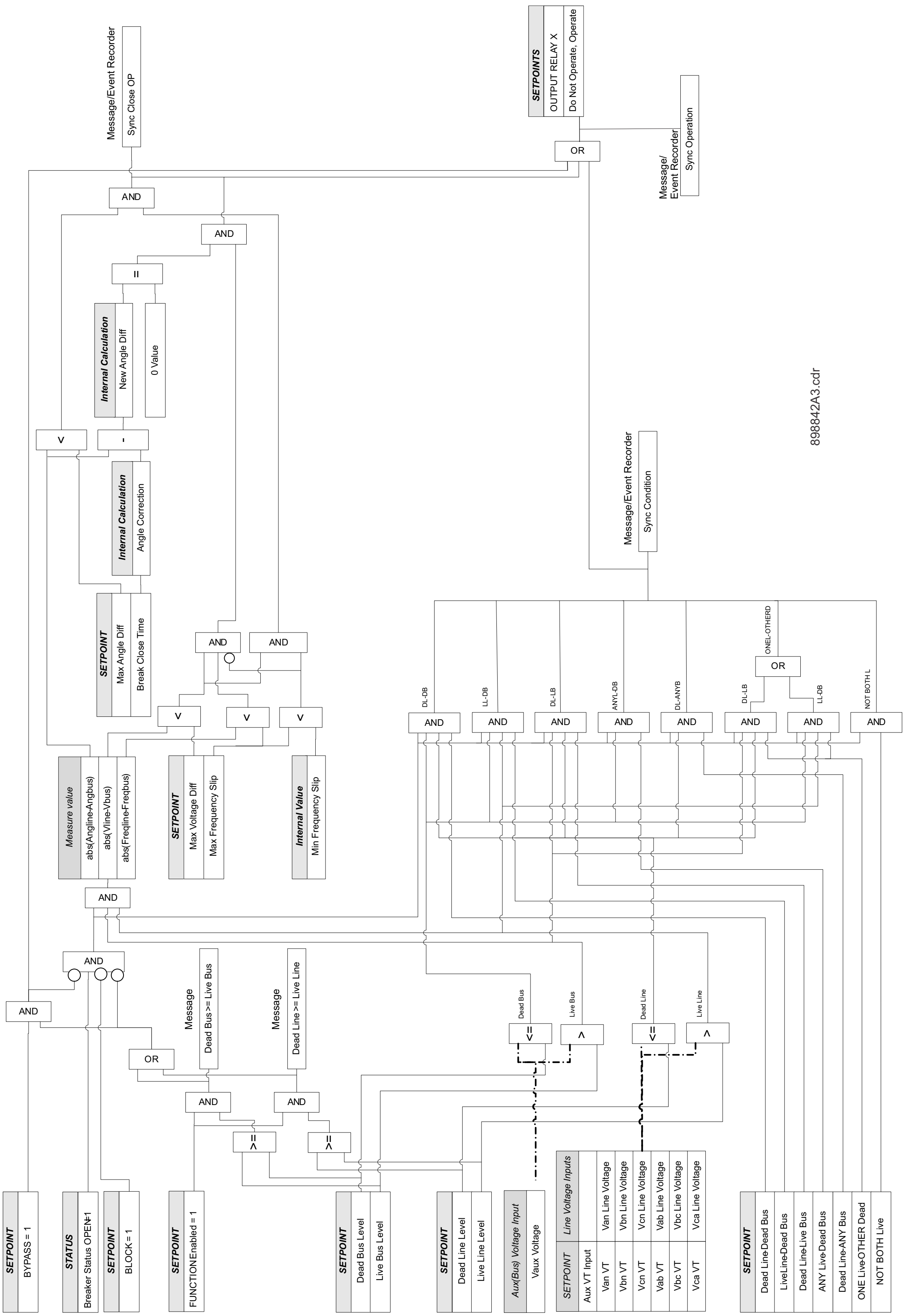
BLOCK

For details see Common setpoints.

OUTPUT RELAYS X

For details see Common setpoints.

Figure 6-62: Synchrocheck Logic diagram



Second harmonic inhibit

The 350 relay can be used for feeder transformer protection. During transformer energization, the inrush current presenting in phase currents may impact some sensitive elements, such as neutral directional overcurrent. Therefore, the ratio of the second harmonic to the fundamental magnitude per phase is monitored. When this ratio exceeds a set pickup level, an inhibit signal is asserted, which can be used to block such sensitive elements.

PATH: **SETPOINTS > S4 CONTROLS > 2ND HARMONIC INHIBIT**

2ND HARMONIC INHIBIT FUNCTION

Range: Disabled, Latched Alarm, Alarm, Control
Default: Disabled

For details see Common setpoints.

PICKUP

Range: 0.1 to 40.0% in steps of 0.1%
Default: 20.0%

DELAY

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

This setting specifies the time delay after pickup the function waits before operating.

PHASES FOR OP

Range: Any One, Any Two, All Three, Average
Default: Any One

This setting defines the phases required for operation as follows:

ANY ONE: At least one phase picked up.

ANY TWO: Two or more phases picked up.

ALL THREE: All three phases picked up.

AVERAGE: The average of three-phase harmonics picked up.

If set to AVERAGE, the relay calculates the average level of the second 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. Only phases where the fundamental current exceeds the cut-off level are included in the average.

MIN OP CURRENT

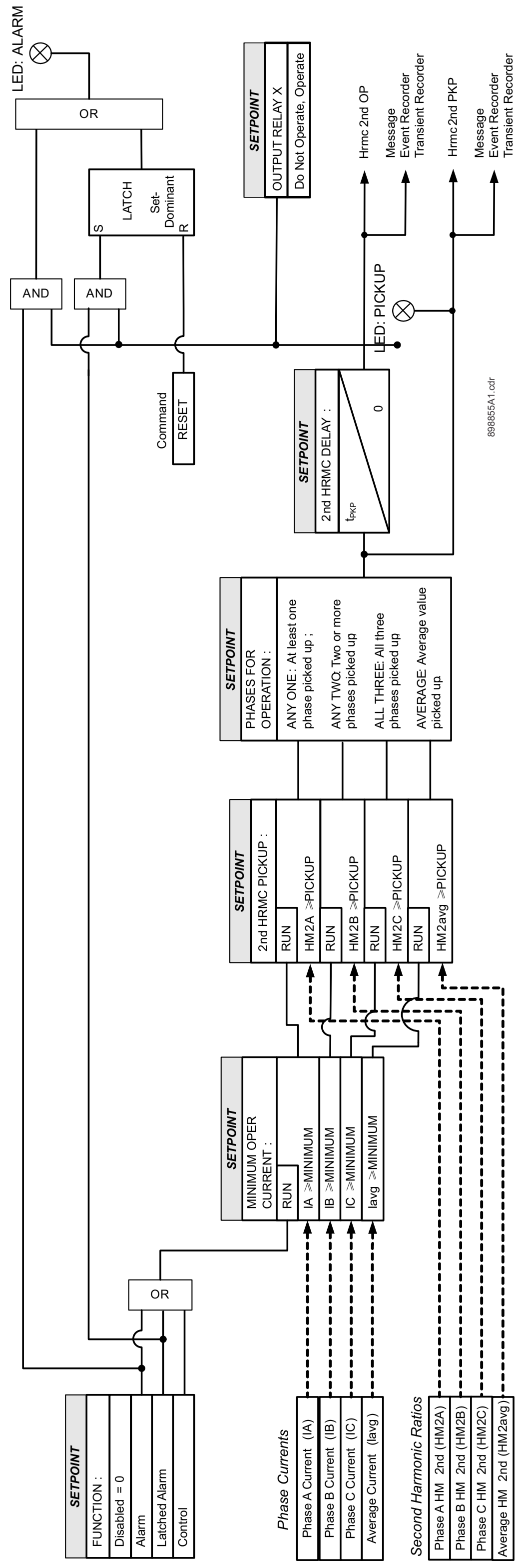
Range: 0.03 to 3.00 x CT in steps of 0.01 x CT
Default: 1.00 x CT

This setting specifies the minimum value of fundamental current required to allow the second harmonic inhibit element to operate.

OUTPUT RELAYS X

For details see Common setpoints.

Figure 6-63: Second harmonic inhibit logic diagram



Lockout (86)

The purpose of the Lockout function is to prevent unwanted closing of the breaker after being tripped by the operation of a protection element. When triggered, the lockout maintains a constant trip signal to trip output relay #1. At the same time, the same signal is used as a block into the close output relay logic to prevent any unwanted, non-safe close commands to that relay.

The lockout block is removed upon a Lockout Reset signal sent to the relay. The Lockout Reset can be initiated either by pressing the relay pushbutton RESET (after it is enabled to perform Lockout resets), or by any contact, virtual, or remote input selected under the Lockout Reset setpoint.

NOTE

Special care needs to be taken selecting the Lockout trigger in cases with Autoreclosure (AR) enabled. In such cases, the lockout may be applied after the AR cycle is complete, and the breaker is tripped. In cases of intermittent fault ending with successful AR, the Lockout should not be applied.

FUNCTION

Range: Disabled, Enabled

Default: Disabled

For details see Common setpoints.

INPUT 1(10)

Range: Off, Any Logic Operand

Default: Off

This setting selects an operand from the list of logic operands. The assertion of the selected operand triggers lockout. Ten trigger input setpoints are provided.

LOCKOUT SUPERVISION

Range: Off, Any logic operand

Default: Off

This setting provides selection of any logic operand to supervise the initiation of lockout state. As an example the open status of the breaker/breakers could be used for lockout supervision.

LOCKOUT RESET

Range: Off, Any Logic Operand

Default: Off

This setting provides selection of any logic operand from the list of operands for resetting the breaker lockout condition.

RESET FROM PB RESET

Range: Disabled, Enabled

Default: Disabled

If Enabled, pressing the front panel Reset pushbutton resets the Lockout. Otherwise, when Disabled, pressing the Reset PB sends a common reset which does not reset the Lockout.

BLOCK RESET LOCKOUT

Range: Off, Any Logic Operand

Default: Any Trip

This setting provides selection of any logic operand to block the reset action of the lockout state. Usually if there is a presence of a trip condition, the reset command will not be executed. The default value is selected as "Any Trip" operand.

BLOCK 1(3)

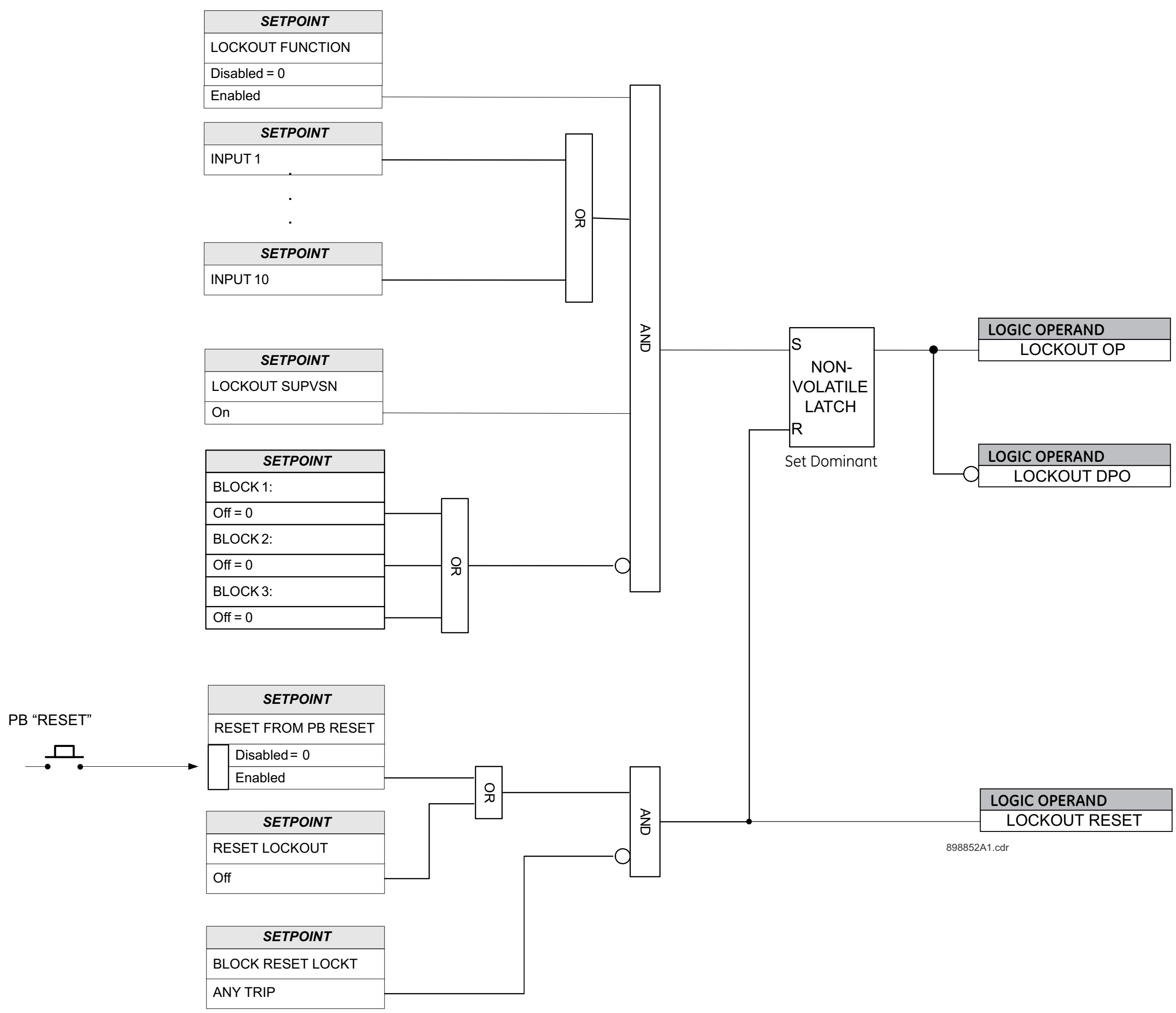
For details see Common setpoints.

Upon assertion of the block selected operand, lockout will not be executed. When the selected lockout blocking input drops out, and upon new trip, the trip and close output relays will be locked out.

NOTE

The lockout state is applied by the relay to TRIP and CLOSE output relays only, that are connected to the trip and close breaker coils respectively. If an attempt is made to close the breaker directly, bypassing the relay outputs, (i.e. from the breaker control switch while the protective relay applies lockout on its TRIP and CLOSE outputs,) the breaker may not close, as the trip signal would have priority over the close signal. In some old breakers, the attempt to close the breaker may lead to an intermittent close followed by an immediate trip, as the lockout state of the relay's output # 1 (TRIP) would be energized.

Figure 6-64: Lockout logic diagram



VT fuse fail (VTFF or 60VTS)

The 350 relay includes one VT Fuse Failure element. The measured voltages from the installed phase VTs are monitored and compared against user programmable levels. If one or two of the three voltages drops to less than 70% of nominal, and at the same time any of the three voltages is greater than 85%, either an Alarm or a Trip will occur after a 1 second delay. The 70% threshold allows for the possibility that the downstream voltage from a blown fuse is pulled up above zero by devices connected between the open fuse and another phase. The VT reference for the VTFF element is the phase to neutral voltage for Wye-connected VTs, and the phase-phase voltage for a Delta-connected VT. The VT Connection, VT Ratio and VT Secondary voltage are user programmable values under **SETPOINTS > S2 SYSTEM SETUP > VOLTAGE SENSING**.

