



GE VERNOVA

345 Transformer Protection System

Transformer protection and control



Instruction manual

345 revision: 2.5x

Manual P/N: 1601-9098-AG

Publication code: GEK-113568Q



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GE VERNOVA 345 Transformer Protection System instruction manual for revision 2.5x.

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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.



GENERAL SAFETY PRECAUTIONS - 345

- 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.

Safety words and definitions

The following symbols used in this document indicate the following conditions



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



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



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



Indicates practices not related to personal injury.

For further assistance

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345 Transformer Protection System

Chapter 1: Introduction

Overview

The 345 is a microprocessor-based relay for primary and backup protection of small to medium size distribution transformers. The relay provides advanced algorithms for automatic magnitude and phase compensation for more than twenty types of two-winding transformers, good sensitivity for the detection of winding ground faults, and the flexibility to set any of the phase, ground, neutral and negative sequence currents over-current elements. The 345 relay has a small footprint and is withdrawable for easy mounting into either new or retrofit installations. The combination of proven hardware, advanced features, and communications, makes the relay superior for total transformer metering, monitoring, protection and control. Equipped with serial (RS485), USB, and Ethernet ports, as well as a wide selection of protocols such as Modbus, DNP3.0, IEC60870-5-103, 60870-5-104, IEC 61850 GOOSE, the 345 relay is the best-in-class for either MCCs, SCADA or inter-relay communications. The 345 provides excellent accessibility and transparency with regard to power system conditions and events, through both its four-line 20 character display, and the EnerVista SR3 Setup program. Conveniently located LEDs indicate the relay status, pickup, operation, and alarm events, as well as the status of each winding breaker.

The 345 relay provides the following key benefits:

- Withdrawable small footprint – saves on rewiring and space.
- Multiple protection groups with the flexibility to switch through a wide selection of main and backup transformer protections and controls.
- Fast setup (Quick Setup) menu for power system configuration and protection.
- Large four-line LCD display, LEDs, and keypad
- Multiple communication protocols and simultaneous access with easy integration into monitoring and control systems.

Description of the 345 Transformer 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.

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

The protection elements are processed four times per power cycle. The protection elements use RMS current, based on the magnitude of the phasor. Hence, protection is impervious to both harmonics and DC transients.

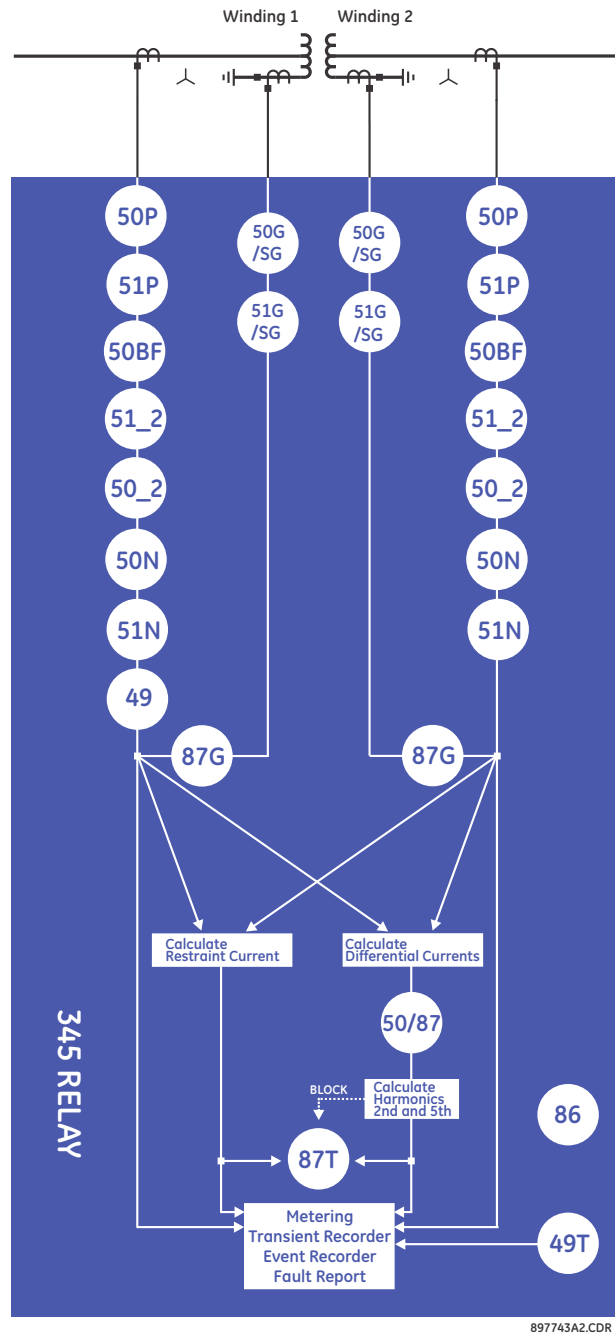


Figure 1-1: Functional block diagram

Table 1-1: ANSI device numbers and functions

ANSI Code	61850 Logical Node	Description
49	PTTR1	Thermal Overload
49T	rtdGGIO6	Temperature Monitoring
50/87	insPDIF1	Instantaneous Differential
50_2	ngseqPIOC1, ngseqPIOC2	Negative Sequence Instantaneous Overcurrent
50BF	RBRF1, RBRF2	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, ngseqPTOC2	Negative Sequence Timed Overcurrent
51G/SG	gndPTOC1, gndPTOC2/ hsePTOC1, hsePTOC2	Ground/Sensitive Ground Timed Overcurrent
51N	ndPTOC1, ndPTOC2	Neutral Timed Overcurrent
51P	phsPTOC1, phsPTOC2	Phase Timed Overcurrent
86	-	Lockout
87G (RGF) ¹	rgfPDIF1, rgfPDIF2	Restricted Ground Fault
87T	pcntPDIF1	Percent Differential

1.Restricted Ground Fault is sometimes coded as "87G", "REF", "87RGF", "87N", "64R", "64REF", etc.

Table 1-2: Other device functions

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

Description
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)

The 345 relay has two identical setpoint groups, with the same set of protection elements. By default setpoint group 1 will be active. Setpoint group 2 can be activated by programming the conditions under S4 Control/Change Setpoint Group menu.

Depending on the relay order code, the type and number of protection elements per setpoint group changes. The full set of protection elements will be available in the setpoint group, if the "Advanced configuration (letter M) is selected in the order code. This includes one Transformer Percent Differential element, one Instantaneous Differential element, two Restricted Ground Fault elements, one Thermal Model, two Breaker Failure elements, two of each Phase-, Ground-, and Neutral Instantaneous Overcurrent elements, two of each Phase-, Ground-, Neutral Timed Overcurrent elements, and two Negative Sequence Timed Overcurrent elements. Some of the protection elements are common for the transformer protection: Percent and Instantaneous differential elements, Thermal Model, and others are generic with programmable AC inputs from either winding currents: the Restricted Ground Fault 1(2), the Phase-, Ground-, and Neutral IOC1(2), the Phase, Ground, and Neutral TOC1(2), and the Negative Sequence TOC1(2) elements.

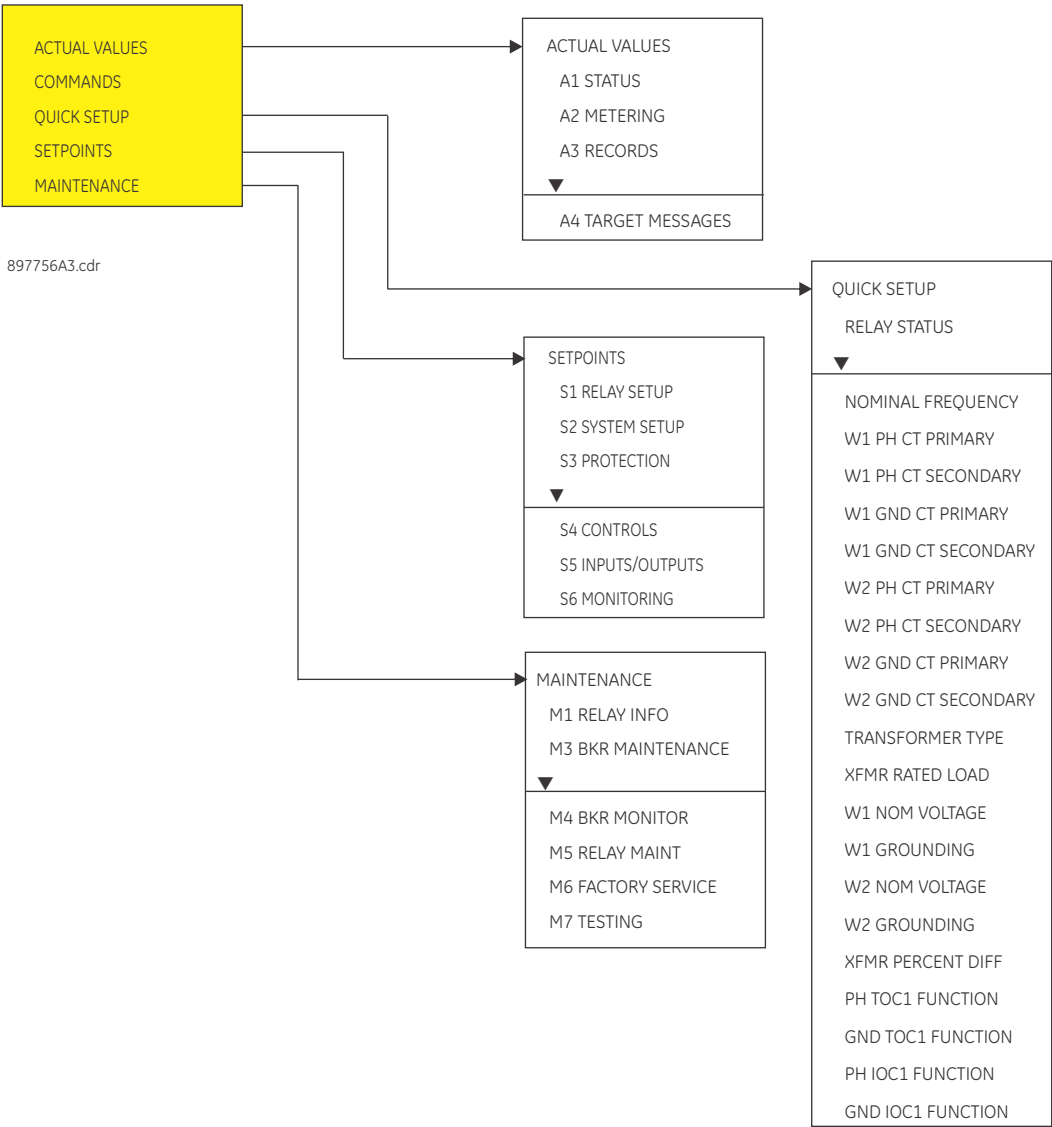


Figure 1-2: Main menu

345 order codes

The information to specify a 345 relay is provided in the following Order Code figure.

	345	-	*	*	*	*	E	*	N	N	*	*	*	*
Interface	345													
User Interface	E													
	L													
Phase Currents ^a	P0													
	P1													
	P5													
Ground Currents ^b	G0													
	G1													
	G5													
	S0													
	S1													
	S5													
Power Supply	L													
	H													
Current Protection ^c							S							
							M							
Communications								S	N					
								1	E					
								3	E					
Case Design ^d									D					
									N					
									X					
Harsh Environment									N					
									H					

- a Phase current option "P0" and Ground current option "G0" is only available on the non-drawout version (Case Design option "N"). Phase current options "P1/P5" and Ground current options "G1/G5" are only available on the drawout version (Case Design option "D" or "X").
- b Ground current options "G0/G1/G5" and "S0/S1/S5" must match the corresponding "P0/P1/P5" Phase current. The selected phase and ground CTs apply to both windings.
- c Current protection option "E" has been discontinued.
- d Case Design option "X" is for ordering purposes only. The relay will show Case Design option "D" in the order code viewed through the HMI or Enervista 3 Series Setup software.

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Figure 1-3: Order Codes



NOTE

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

Empty chassis

The 345 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.

345 - CH - * * * N N * * *						
Phase Currents	P1					1 A 3-phase CTs (Winding 1 - 1 A, Winding 2 - 1 A)
	P5					5 A 3-phase CTs (Winding 1 - 5 A, Winding 2 - 5 A)
Ground Currents ^a	G1					1 A standard ground CTs (Winding 1 - 1 A, Winding 2 - 1 A)
	G5					5 A standard ground CTs (Winding 1 - 5 A, Winding 2 - 5 A)
	S1					1 A sensitive ground CTs (Winding 1 - 1 A, Winding 2 - 1 A)
	S5					5 A sensitive ground CTs (Winding 1 - 5 A, Winding 2 - 5 A)
Communications		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
		3	E			Standard + Ethernet (Copper & Fiber - MTRJ), Modbus TCP/IP, DNP3.0, IEC 60870-5-104, IEC 61850
Harsh Environment			N			None
			H			Harsh Environment Conformal Coating

^a Ground current options "G1/G5" must match the corresponding "P1/P5" Phase currents

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Figure 1-4: 350 chassis order codes

Remote Module I/O

The remote RTD Module provides additional protection by monitoring the temperature of key components in the equipment.

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

897800RMIO-A1.fm

Accessories

- 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 - 3'



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

Specifications



Specifications are subject to change without notice.



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



To obtain the element operating 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.

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

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

Pickup Level:..... 0.05 to 20.00 x CT in steps of 0.01 x CT

Dropout Level: 97% of Pickup @ $I > 1 \times CT$
Pickup - $0.02 \times CT$ @ $I < 1 \times CT$

Curve Shape:..... ANSI Extremely/Very/Moderately/Normally Inverse
 Definite Time (0.1 s base curve)
 IEC Curve A/B/C and Short Inverse
 IAC Extremely/Very/-/Short Inverse

Curve Multiplier:..... 0.05 to 50.00 in steps of 0.01

Reset Time: Instantaneous, Linear

Curve Timing Accuracy: $\pm 3\%$ of expected inverse time or 1 cycle, whichever is greater, from pickup to operate

Level Accuracy:..... per CT input

SENSITIVE GROUND TIMED OVERCURRENT (51SG)

Pickup Level:..... 0.005 to 3.000 x CT in steps of 0.001 x CT

Dropout Level: 97% of Pickup @ $I > 0.1 \times CT$
Pickup - $0.002 \times CT$ @ $I < 0.1 \times CT$

Curve Shape:..... ANSI Extremely/Very/Moderately/Normally Inverse
 Definite Time
 IEC Curve A/B/C/Short
 IAC Extremely/Very/-/Short Inverse

Curve Multiplier:..... 0.05 to 50.00 in steps of 0.1

Reset Time: Instantaneous, Linear

Curve Timing Accuracy: $\pm 3\%$ 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 @ $I > 1 \times CT$ Pickup - 0.02 x CT @ $I < 1 \times CT$
Time Delay:	0.00 to 300.00 sec in steps of 0.01
Operate Time:	<30 ms @ 60Hz ($I > 2.0 \times PKP$, No time delay) <35 ms @ 50Hz ($I > 2.0 \times PKP$, 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 @ $I > 0.1 \times CT$ Pickup - 0.002 x CT @ $I < 0.1 \times CT$
Time Delay:	0.00 to 300.00 sec in steps of 0.01
Operate Time:	<30 ms @ 60Hz ($I > 2.0 \times PKP$, No time delay) <35 ms @ 50Hz ($I > 2.0 \times PKP$, No time delay)
Time Delay Accuracy:	1% or 1 cycle, whichever is greater (Time Delay selected)
Level Accuracy:	per CT input

TRANSFORMER THERMAL PROTECTION (49)

Current:	RMS current - max (I_a , I_b , I_c)
Pickup Accuracy:	per current inputs
Timing Accuracy:	$\pm 3\%$ of expected time, or 30 ms (whichever is greater) @ $I > 1.5 \times PKP$

TRANSFORMER PERCENT DIFFERENTIAL PROTECTION (87T)

Differential/Restraint Characteristic:	Dual Slope, Dual Breakpoint
Minimum Pickup Level:	0.05 to 1.00 x CT in steps of 0.01
Slope 1 Range:	15 to 100% in steps of 1%
Slope 2 Range:	50 to 100% in steps of 1%
Kneepoint 1:	0.50 to 4.00 x CT in steps of 0.01
Kneepoint 2:	1.00 to 10.00 x CT in steps of 0.01
2 nd Harmonic Inhibit Level:	1.0 to 40.0% in steps of 0.1%
2 nd Harmonic Inhibit Mode:	Per-phase, 2-out-of-3, Average, 1-out-of-3
5 th Harmonic Inhibit Level:	1.0 to 40.0% in steps of 0.1%
Dropout Level:	95% of Pickup
Operate Time:	< 20 ms (no harmonics inhibits selected) < 30 ms (harmonics inhibits selected)
Level Accuracy:	per current inputs

TRANSFORMER INSTANTANEOUS DIFFERENTIAL PROTECTION (50/87)

Pickup Level:	3.00 to 20.00 x CT in steps of 0.01 x CT
Dropout Level:	95% of Pickup
Operate Time:	<30 ms
Level Accuracy:	per current inputs

RESTRICTED GROUND FAULT

Number of Elements:	2
Pickup Level:	0.02 to 20.00 x CT in steps of 0.01 0.002 to 2.000 x CT (with sensitive CTs)
GND Supervision Level:	0.02 to 20.00 x CT in steps of 0.01 0.002 to 2.000 x CT (with sensitive CTs)
Dropout Level:	97% of Pickup
Slope Range:	0 to 100% in steps of 1
Pickup Delay:	0.00 to 600.0 s in steps of 0.01
Operate Time:	< 30 ms @ 0 ms time delay
Level Accuracy:	per current inputs

Metering

PHASE & GROUND CURRENT INPUTS

CT Primary:	1 to 6000 A
Range:	0.02 to $20 \times \text{CT}$
Input type:	1 A or 5 A (must be specified with order P1G1 or P5G5) Configurable 1 A or 5 A (must be specified with order P0G0)
Nominal frequency:	50/60 Hz
Burden:	<0.1 VA at rated load
Accuracy at nominal frequency:	3% $\pm 10 \text{ mA}$ or $\pm 20\%$ of reading from 0.02 to $0.19 \times \text{CT}$, 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 $40 \times \text{rated current}$ continuous at $3 \times \text{rated current}$

SENSITIVE GROUND CURRENT INPUT

CT Primary:	1 to 600 A
Range:	0.002 to $3 \times \text{CT}$
Input type:	1 A or 5 A (must be specified with order P1S1 or P5S5) Configurable 1 A or 5 A (must be specified with order P0S0)
Nominal frequency:	50/60 Hz
Burden:	<0.1 VA at rated load
Accuracy at nominal frequency:	3% $\pm 10 \text{ mA}$ or $\pm 20\%$ of reading from 0.02 to $0.19 \times \text{CT}$, 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 $40 \times \text{rated current}$ continuous at $3 \times \text{rated current}$

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: I_a , I_b , I_c , I_g , I_{sg} , I_n - magnitudes and angles Voltages: V_{an} , V_{bn} , V_{cn} , V_{ab} , V_{bc} , V_{ca} , V_{aux} - 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, ground differential current, negative sequence current, restraint current, per-phase differential current, per-phase differential second harmonic current, thermal capacity
Data Storage:	RAM - battery backed up; 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 $\pm$ 10% IRIG formats accepted: B001, B002, B003, B004
Accuracy with IRIG-B:	$\pm$ 1 ms
Accuracy without IRIG-B:	$\pm$ 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 FAILURE (50BF)

Pickup Level:	0.05 to 20.00 x CT in steps of 0.01 x 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 x pickup at 60 Hz <16 ms typical at 2 x pickup at 50 Hz

LOCKOUT

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

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:	$\pm$ 10°C
Timing Accuracy:	$\pm$ 1 second

Monitoring

BREAKER HEALTH

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

DEMAND

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

RTD (49T)

Pickup:.....1 to 250°C in steps of 1°C
 Pickup Hysteresis:2°C
 Time Delay:.....3 sec
 Elements:Trip and Alarm

RTD TROUBLE ALARM(49T)

RTD Trouble Alarm:.....<-50°C or >250°C

Inputs

CONTACT INPUTS

Inputs:.....10
 Selectable thresholds:.....17, 33, 84, 166 VDC
 $\pm 10\%$
 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

RTD INPUTS

RTD Type:.....100 Ohm platinum (DIN.43760)
 RTD Sensing Current:.....5 mA
 Isolation:.....2 kV from base unit (RMIO only)
 Distance:250 m maximum
 Range:-50 to +250°C
 Accuracy:..... $\pm 3^\circ\text{C}$
 Lead Resistance:.....25 Ohm max per lead
 RTD Trouble Alarm:.....<-50 or >250°C
 RTD Inputs Available:.....12 maximum with the RMIO option connected

Outputs

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

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 @ 250 VAC Pilot duty A300
Break (AC resistive):	277 VAC / 10 A

TRIP SEAL-IN

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

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
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
Product type:	Class 1 Laser product

USB

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

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

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

345 Transformer Protection System

Chapter 2: Installation

Mechanical installation

This section describes the mechanical installation of the 345 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 345 are on the following pages. Additional dimensions for mounting and panel cutouts are shown in the following sections.