PATH: **SETPOINTS > S4 CONTROL > VT FUSE FAILURE**

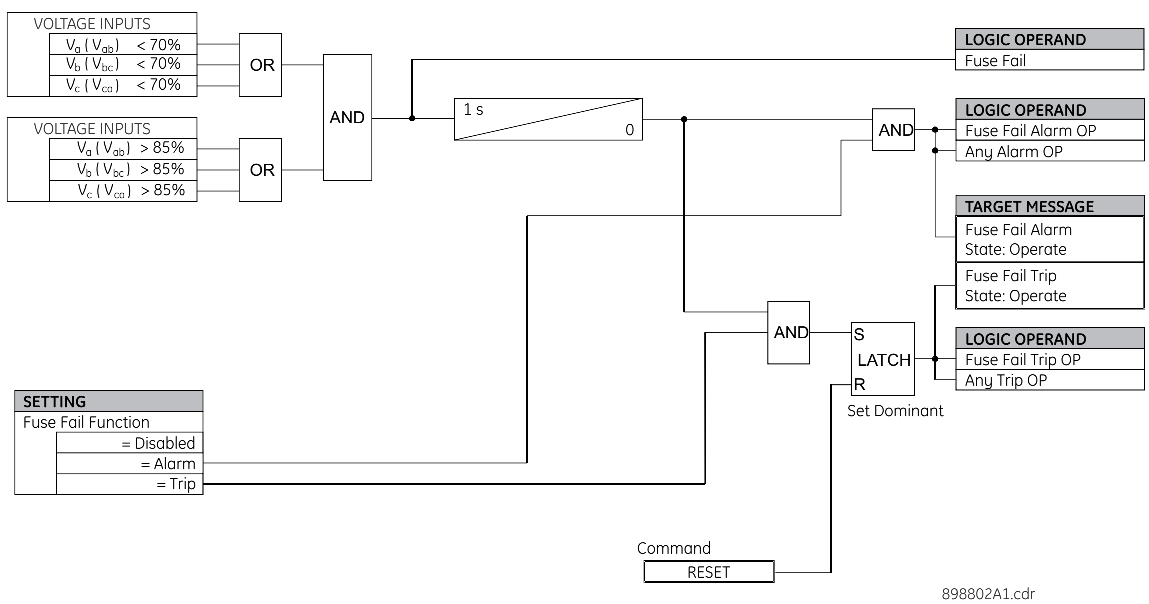
FUSE FAIL FUNCTION

Range: Disabled, Alarm, Trip

Default: Trip

For details see Common setpoints.

Figure 6-65: Fuse Fail Protection Logic Diagram



NOTE: The VTFF uses phase to neutral voltages V_a, V_b and V_c when "Wye" VT type is selected under Voltage Sensing/VT connections setpoint, and uses phase-phase voltages V_{ab} , V_{bc} and V_{ca} when "Delta" type is selected comparators.

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 ("LightSns# Trbl" and "LightSns Trbl") 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, a user can design customized logic using individual "Light Sensor # OP" operands from different light sensors.

NOTE

Arc Flash protection should be connected to the SSR outputs (AUX5 and AUX6). If connected to other outputs using logic elements, the total element operating time increases by 8 ms plus the logic element protection cycle timer.

Path: **Setpoints > S4 Controls > Arc Flash**

FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm, Control

Default: Disabled

The selection of Trip, Alarm, Latched Alarm or Configurable setting enables the HS Phase/Ground IOC function.

HS PHASE PKP

Range: 0.05 to 30.00 x CT in steps of 0.01 x CT

Default: 2.00 x CT

The Light sensor is supervised by the high-speed overcurrent function, based on a fast RMS measurement updated every 1/8 of power cycle. In order to permit the arc flash function to trip, at least one HS Phase current value must be higher that this setpoint.

HS GROUND PKP / HS SENS GROUND PKP

Range: 0.05 to 30.00 x CT in steps of 0.01 x CT

Default: 1.00 x CT

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

Default: 0.100 x CT

The Light sensor is supervised by the high-speed overcurrent function, based on a fast RMS measurement updated every 1/8 of power cycle. In order to permit the arc flash function to trip, at least one HS Ground value must be higher that this setpoint.

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.

LIGHT SENSOR 1(4)

Range: Disabled, Enabled

Default: 0.01 s

This setting indicates which sensors have been connected. The internal self-test logic includes all enabled sensors when checking for sensor failure; sensors not in use should be set to Disabled.

SEAL-IN TIMER

Range: 0.00 to 10.00 s

Default: Enabled

This timer indicates the minimum time the Arc flash trip operation state is kept raised.

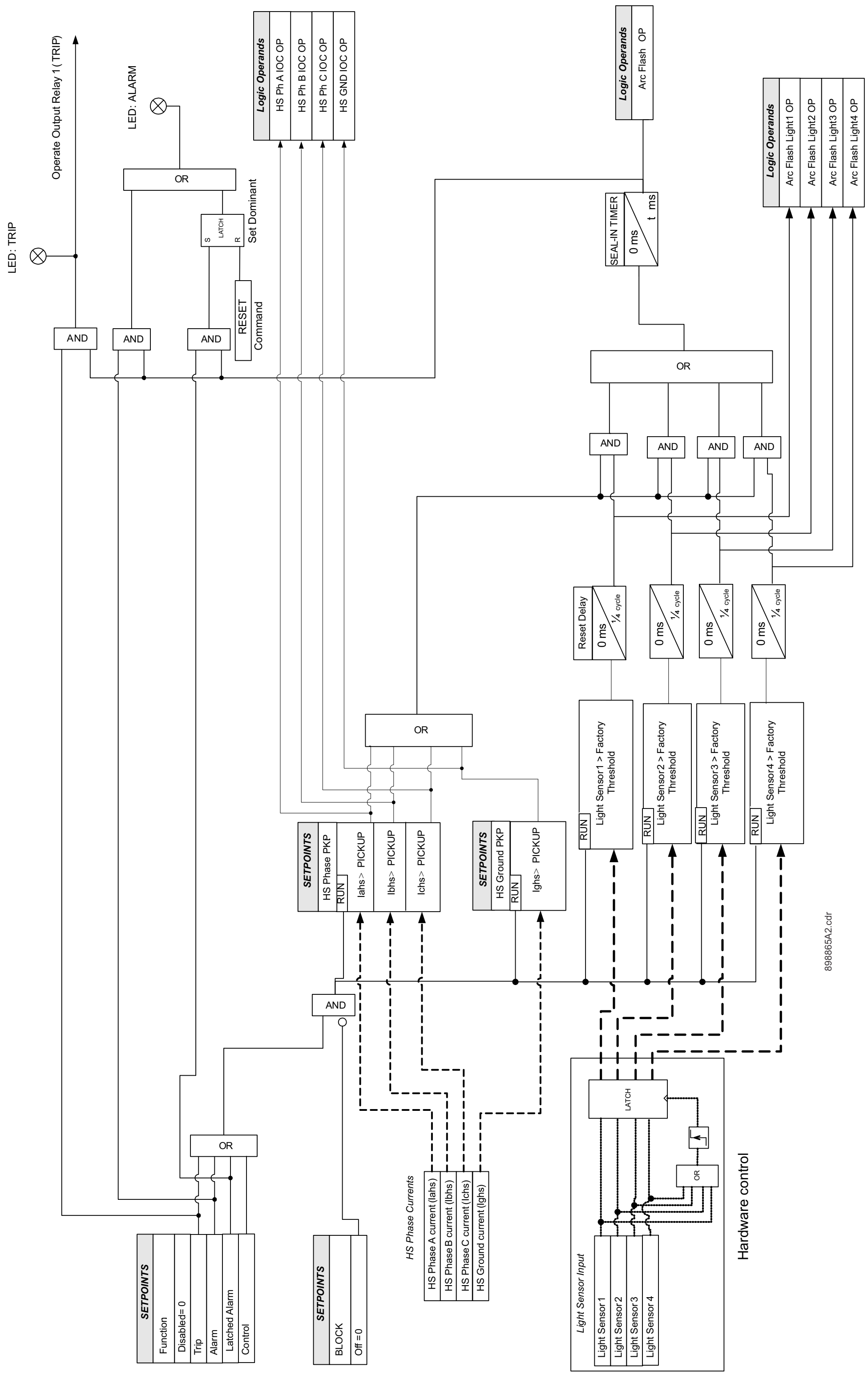
BLOCK

For details see Common setpoints.

OUTPUT RELAY X

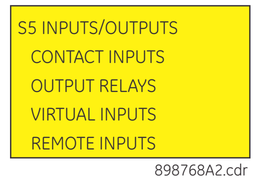
For details see Common setpoints.

Figure 6-66: Arc Flash logic diagram



S5 Inputs/Outputs

Figure 6-67: Main inputs/outputs menu



Contact inputs

The 350 relay is equipped with eight (8) contact inputs, which can be used to provide a variety of functions such as for circuit breaker control, external trips, blocking of protection elements, etc. All contact inputs are wet type contacts (refer to the 350 typical wiring diagram) that require an external DC voltage source. The voltage threshold (17V, 33V, 84V, 166V) is selectable, and it applies for all eight contact inputs.

The contact inputs are either open or closed with a programmable debounce time to prevent false operation from induced voltage. Because of de-bouncing, momentary contacts must have a minimum dwell time greater than half power frequency cycle. The debounce time is adjustable by the user.

PATH: SETPOINTS > S5 INPUTS/OUTPUTS > CONTACT INPUTS

SELECT DC VOLTAGE

Range: 17 V, 33 V, 84 V, 166 V
Default: 84 V

52a BKR INPUT 1

Range: Select alpha-numeric name
Default: 52a (CI#1)

52b BKR INPUT 2

Range: Select alpha-numeric name
Default: 52b (CI#2)

CONTACT INPUT X [3 to 10]

Range: Select alpha-numeric name
Default: Input X

DEBOUNCE TIME

↳

CONTACT INPUT X [1 TO 10]

Range: 1 to 64 ms
Default: 2 ms

Each of the contact inputs 3 to 8, can be named to reflect the function it represents within the application. Up to 18 alpha-numeric characters are available for names.

The debounce time is used to discriminate between oscillating inputs. The state will be recognized if the input is maintained for a period consisting of the protection pass plus the debounce setting.

NOTE

Contact Input 1 and Contact Input 2 are named by the factory as 52a and 52b respectively and are used for monitoring the breaker open/close state when wired to the breakers auxiliary contacts 52a and 52b.

Output relays

The 350 relay is equipped with seven electromechanical output relays: two special relays designated for Breaker Trip and Close (Relay 1 "Trip", Relay 2 "Close"), four general purpose relays (Auxiliary Relays 3 to 6), and one Critical Failure relay for fail-safe relay indication. The special purpose relays have fixed operating characteristics and the general purpose relays can be configured by the user. Logic diagrams for each output relay are provided for detailed explanation of their operation.

Operation of these breaker-control relays is designed to be controlled by the state of the circuit breaker as monitored by a 52a or 52b contact.

- The Trip and Close relays reset after the breaker is detected in a state corresponding to the command. When a relay feature sends a command to one of these special relays, it will remain operational until the requested change of breaker state is confirmed by a breaker auxiliary contact and the initiating condition has reset.
- If the initiating feature resets, but the breaker does not change state, the output relay will be reset after a default interval of 2 seconds.
- If neither of the breaker auxiliary contacts, 52a nor 52b, is programmed to a logic input, the Trip Relay is de-energized after either the delay programmed in the Breaker Failure feature, or a default interval of 100 ms after the initiating input resets. The Close Relay is de-energized 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 40 ms.

52a Contact Configured	52b Contact Configured	Relay Operation
Yes	Yes	Trip Relay remains operational until 52b indicates an open breaker. Close Relay remains operational until 52a indicates a closed breaker.
Yes	No	Trip Relay remains operational until 52a indicates an open breaker. Close Relay remains operational until 52a indicates a closed breaker.
No	Yes	Trip Relay remains operational until 52b indicates an open breaker. Close Relay remains operational until 52b indicates a closed breaker.
No	No	Trip Relay operates until either the Breaker Failure delay expires (if the Breaker Failure element is enabled), or 100 ms after the feature causing the trip resets. Close Relay operates for 200 ms.

Output Relay 1 "Trip"

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **SETPOINTS > S5 INPUTS/OUTPUTS > OUTPUT RELAYS > RELAY 1 TRIP**

SEAL IN TIME

Range: 0.00 to 9.99 s in steps of 0.01

Default: 0.04 s

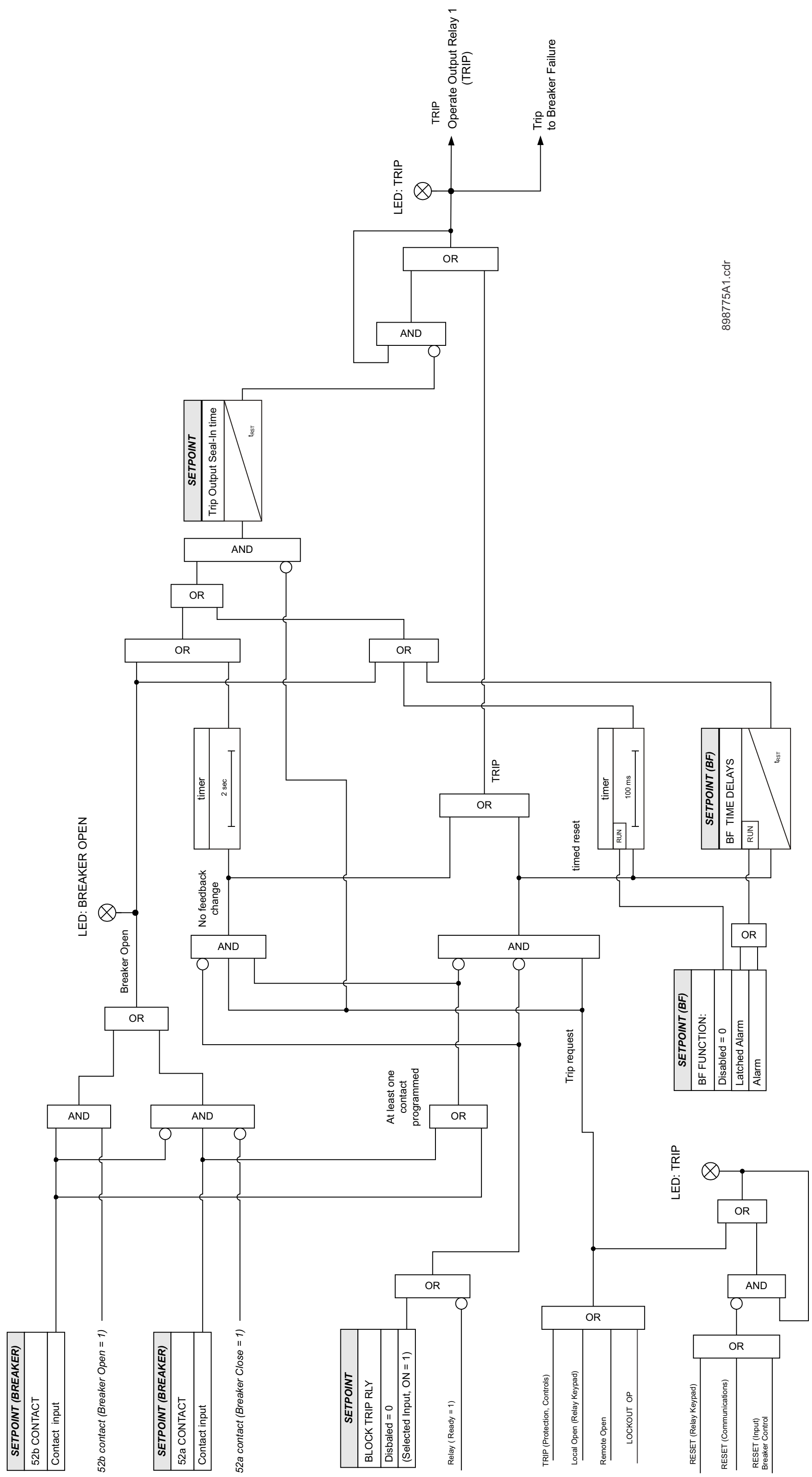
This setting defines the time to be added to the reset time of the Relay 1 Trip output, thus extending its pulse width. This is useful for those applications where the 52 contacts reporting the breaker state are faster than the 52 contacts that are responsible for interrupting the coil current.