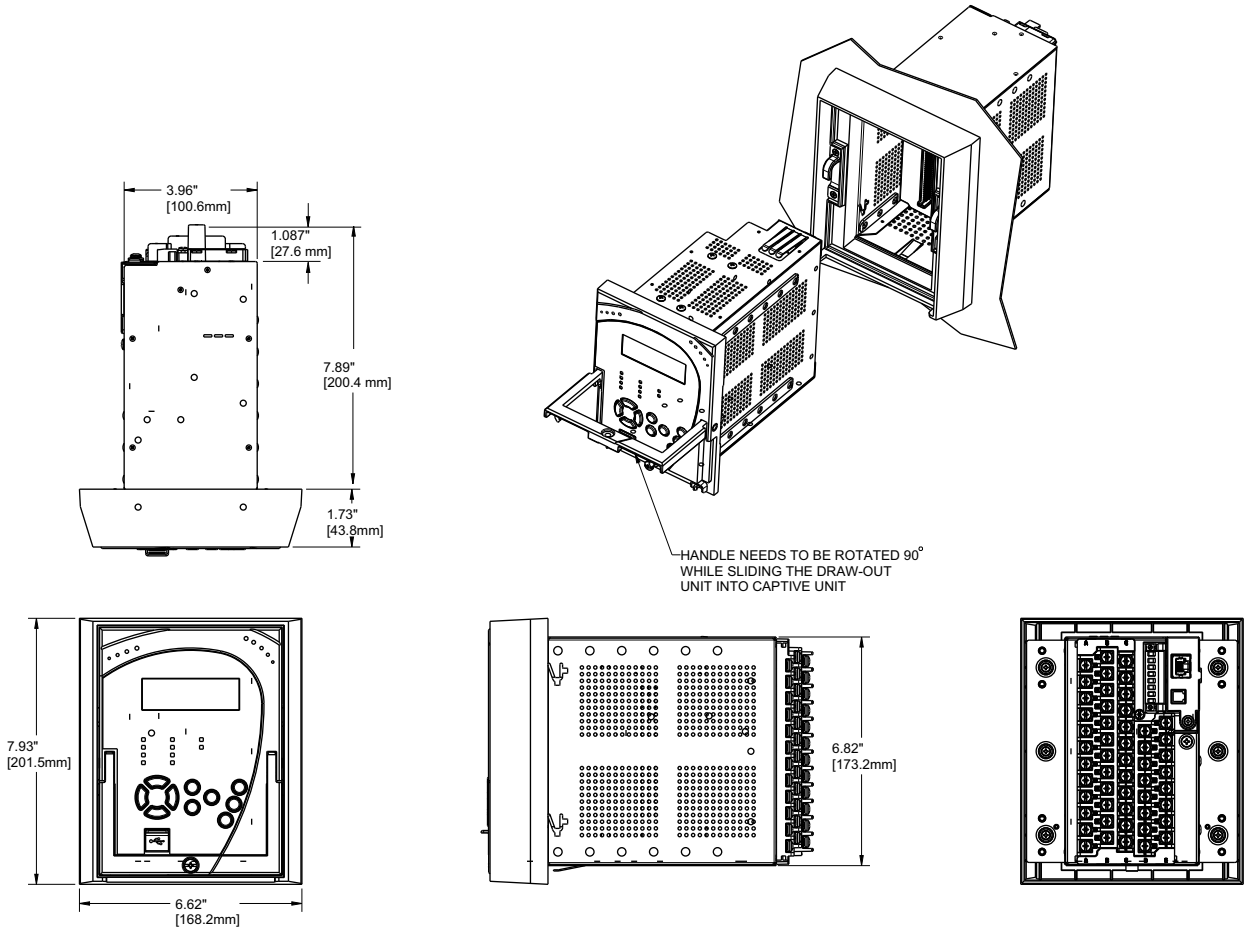


Figure 2-1: 345 dimensions - Drawout unit

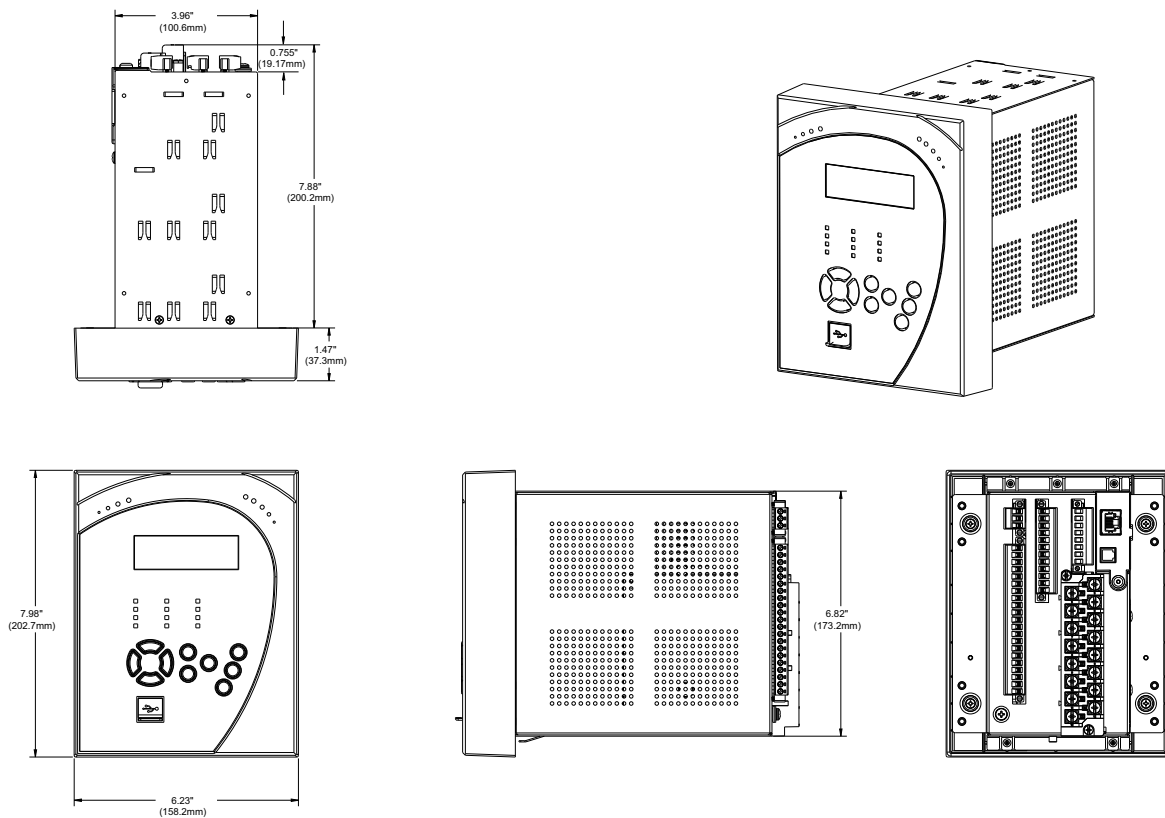


Figure 2-2: 345 dimensions - Non-drawout unit

Product identification

The product identification label is located on the side panel of the 345. This label indicates the product model, serial number, and date of manufacture.



Figure 2-3: 345 Product label



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 below.

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.

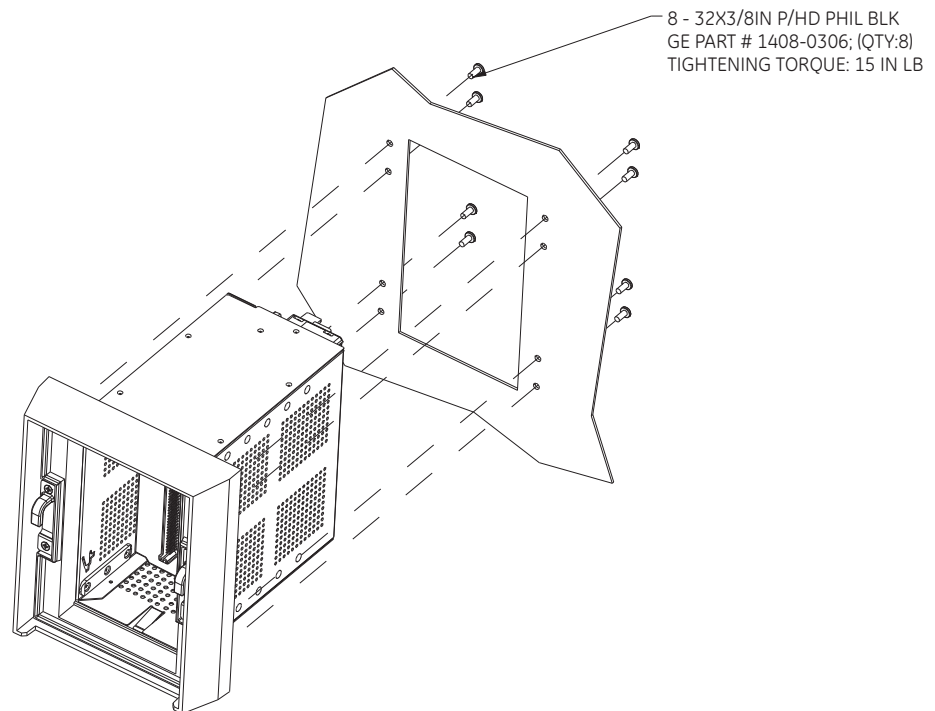


Figure 2-4: Standard panel mounting - Drawout

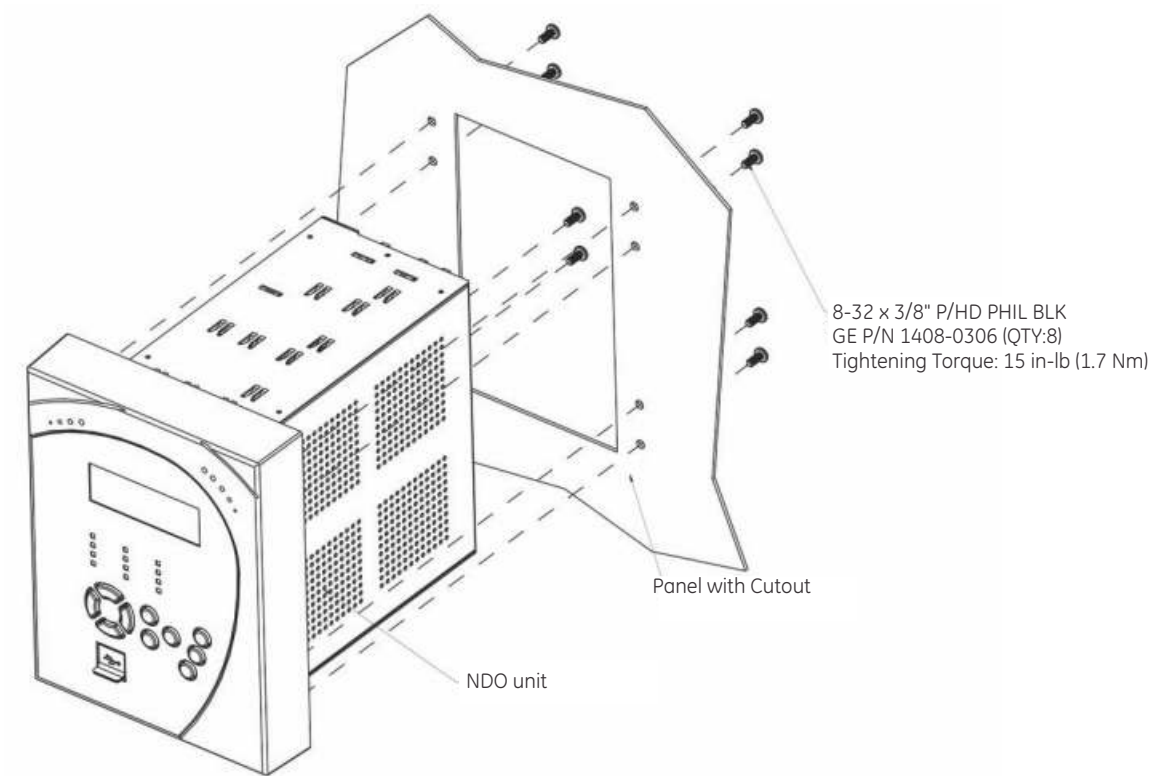


Figure 2-5: Standard Panel mounting - Non-drawout

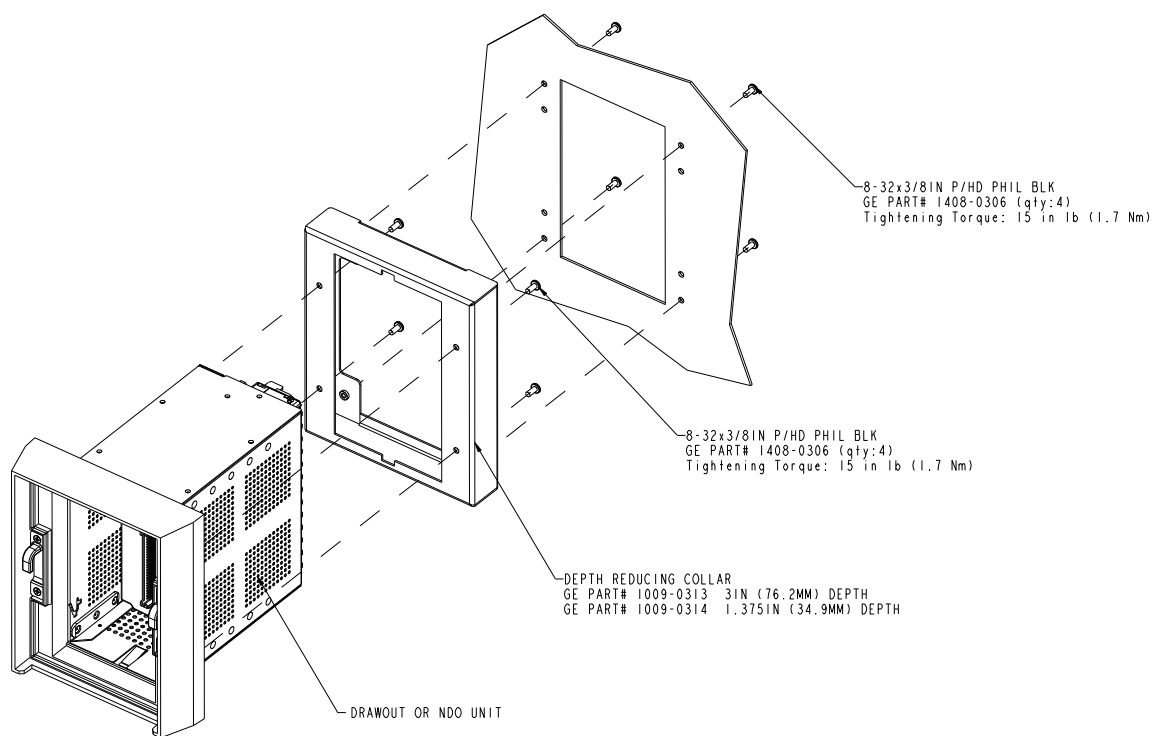


Figure 2-6: Depth Reducing collar (optional)

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.

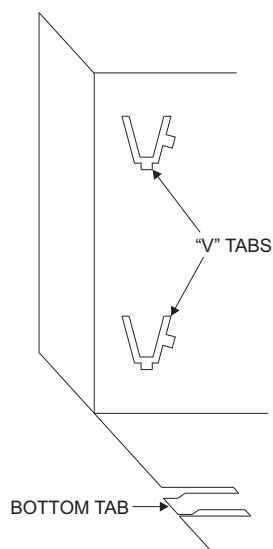


Figure 2-7: Mounting tabs (optional)

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.

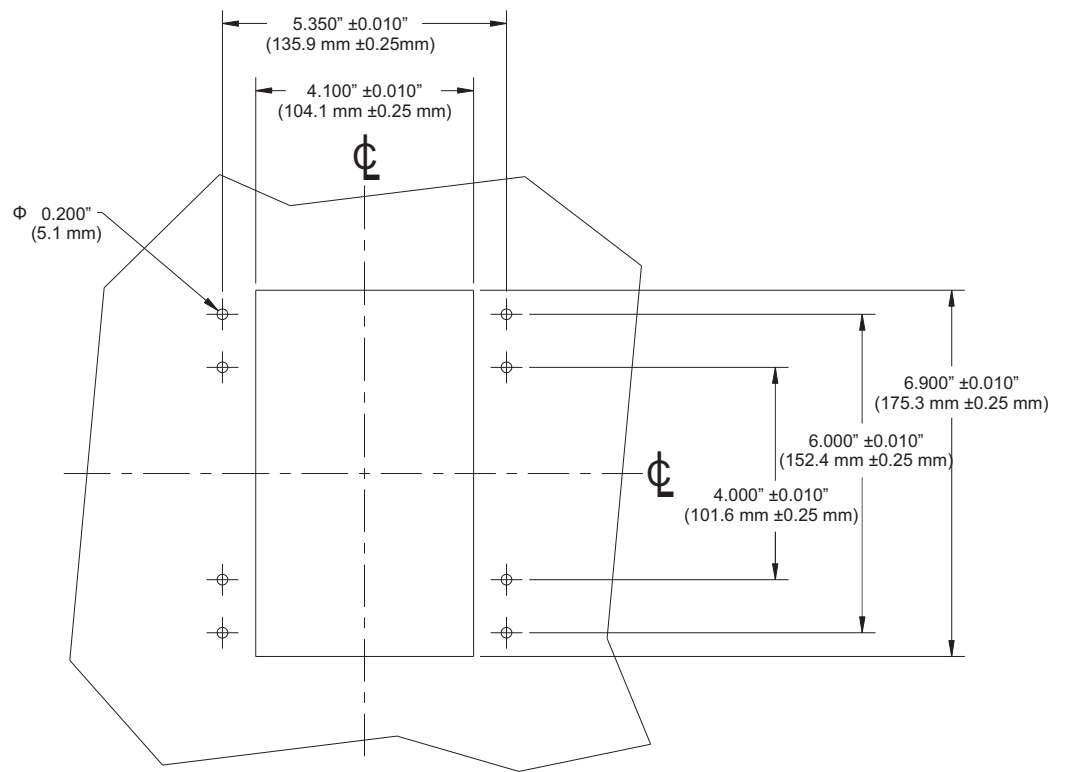


Figure 2-8: Panel cutout dimensions

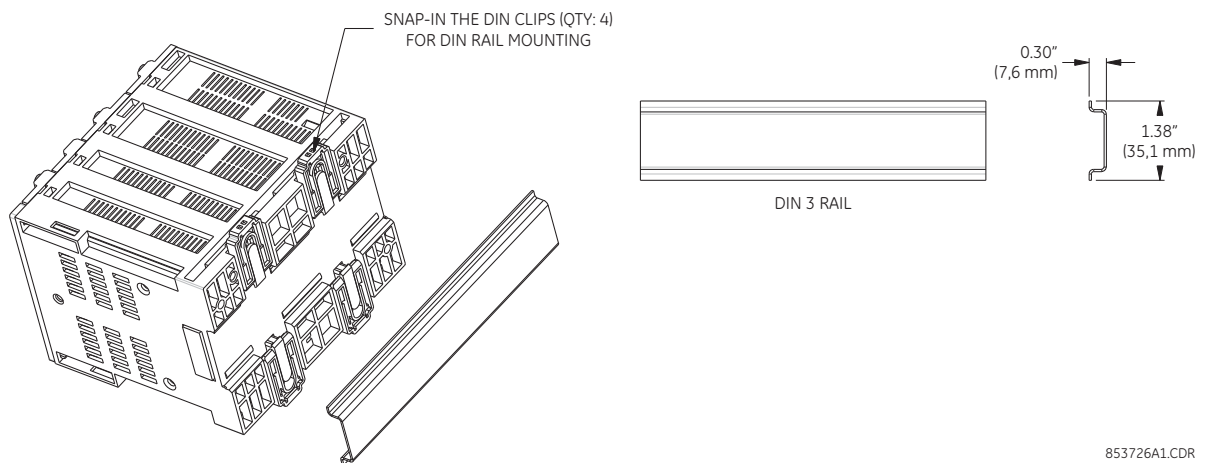


Figure 2-9: RMIO - DIN rail mounting - Base & Expansion units

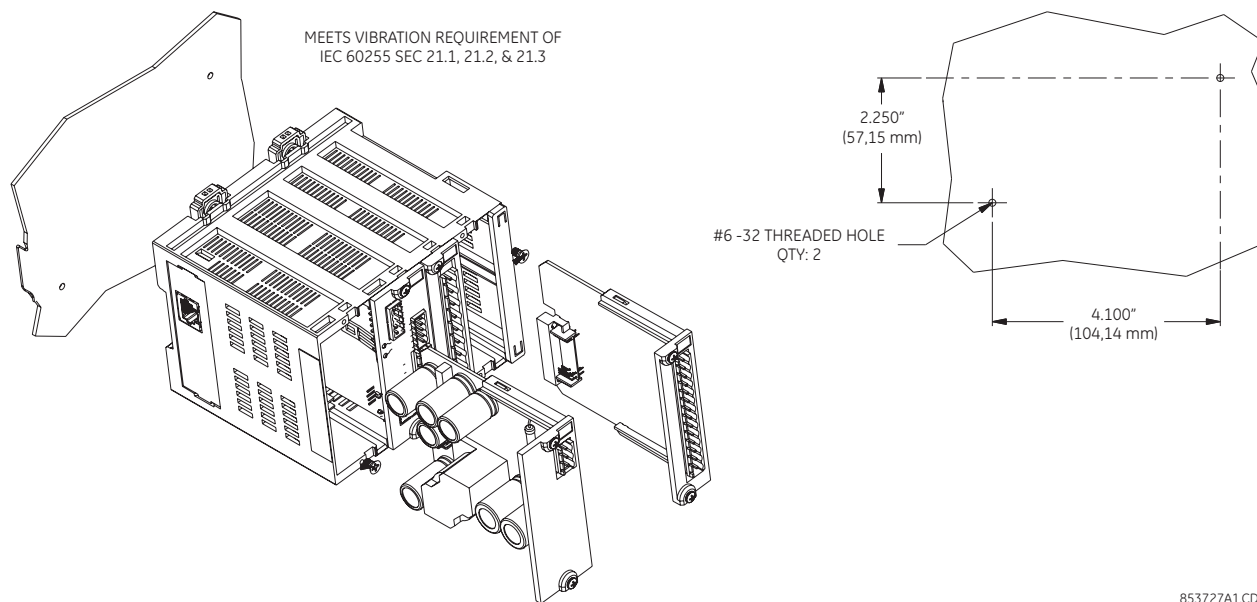


Figure 2-10: RMIO - Base Unit screw mounting

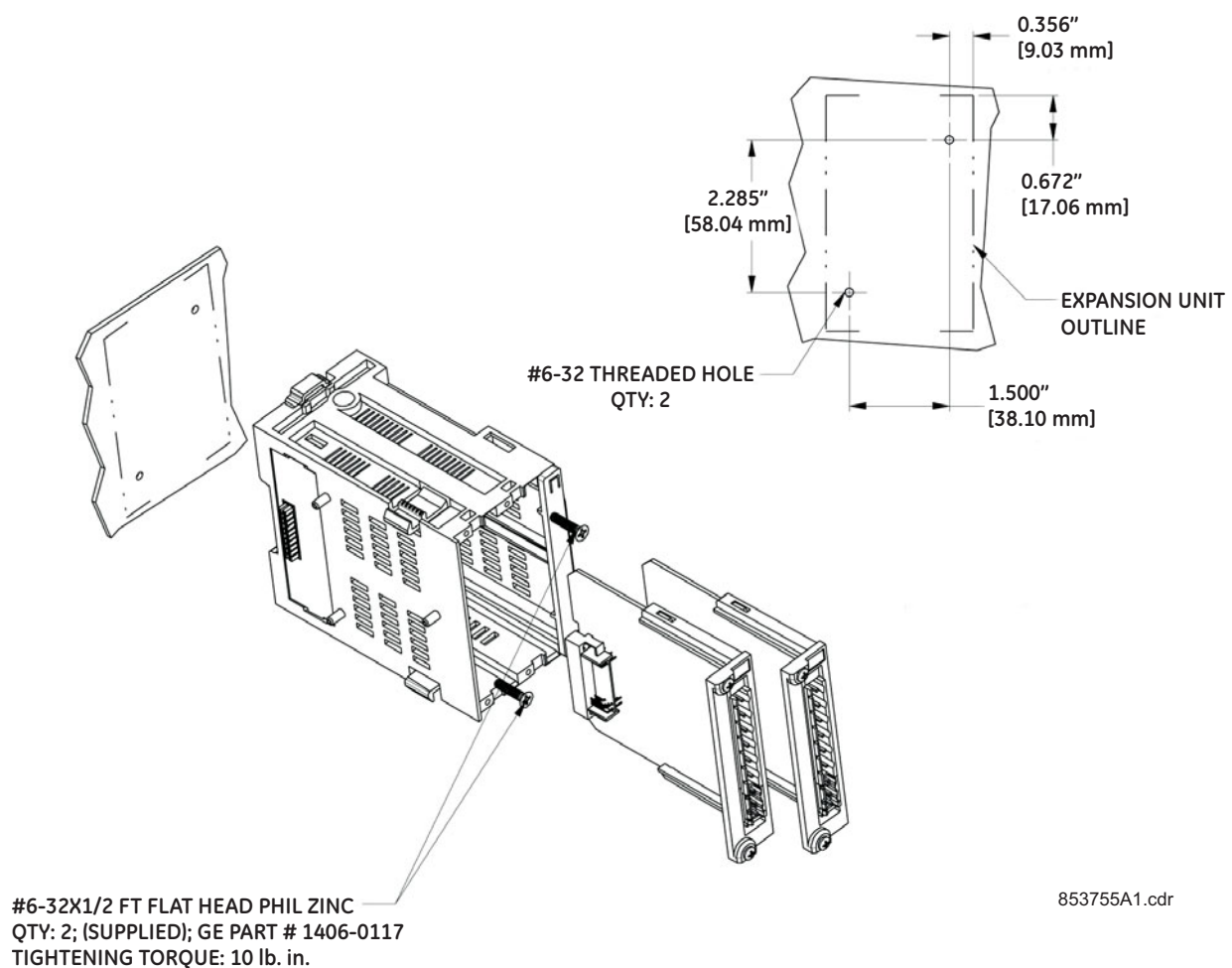


Figure 2-11: RMIO - Expansion Unit screw mounting

Drawout unit withdrawal and insertion

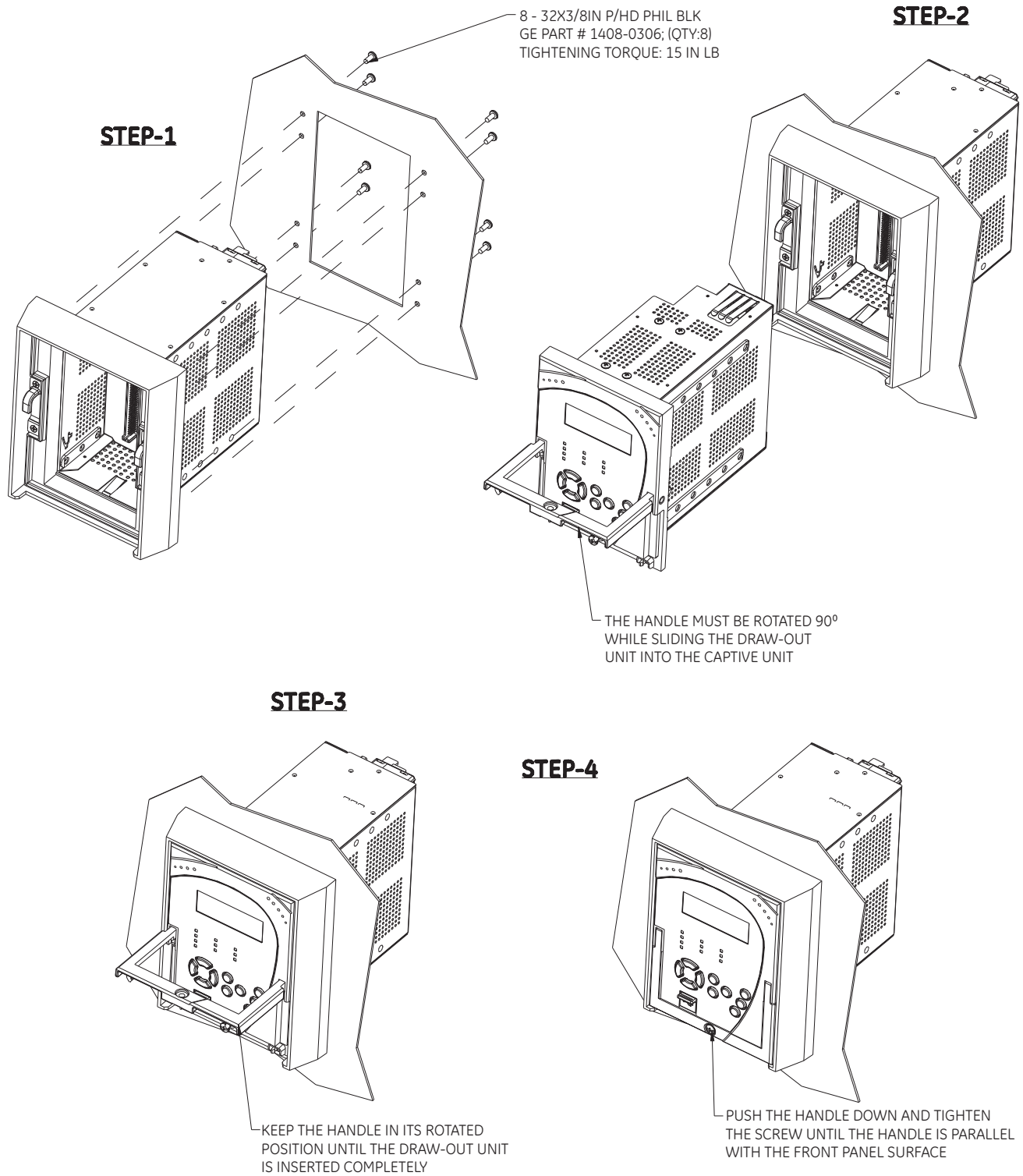


Figure 2-12: Unit withdrawal and insertion diagram

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:

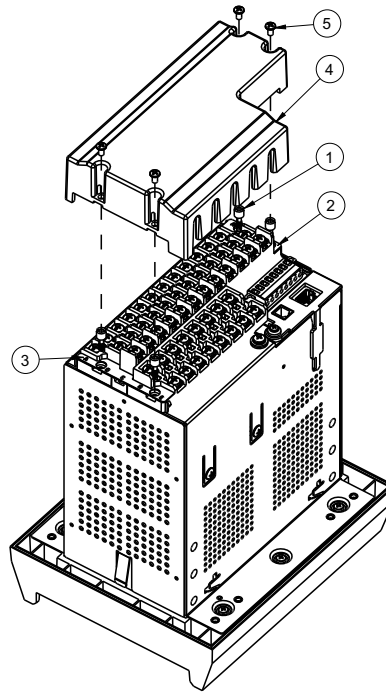


Figure 2-13: IP20 Cover mounting - Drawout unit only

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.

Electrical installation

This section describes the electrical installation of the 345 system, including typical wiring diagrams and terminal identification.

Typical Wiring Diagrams

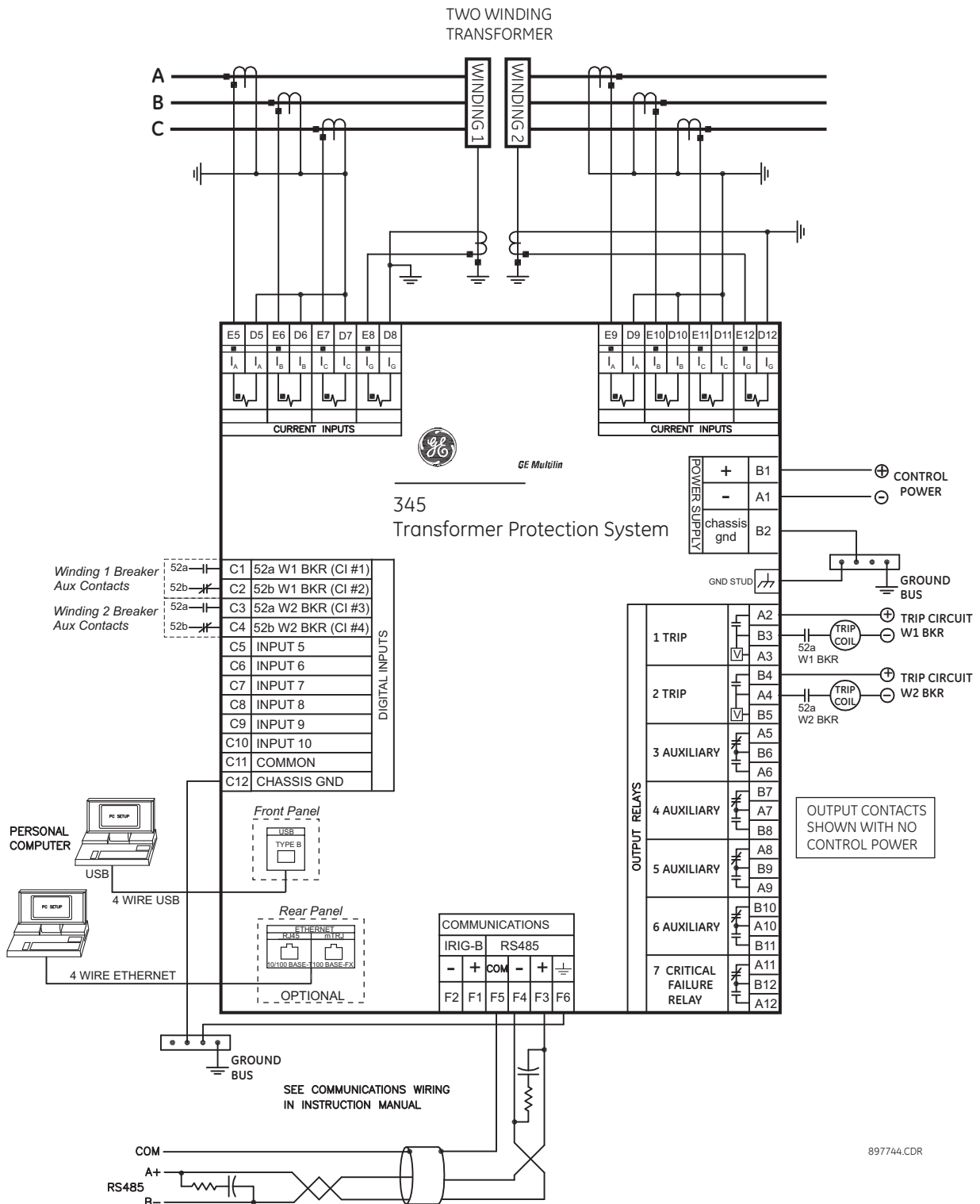


Figure 2-14: Typical wiring diagram – Drawout

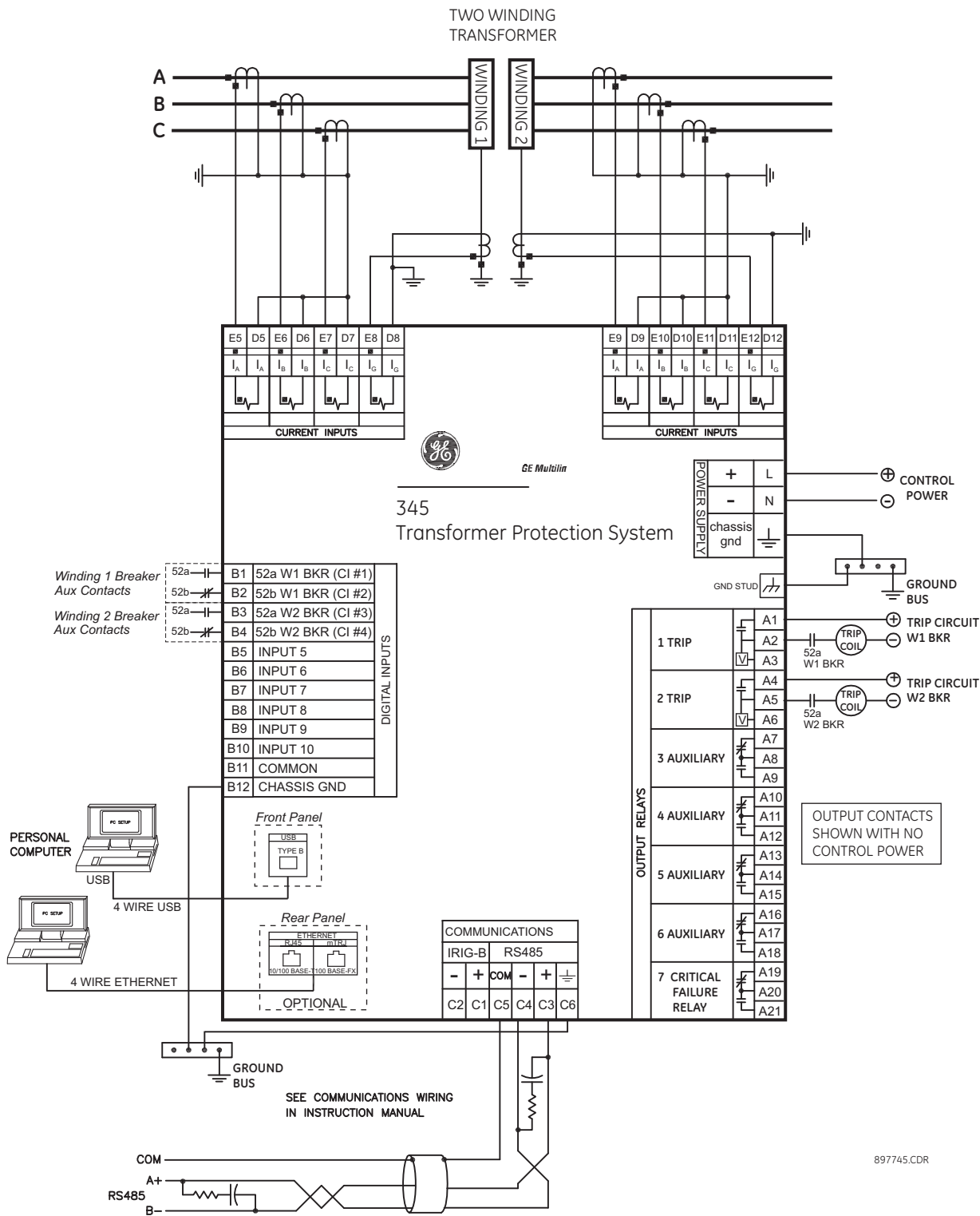


Figure 2-15: Typical wiring diagram - Non-drawout

345 Terminal identification



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.

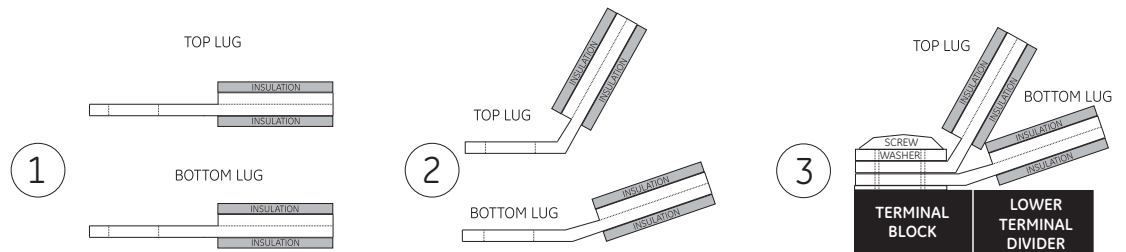


Figure 2-16: Orient the lugs correctly...