BLOCK RLY 1 TRIP

For details see Common setpoints.

This setting defines a block to the Trip Output relay. When the selected input is asserted, the Trip Output relay will be blocked.

Figure 6-68: Relay 1 "TRIP" logic diagram



Output Relay 2 "Close"

PATH: **SETPOINTS > S5 INPUTS/OUTPUTS > OUTPUT RELAYS > RELAY 2 CLOSE**

SEAL IN TIME

Range: 0.00 to 9.99 s in steps of 0.01

Default: 0.04 s

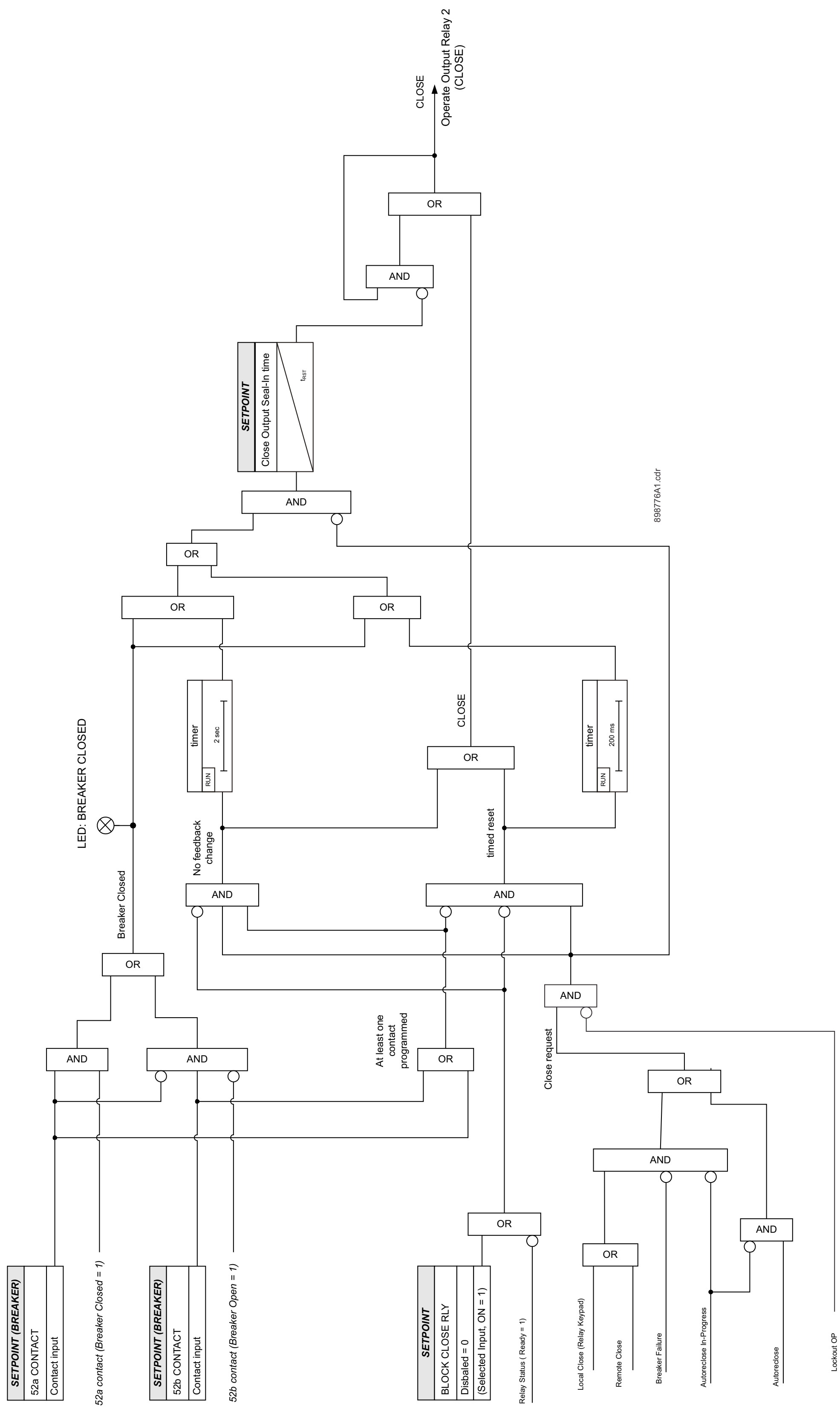
This setting defines the time to be added to the reset time of the Relay 2 Close output, thus extending its pulse width. This is useful for those applications where the 52 contacts reporting the breaker state are faster than the 52 contacts that are responsible for interrupting the coil current.

BLOCK RLY 2 CLOSE

For details see Common setpoints.

This setting defines a block to the Close Output relay. When the selected input is asserted, the Close Output relay will be blocked. The block function can be useful for breaker maintenance purposes.

Figure 6-69: Relay 2 "CLOSE" logic diagram



Auxiliary Output Relays 3 to 6

The 350 relay is equipped with four auxiliary output relays numbered from 3 to 6. All these relays are available for selection for operation of protection, control, or maintenance features. Each auxiliary relay can be selected as either **Self-Reset**, or **Latched**. If the Self-Reset type is selected, the output relay will be energized as long as the element is in operating mode and will reset when the element drops out. If the Latched type is selected, the output relay will stay energized, after the element dropout, and will be de-energized upon the reset command.

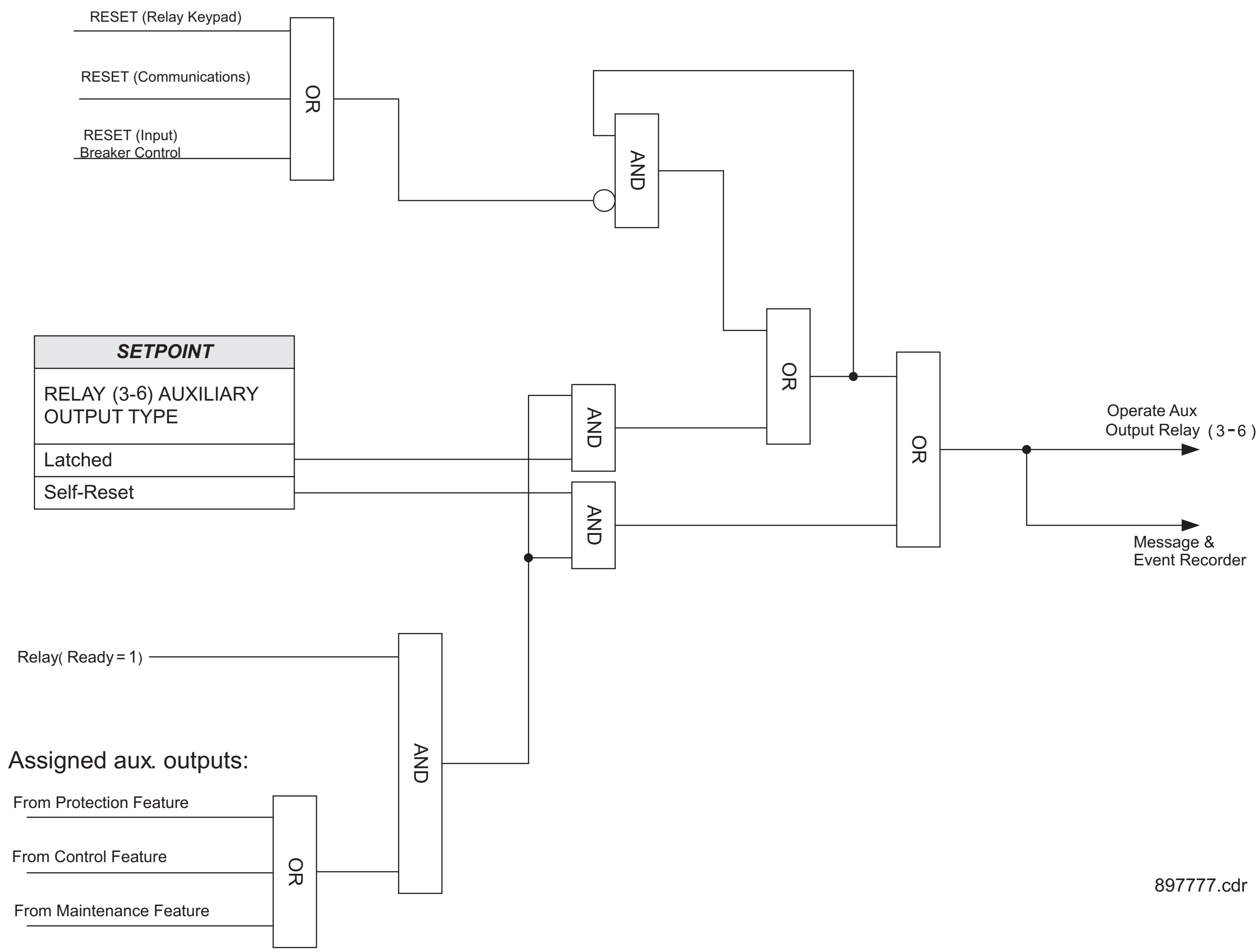
PATH: SETPOINTS > S5 INPUTS/OUTPUTS > OUTPUT RELAYS > RELAY 3(6) AUXILIARY

OUTPUT TYPE

Range: Self Reset, Latched

Default: Self Reset

Figure 6-70: Auxiliary relays



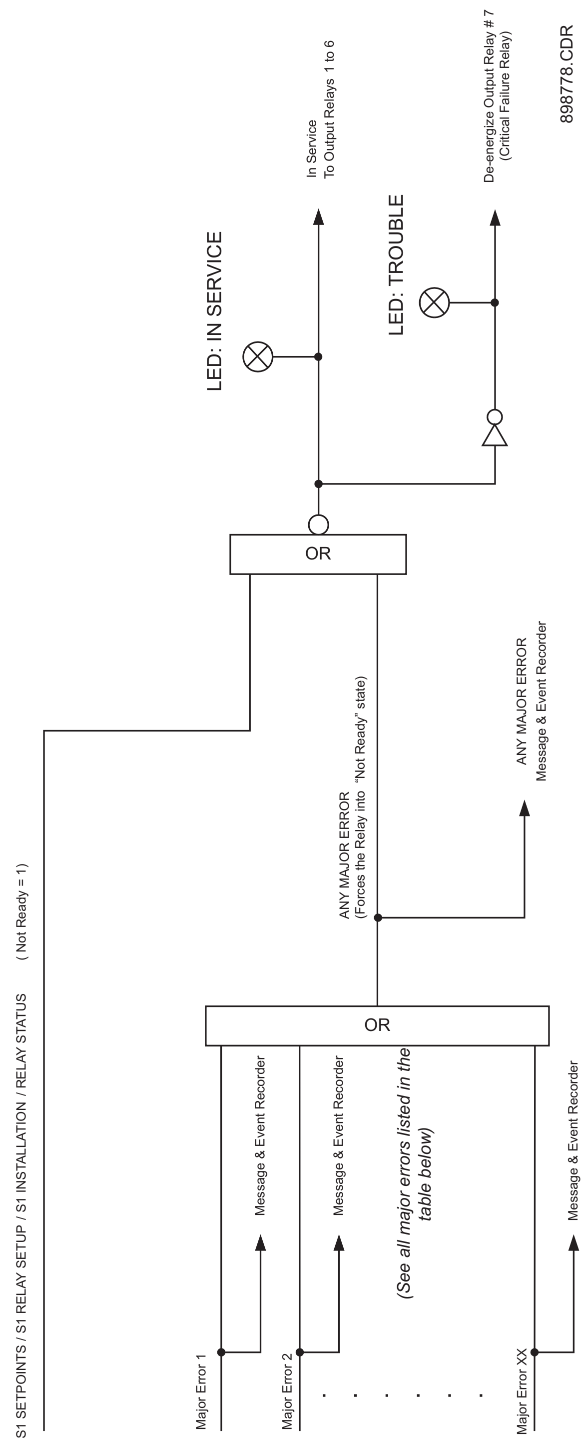
Critical Failure Relay #7

The 350 relay is also equipped with one output relay (# 7 - "Critical Failure Relay") for fail-safe indication. There are no user-programmable setpoints associated with this output relay. The logic for this relay is shown below.

The Critical Failure Relay (Output Relay 7) is a form C contact (refer to the Typical Wiring Diagram) with one NO and one NC contacts (no control power). Output relay 7 is energized or de-energized (state change) depending on the following conditions:

1. Output Relay 7 will be **de-energized**, if the relay is not IN-SERVICE or the control power is not applied to the relay
2. Output Relay 7 will be **energized** when the control power is applied to the relay and the relay is IN-SERVICE mode.
3. Output Relay 7 will stay **de-energized**, when the control power is applied, if the relay was not programmed as “Ready”, or upon major self-test failure during relay boot up.
4. Output Relay 7 will change state from **energized** to **de-energized** if the 350 relay experiences any major self-test failure.

Figure 6-71: Output relay 7: Critical Failure Relay



Virtual inputs

There are 32 virtual inputs that can be individually programmed to respond to input commands entered via the relay keypad, or by using communication protocols.

Virtual input programming begins with enabling the Virtual Input Function, and selecting the Virtual Input Type **Self-Reset** or **Latched** under **SETPOINTS > S5 INPUTS/OUTPUTS > VIRTUAL INPUTS**. Next, the user can assign a command **On/Off** to the enabled Virtual Input under **SETPOINTS > S4 CONTROLS > VIRTUAL INPUTS**. Referring to the Virtual Inputs logic diagram below, a Virtual Input type can be selected to be either **Self-Reset**, or **Latched**. When **Self-Reset** is selected and the “On” command is executed, the virtual input is evaluated as a pulse at a rate of one protection pass. To prolong the time of the virtual input pulse, one can assign it as a trigger source to a logic element with a dropout timer set to the desired pulse time. Selecting the **Latched** type, will latch the virtual input state, when the “On” command is executed.

NOTE

The "On" state of the Virtual Input will be retained in the case of cycling of the relay control power supply.