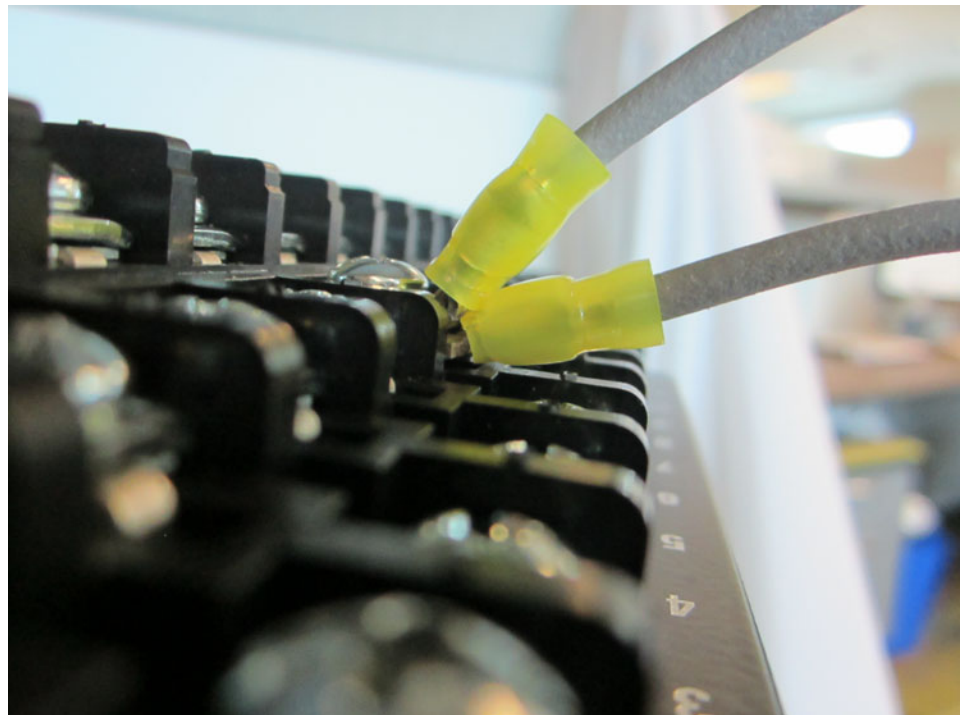


Figure 2-17: CORRECT INSTALLATION METHOD

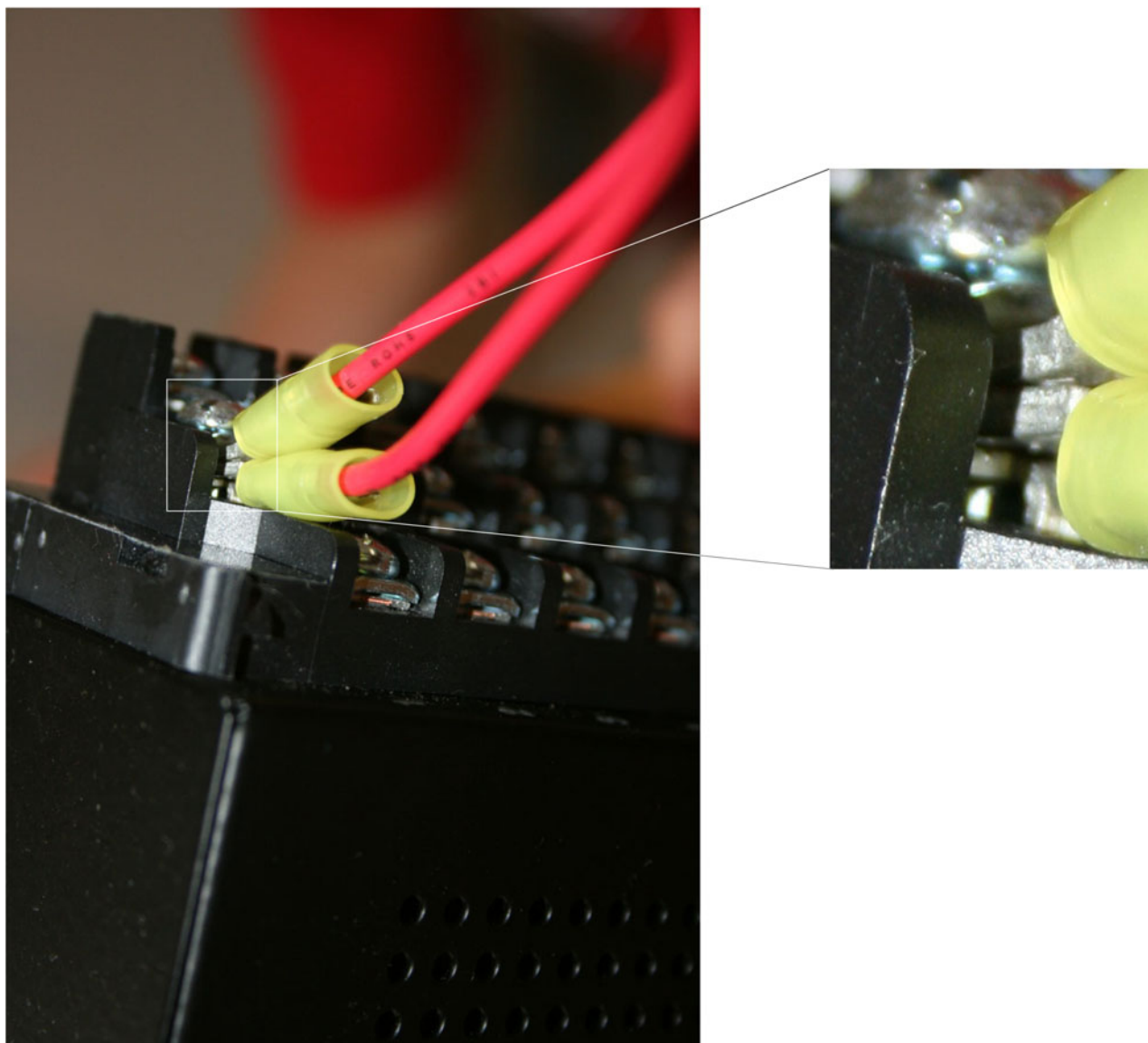


Figure 2-18: INCORRECT INSTALLATION METHOD (lower lug reversed)

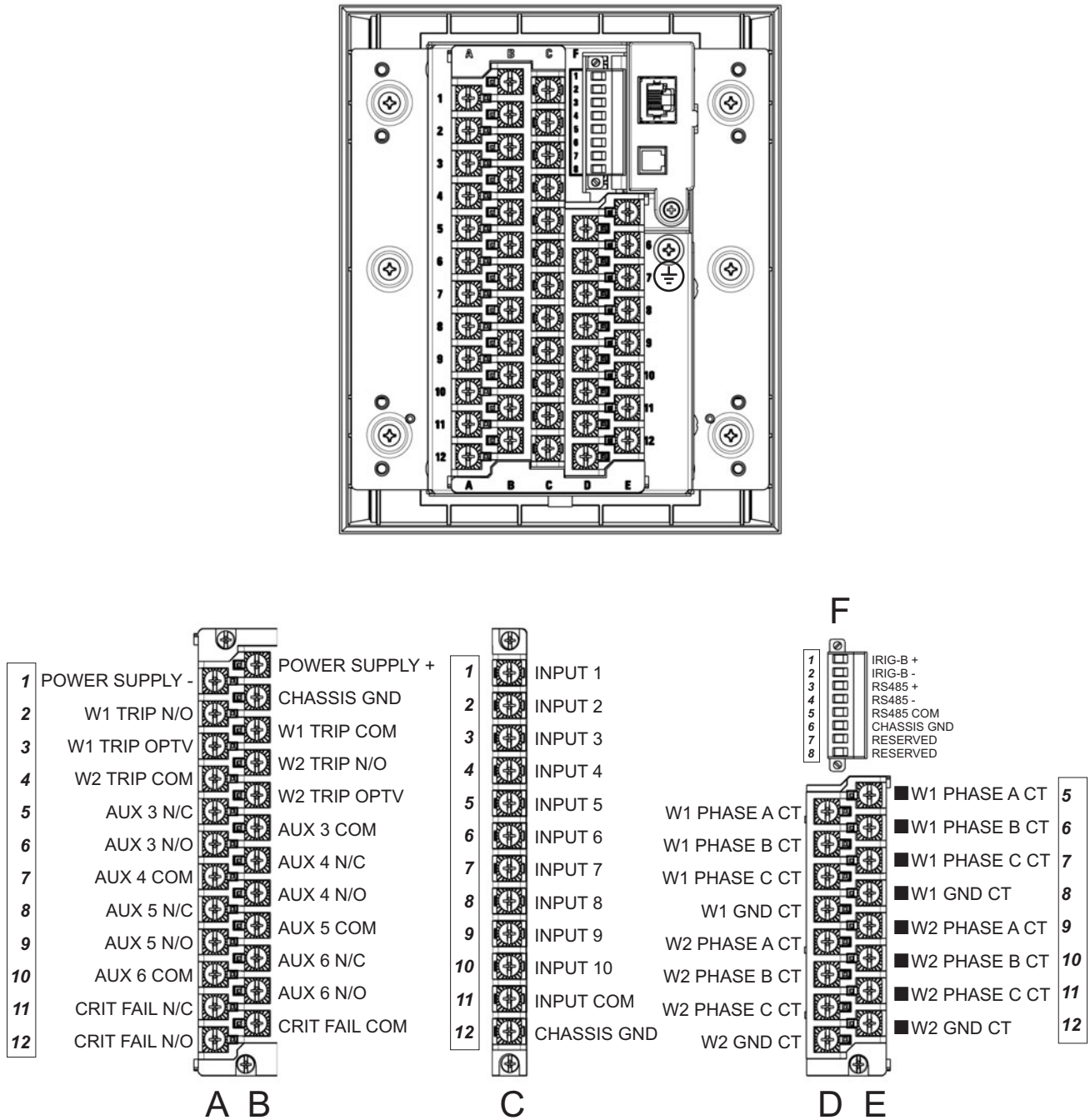


Figure 2-19: Terminal Identification - Drawout

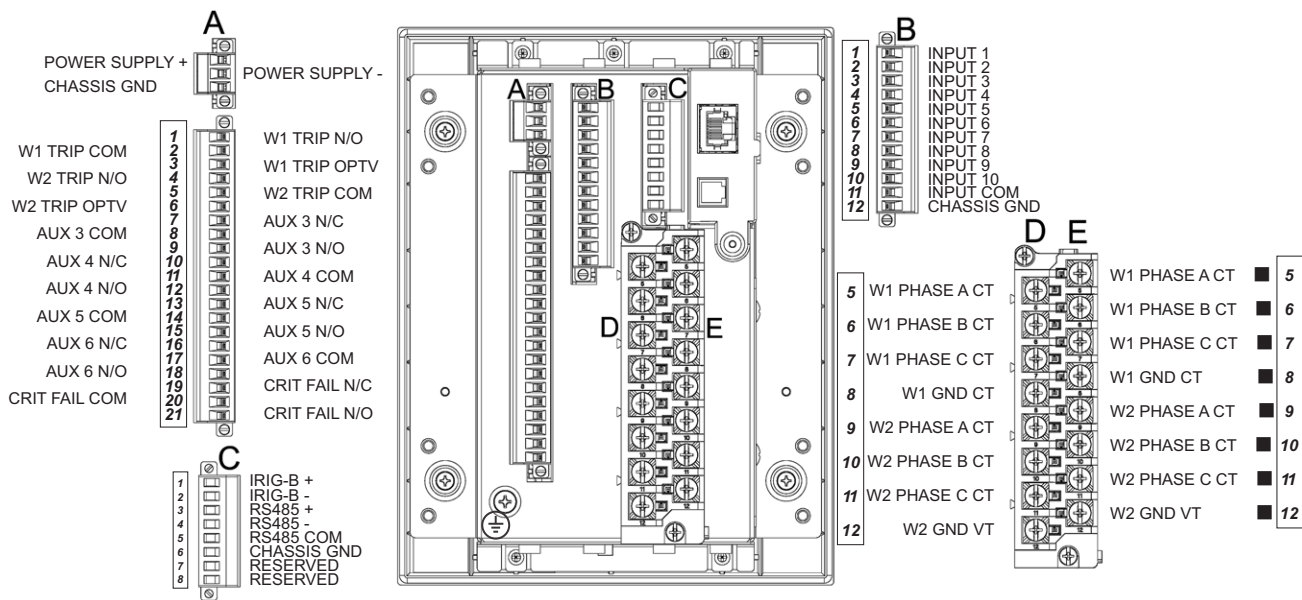


Figure 2-20: Terminal Identification - Non-drawout

Wire range

Use the following guidelines 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 mm² to 0.3 mm²): Single wire termination with/without 9.53 mm (0.375") maximum diameter ring terminals (#8).
- 14 AWG to 22 AWG (2.1 mm² to 0.3 mm²): Multiple wire termination with matching wire sizes and stranding. Two wires maximum per circuit.
- 14 AWG to 22 AWG (2.1 mm² to 0.3 mm²): Multiple wire termination with 9.53 mm (0.375") maximum diameter ring terminals (#8). Two ring terminals maximum per circuit.
- Suggested wiring screw tightening torque, tighten to 12 in-lb (1.35 N-m).
- Minimum suggested temperature rating for the conductors is 75C.

Use the following guidelines when selecting wires to connect to terminal strip F (Drawout case design), and terminal strips A,B,C (Non-drawout case design):

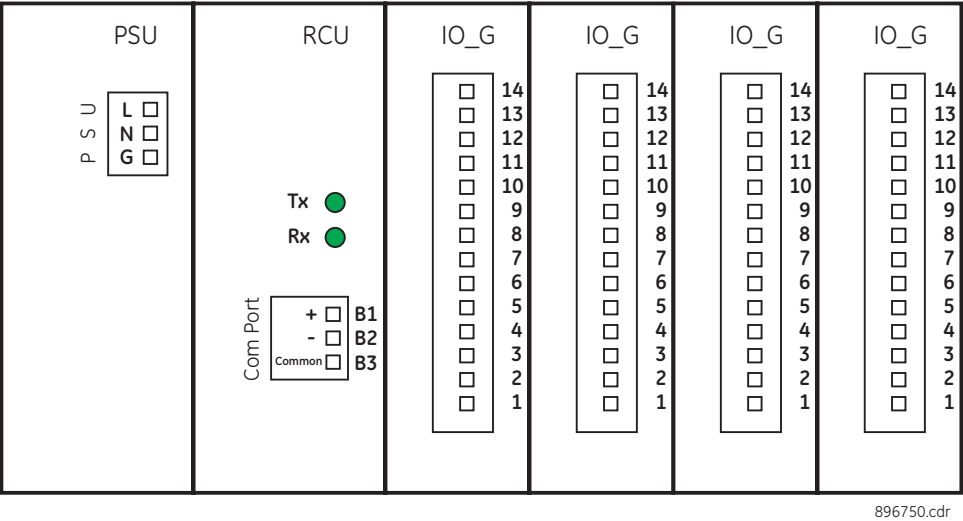
- 12 AWG to 24 AWG (3.3 mm² to 0.2 mm²)
- Suggested wiring screw tightening torque: 4.5 in-lbs (0.5 N-m)
- The uncovered communications cable shield connected to the common terminal should not exceed 1" (2.5 cm) for proper EMC shielding of the communications cable.

RMIO module installation

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



Figure 2-21: RMIO unit showing 2 IO_G modules



896750.cdr

Figure 2-22: RMIO terminal identification with 4 IO_G modules

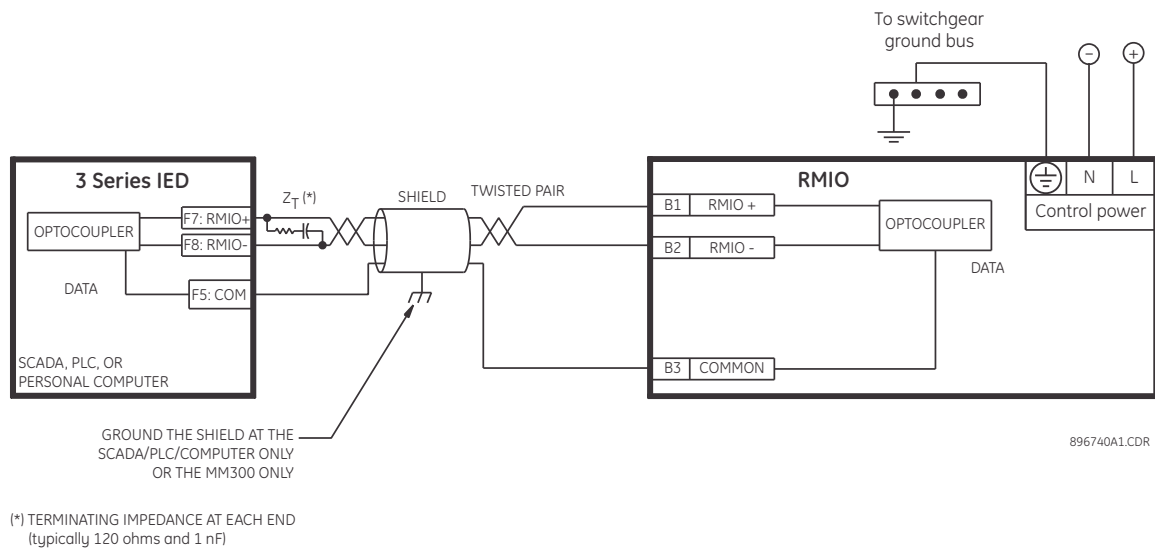


Figure 2-23: RMIO wiring diagram



F5, F7, and F8 refer to terminals shown on the above 345 Terminal Identification diagrams.

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

Current inputs

The 345 relay has eight (8) 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 $20 \times$ 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

Two ground inputs - one per winding - are referred to throughout this manual as the **Ground Current** or **Sensitive Ground Current** inputs. 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 inputs (Terminals D8 and E8 for W1, and D12 and E12 for W2) are used in conjunction with a Zero Sequence CT as source, or in the neutral of wye-connected source CTs. When using the residual connection set the GROUND CT PRIMARY setpoint to a value equal to the PHASE CT PRIMARY setpoint.

In cases where the relay is equipped with sensitive ground CT (terminals D8 and E8 for W1, and D12 and E12 for W2) the sensitive ground current input is intended for use 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.



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

The ground CT wiring in the figure below, shows 3 possible ways for wiring the Winding 1 ground CT (terminals D8, E8). The Winding 2 ground CT wiring (terminals D12, E12) is similar.

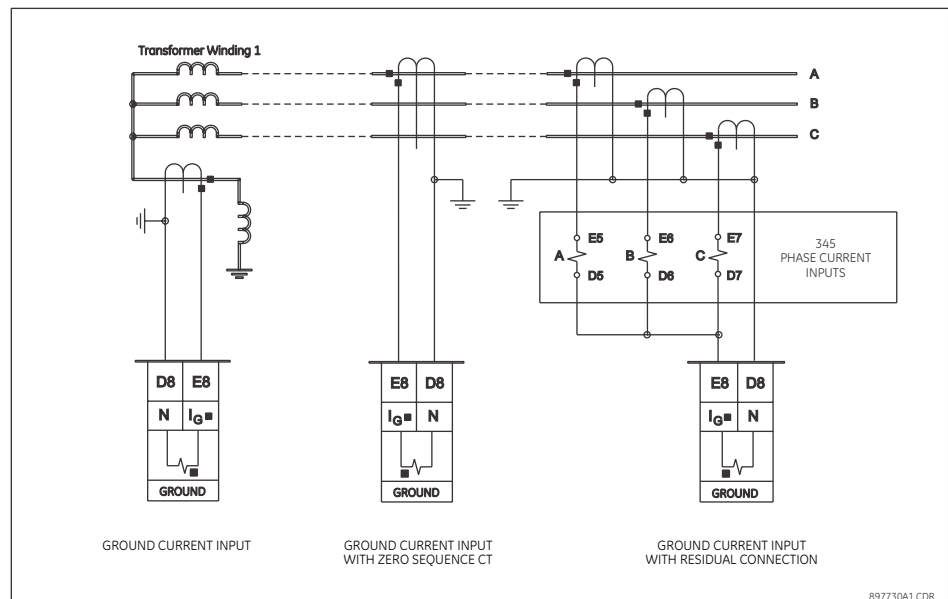


Figure 2-24: Ground/Sensitive Ground wiring

For Winding 2 ground CT, use relay terminals D12-E12 in the same wiring configuration as shown above for Winding 1.

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.

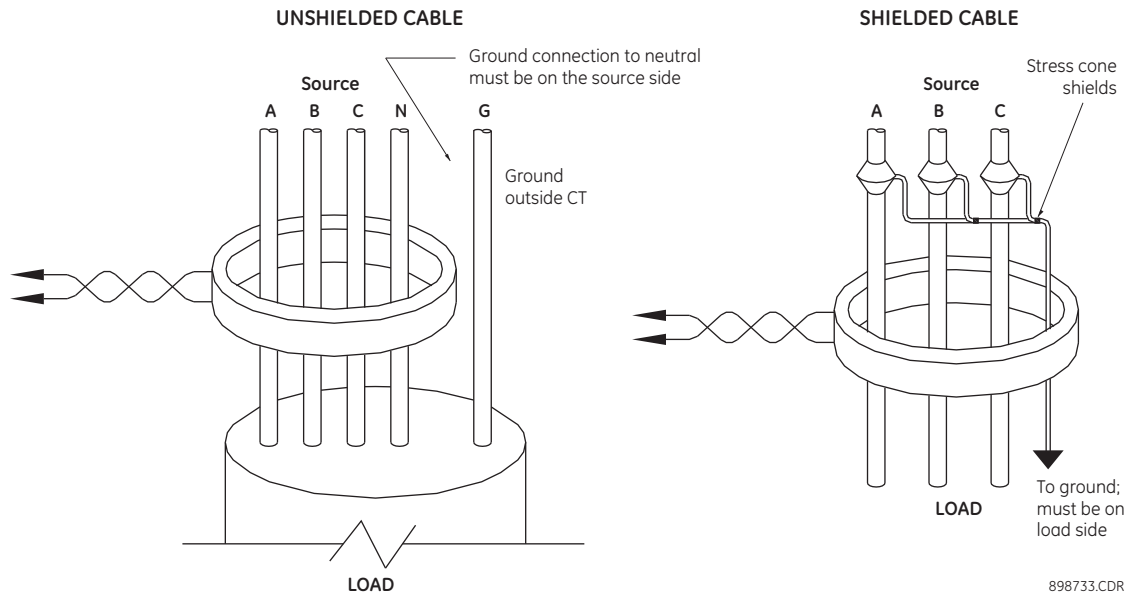


Figure 2-25: Zero sequence core balance (CT) installation

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.

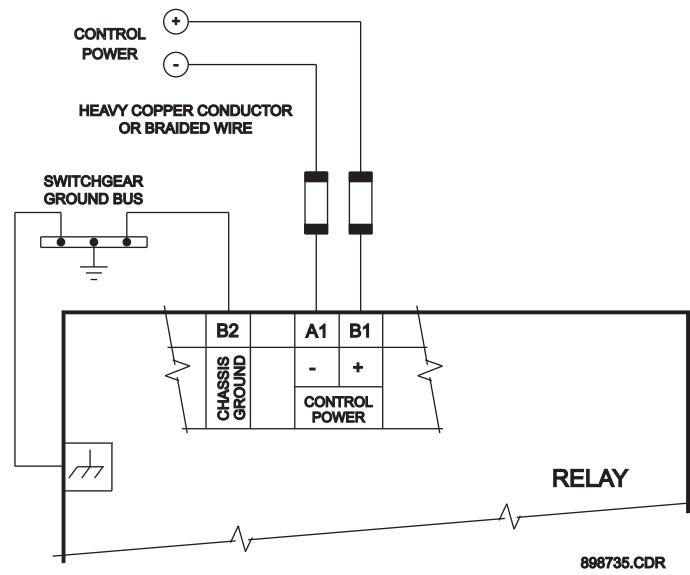


Figure 2-26: Control power connection

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).



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.

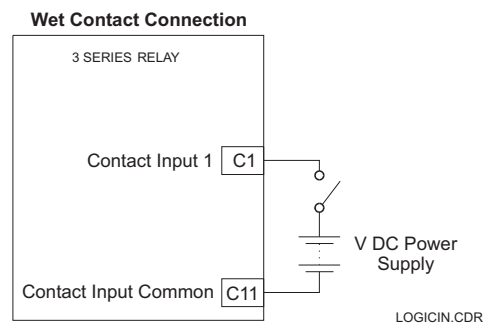


Figure 2-27: Wet contact connections

Trip1 and Trip2 output relays

The 345 relay is equipped with seven electromechanical relays: two special relays designed for Winding 1 Breaker trip and Winding 2 Breaker trip, 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 two Trip output relays is designed to be controlled by the state of the circuit breaker as monitored by a 52a or 52b contact.

- The Trip 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.
- If a delay is programmed for the Trip 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.
Yes	No	Trip Relay remains operational until 52a indicates an open breaker.
No	Yes	Trip Relay remains operational until 52b indicates an open 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.

Breaker monitoring (Trip coil monitoring) is performed by a built-in voltage monitor on Form A output relays: #1 Trip, and #2 Trip. 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 #1 Trip coil monitoring, or/and B4, and B5 for #2 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 figures below show the two different connections of the breaker Trip coil to the relay's trip output #1 terminals (output #2 Trip coil monitoring) for both no voltage monitoring and voltage monitoring of the trip circuit integrity.



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.

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

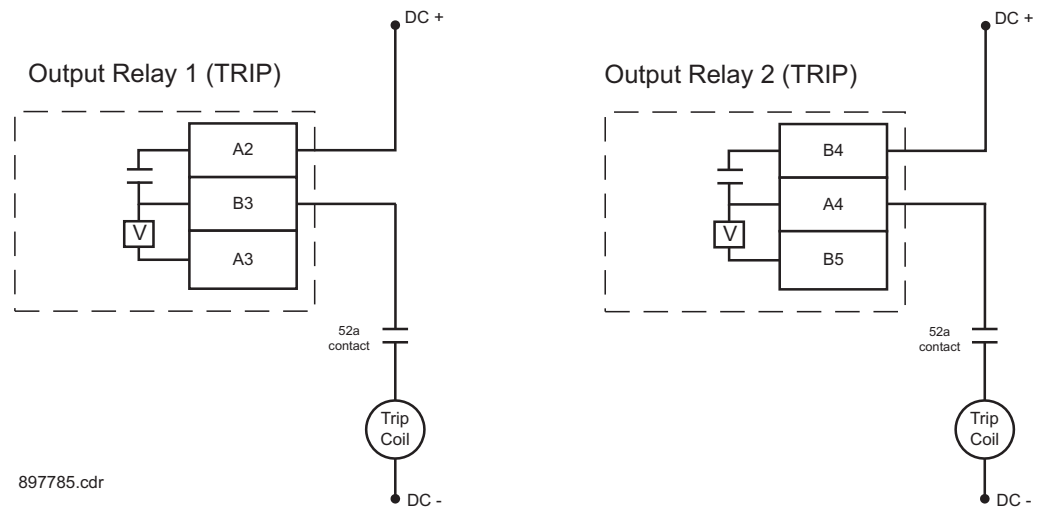


Figure 2-28: Relay #1 Trip and Relay #2 Trip circuits with no voltage monitoring



All AUX contacts are shown when the breaker is open.

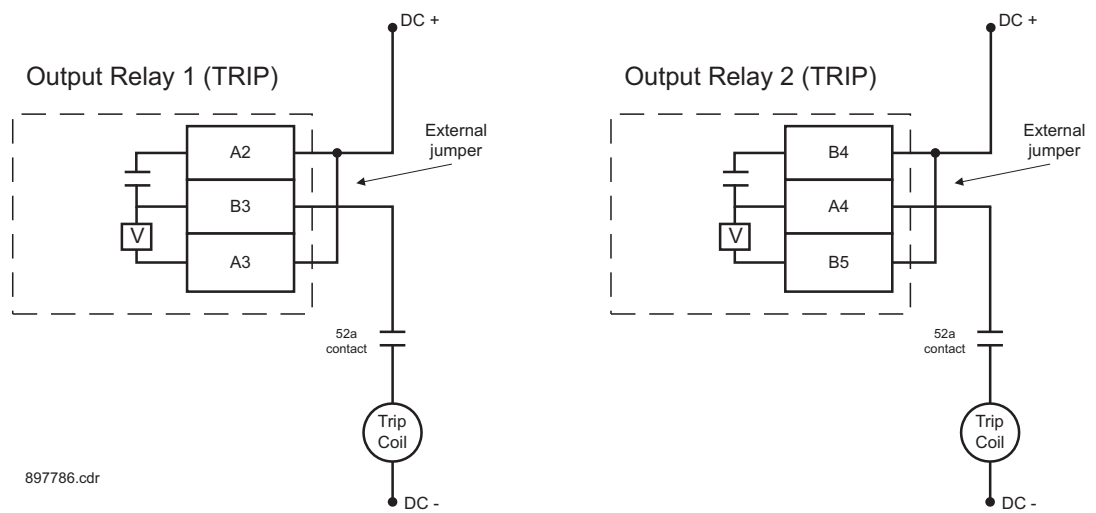


Figure 2-29: Relay #1 Trip and Relay #2 Trip circuits with voltage monitoring

Serial communications

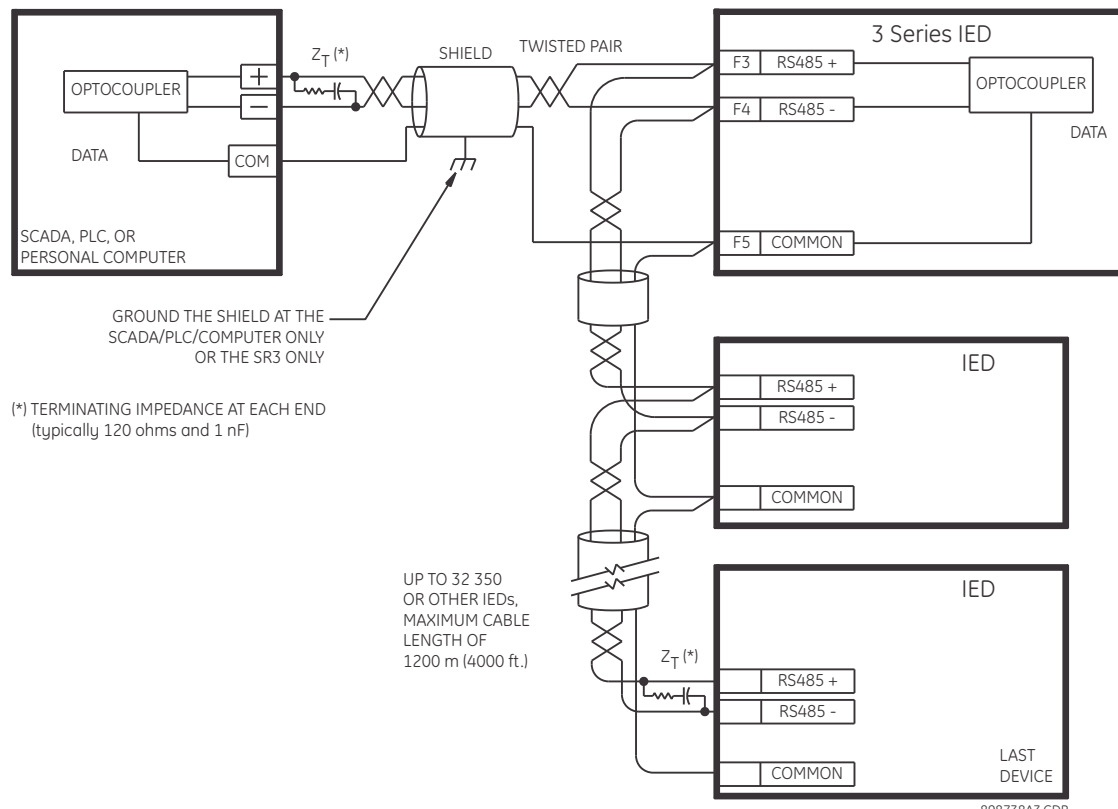


Figure 2-30: RS485 wiring diagram

One two-wire RS485 port is provided. Up to 32 345 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 345 . 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 345 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 345 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.

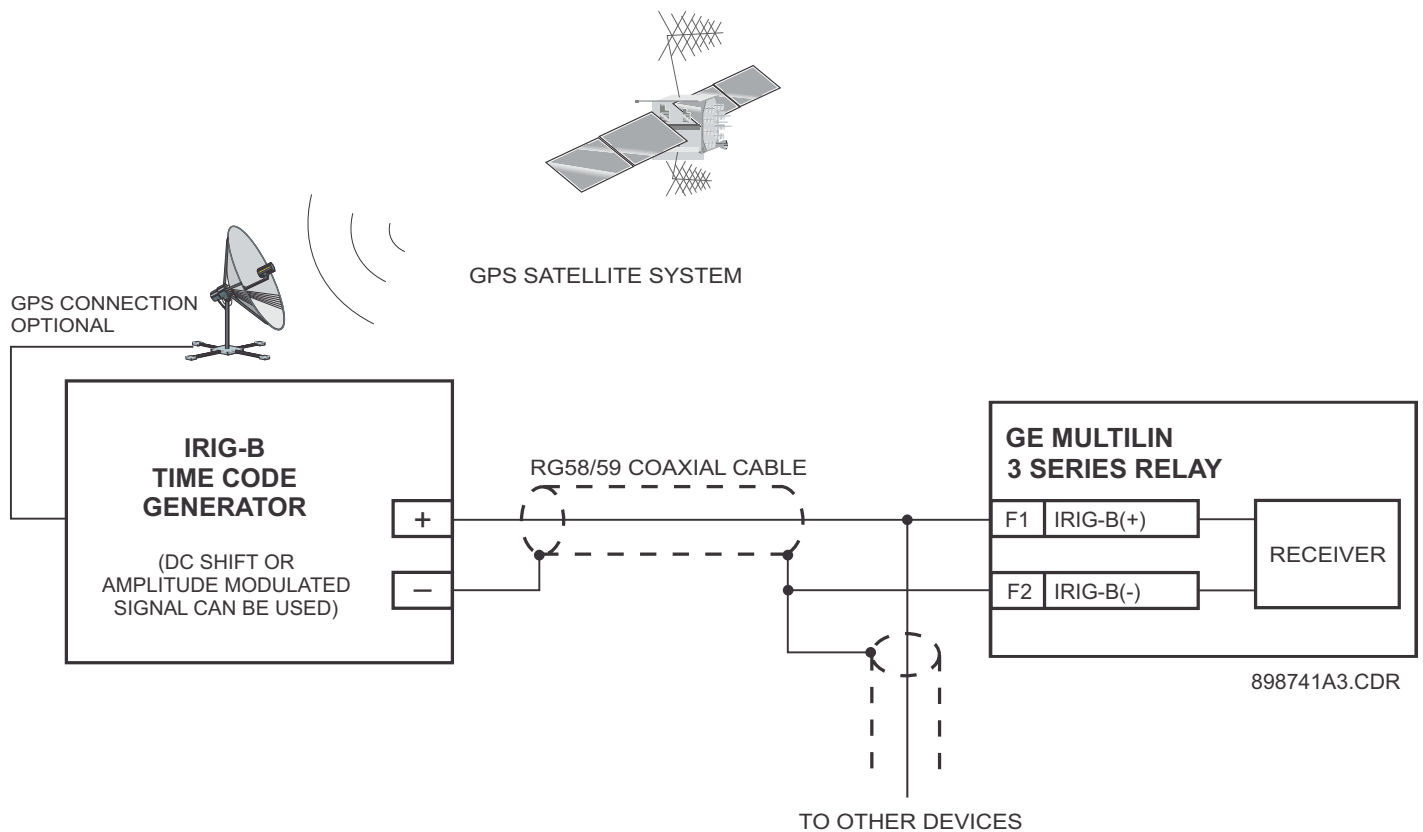


Figure 2-31: IRIG-B connection

345 Transformer Protection System

Chapter 3: Interfaces

There are two methods of interfacing with the 345 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 345 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

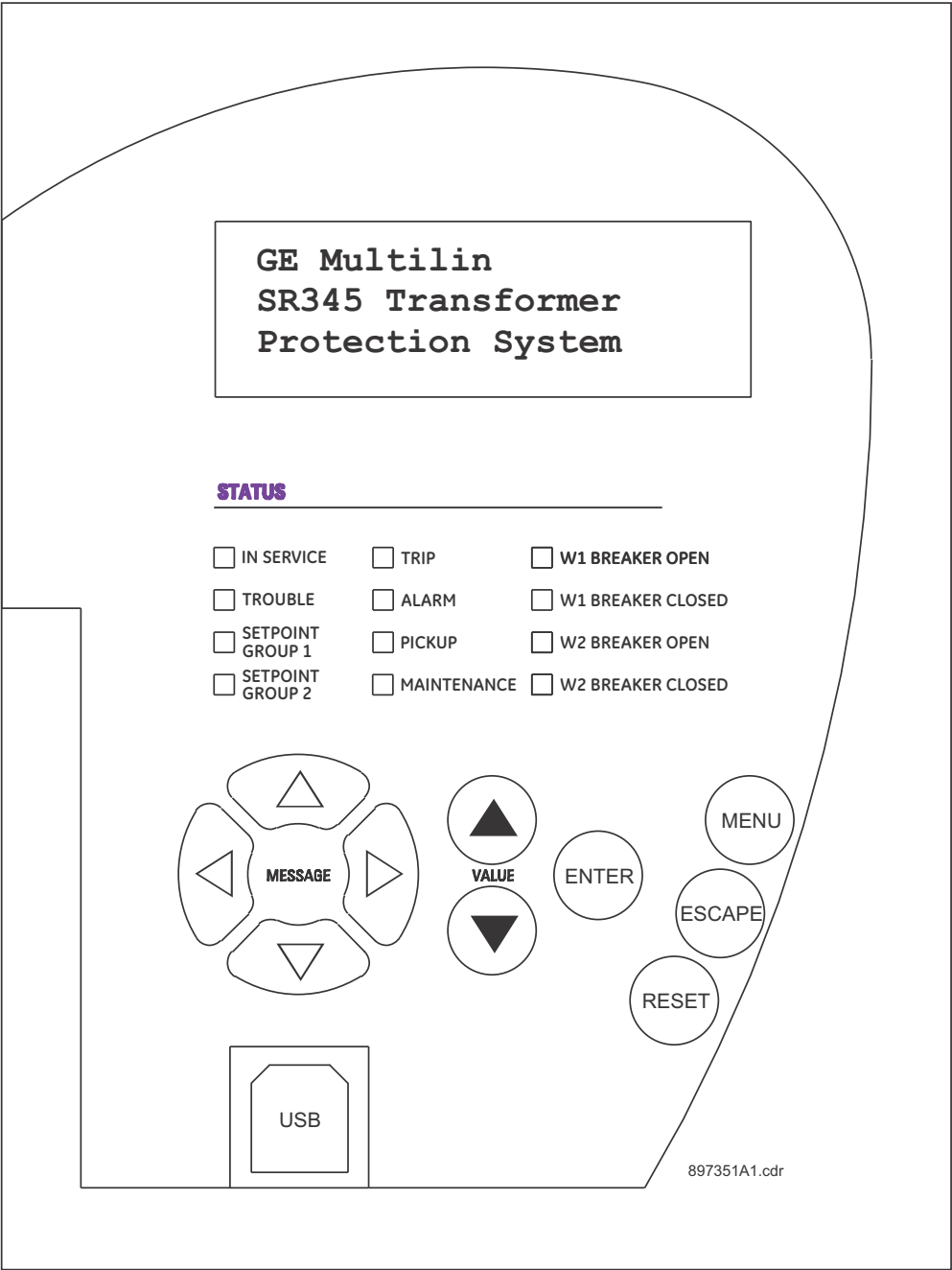


Figure 3-1: Transformer Protection System Front Panel

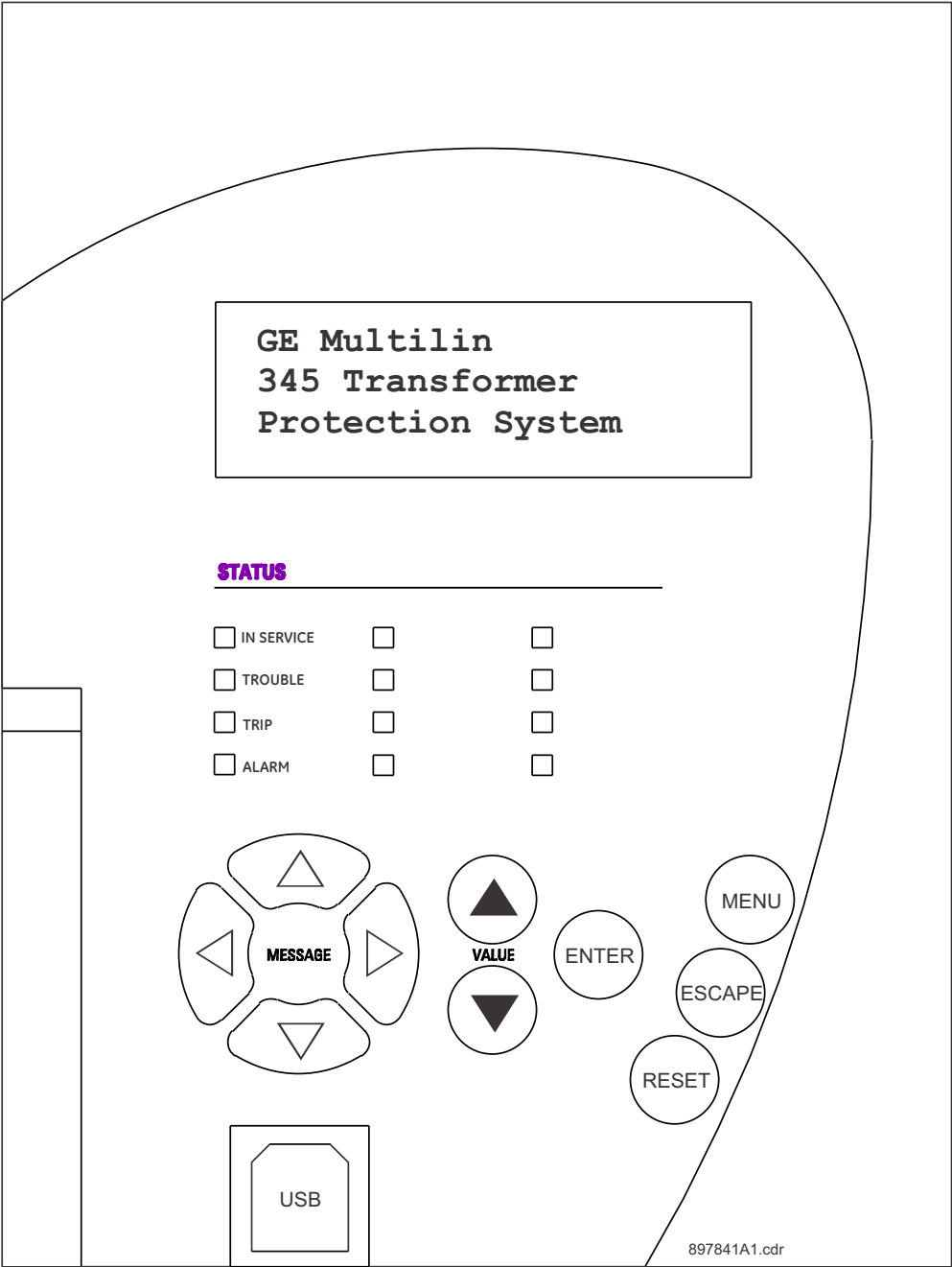


Figure 3-2: 345 Feeder Protection System Front Panel - Programmable LEDs

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 345 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:

ACTUAL VALUES
COMMANDS
QUICK SETUP
SETPOINTS
MAINTENANCE

Figure 3-3: The five Main Menu headers

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.