PATH: **SETPOINTS > S5 INPUTS/OUTPUTS > VIRTUAL INPUTS**

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

VI x NAME

Range: 14 characters

Default: Virtual IN x

This setting defines a programmable name for the Virtual Input.

VI x FUNCTION

Range: Disabled/Enabled

Default: Disabled

The Virtual Input is enabled and ready to be triggered when set to **Enabled**. All virtual inputs will appear under the **S4 CONTROLS > SETPOINTS > VIRTUAL INPUTS** menu.

VI x TYPE

Range: Self-Reset, Latched

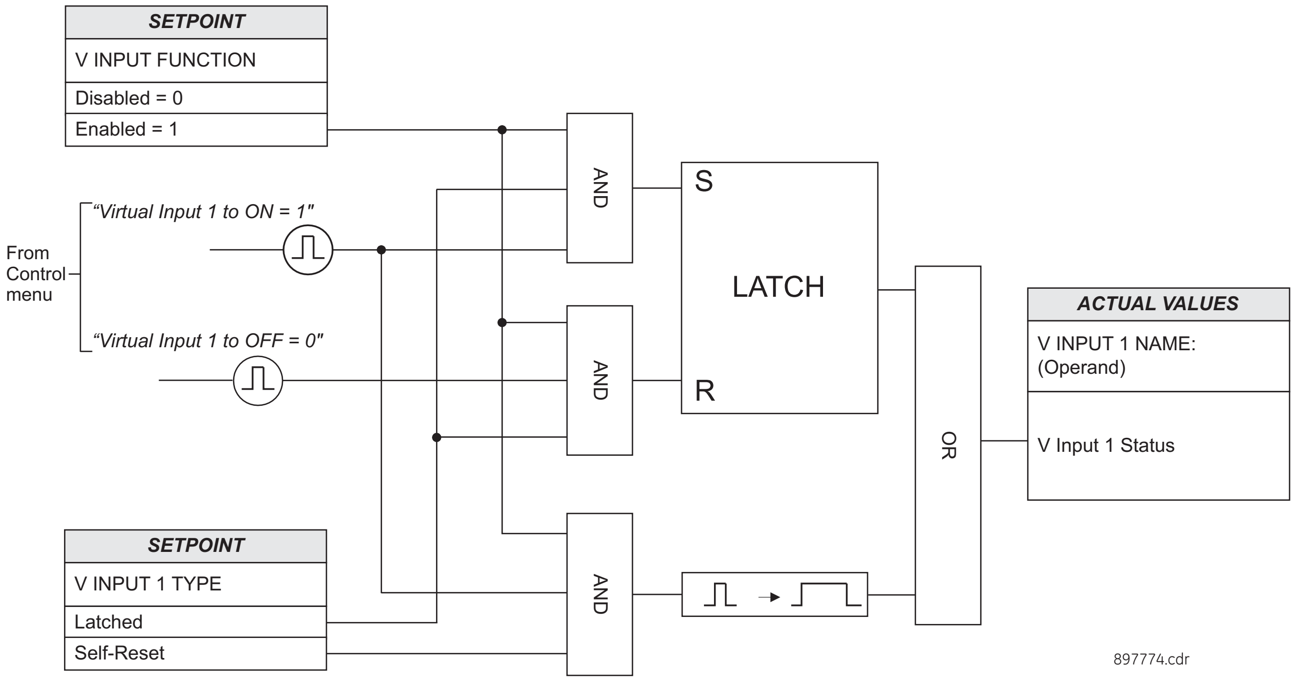
Default: Self-reset

When the **Self-Reset** type is selected, the Virtual Input will be evaluated for one protection pass only, upon “On” initiation and it will reset. When the **Latched** type is selected, the virtual input will keep the state “On” until reset command “Off” is initiated.

NOTE

See also the Virtual Inputs section under **S4 CONTROLS**, on how to trigger a virtual input signal state.

Figure 6-72: Virtual inputs scheme logic

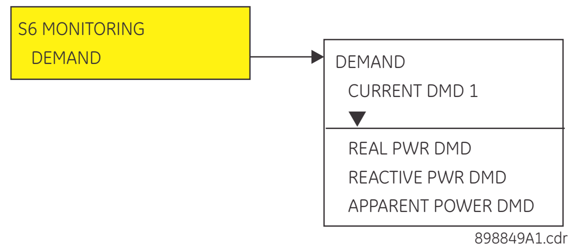


Remote inputs

Remote Inputs are available for programming under the EnerVista 3 Series Setup software. Refer to the *3 Series Communications Guide* for details.

S6 Monitoring

Figure 6-73: Main monitoring menu



Demand

Current Demand is measured on each phase, and on three phases for real, reactive, and apparent power. Setpoints allow the user to emulate some common electrical utility demand measuring techniques for statistical or control purposes.

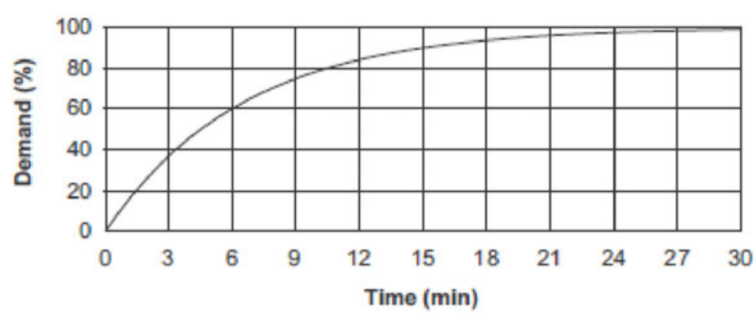
NOTICE

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 6-74: 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: S6 MONITORING > DEMAND > CURRENT DEMAND 1

FUNCTION

Range: Disabled, Alarm, Latched Alarm

Default: Disabled

For details see Common setpoints.

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 and allows the user to approximately match the response of the relay to analog instruments. The setpoint is visible only if MEASUREMENT TYPE is “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”.

PKP

Range: 10 to 10000 A in steps of 1 A

Default: 1000 A

This setpoint sets the Current Demand Pickup level.

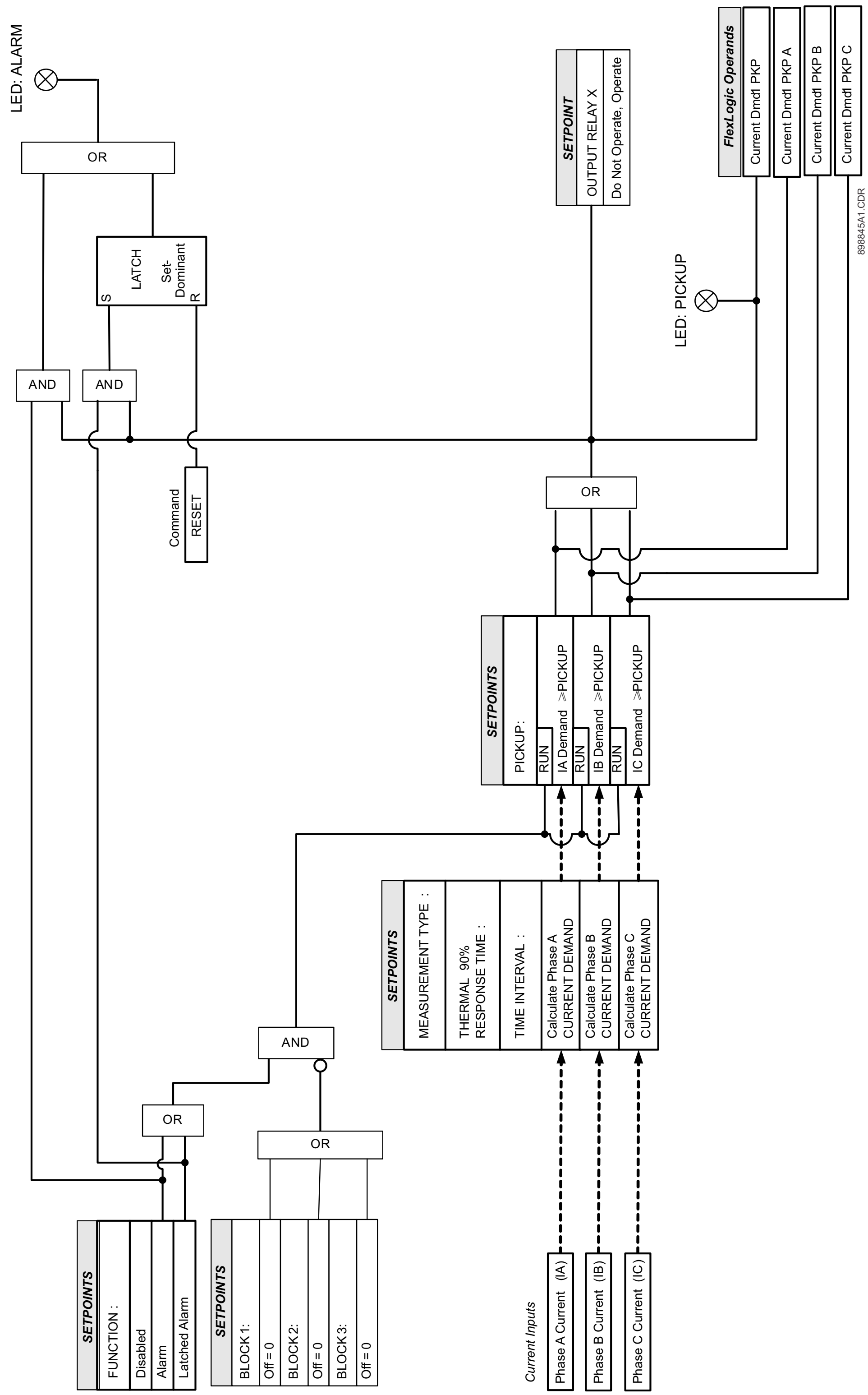
OUTPUT RELAY X

For details see Common setpoints.

BLOCK

For details see Common setpoints.

Figure 6-75: Current Demand logic diagram



Real Power

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: **S6 MONITORING > DEMAND > REAL POWER DEMAND**

FUNCTION

Range: Disabled, Alarm, Latched Alarm

Default: Disabled

For details see Common setpoints.

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 and allows the user to approximately match the response of the relay to analog instruments. The setpoint is visible only if MEASUREMENT TYPE is " 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".

PKP

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.

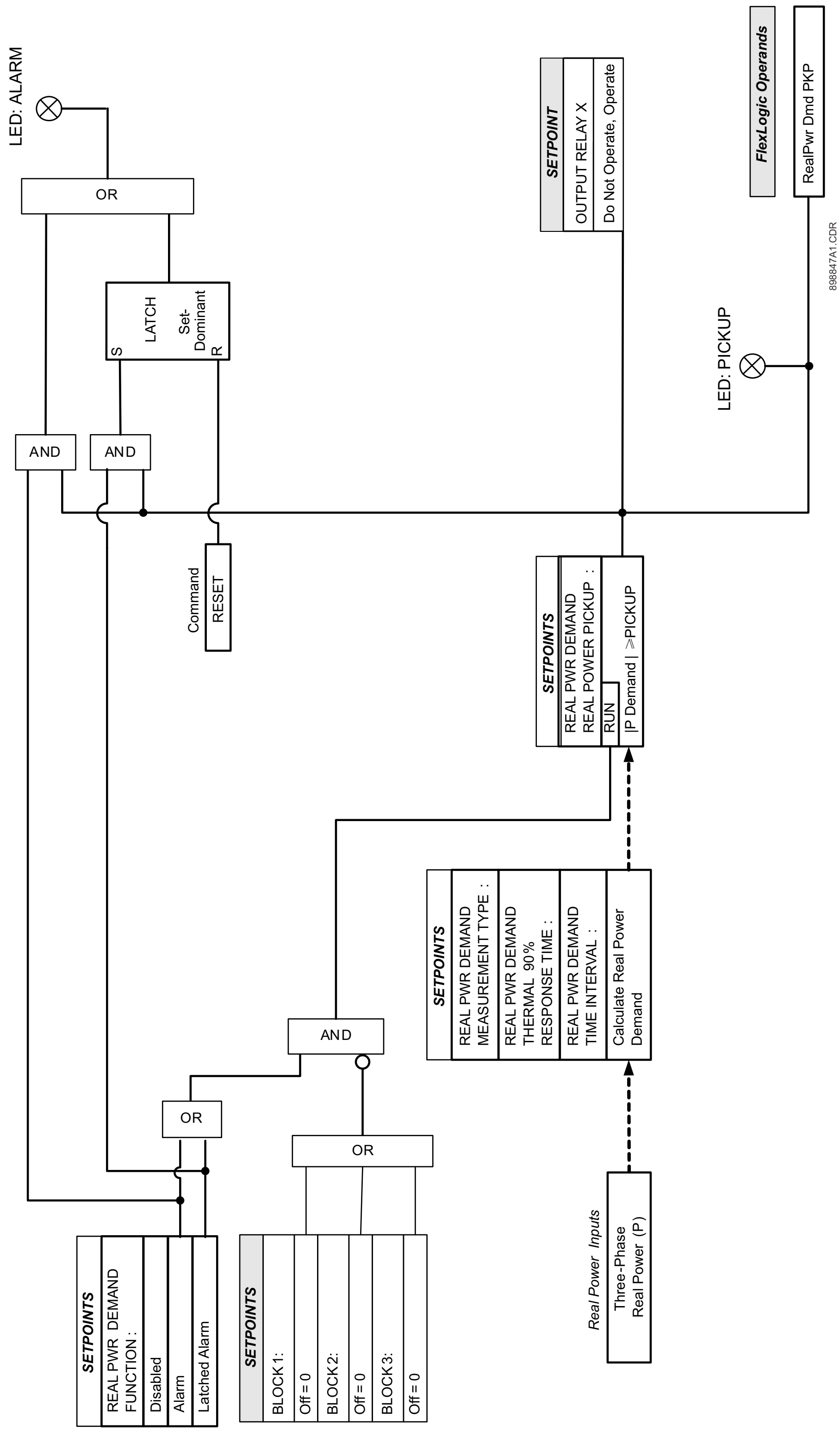
OUTPUT RELAYS X

For details see Common setpoints.

BLOCK

For details see Common setpoints.

Figure 6-76: 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: **S6 MONITORING > DEMAND > REACTIVE POWER DEMAND**

FUNCTION

Range: Disabled, Alarm, Latched Alarm

Default: Disabled

For details see Common setpoints.

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 and allows the user to approximately match the response of the relay to analog instruments. The setpoint is visible only if MEASUREMENT TYPE is “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”.

PKP

Range: 0.1 to 300000.0 kvar in steps of 0.1 kvar.

Default: 1000.0 kvar

The setting sets the Reactive Power Demand Pickup level. The absolute value of reactive power demand is used for the Pickup comparison.