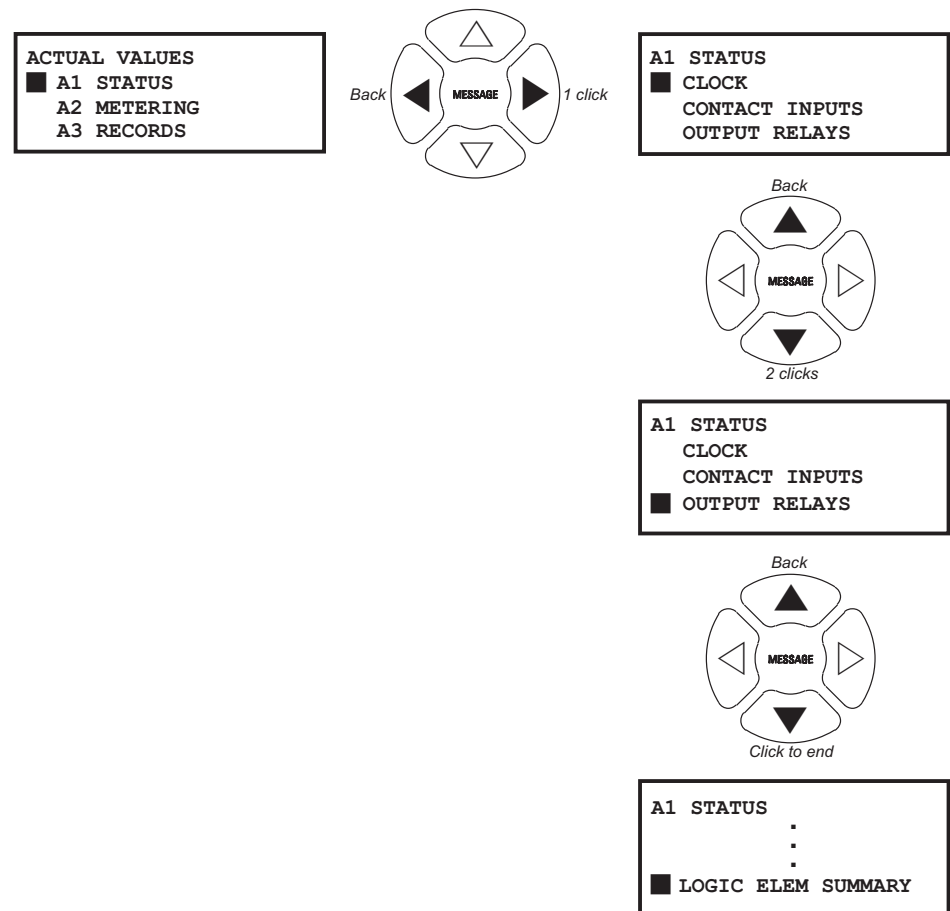


Figure 3-4: Typical paging operation from Main Menu selection

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**

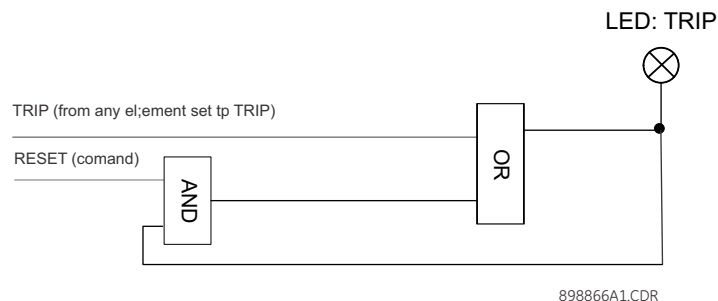
This LED will turn “ON”, when the relay is in the not programmed (Not Ready) state under **S1 RELAY SETUP > INSTALLATION > RELAY STATUS**, or upon detection of a major self-test error. The relay will turn back to “IN-SERVICE” if no major self-test error is present.

- **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.

- **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.

- **W1 BREAKER OPEN: Red/Green/Orange/Off – programmable color, default Green**

This LED is lit when the winding 1 breaker is detected open.

- **W1 BREAKER CLOSED: Red/Green/Orange/Off – programmable color, default Green**

This LED is lit when the winding 1 breaker is detected closed.

- **W2 BREAKER OPEN: Red/Green/Orange/Off – programmable color, default Green**

This LED is lit when the winding 2 breaker is detected open.

- **W2 BREAKER CLOSED: Red/Green/Orange/Off – programmable color, default Green**

This LED is lit when the winding 2 breaker is detected closed.



NOTE

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

LED status indicators - Front panel with programmable LEDs

- **IN SERVICE: Green**

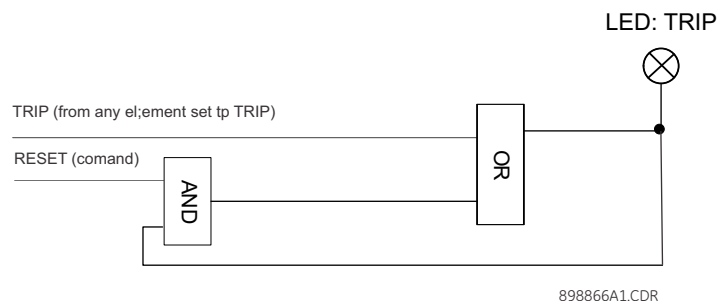
This LED will be continuously “ON”, when the relay is set to “Ready” under **S1 RELAY SETUP > INSTALLATION > RELAY STATUS**, and no major self-test errors have been detected.

- **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:

```

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

Figure 3-5: Typical target message

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.



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.

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

Figure 3-6: Typical Self-test warning

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 S1 RELAY 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 345 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*	
MAINTENANCE ALERT: High Ambient Temperature	No	The ambient temperature is above 80°C.	Every 1 hour	Increase ventilation to the surroundings.

Self-test Error Message	Latched Target Message?	Description of Problem	How Often the Test is Performed	What to do
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.
MAINTENANCE ALERT: RMIO Mismatch	No	RMIO Module is not validated; communications with the RMIO module are lost or interrupted.	Every 5 seconds*	Validate the RMIO Module; check CANBUS communication.

* 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.

```

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

```

Figure 3-7: Typical Flash message

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.

Software setup

Quick setup - Software interface

Quick Setup SR345 Relay (Device Offline)

Quick Setup

Relay Status: Nominal Frequency:

Current Sensing

W1 Phase CT Primary: A Transformer Type:
 W1 Phase CT Secondary: Transformer Rated MVA: MVA
 W1 Ground CT Primary: A Winding 1 Nominal Voltage: kV
 W1 Ground CT Secondary: Winding 1 Grounding:
 W2 Phase CT Primary: A Winding 2 Nominal Voltage: kV
 W2 Phase CT Secondary: Winding 2 Grounding:
 W2 Ground CT Primary: A
 W2 Ground CT Secondary:

Protection Elements

Transformer Percent Function:
 Minimum Differential Pickup: x CT
 Slope1: %
 BreakPoint1: x CT
 BreakPoint2: x CT
 Slope2: %

CT Input: Pickup: x CT
 Curve: TDM:

Phase TOC1: Ground TOC1:
 CT Input: CT Input:
 Pickup: x CT Pickup: x CT

Buttons:

- **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 345 firmware

The EnerVista 3 Series Setup software allows immediate access to all 345 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 345 connected to the computer. In this case, settings may be saved to a file for future use. If a 345 is connected to a PC and communications are enabled, the 345 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 the GE Multilin website at <http://www.gegridsolutions.com/multilin>

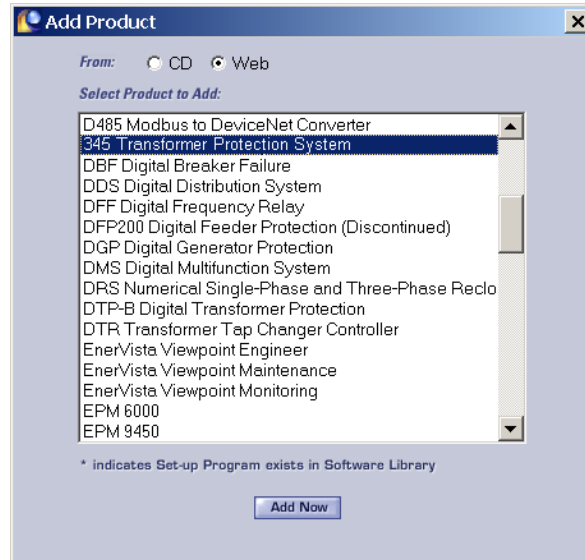
Installing the EnerVista 3 Series Setup software

After ensuring the minimum requirements indicated earlier, use the following procedure to install the EnerVista 3 Series Setup software from the GE Multilin website using EnerVista Launchpad. The no-charge EnerVista Launchpad software provides easy installation of Multilin software, notification of new software and document releases, and manages configuration files for different Multilin devices.

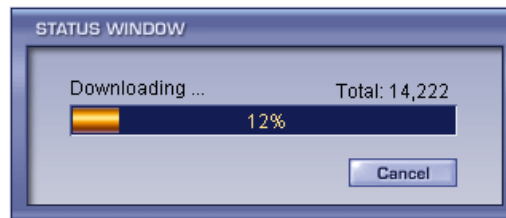
1. Navigate to: <http://www.gegridsolutions.com/multilin/enervista/launchpad>.
2. Click **Software** on the left menu and download the latest EnerVista Launchpad package.
3. Double-click the downloaded file to start the installation.
4. When installation is complete, start the EnerVista Launchpad application.
5. Click the **IED Setup** section of the LaunchPad toolbar.



6. In the EnerVista Launchpad window, click the **Add Product** button and select the 345 Feeder Protection System as shown below. Select the Web option to ensure the most recent software release, then click the **Add Now** button to list software items for the 345 .



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

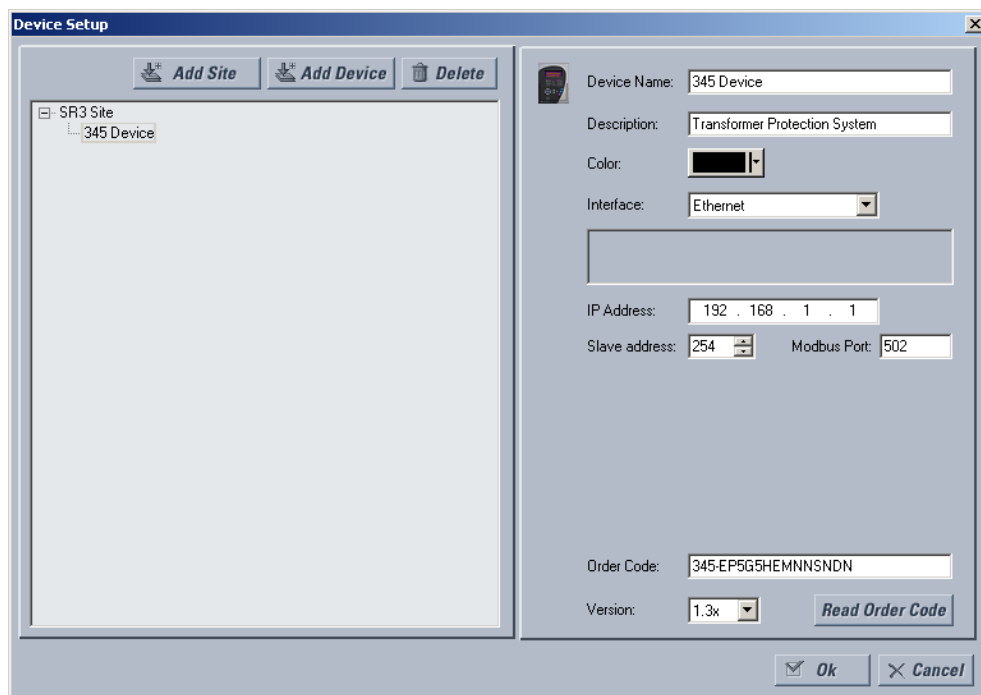


8. Select the complete path, including the new directory name, where the EnerVista 3 Series Setup software will be installed.
9. Click on **Next** to begin the installation. The files will be installed in the directory indicated, the USB driver will be loaded into the computer, and the installation program will automatically create icons and add EnerVista 3 Series Setup software to the Windows start menu.
10. The 345 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 345 Relay using the USB port:

11. Plug the USB cable into the USB port on the 345 Relay then into the USB port on your computer.
12. Launch EnerVista 3 Series Setup from LaunchPad.
13. In **EnerVista > Device Setup**:



14. Select **USB** as the Interface type.
15. Select **345 Relay** as the USB device.

Upgrading the software

The latest EnerVista software and firmware can be downloaded from:

<https://www.gegridsolutions.com/>

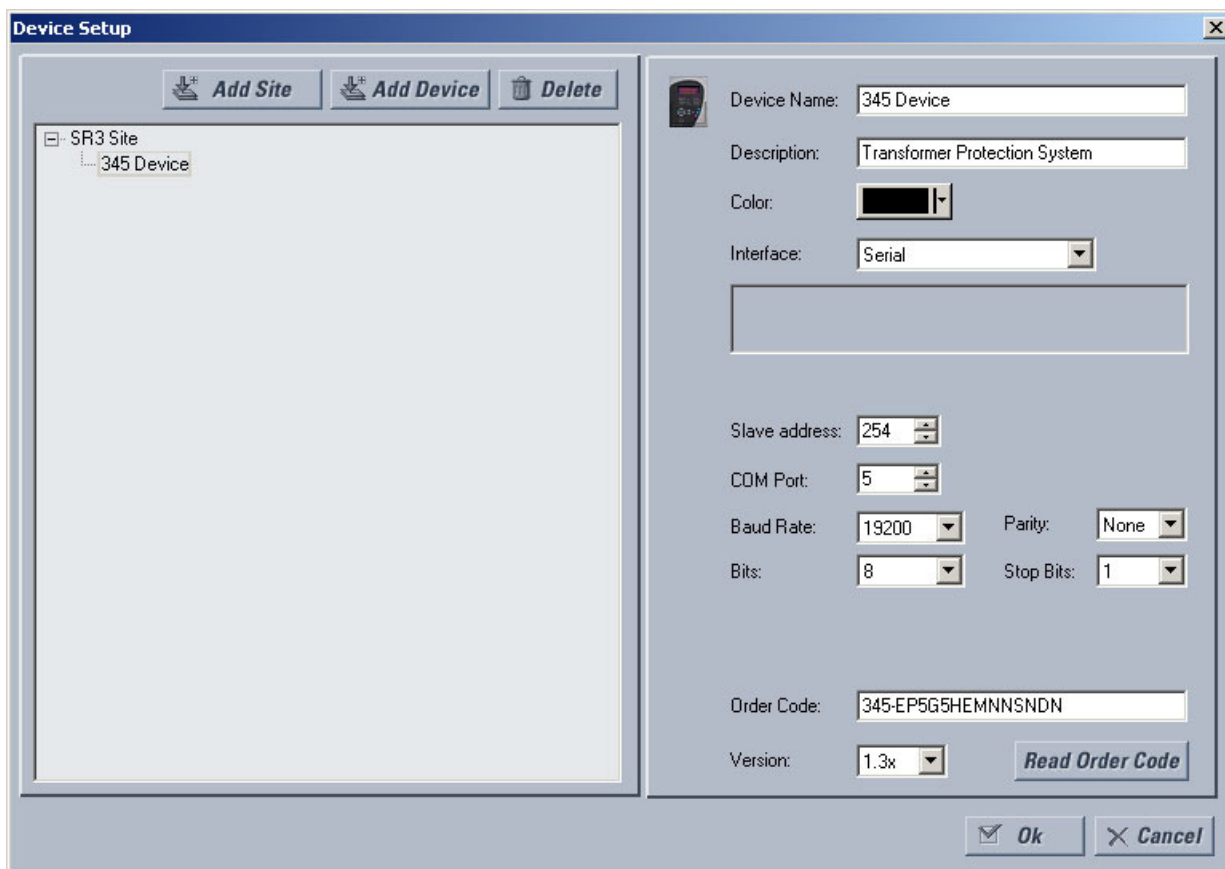
After upgrading, check the version number under **Help > About**. If the new version does not display, try uninstalling the software and reinstalling the new versions.

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.

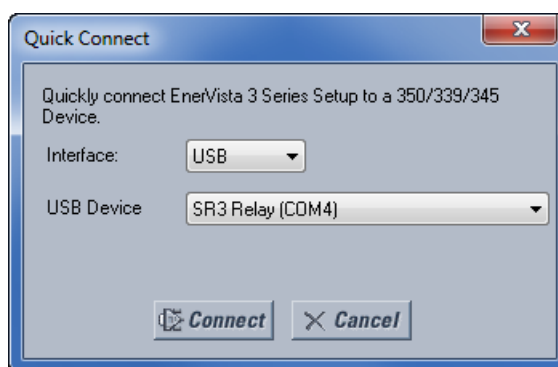


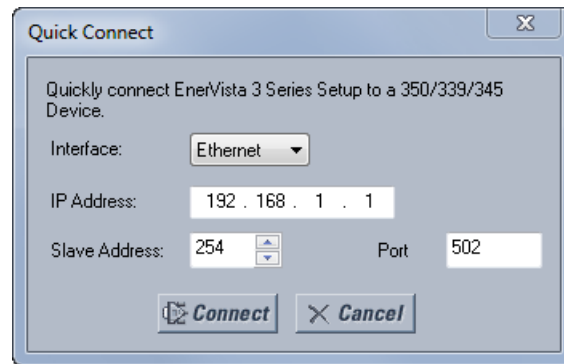
8. Click the **Read Order Code** button to connect to the 345 device and upload the order code.
9. Click **OK** when the relay order code has been received. The new device will be added to the Site List window (or Online window) located in the top left corner of the main EnerVista 3 Series Setup window.

The 345 Site Device has now been configured for USB communications. Proceed to *Connecting to the Relay* below, to begin communications.

Using the Quick Connect feature

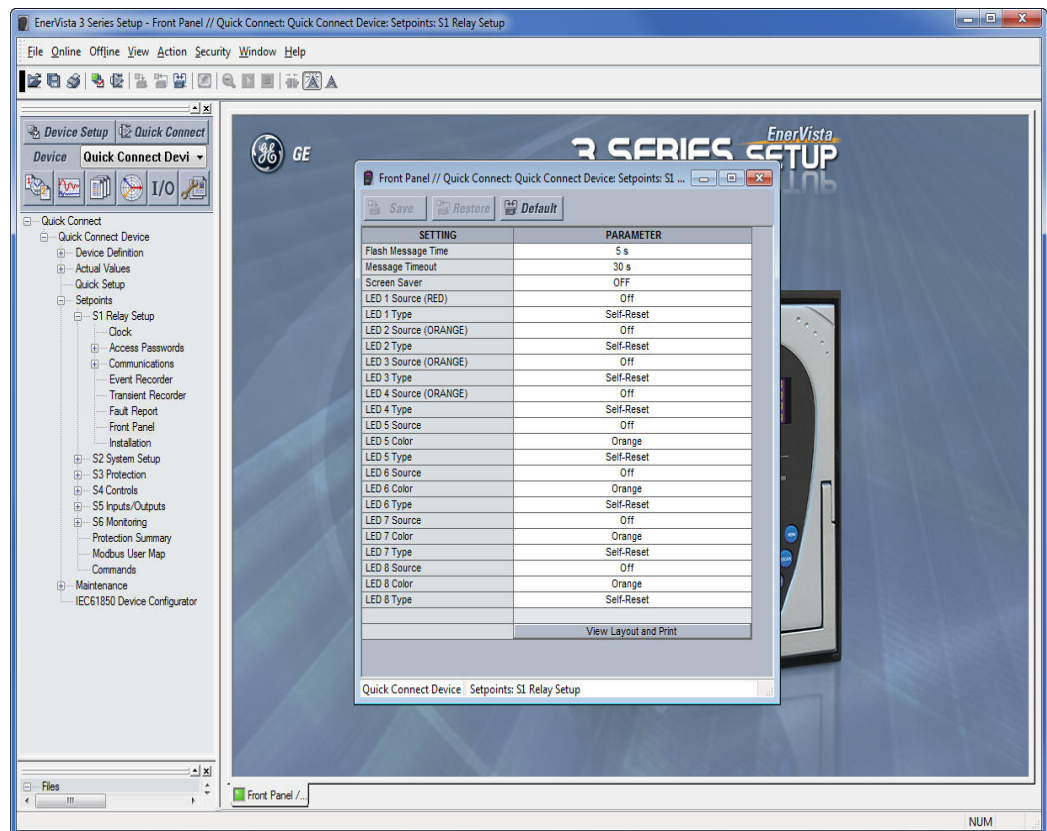
The **Quick Connect** button can be used to establish a fast connection through the front panel USB port of a 345 relay, or through the Ethernet port. The following window will appear when the **QuickConnect** button is pressed:





As indicated by the window, the "Quick Connect" feature can quickly connect the EnerVista 3 Series Setup software to a 345 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 345 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.

345 supports a maximum of 3 TCP/IP sessions.

1. Install and start the latest version of the EnerVista 3 Series Setup Setup software. 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.

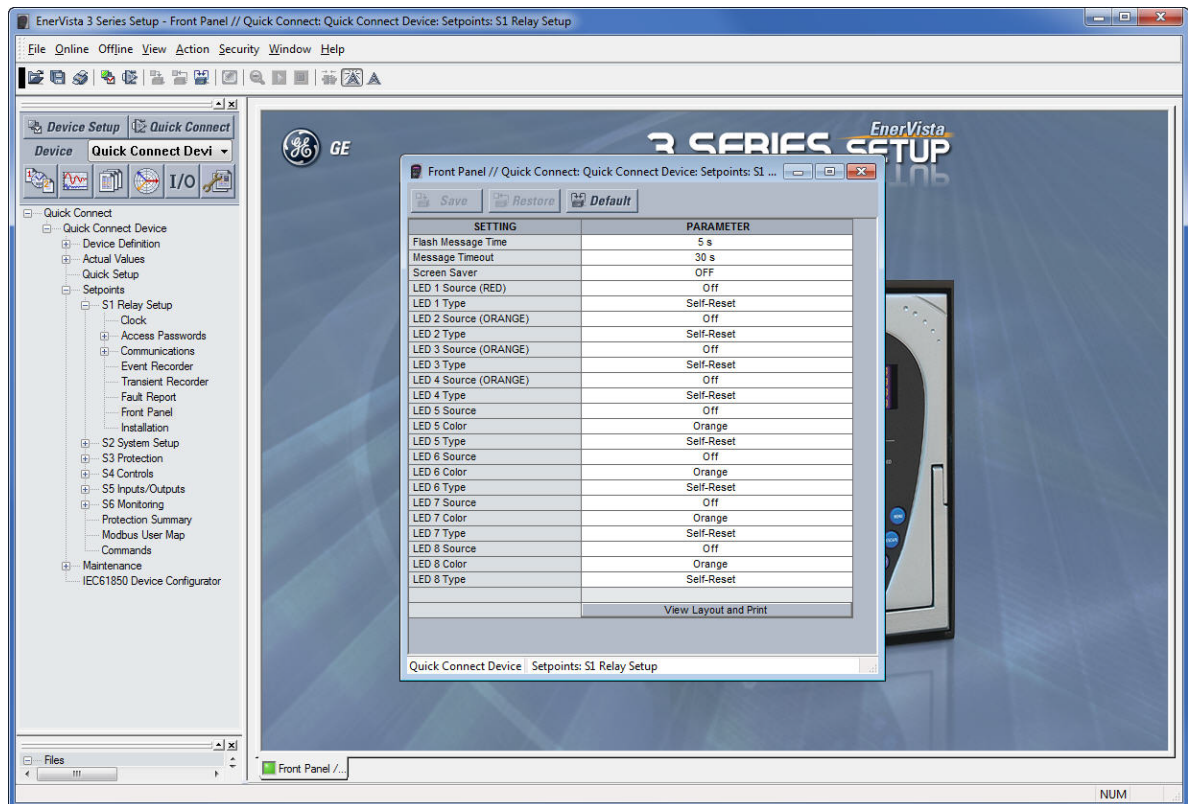
8. Enter the IP address, slave address, and Modbus port values assigned to the 345 relay (from the S1 RELAY SETUP > COMMUNICATIONS > ETHERNET menu).
9. Click the **Read Order Code** button to connect to the 345 and upload the order code. If a communications error occurs, ensure that the Ethernet communication 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 345 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

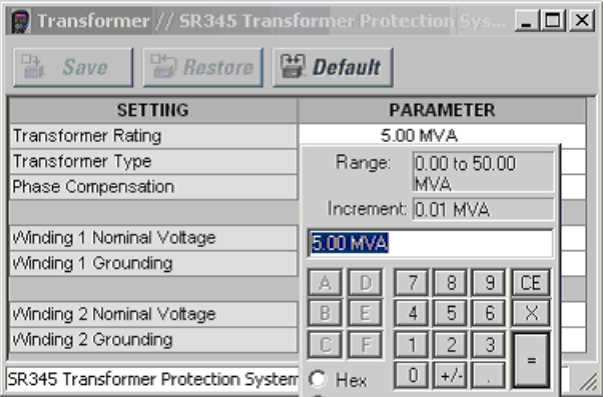
The System Setup page will be used as an example to illustrate the entering of setpoints. In this example, we will be changing the power system setpoints.

1. Establish communications with the relay.

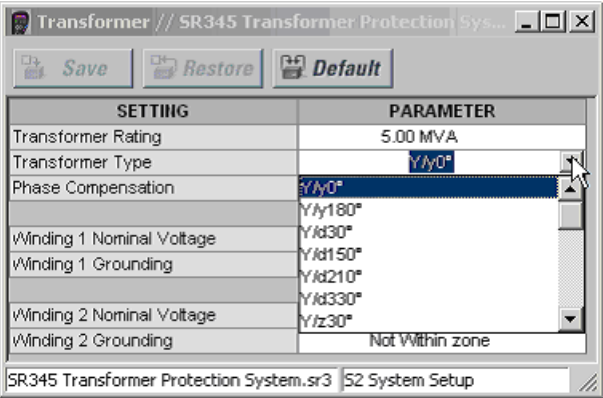
2. Select the **Setpoint > System Setup > Transformer** menu item.

3. Select the **Transformer Rating** 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. Transformer type below), clicking anywhere within the setpoint value box displays a dropdown selection menu arrow. Select the desired value from this list.



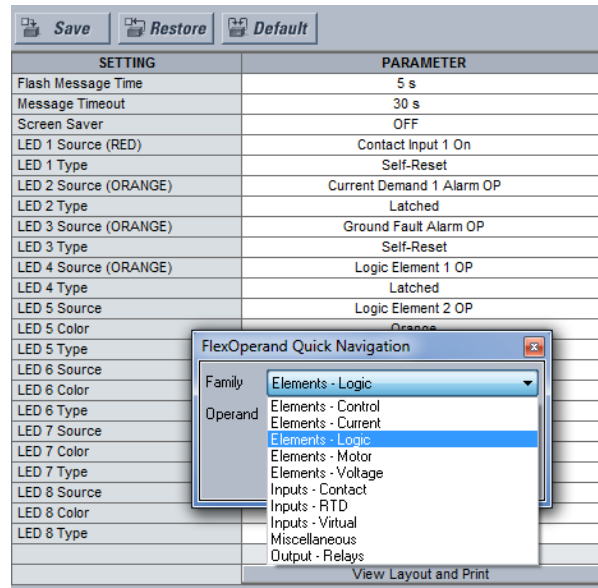
6. For setpoints requiring an alphanumeric text string (e.g. "relay name"), the value may be entered directly within the setpoint value box.

7. In the **Setpoint > System Setup > Transformer** dialog box, click on **Save** to save the values into the 345 . 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.

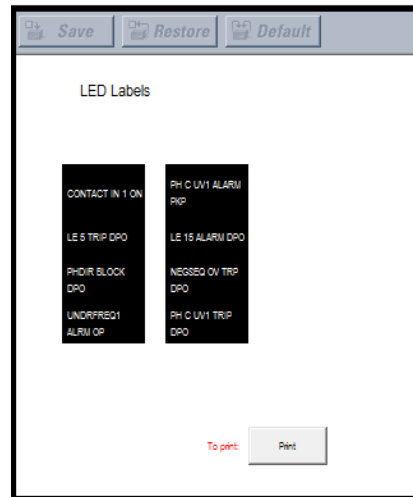


4. Select a Type for the LED (Latched or Self-Reset), and a Color if applicable.
5. Repeat this process for all programmable LED Source, Type, and Color parameters.

The screenshot shows a window with a table of settings. The table has two columns: 'SETTING' and 'PARAMETER'. The 'SETTING' column lists various parameters like 'Flash Message Time', 'Message Timeout', 'Screen Saver', and eight LED Source, Type, and Color settings. The 'PARAMETER' column shows the current values for these settings. The 'View Layout and Print' button is visible at the bottom right of the table.

SETTING	PARAMETER
Flash Message Time	5 s
Message Timeout	30 s
Screen Saver	OFF
LED 1 Source (RED)	Contact Input 1 On
LED 1 Type	Self-Reset
LED 2 Source (ORANGE)	Current Demand 1 Alarm OP
LED 2 Type	Latched
LED 3 Source (ORANGE)	Ground Fault Alarm OP
LED 3 Type	Self-Reset
LED 4 Source (ORANGE)	Logic Element 1 OP
LED 4 Type	Latched
LED 5 Source	Logic Element 2 OP
LED 5 Color	Orange
LED 5 Type	Latched
LED 6 Source	Emergency Restart
LED 6 Color	Red
LED 6 Type	Self-Reset
LED 7 Source	Off
LED 7 Color	Orange
LED 7 Type	Self-Reset
LED 8 Source	Off
LED 8 Color	Orange
LED 8 Type	Self-Reset

6. In the **Setpoint > S1 Relay Setup > Front Panel** dialog box, click **Save** to save the values into the 345. 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 345 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.

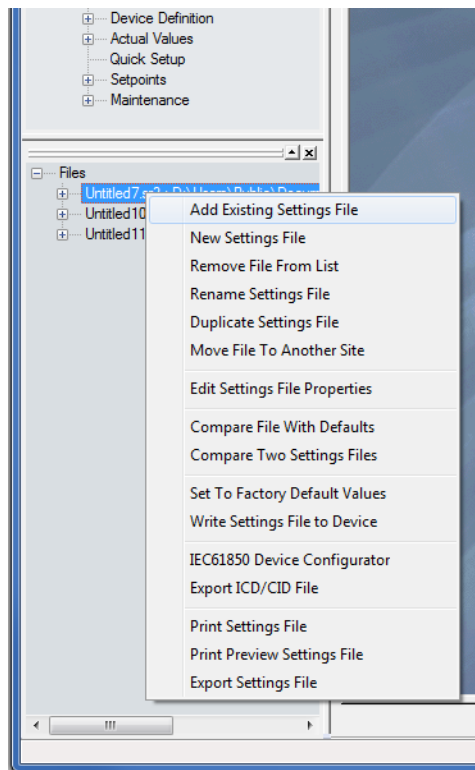
The setpoint files in the EnerVista 3 Series Setup window are accessed in the Files Window. Use the following procedure to download and save setpoint files to a local PC.

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.



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>.

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 345 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 345 firmware has been upgraded. This is illustrated in the following procedure:

1. Establish communications with the 345 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.

- 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.
- 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".

Edit Settings File

STEP 1 → 2 → 3 → 4 → 5 → 6

File Name:

Description:

Old File Version: New File Version:

Old Serial # Lock: New Serial # Lock:

Old Order Code: New Order Code:

Order Code:



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>.

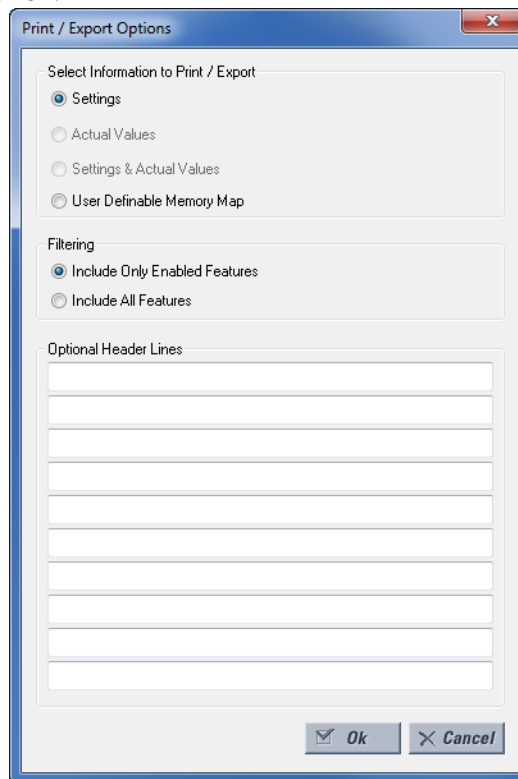
- Enter any special comments about the setpoint file in the "Description" field.
- Select the desired firmware version from the "New File Version" field.
- When complete, click **OK** to convert the setpoint file to the desired revision. See *Loading Setpoints from a File* below, for instructions on loading this setpoint file into the 345.

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:

- Select a previously saved setpoints file in the File pane or establish communications with a 345 device.
- 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 345 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

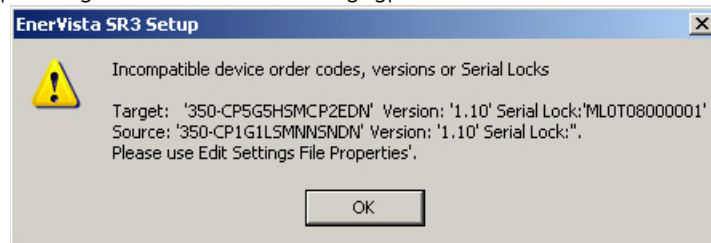
Loading setpoints from a file



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 345 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 345 firmware, follow the procedures listed in this section. Upon successful completion of this procedure, the 345 will have new firmware installed with the factory default setpoints. The latest firmware files are available from the GE Multilin website at <http://www.GEgrid solutions.com/multilin>.



NOTE

EnerVista 3 Series Setup software prevents incompatible firmware from being loaded into a 345 relay.



NOTE

Before upgrading firmware, it is very important to save the current 345 settings to a file on your PC. After the firmware has been upgraded, it will be necessary to load this file back into the 345. Refer to *Downloading and Saving Setpoints Files* for details on saving relay setpoints to a file.

Loading new relay firmware

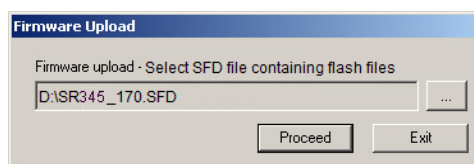
Loading new firmware into the 345 flash memory is accomplished as follows:

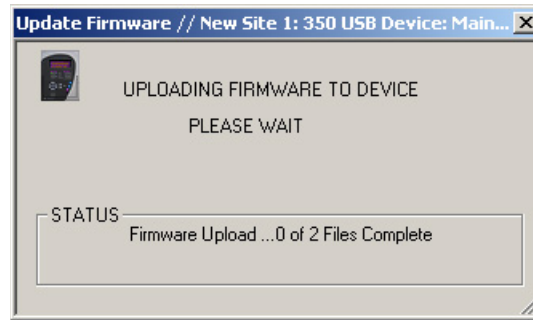
1. Connect the relay to the local PC and save the setpoints to a file as shown in *Downloading and Saving Setpoints Files*.
2. Select the **Maintenance > Update Firmware** menu item.
3. The EnerVista 3 Series Setup software will request the new firmware file. Locate the folder that contains the firmware files to load into the 345. The firmware filename has the following format:

SR345_150.SFD

↑
Firmware Rev #

4. EnerVista 3 Series Setup software now prepares the 345 to receive the new firmware file. The 345 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 345, 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 345 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 345 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.

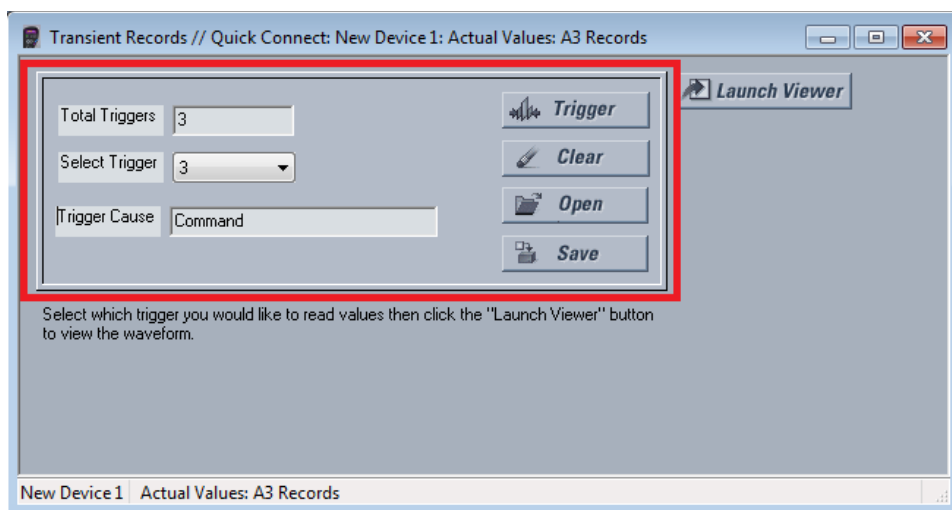
The addresses are rearranged when new features are added or existing features are enhanced or modified.

Advanced EnerVista 3 Series Setup features

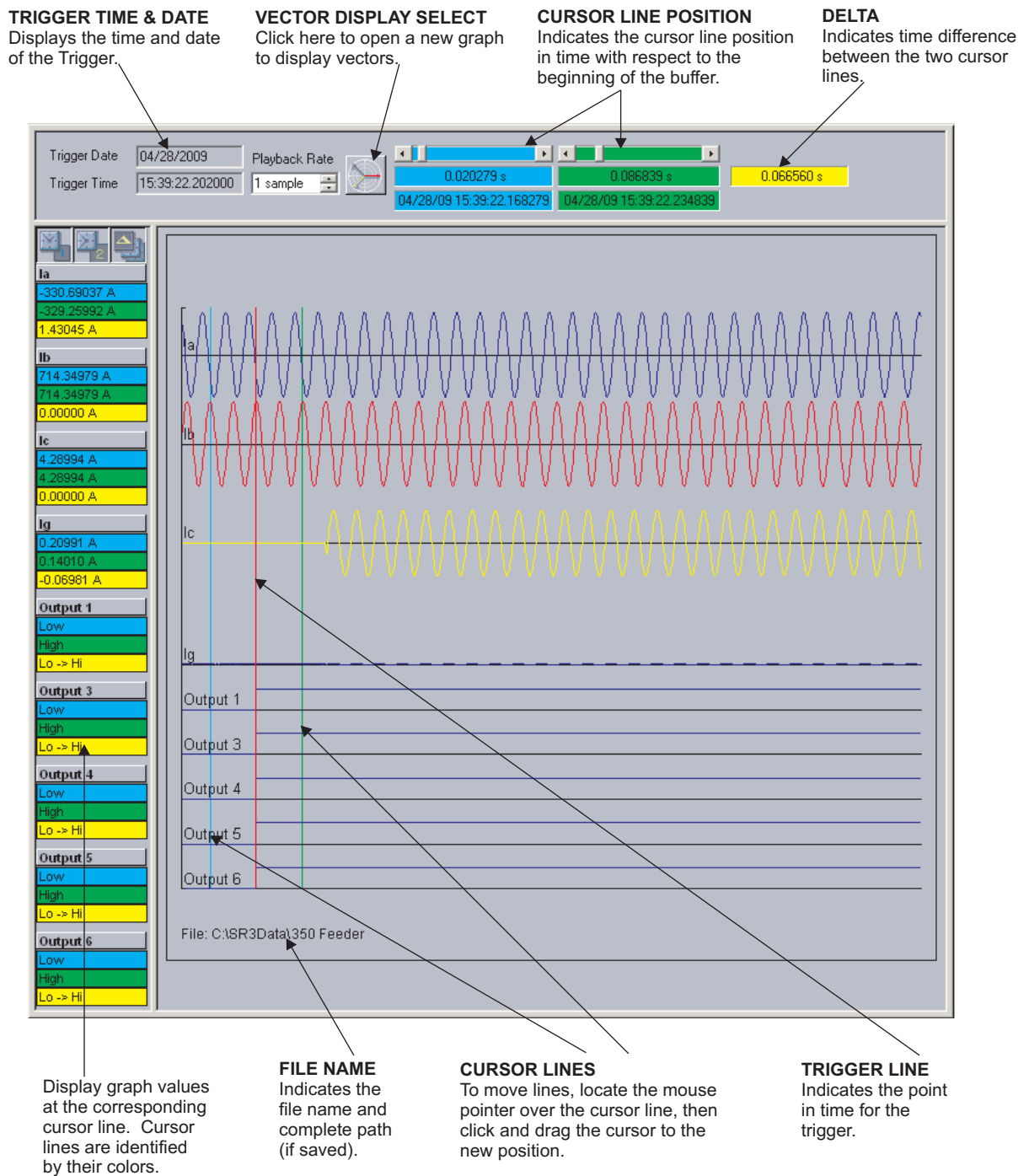
Transient recorder (Waveform capture)

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.

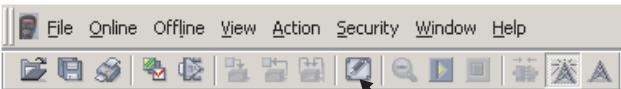
- With EnerVista 3 Series Setup software running and communications established, select the **Actual Values > A3 Records > Transient Records** menu item to open the Transient Recorder Viewer window.



- Click on **Trigger Waveform** to trigger a waveform capture. Waveform file numbering starts with the number zero in the 345, 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.

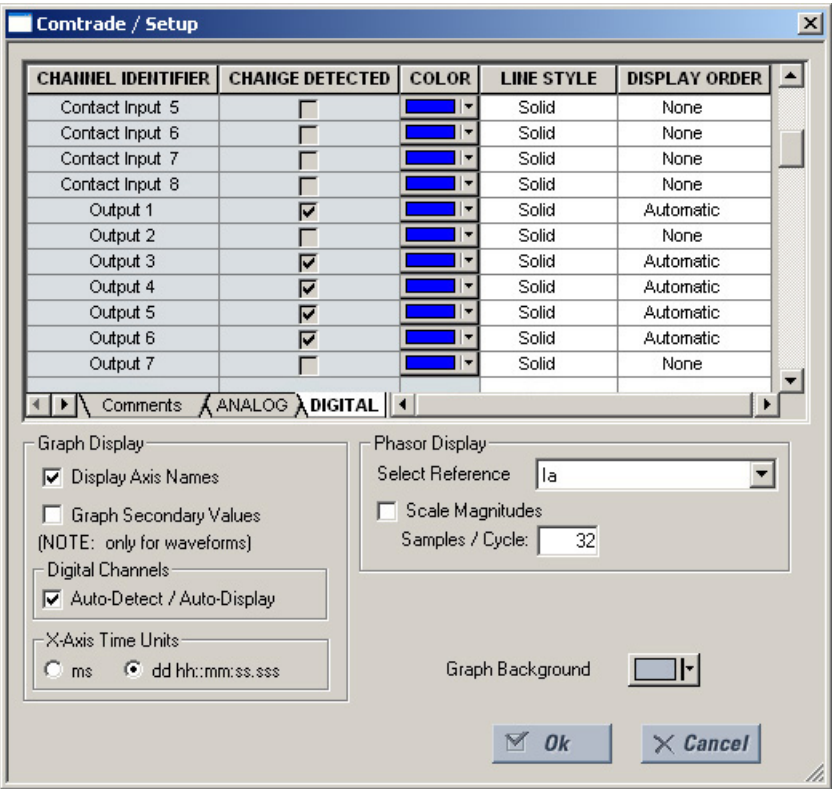


- The red vertical line indicates the trigger point.
- The date and time of the trigger are displayed at the top left corner of the window. To match the captured waveform with the event that triggered it, make note of the time and date shown in the graph, then find the event that matches the same time 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.



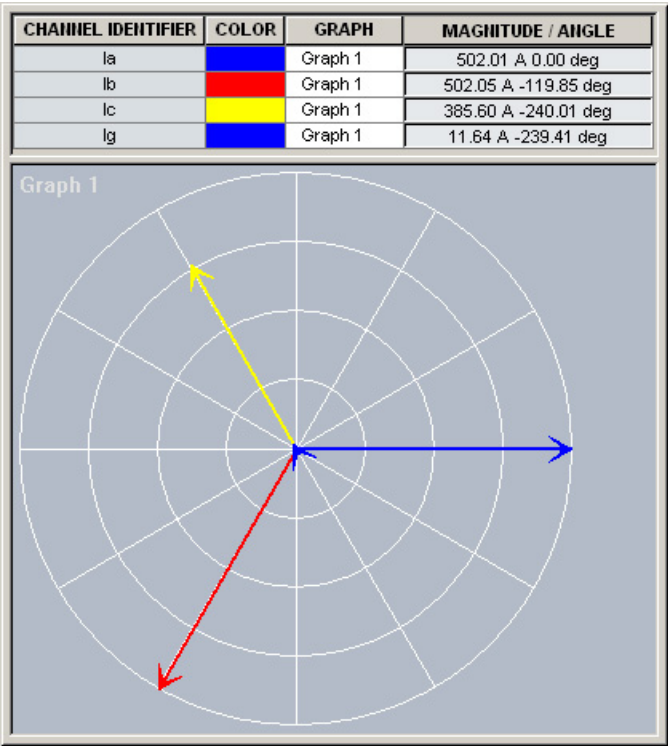
Preference Button

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:



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:

Save

Restore

Default

Elements to Show

All

Enabled