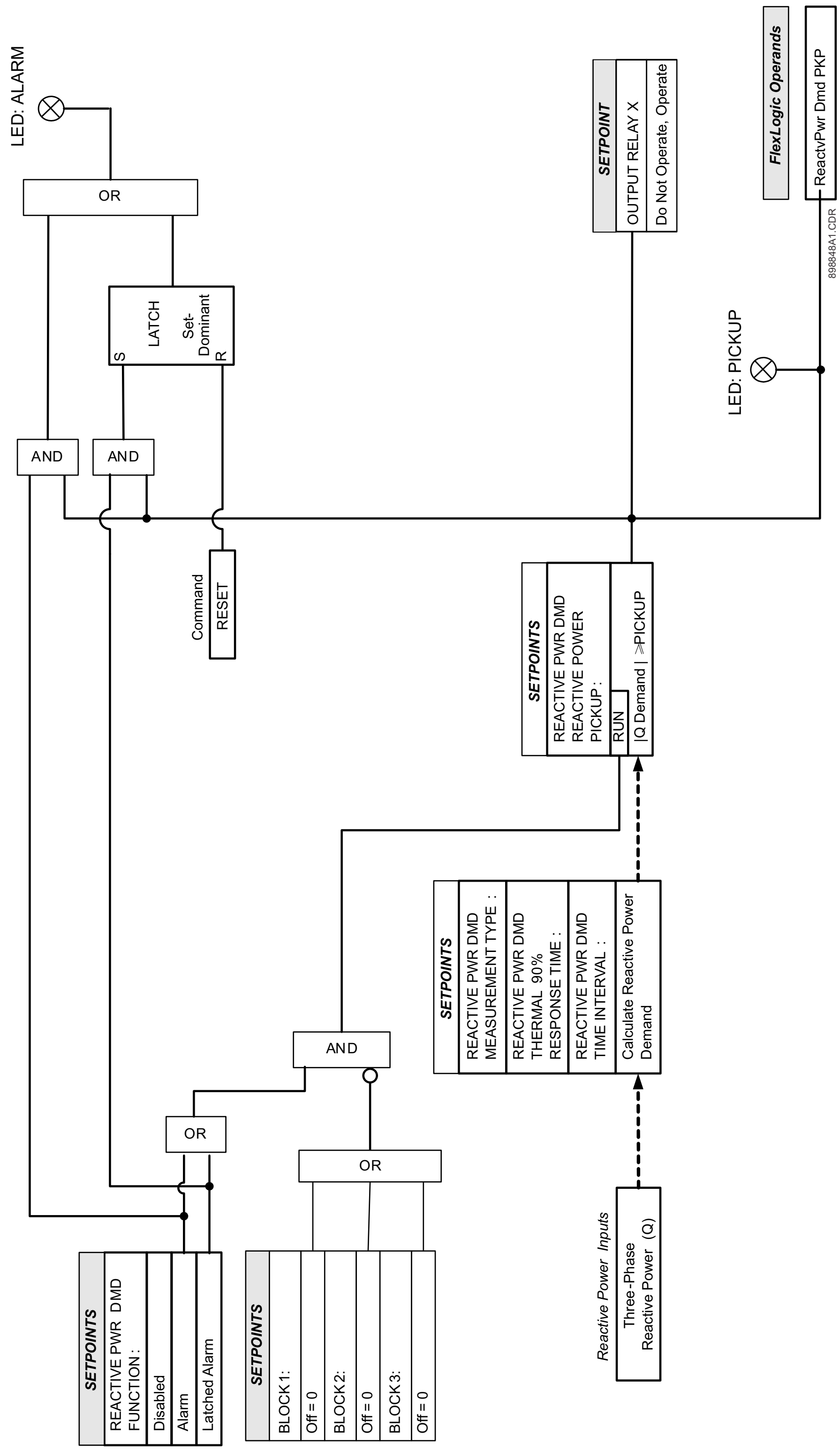
OUTPUT RELAY X

For details see Common setpoints.

BLOCK

For details see Common setpoints.

Figure 6-77: Reactive Power Demand logic diagram



Apparent Power

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: **S6 MONITORING > DEMAND > APPARENT PWR DEMAND**

FUNCTION

Range: Disabled, Alarm, Latched Alarm
Default: Disabled

For details see Common setpoints.

MEASUREMENT TYPE

Range: Blk Interval, Exponential, Rolling Dmd
Default: Blk Interval

This setpoint 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 Apparent Power to indicate 90% of the actual value and allows the user to approximately match the response of the relay to analog instruments. The setpoint is visible only if MEASUREMENT TYPE is “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 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

This setpoint sets the Apparent Power Demand Pickup level.

BLOCK

For details see Common setpoints.

OUTPUT RELAY X

For details see Common setpoints.

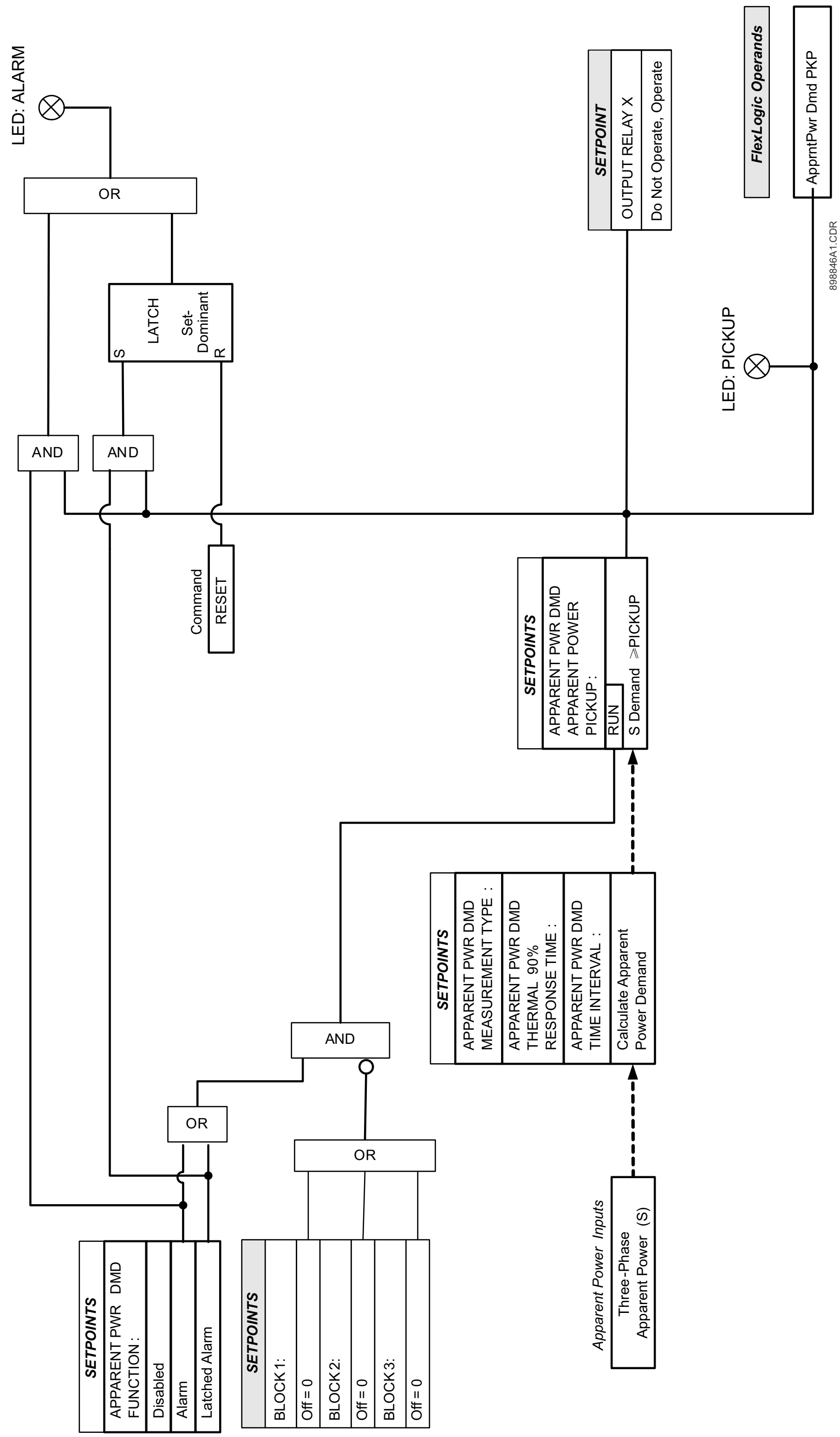
EVENTS

Range: Enabled, Disabled
Default: Enabled

TARGETS

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

Figure 6-78: Apparent Power Demand logic diagram



350 Feeder Protection System

Chapter 7: Maintenance

Information about the relay and the breaker can be obtained through the features included in the Maintenance page.

Figure 7-1: Main maintenance menu

```
MAINTENANCE
  M1 RELAY INFO
  M3 BKR MAINTENANCE
▼
  M4 BKR MONITOR
  M5 RELAY MAINTENANCE
  M6 FACTORY SERVICE
  M7 TESTING
```

898761A2.cdr

M1 Relay information

PATH: **MAINTENANCE > M1 RELAY INFO**

RELAY NAME

Range: alpha-numeric name of up to 14 characters
Default: Motor Name

ORDER CODE
350-EP5S5HSMCP3EDN

This screen shows the relay Order Code.

MAIN FIRMWARE REVISION
1.41

This screen shows the relay Main Firmware Revision.

MAIN BUILD DATE
Aug 16 2015

This screen shows the relay Main Firmware Build Date.

MAIN BUILD TIME
15:57:46

This screen shows the relay Main Firmware Build Time.

MAIN BOOT REVISION
1.20

This screen shows the relay Main Boot Code Revision.

MAIN BOOT DATE
Dec 11 2015

This screen shows the relay Main Boot Code Build Date.

MAIN BOOT TIME
10:44:54

This screen shows the relay Main Boot Code Build Time.

COMM HARDWARE REVISION
C

This screen shows the relay Comm Hardware Revision.

COMM FIRMWARE REVISION
1.40

This screen shows the relay Comm Code Revision.

COMM BUILD DATE
Aug 16 2015

This screen shows the relay Comm Code Build Date.

COMM BUILD TIME
16:20:45

This screen shows the relay Comm Code Build Time.

COMM BOOT REVISION
1.30

This screen shows the relay Comm Boot Code Revision.

COMM BOOT TIME
16:22:41

This screen shows the relay Comm Boot Code Build Time.

SERIAL NUMBER
ML0A08999014

Each relay has a unique serial number.

ETHERNET MAC ADR
00:A0F4:00:33:00

This screen shows the Ethernet MAC Address of the relay.

FPGA VERSION
1.00

This screen shows the FPGA Version.

M3 Breaker maintenance

Figure 7-2: Breaker maintenance menu

M3 BKR MAINTENANCE
TRIP COIL
CLOSE COIL
▼
BKR TRIP COUNTER
BREAKER HEALTH
RESET COUNTERS

898860A1.cdr

Trip coil

The Trip coil monitoring is performed by a built-in voltage monitor on the Form A output relay: #1 Trip. The voltage monitor is connected across the Form A contact, and effectively the relay detects healthy current through the circuit. To do that, an external jumper must be made between terminals "A2" and "A3" for Trip coil monitoring.

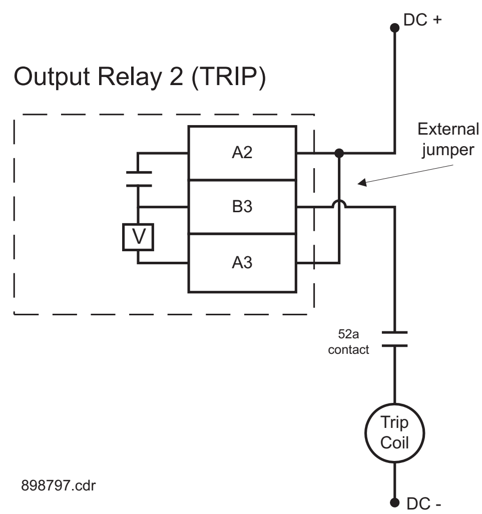
As long as the current through the Voltage Monitor is above the threshold of the trickle currents (see Technical Specification for Form A output relays), the circuit integrity for the Trip coil is effectively normal. If the Trip coil circuit gets disconnected, or if in general a high resistance is detected in the circuitry, a Trip alarm will be set and the "ALARM" and "MAINTENANCE" LEDs will be on.

Example 1: The figure below shows the connections of the breaker trip coil to the relay's trip output relay for voltage monitoring of the trip circuit.

NOTE

To monitor the trip coil circuit integrity, use the relay terminals "A2" and "B3" to connect the Trip coil, and provide a jumper between terminals "A2" and "A3" (voltage monitor).

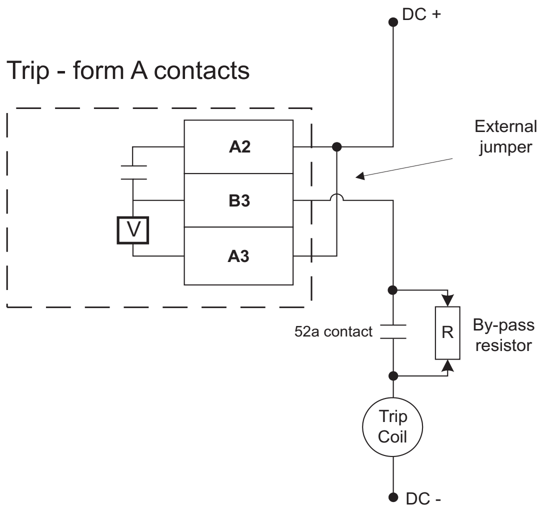
Figure 7-3: Trip Coil circuit with voltage monitoring



Example 2: Some applications require that the Trip coil be monitored continuously, regardless of the breaker position (open or closed). This can be achieved by connecting a suitable resistor (see the table) across breaker auxiliary contact 52a in the trip circuit. With

such connections, the trickle current will be maintained by the resistor when the breaker is open. For these applications the setting for “BYPASS BKR STATUS” should be set to ENABLED.

Figure 7-4: Trip circuit with continuous monitoring



VALUES OF RESISTOR ‘R’

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

898787.cdr

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **MAINTENANCE > M3 BKR MAINTENANCE > TRIP COIL**

TRIP COIL FUNCTION

Range: Disabled, Alarm, Latched Alarm

Default: Disabled

For details see Common setpoints.

The “ALARM” and “MAINTENANCE” LEDs will light up upon detection of a trip coil circuitry problem.

TRIP COIL DELAY

Range: 1 to 10 sec in steps of 1 sec

Default: 5 s

This setting defines the Trip Coil Monitor Delay, before targets appear on the display, “ALARM” and “MAINTENANCE” LEDs light up on the front panel, and selected output relays operate.

BYPASS BKR STATUS

Range: Disabled, Enabled

Default: Disabled

Set the “BYPASS BKR STATE” to Enabled when a by-pass resistor is connected across the breaker auxiliary contact for continuous Trip circuit integrity monitoring. The circuits will be monitored regardless of breaker position. When “BYPASS BKR STATE” is set to Disabled, monitoring of the trip coil will be blocked when the breaker is open.

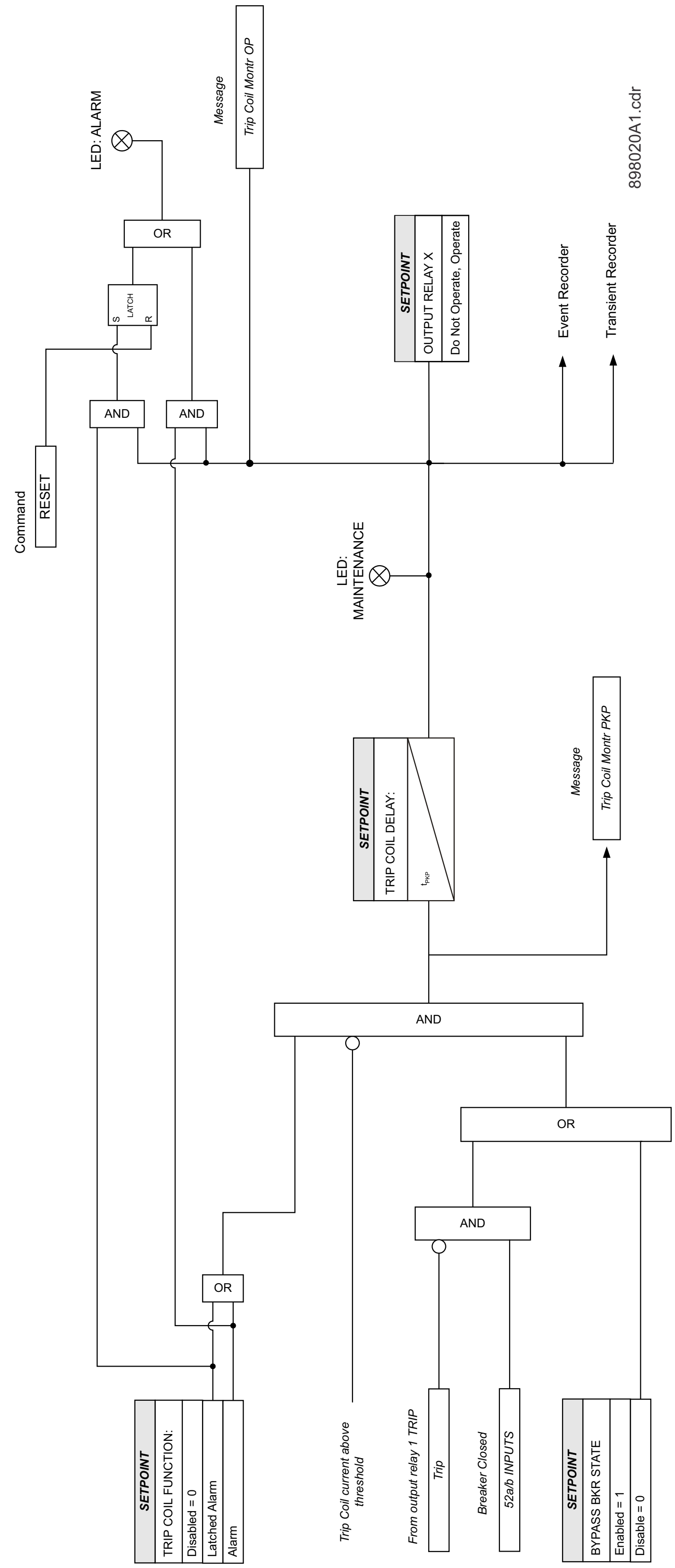
OUTPUT RELAY X

Range: Do not operate, Operate

Default: Do not operate

For details see Common setpoints.

Figure 7-5: Trip coil monitoring logic diagram



Close coil

Close coil monitoring is performed by a built-in voltage monitor on the Form A output relay: #2 Close. The voltage monitor is connected across the Form A contact, and effectively the relay detects healthy current through the circuit. To do that, an external jumper should be made between terminals “B4”, and “B5” for Close coil monitoring.

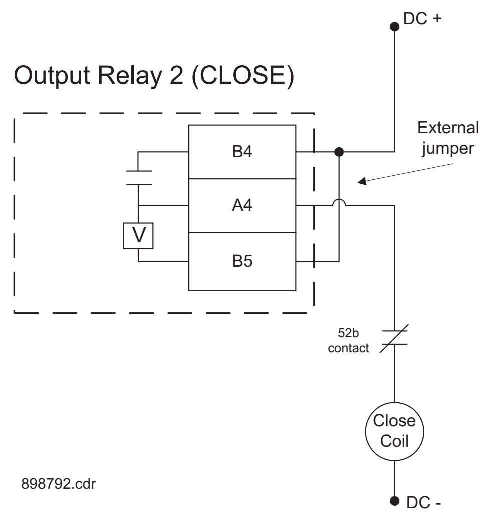
As long as the current through the Voltage Monitor is above the threshold of the trickle currents (see Technical Specification for Form A output relays), the circuit integrity for the Close coil is effectively normal. If the Close coil circuit gets disconnected, or if in general a high resistance is detected in the circuitry, a Close Coil alarm will be set and the “ALARM” and “MAINTENANCE” LEDs will be on.

Example 1: The figure below shows the connection of the breaker close coil to the relay’s close output relay for voltage monitoring of the close circuit.

NOTE

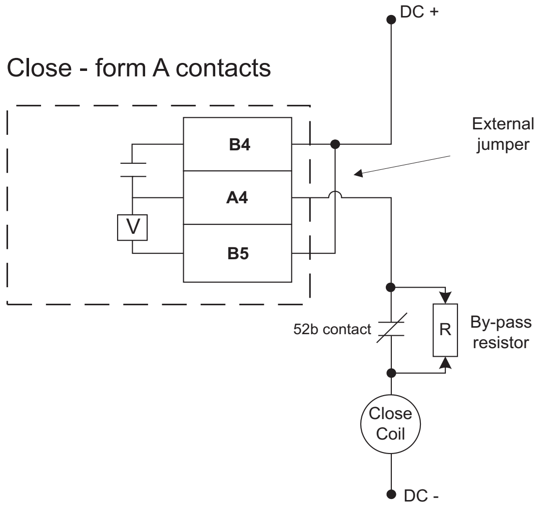
To monitor the close coil circuit integrity, use the relay terminals “B4” and “A4” to connect the Close coil, and provide a jumper between terminals “B4” and “B5” (voltage monitor).

Figure 7-6: Close Coil circuit with voltage monitoring



Example 2: Some applications require that the Close Coil be monitored continuously, regardless of the breaker position (open or closed). This can be achieved by connecting a suitable resistor (see the table) across breaker auxiliary contact 52b in the Close circuit. With such connections, the trickle current will be maintained by the resistor when the breaker is closed. For these applications the setting for “BYPASS BKR STATUS” should be set to ENABLED.

Figure 7-7: Close Coil circuit with continuous monitoring



VALUES OF RESISTOR 'R'

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

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The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **MAINTENANCE > M3 BKR MAINTENANCE**

CLOSE COIL FUNCTION

Range: Disabled, Alarm, Latched Alarm

Default: Disabled

For details see Common setpoints.

The "ALARM" and "MAINTENANCE" LEDs will light up upon detection of a close coil circuitry problem.

CLOSE COIL DELAY

Range: 1 to 10 sec in steps of 1 sec

Default: 5 s

This setting defines the Close Coil Monitor Delay, before targets appear on the display, "ALARM" and "MAINTENANCE" LEDs light up on the front panel, and selected output relays operate.

BYPASS BKR STATUS

Range: Disabled, Enabled

Default: Disabled

Set the "BYPASS BKR STATE" to Enabled when a by-pass resistor is connected across the breaker auxiliary contact for continuous Close circuit integrity monitoring. The circuits will be monitored regardless of breaker position. When "BYPASS BKR STATE" is set to Disabled, monitoring of the close coil will be blocked when the breaker is closed.

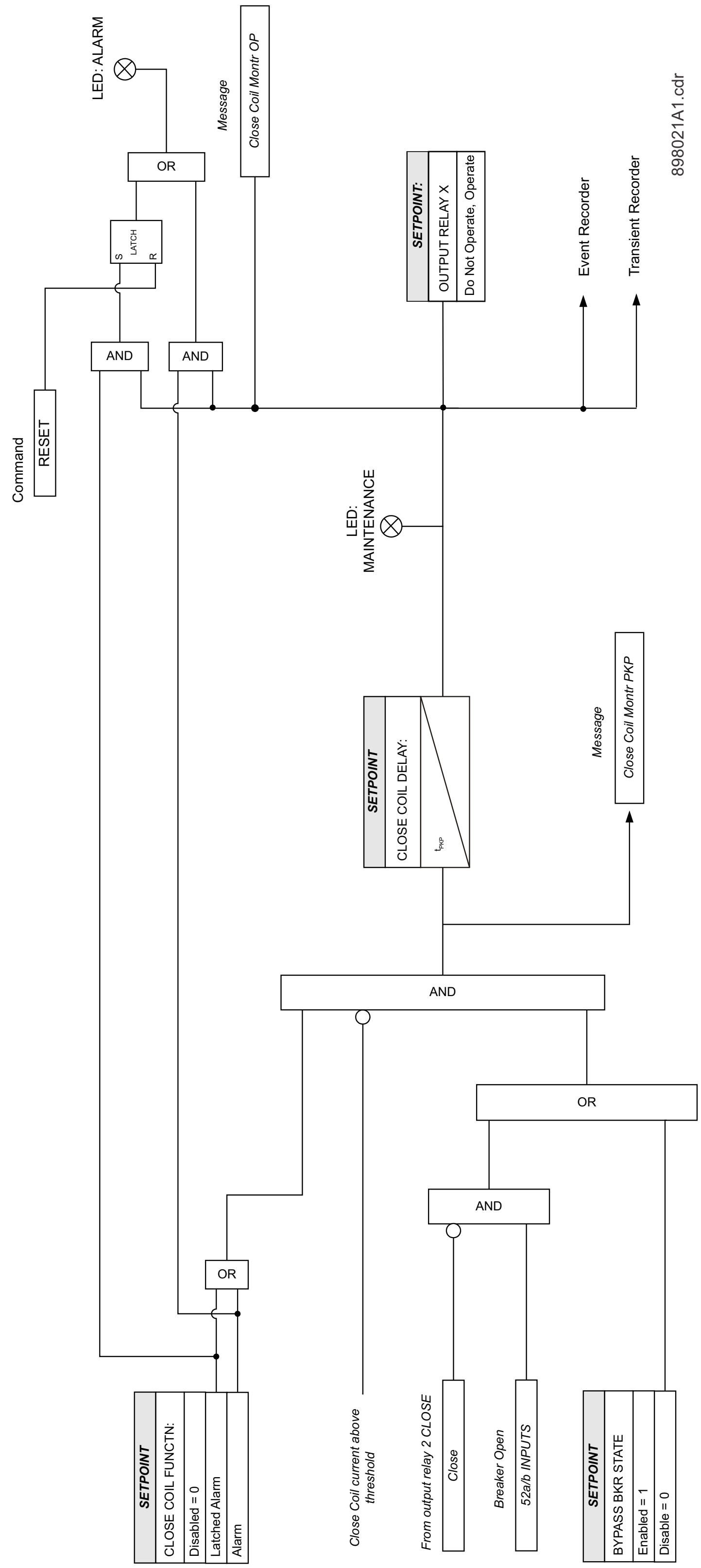
OUTPUT RELAY X

Range: Do not operate, Operate

Default: Do not operate

For details see Common setpoints.

Figure 7-8: Close coil monitoring logic diagram



Breaker trip counter

When the total number of breaker trips detected reaches the TRIP COUNTER LIMIT setpoint, an output will occur.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **MAINTENANCE > M3 BKR MAINTENANCE > BKR TRIP COUNTER**

TRIP COUNT FUNC

Range: Disabled, Alarm, Latched Alarm

Default: Disabled

For details see Common setpoints.

INITIAL TRIPS

Range: 0 to 10000 in steps of 1

Default: 0

This setting defines the number of breaker trips, that occurred before enabling the breaker trip counter for breaker monitoring.

TRIP COUNTER LIMIT

Range: 1 to 10000 trips in steps of 1

Default: 1 trip

This setting defines the limit number for breaker trips. The BKR TRIP COUNTER will operate and produce an output if the number of breaker trips reaches the set limit.

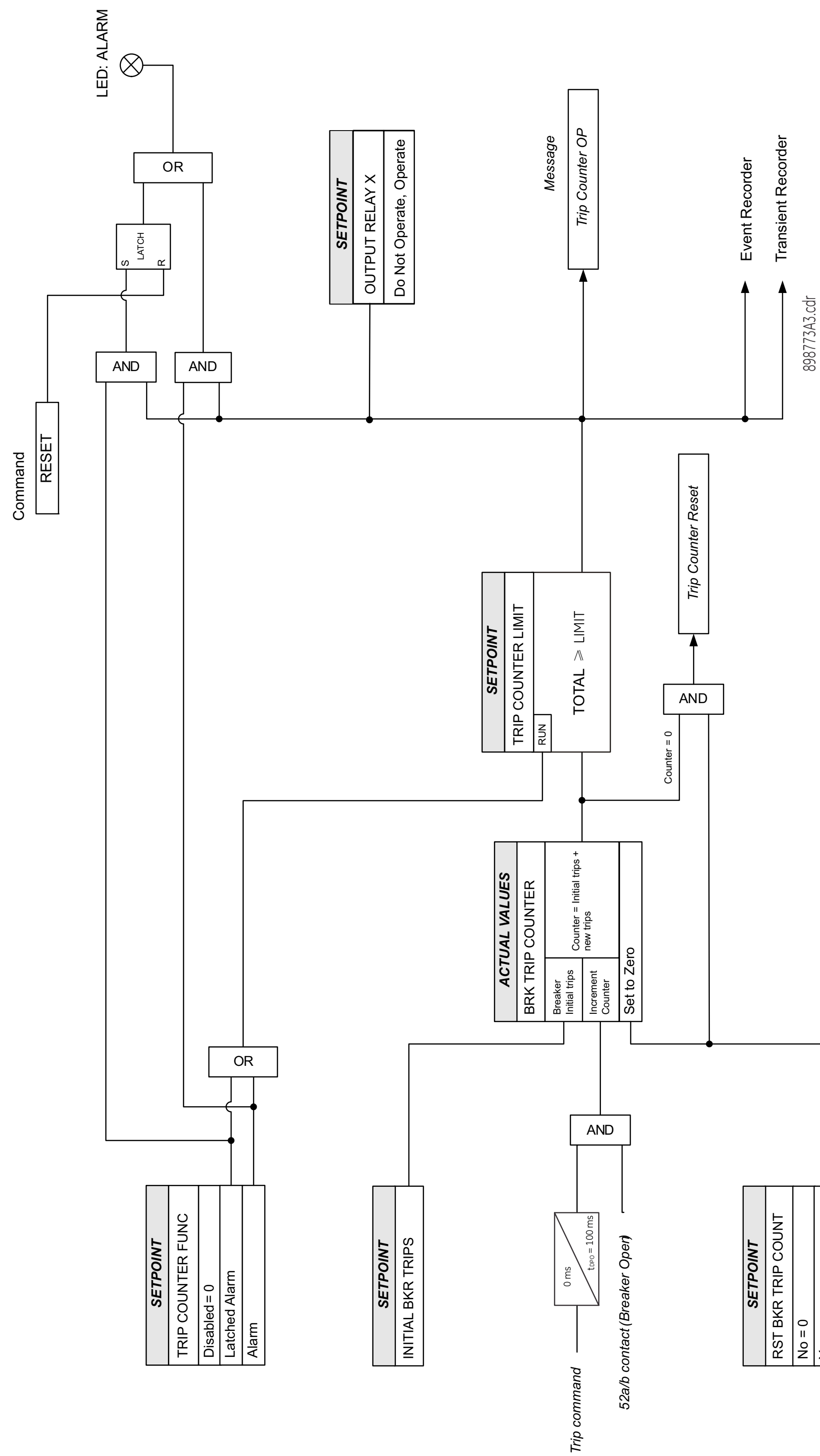
OUTPUT RELAY X

Range: Do not operate, Operate

Default: Do not operate

For details see Common setpoints.

Figure 7-9: BKR trip counter logic diagram



Breaker health

The 350 relay provides breaker health information by monitoring and analyzing the tripping time, closing time and the spring charging time. The breaker health status depends on many factors, such as number of permissible operations, magnitude of breaking current, mechanical wear, and contact wear.

The operation count provides direct information when compared to the maximum number of permissible breaker operations. Longer tripping times and closing times can provide an estimation of trip/close coil mechanical wear. An increased spring charging time may give early notice of developing problems in motor and spring mechanisms.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **MAINTENANCE > M3 BKR MAINTENANCE > BKR HEALTH**

BREAKER HEALTH FUNCTION

Range: Disabled, Alarm, Latched Alarm
Default: Disabled

For details see Common setpoints.

BREAKER HEALTH MODE

Range: Detection, Monitoring
Default: Detection

The Breaker HEALTH function 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 users configure the pickup settings based on historical true values. The tripping time, closing time, and spring charging time are measured and displayed under **MAINTENANCE > M4 BKR MONITOR**. The Breaker Alarm Counter element does not pick up when in detection mode. Monitoring mode is the normal mode, where measurements are analyzed and the element picks up accordingly.

ALARM COUNTER LIMIT

Range: 0 to 100000 in steps of 1
Default: 0

This setting selects count limit for the alarm counter above which the Breaker Alarm Counter function will pick up and produce an alarm.

The alarm counter is increased if any of the following conditions are present:

- The actual breaker trip time is higher than the preset TRIP TIME PICKUP
- The actual breaker closing time is higher than the preset CLOSE TIME PICKUP
- The actual spring charging time is higher than the preset CHARGE TIME PICKUP

TRIP TIME PICKUP

Range: 0.00 to 10.00 s in steps of 0.01 s
Default: 0.05 s

This setting defines the pickup level of the Trip time. The Trip time interval is initiated by the TRIP TRIGGER signal and stopped by OPEN STATUS signal.

The trip time of the breaker is detected based on the trip or open command issued by the relay, and the detection of breaker open status.

CLOSE TIME PICKUP

Range: 0.00 to 10.00 s in steps of 0.01 s
Default: 0.05 s

This setting defines the pickup level of the Close time. The Close time interval is initiated by the CLOSE TRIGGER signal and stopped by CLOSE STATUS signal.

The close time of the breaker is detected based on the close command issued by the relay, and the detection of breaker close status.

INCOMP TRP/CLS TIME

Range: 0.00 to 600.00 s in steps of 0.01 s

Default: 0.10 s

This setting declares a breaker operation failure condition if the breaker does not respond within this time delay. This setting should be greater than the TRIP TIME PICKUP value and CLOSE TIME PICKUP value.

SPRING CHARGE INPUT

Range: Off, Contact Input 1 to 10, Virtual Input 1 to 32, Remote Input 1 to 32, Logic Elements 1 to 16, CT Fail Alarm PKP, CT Fail Alarm OP, 2nd Harmonic Alarm, 2nd Harmonic

Default: Off

This 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.

CHARGE TIME PICKUP

Range: 0.00 to 60.00 s in steps of 0.01 s

Default: 15.00 s

This setting defines the pickup level of the Spring Charge time. The Spring Charge time is measured from the pulse duration of the SPRING CHARGE STATUS.

INCOMP CHARGE TIME

Range: 0.00 to 600.00 s in steps of 0.01 s

Default: 45.00 s

This setting declares a Charge time failure condition if the spring charging process is not finished after this time delay. This setting should be greater than the CHARGE TIME PICKUP value.

BLOCK 1 (3)

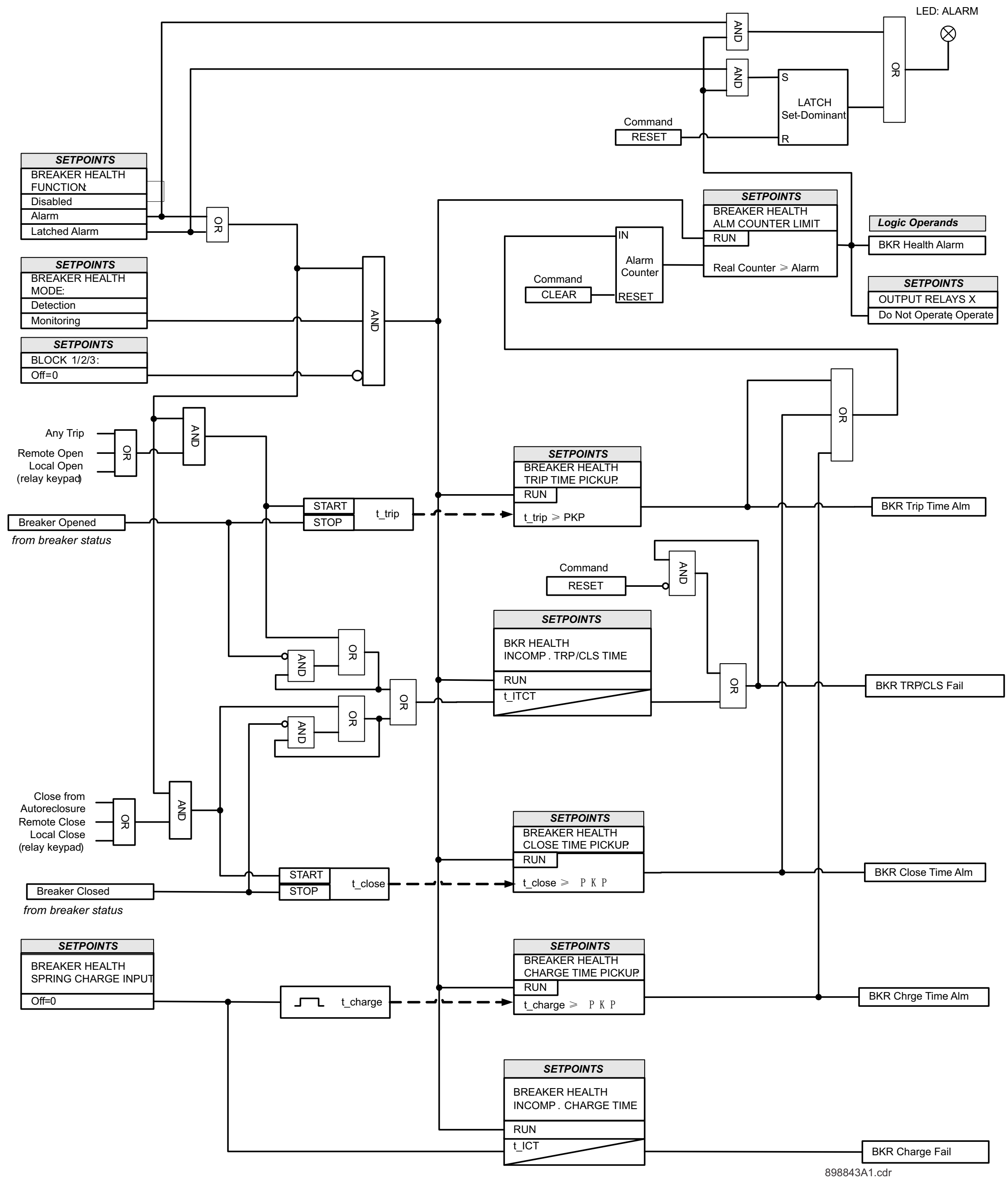
For details see Common setpoints.

The element will be blocked when the selected operand is asserted. For example, the breaker failure operand can be used to block this element.

OUTPUT RELAY X

For details see Common setpoints.

Figure 7-10: Breaker health logic diagram


LED: ALARM
AND
AND
OR
S
LATCH
Set-Dominant
R
Command
RESET
SETPOINTS
BREAKER HEALTH FUNCTION:
Disabled
Alarm
Latched Alarm
OR
SETPOINTS
BREAKER HEALTH ALM COUNTER LIMIT
RUN
Real Counter > Alarm
IN
Alarm Counter
RESET
Command
CLEAR
Logic Operands
BKR Health Alarm
SETPOINTS
OUTPUT RELAYS X
Do Not Operate, Operate
SETPOINTS
BREAKER HEALTH MODE:
Detection
Monitoring
AND
SETPOINTS
BLOCK 1/2/3:
Off=0
Any Trip
Remote Open
Local Open (relay keypad)
OR
AND
SETPOINTS
BREAKER HEALTH TRIP TIME PICKUP
RUN
t_trip > PKP
START
STOP
t_trip
BKR Trip Time Alm
Breaker Opened
from breaker status
Command
RESET
AND
SETPOINTS
BKR HEALTH INCOMP. TRP/CLS TIME
RUN
t_ITCT
OR
BKR TRP/CLS Fail
Close from Autoreclosure
Remote Close
Local Close (relay keypad)
SETPOINTS
BREAKER HEALTH CLOSE TIME PICKUP
RUN
t_close > PKP
START
STOP
t_close
BKR Close Time Alm
Breaker Closed
from breaker status
SETPOINTS
BREAKER HEALTH SPRING CHARGE INPUT
Off=0
t_charge
SETPOINTS
BREAKER HEALTH CHARGE TIME PICKUP
RUN
t_charge > PKP
BKR Chrge Time Alm
SETPOINTS
BREAKER HEALTH INCOMP. CHARGE TIME
RUN
t_ICT
BKR Charge Fail
898843A1.cdr

Reset counters

Reset counter commands clear various counters.

PATH: MAINTENANCE > M3 RESET COUNTERS

RST BKR TRIP COUNT

Range: No, Yes

Default: No

Entering a "Yes" command will clear the Trip Counters, and an event - "Reset Trip Counter" - will be recorded

RST BKR ALARM COUNT

Range: No, Yes

Default: No

Entering a "Yes" command will clear the Alarm Counters, and an event - "Reset Alarm Counter" - will be recorded

RST BKR TRIP TIMES

Range: No, Yes

Default: No

Entering a "Yes" command will clear the Trip Time Counters, and an event - "Reset Trip Time Coutner" - will be recorded

RST BKR CLOSE TIMES

Range: No, Yes

Default: No

Entering a "Yes" command will clear the Close Time Counters, and an event - "Reset Close Time Counter" - will be recorded

RST BKR CHARGE TIMES

Range: No, Yes

Default: No

Entering a "Yes" command will clear the Charge Time Counters, and an event - "Reset Charge Time Counter" - will be recorded

RESET ALL

Range: No, Yes

Default: No

Entering a "Yes" command will clear all counters, and an event - "Resets All Counters" - will be recorded

M4 Breaker monitor

The status of the breaker trip and close coils, as well as the trip and close circuits, can be monitored under **MAINTENANCE > M4 BKR MONITOR**. In the case where a breaker coil or circuit fails, the relay will display the message "Unhealthy" for the corresponding coil.

Further information on the breaker is provided under **BKR TRIP COUNTER**, where the 350 stores the number of trips. The counter can be reset under **M3 RESET COUNTERS > RST BKR TRIP COUNT** set to "Yes".

PATH: MAINTENANCE > M4 BKR MONITOR

TRIP COIL
Healthy
Range: Healthy, Unhealthy

CLOSE COIL
Healthy
Range: Healthy, Unhealthy

BKR TRIP COUNTER
5
Range: 0 to 10000 trips

BKR ALARM COUNTER
5
Range: 0 to 10000 trips

LAST TRIP TIME
5
Range: 0 to 10000 ms

AVG TRIP TIME
5
Range: 0 to 10000 ms

LAST CLOSE TIME
5
Range: 0 to 10000 ms

AVG CLOSE TIME
5
Range: 0 to 10000 ms

LAST CHARGE TIME
5
Range: 0 to 60000 ms

AVG CHARGE TIME
5
Range: 0 to 60000 ms

M5 Relay maintenance

Ambient temperature

The 3 Series relay has a temperature monitor feature that measures the ambient temperature around the chassis of the relay. The relay extrapolates the ambient temperature from an internal temperature sensor inside the product. This feature can be used to signal the customer that the product is being subjected to temperatures that can degrade the product life and proper action should be initiated. For example the air conditioning, heating or ventilation system should be checked.

The purpose of the feature is to measure the immediate temperature around the product. There are several factors that can alter the measurement that need to be considered for the application of this feature.

- Any forced air flow or obstructions that can interrupt even distribution of the ambient temperature.
- Installation of the relay should be for normal operation (CT, VT, inputs, outputs).

PATH: **MAINTENANCE > M5 RELAY MAINTENANCE > AMBIENT TEMP**

AMBIENT TEMPERATURE

Range: Disabled, Alarm, Latched Alarm

Default: Disabled

For details see Common setpoints.

HI ALARM LEVEL

Range: 20°C to 80°C in steps of 1°C

Default: 60°C

This setting specifies the temperature level monitored by the Ambient Temperature Alarm high logic. The alarm will occur when the temperature remains above this level.

LOW ALARM LEVEL

Range: -40°C to 20°C in steps of 1°C

Default: 10°C

This setting specifies the temperature level monitored by the Ambient Temperature Alarm low logic. The alarm will occur when the temperature remains below this level.

HYSTERESIS LEVEL

Range: 2°C to 10°C in steps of 1°C

Default: 2°C

This setting allows the user to select the dropout level for the feature.

TIME DELAY

Range: 1 to 60 min in steps of 1 min

Default: 1 min

This timer starts when either the high or low level thresholds have exceeded their respective levels.

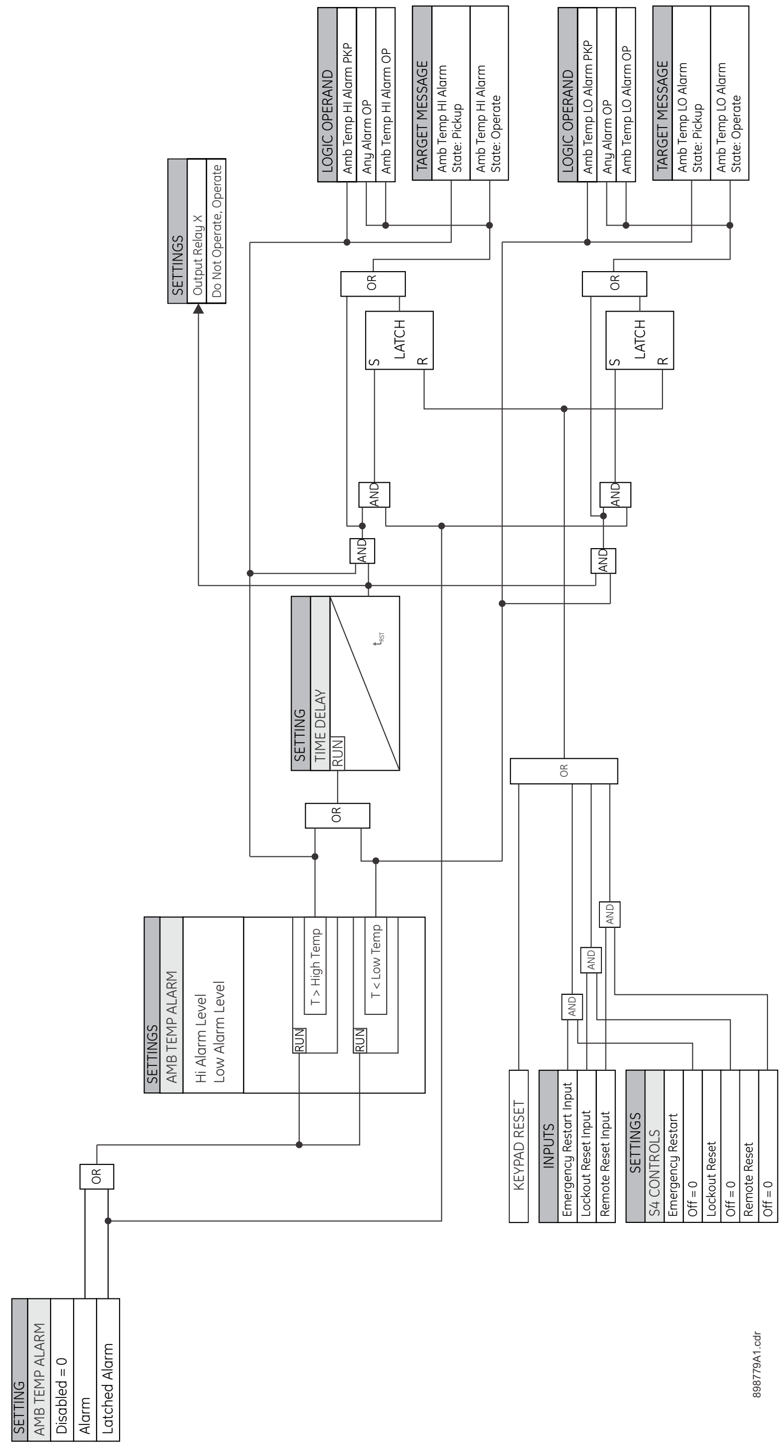
OUTPUT RELAY X

Range: Do Not Operate, Operate

Default: Do Not Operate

For details see Common setpoints.

Figure 7-11: Ambient Temperature Alarm logic diagram



M7 Testing

The Test Mode for 3 Series relays consists of testing front panel LEDs and Outputs Relays

The test mode state is indicated on the relay faceplate by a combination of the Maintenance LED (faceplate option E), the In-Service LED, the Trouble LED, and the critical fail relay, as shown in the following table.

Tests	Test Mode	Faceplate Option	Output Relay setting	In-Service LED	Trouble LED	Maintenance LED	Critical fail relay (output 7)	Prot. & Control elements
All Test = Disabled	Disabled	E, L	Normal operation	Not affected	Not affected	Not affected	Normal operation	Normal operation
Force LED = Enabled	Enabled	E	Normal operation	Blinking GREEN	Not affected	Off	Energized	Normal operation
Force Output = Enabled	Enabled	E	Controlled from Test settings	Off	Blinking Orange	On	De-energized	Not operational
All Test = Enabled	Enabled	E	Controlled from Test settings	Off	Blinking Orange	Off	De-energized	Not operational
Force LED = Enabled	Enabled	L	Normal operation	Blinking GREEN	Not affected	Off	Energized	Normal operation
Force Output = Enabled	Enabled	L	Controlled from Test settings	Off	Blinking Orange	Off	De-energized	Not operational
All Test = Enabled	Enabled	L	Controlled from Test settings	Off	Blinking Orange	Off	De-energized	Not operational

The following cases should be considered when using Test Mode:

1. When the relay is tripped, Test Mode cannot be Enabled.

   Changing Force LEDs or Force Output Relays to "Enabled" will have no effect. The value "Enabled" will not be accepted, and the value "Disabled" will be kept.
2. If the relay is in Force LEDs test mode, and trips, the relay leaves Test Mode and the Force LEDs setting automatically changes to "Disabled".

NOTE

Performing tests such as Forcing Output Relays should be carefully planned. Fault conditions are not detected by the relay while in Force Output Relays mode, since the protection and control elements are not operational during this mode.

Force LEDs

The LED lamp test is allows you to turn on each front panel LED individually. Testing the LEDs is only available from the relay front panel.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: MAINTENANCE > M7 TESTING > FORCE LEDS

FORCE LEDS

Range: Disabled, Enabled

Default: Disabled

When the Force LEDs setpoint is set to Enabled, the relay Maintenance LED starts flashing (faceplate option E), the In-service LED turns off, and the Critical Failure Relay is de-energized, indicating the relay is in test mode.

LED 1(12)

Range: Off, On

Default: Off

Force output relays

For testing purposes, the 350 relay provides the ability to override the normal function of the output contacts. This is done by forcing each of them to ON or OFF.

The following path is available using the keypad. For instructions on how to use the keypad, please refer to *Chapter 3 - Working with the Keypad*.

PATH: **MAINTENANCE > M7 TESTING > FORCE LEDS**

FORCE OUTP RELAYS

Range: Disabled, Enabled

Default: Disabled

Set FORCE OUTP RELAYS to "Enabled" to override the normal operation of the output contact, with the programmed state.

When the FORCE OUTP RELAYS setpoint is set to Enabled, the relay Maintenance LED starts flashing (faceplate option E), the In-service LED turns off, the Trouble LED starts blinking orange, and the Critical Failure Relay is de-energized, indicating the relay is in test mode. Output relays may then be turned on and off individually using the setpoints listed below.

NOTE

Note that the FORCE OUTP RELAYS setpoint will always default to the Disabled state at power up.

RELAY 1 TRIP
RELAY 2 CLOSE
RELAY X AUXILIARY

Range: Off, On

Default: Off

Select "On" to energize the output, and "Off" to de-energize it. When energized, the normally open contact of the output relay will close, and the normally closed contact will open. FORCE OUTP RELAYS must be set to "Enabled" for this setting to take effect.

General maintenance

The 350 requires minimal maintenance. As a microprocessor-based relay, its characteristics do not change over time. The expected service life of a 350 is 20 years when the environment and electrical conditions are within stated specifications.

While the 350 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.

NOTICE

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

Unscheduled maintenance (system interruption)

- View the event recorder and oscillography for correct operation of inputs, outputs, and elements.

350 Feeder Protection System

Appendix

Warranty

For products shipped as of 1 October 2013, GE warrants most of its GE manufactured products for 10 years. For warranty details including any limitations and disclaimers, see our Terms and Conditions at https://www.gegridsolutions.com/multilin/warranty.htm

For products shipped before 1 October 2013, the standard 24-month warranty applies.

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

Change notes

Manual Revision history

Table 1: Revision History

MANUAL P/N	RELEASE DATE
1601-9086-A1	12 May 2009
1601-9086-A2	4 June 2009
1601-9086-A3	4 June 2009
1601-9086-A4	30 June 2009
1601-9086-A5	30 June 2009
1601-9086-A6	6 December 2010
1601-9086-A7	18 January 2011
1601-9086-A8	10 May 2010
1601-9086-A9	9 December 2011
1601-9086-AA	29 February 2012
1601-9086-AB	29 September 2012
1601-9086-AC	29 February 2012
1601-9086-AD	13 June 2013
1601-9086-AE	12 July 2013
1601-9086-AF	20 August 2013
1601-9086-AG	26 August 2014
1601-9086-AH	27 February 2015
1601-9086-AJ	10 June 2015
1601-9086-AK	17 December 2015
1601-9086-AL	15 July 2016
1601-9086-AM	10 March 2017
1601-9086-AN	13 June 2017
1601-9086-AP	30 September 2017

Table 2: Major Updates for 350-AP

Page Number	CHANGES
Cover	Manual revision number from AN to AP
Chapter 1	Removed Data Logger from Table 1-2 Updated notes at the beginning of the Specifications section Updated voltage and current input accuracy to be at nominal frequency Updated Undervoltage time delay accuracy Added Underfrequency voltage DPO
Chapter 2	Added installation of loop sensor without sensor fiber extension to Loop sensor installation section (Arc Flash)
Chapter 6	Added note to Phase Directional (67P) setpoints Added note to Logic Elements, Trigger Logic setpoint
General	Minor Corrections

Table 3: Major Updates for 350-AN

Page Number	CHANGES
Cover	Manual revision number from AM to AN Added optical electronic device warning
Chapter 1	Updated functional block diagram Updated Order Codes Added Arc Flash System Order Codes New Specifications: Arc Flash HS Phase/Ground Instantaneous Overcurrent HS 50P/50G Arc Flash Sensor Fiber Outputs: Arc Flash option
Chapter 2	Added Arc Flash Sensor section: Sensor fiber handling and storage Point sensor installation Loop sensor installation
Chapter 6	Updated Cold Load Pickup logic diagram
General	Minor Corrections

Table 4: Major Updates for 350-AM

Page Number	CHANGES
Cover	Manual revision number from AL to AM 350 revision to 2.3x Added class 1M device warning
General	Changed features for 2.3x: Programmable LEDs setpoint added to configure LEDs as TYPE self-reset or latched. Now available for NDO. Event Recorder Lockout setpoint descriptions updated Password and Security setpoint added and description updated Trip Counter logic diagram updated Redundancy Mode (Link Loss Alert - LLA added)
General	New features for 2.3x: Arc Flash Volts per Hertz
Chapter 1	Updated Order Codes Updated Line Diagram and Table 1-1 Protection Elements Specifications: Dropout Level updated for several elements. Ingress Protection rating updated to IP54
Chapter 2	SR 735 adapter plate dimensions corrected
Chapter 4	A2 METERING > CURRENT parameters updated
Chapter 6	Updated Redundancy Mode (LLA) settings Removed duplicate BLOCK descriptions, referring instead to Common Setpoints section. Added to description of Synchrocheck algorithm.
General	Corrections throughout

Table 5: Major Updates for 350-AL

Page Number	CHANGES
Cover	Manual revision number from AK to AL 350 revision to 2.2x

Table 5: Major Updates for 350-AL

Page Number	CHANGES
General	Changed features for 2.2x: System Setup, Ground Fault, Logic Elements, Trip Counter, Transient Recorder, VT Fuse Fail, Thermal Overload.
General	New features for 2.2x: Breaker Health, CT Failure Detection, Demand, Fault Reports, Directional Power, Testing, Positive Sequence UV, Lockout, Broken Conductor, Second Harmonic Inhibit, Wattmetric Ground Fault.
Chapter 1	Updated Order Codes Updated Line Diagram and Table 1-1 Protection Elements Added Table 1-2 Other Elements
Chapter 6	Updated Common Setpoints section Removed duplicate FUNCTION and OUTPUT RELAY descriptions, referring instead to Common Setpoints section.
General	Corrections throughout

Table 6: Major Updates for 350-AK

Page Number	CHANGES
	Manual revision number from AJ to AK Branding change to Grid Solutions
Chapter 1	Order codes: added Accessories list Specifications, Data capture, updated Clock Accuracy Specifications, Metering: added Energy Accuracy Specifications, Power Supply: - Changed High Range Power Supply Range to 250 VDC - Added Fuse rating Specifications, Control: updated Breaker Failure values Specifications, Testing and certification: - Added EAC certification - Added Country of origin, Date of manufacture, Declaration of Conformity - Updated Dielectric voltage withstand test levels Specifications, Environmental: added Noise specification
Chapter 2	Added table of adapter plate part numbers to Mounting section
Chapter 3	Added Upgrading the software Updated Downloading and saving setpoints Added Uninstalling files and clearing data
Chapter 5	Updated Quick setup - Front control panel section
Chapter 6	Updated Subnet IP Mask default value Updated Buffer Setup default value Updated Trigger Position default value Updated Synchrocheck logic diagram
Chapter 7	Added General maintenance
Appendix	Added Repairs
General	Minor corrections

Table 7: Major Updates for 350-AJ

Page Number	CHANGES
	Manual revision number from AH to AJ
Chapter 2	Updated RS485 Wiring diagram Updated IRIG-B Connection diagram
Chapter 3	Updated firmware filename format

Table 7: Major Updates for 350-AJ

Page Number	CHANGES
Chapter 5, 6,	Changed TOC PICKUP range lower value from 0.04 to 0.05
Chapter 7	Updated TIME DELAY default to 1 min
General	Minor corrections

Table 8: Major Updates for 350-AH

Page Number	CHANGES
	Manual revision number from AG to AH
Chapter 1	Updated Order Codes and table to add Synchrocheck
Chapter 4	Added Redundancy and IEEE 1588 PTP
Chapter 6	Added OPC-UA, Redundancy, and Synchrocheck
General	Minor corrections

Table 9: Major Updates for 350-AG

Page Number	CHANGES
	Manual revision number from AF to AG
Chapter 1	Added note to specifications
Chapter 1	Changed Time Delay Accuracy to Curve Timing Accuracy
Chapter 3	Updated hardware and software requirements.
Chapter 3	Replaced image for Transient Recorder Viewer window with updated image.

Table 10: Major Updates for 350-AF

Page Number	CHANGES
	Manual revision number from AE to AF
	Software revision number from 1.5x to 1.60
Chapter 1	Added 67P Order Codes for models with Directional protection (Order Code Other Protection characters “P” and “R”)
Chapter 1	Updated Order Codes adding programmable LEDs option (Language character “L”) and removing Chinese option (Language character “C”)
Chapter 3, 6	Added section on programmable LEDs
General	Increased VT Ratio setting to 1500:1
Chapter 6	Added new 67N and 67G settings to define directional effect on overcurrent elements when direction cannot be calculated
General	Changed Time Delay Multiplier maximum to 50.00 and minimum to 0.05
Chapter 1, 4	Changed Power Metering maximum to 100 from 3000

Table 11: Major Updates for 350-AE

Page Number	CHANGES
	Manual revision number from AD to AE
Chapter 6	Clarify SR3 IEC 61850 GOOSE details

Table 12: Major Updates for 350-AD

Page Number	CHANGES
	Manual revision number from AC to AD
Chapter 1	Updated Type Tests table
General	Minor Corrections

Table 13: Major Updates for 350-AC

Page Number	CHANGES
	Manual revision number from AB to AC
Chapter 1	Revise time delay parameters
Chapter 2	Revise Non-drawout-Adapter plate mounting drawing
Chapter 6	Add missing setpoint titles
General	Minor Corrections

Table 14: Major Updates for 350-AB

Page Number	CHANGES
	Manual revision number from AA to AB
Chapter 1	Add Case design option N (relay with non-drawout design)
Chapter 2	Add dimensions, mounting and wiring for non-drawout unit
General	Minor Corrections

Table 15: Major Updates for 350-AA

Page Number	CHANGES
	Manual revision number from A9 to AA
Chapter 2	Revise Control Power parameters

Table 16: Major Updates for 350-A9

Page Number	CHANGES
	Manual revision number from A6 to A9
General	Add support for additional safety/protection elements

Table 17: Major Updates for 350-A6

Page Number	CHANGES
	Manual revision number from A5 to A6
Chapter 1	Add Protection Elements 67G and 67N to Protection Functions
Chapter 1	Add Comm option 3E to Order Code Table
Chapter 7	Add Ambient Temp section (Ch 7 - Maintenance)
General	Increase number of Logic Elements to 16
General	Minor Corrections

Table 18: Major Updates for 350 A1 to A5

Page Number	CHANGES
	Manual revision numbers from A1 to A5
General	Minor Corrections