Click Status to View Settings Information

GROUPED ELEMENTS	OUTPUT RELAYS				GROUP 1	OUTPUT RELAYS				GROUP 2
	R3	R4	R5	R6		R3	R4	R5	R6	
Transformer Percent Differential (87T)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Transformer Instantaneous Differential (87T-50)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Restricted Ground Fault1 (64RGF)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Restricted Ground Fault2 (64RGF)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Thermal Overload (49)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Phase TOC1 (51P)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Phase TOC2 (51P)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Phase IOC1 (50P)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Phase IOC2 (50P)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Ground TOC1 (51G)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Ground TOC2 (51G)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Ground IOC1 (50G)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Ground IOC2 (50G)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Neutral TOC1 (51N)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Neutral TOC2 (51N)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Neutral IOC1 (50N)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Neutral IOC2 (50N)	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Negative Sequence TOC1 (46 (51_2))	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Negative Sequence TOC2 (46 (51_2))	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Negative Sequence IOC1 (46 (50_2))	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
Negative Sequence IOC2 (46 (50_2))	☐	☐	☐	☐	Disabled	☐	☐	☐	☐	Disabled
CONTROL ELEMENTS	OUTPUT RELAYS				STATUS					
	R3	R4	R5	R6						
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					
W1 Breaker Fail (50BF)	☐	☐	☐	☐	Disabled					
W2 Breaker Fail (50BF)	☐	☐	☐	☐	Disabled					
Lockout (86)	☒	☒	☒	☒	Disabled					
MAINTENANCE	OUTPUT RELAYS				STATUS					
	R3	R4	R5	R6						
W1 Breaker Trip Coil	☐	☐	☐	☐	Disabled					
W2 Breaker Trip Coil	☐	☐	☐	☐	Disabled					
Ambient Temperature	☐	☐	☐	☐	Disabled					
W1 Breaker Trip Counter	☐	☐	☐	☐	Disabled					
W2 Breaker Trip Counter	☐	☐	☐	☐	Disabled					
W1 Breaker Health	☐	☐	☐	☐	Disabled					
W2 Breaker Health	☐	☐	☐	☐	Disabled					
MONITORING	OUTPUT RELAYS				STATUS					
	R3	R4	R5	R6						

3-34

345 TRANSFORMER PROTECTION SYSTEM – INSTRUCTION MANUAL

Password security

Password security is an optional feature of the 345 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. 345 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**.



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

SETTING	PARAMETER
MASTER PASSWORD	
Change Master Password	Yes
Enter New Master Password	
Confirm New Master Password	
Change Password	

Quick Connect Device | Setpoints: S1 Relay Setup: Access Passwords

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.

SETTING	PARAMETER
MASTER PASSWORD	
Enter Master Password	
Encrypted Password	
Login	

USB | Setpoints: S1 Relay Setup: Access Passwords

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.

REMOTE PASSWORDS	
Change Remote Setting Password	Yes
Enter New Remote Setting Password	
Confirm New Remote Setting Password	
	Change Password
Change Remote Control Password	Yes
Enter New Remote Control Password	
Confirm New Remote Control Password	
	Change Password

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.

SETTING	PARAMETER
MASTER PASSWORD	
Change Master Password	No
Change User Passwords	Yes
O/W Local SP Pwd	Yes
LOCAL PASSWORDS	
Overwrite Local Setting Password	Yes
Enter New Local Setting Password	
Confirm New Local Setting Password	
	Change Password
Overwrite Local Control Password	Yes
Enter New Local Control Password	
Confirm New Local Control Password	
	Change Password

Quick Connect Device | Setpoints: S1 Relay Setup: Access Passwords

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.

345 Transformer 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.

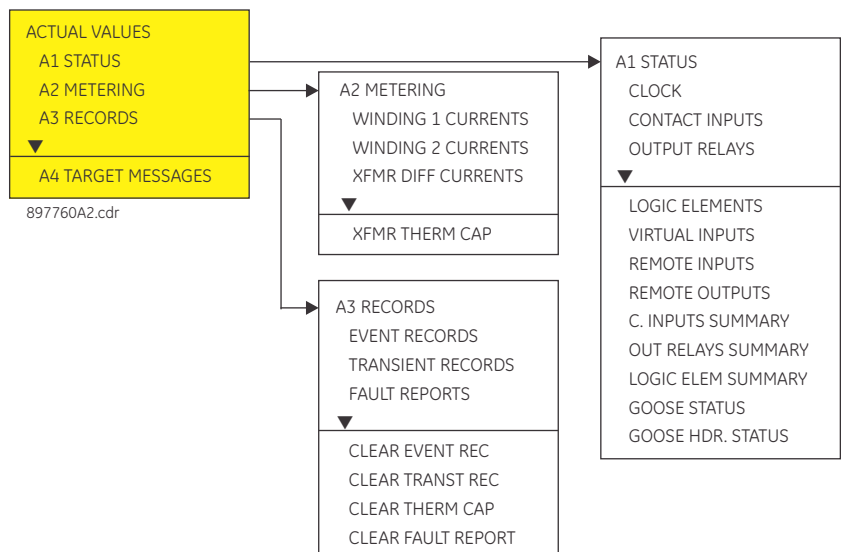


Figure 4-1: Main Actual Values menu

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

52a W1 BRK (CI #1) (Contact Input 1)

OFF

Range: Off, On

The status of this contact shows the W1 breaker close/open state, when wired to a 52a breaker auxiliary contact.

52b W1 BRK (CI#2) (Contact Input 2)

OFF

Range: Off, On

The status of this contact shows the W1 breaker close/open state, when wired to a 52b breaker auxiliary contact.

52a W2 BRK (CI#3) (Contact Input 3)

OFF

Range: Off, On

The status of this contact shows the W2 breaker close/open state, when wired to a 52a breaker auxiliary contact.

52b W2 BRK (CI#4) (Contact Input 4)

OFF

Range: Off, On

The status of this contact shows the W2 breaker close/open state, when wired to a 52b breaker auxiliary contact.

CONTACT INPUT 5 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

RELAY 1 TRIP (Output Relay #1)

OFF

Range: Off, On

The "ON" state of Output Relay #1 (W1 TRIP) shows that a TRIP command has been sent to the W1 breaker.

RELAY 2 TRIP (Output Relay #2)

OFF

Range: Off, On

The "ON" state of Output Relay #2 (W2 TRIP) shows that a TRIP command has been sent to the W2 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#5	OFF
52b	OFF	CI#6	OFF
52a	OFF	CI#7	OFF
52b	OFF	CI#8	OFF
CI#9	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

R1 TRIP	OFF	RLY#5	OFF
R2 TRIP	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.



Output relay #7 is the Critical Failure relay, used to indicate the correct functioning of the 345 relay. This output relay shows the status "ON" when the 345 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.

A2 Metering

The relay measures fundamental frequency phase and ground currents, and all auxiliary analog inputs. Other values like neutral current, symmetrical components, differential and restraint currents 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 phase A current phasor.

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

Winding 1 Current

Path: ACTUAL VALUES > A2 METERING > WINDING 1 CURRENT

W1 PH A CURRENT

0.0 A 0° lag

Range: 1 to 6000 A, 0 to 359° lag

W1 PH B CURRENT

0.0 A 0° lag

Range: 1 to 6000 A, 0 to 359° lag

W1 PH C CURRENT

0.0 A 0° lag

Range: 1 to 6000 A, 0 to 359° lag

W1 NTRL CURRENT

0.0 A 0° lag

Range: 1 to 6000 A, 0 to 359° lag

W1 GND CURRENT

0.0 A 0° lag

Range: 1 to 6000 A, 0 to 359° lag

W1 SENS GND CURRENT

0.0 A 0° lag

Range: 1 to 600 A, 0 to 359° lag

W1 NEG SEQ CURRENT

0.0 A 0° lag

Range: 1 to 6000 A, 0 to 359° lag

W1 GND DIFF CURRENT

0.00 x CT 0° lag

Winding 2 Current

Path: [ACTUAL VALUES > A2 METERING > WINDING 2 CURRENT](#)

W2 PH A CURRENT

0.0 A 0° lag

Range: 1 to 6000 A, 0 to 359° lag

W2 PH B CURRENT

0.0 A 0° lag

Range: 1 to 6000 A, 0 to 359° lag

W2 PH C CURRENT

0.0 A 0° lag

Range: 1 to 6000 A, 0 to 359° lag

W2 NTRL CURRENT

0.0 A 0° lag

Range: 1 to 6000 A, 0 to 359° lag

W2 GND CURRENT

0.0 A 0° lag

Range: 1 to 6000 A, 0 to 359° lag

W2 SENS GND CURRENT

0.0 A 0° lag

Range: 1 to 600 A, 0 to 359° lag

W2 NEG SEQ CURRENT

0.0 A 0° lag

Range: 1 to 6000 A, 0 to 359° lag

W2 GND DIFF CURRENT

0.00 x CT 0° lag

Transformer Differential and Restraint Currents

Path: [ACTUAL VALUES > A2 METERING > XFMR DIFF CURRENTS](#)

PH A DIFF CURRENT

0.00 x CT 0° lag

PH A RESTR CURRENT

0.00 x CT 0° lag

DIFF 2 HARM PH A

0.0 % f0

DIFF 5 HARM PH A

0.0 % f0

PH B DIFF CURRENT

0.00 x CT 0° lag

PH B RESTR CURRENT

0.00 x CT 0° lag

DIFF 2 HARM PH B
0.0 % f0

DIFF 5 HARM PH B
0.0 % f0

PH C DIFF CURRENT
0.00 x CT 0° lag

PH C RESTR CURRENT
0.00 x CT 0° lag

DIFF 2 HARM PH C
0.0 % f0

DIFF 5 HARM PH C
0.0 % f0

Transformer Thermal Capacity

Path: [ACTUAL VALUES > A2 METERING > XFMR THERMAL CAP](#)

THERM CAP PH A
0.0%
Range: 1 to 150%

THERM CAP PH B
0.0%
Range: 1 to 150%

THERM CAP PH C
0.0%
Range: 1 to 150%

Current Demand 1(2)

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*

Clear current demand 1 (2)

Path: ACTUAL VALUES > A2 METERING > CLEAR CURR DEMAND 1 (2)**CLEAR CURR DEMAND 1 (2)****NO***Range: No, Yes*

When set to "YES," pressing the ENTER key will clear all current demand 1 or current demand 2 data.

A3 Records

The 345 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.

**NOTE**

By default the last 50 events are shown in the Event Recorder. Change this value under **File > Preferences** to view up to 256 events.

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:5655 E5655 Jan 05, 10 Ph IOC1 Trip OP 17:32:28.376 ▶	E5655 TRIP Ph IOC1 Trip OP W1 Ia x CT(W1)0.08 x CT 0° Lag
	▼
	E5655 TRIP Ph IOC1 Trip OP W1 Ib x CT(W1)0.00 x CT 0° Lag
	▼
	E5655 TRIP Ph IOC1 Trip OP W1 Ic x CT(W1)0.00 x CT 0° Lag
	▼
	E5655 TRIP Ph IOC1 Trip OP W1 Ig x CTg(W1)0.00 x CT 0° Lag
	▼
	E5655 TRIP Ph IOC1 Trip OP W1 In x CT(W1)0.08 x CT 0° Lag
	▼
	E5655 TRIP Ph IOC1 Trip OP W1 Igd x CT(W1)0.08 x CT
	▼
	E5655 TRIP Ph IOC1 Trip OP W1 Igr x CT(W1)0.08 x CT
	▼
	E5655 TRIP Ph IOC1 Trip OP W1 I_2 x CT(W1)0.03 x CT
	▼
	E5655 TRIP Ph IOC1 Trip OP W2 Ia x CT(W2)0.00 x CT 0° Lag
	▼
	E5655 TRIP Ph IOC1 Trip OP W2 Ib x CT(W2)0.00 x CT 0° Lag
	▼
	E5655 TRIP Ph IOC1 Trip OP W2 Ic x CT(W2)0.00 x CT 0° Lag
	▼
	E5655 TRIP Ph IOC1 Trip OP W2 Ig x CTg(W2)0.00 x CT 0° Lag
	▼
	E5655 TRIP Ph IOC1 Trip OP W2 In x CT(W2)0.00 x CT 0° Lag
	▼
	E5655 TRIP Ph IOC1 Trip OP W2 Igd x CT(W2)0.00 x CT
	▼
	E5655 TRIP Ph IOC1 Trip OP W2 Igr x CT(W2)0.00 x CT
	▼
	E5655 TRIP Ph IOC1 Trip OP W2 I_2 x CT(W1)0.00 x CT
	▼
	E5655 TRIP Ph IOC1 Trip OP Ph A Diff, x CT(W1)0.08
	▼
	E5655 TRIP Ph IOC1 Trip OP Ph B Diff, x CT(W1)0.00

▼	E5655 TRIP Ph IOC1 Trip OP Ph C Diff, x CT(W1)0.00
▼	E5655 TRIP Ph IOC1 Trip OP Ph A Rest, x CT(W1)0.00
▼	E5655 TRIP Ph IOC1 Trip OP Ph B Rest, x CT(W1)0.00
▼	E5655 TRIP Ph IOC1 Trip OP Ph C Rest, x CT(W1)0.00
▼	E5655 TRIP Ph IOC1 Trip OP 2nd Harm Ph A Diff6.2% fo
▼	E5655 TRIP Ph IOC1 Trip OP 2nd Harm Ph B Diff0.0% fo
▼	E5655 TRIP Ph IOC1 Trip OP 2nd Harm Ph C Diff0.0% fo
▼	E5655 TRIP Ph IOC1 Trip OP Therm Cap Ph A1.1% fo
▼	E5655 TRIP Ph IOC1 Trip OP Therm Cap Ph B0.0%
▼	E5655 TRIP Ph IOC1 Trip OP Therm Cap Ph C0.0%

Each event is saved with event number, date and time, and contains information such as per-phase current, ground current or sensitive ground current, neutral current, negative sequence current, ground differential current, per-phase differential and restraint currents. Second and fifth harmonic per-phase differential current. All per Winding 1 and 2. The Event Recorder can be cleared from **ACTUAL VALUES > A3 RECORDS > CLEAR EVENT REC** setpoint. The following table provides a list of the event types:

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

Event Type	Display	Description
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: 345-EP5G5HEMNN2EDN

NAME: XFMR 5

F/W REVISION: 2.20

W1 PH A CURRENT

0.0 A 0° lag

W1 PH B CURRENT

0.0 A 0° lag

W1 PH C CURRENT
0.0 A 0° lag

W1 NTRL CURRENT
0.0 A 0° lag

W1 GND CURRENT
0.0 A 0° lag

W2 PH A CURRENT
0.0 A 0° lag

W2 PH B CURRENT
0.0 A 0° lag

W2 PH C CURRENT
0.0 A 0° lag

W2 NTRL CURRENT
0.0 A 0° lag

W2 GND CURRENT
0.0 A 0° lag

PH A DIFF CURRENT
0.00 x CT 0° lag

PH A RESTR CURRENT
0.00 x CT 0° lag

PH B DIFF CURRENT
0.00 x CT 0° lag

PH B RESTR CURRENT
0.00 x CT 0° lag

PH C DIFF CURRENT
0.00 x CT 0° lag

PH C RESTR CURRENT
0.00 x CT 0° lag

FREQUENCY
60.00 Hz

Learned data

Clearing learned data (ACTUAL VALUES > A3 RECORDS > CLEAR LEARNED DATA) resets all these values to their default settings.

RTD 1 to 12 MAX TEMPERATURE

Range: -50 to 250°C

The maximum temperature experienced by each of the RTDs.

Once a second each of the RTD temperature values is captured. For each RTD, if the captured RTD temperature value is greater than the RDT maximum temperature already stored, the RDT maximum temperature is set to this latest captured RTD temperature value. The RTD maximum temperature values are maintained in non-volatile memory to carry over a relay power interruption.

Clear learned data

CLEAR LEARNED DATA

No

Range: No, Yes

When set to "Yes," pressing the ENTER key will clear all learned data.

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.

Examples of how the messages appear on the display:

Example 1:

Phase IOC1 Settings:

- PH IOC1 FUNCTION = Trip
- PH IOC1 PICKUP = $1.00 \times CT$
- PH IOC1 DELAY = 0.20 s

When current greater than the IOC1 pickup level is applied, the 3345 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 = $1.00 \times CT$
- PH IOC1 DELAY = 0.20 s

When current greater than the IOC1 pickup level is applied, the 345 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 = $1.00 \times CT$
- PH IOC1 DELAY = 0.20 s

When current greater than the IOC1 pickup level is applied, the 345 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.

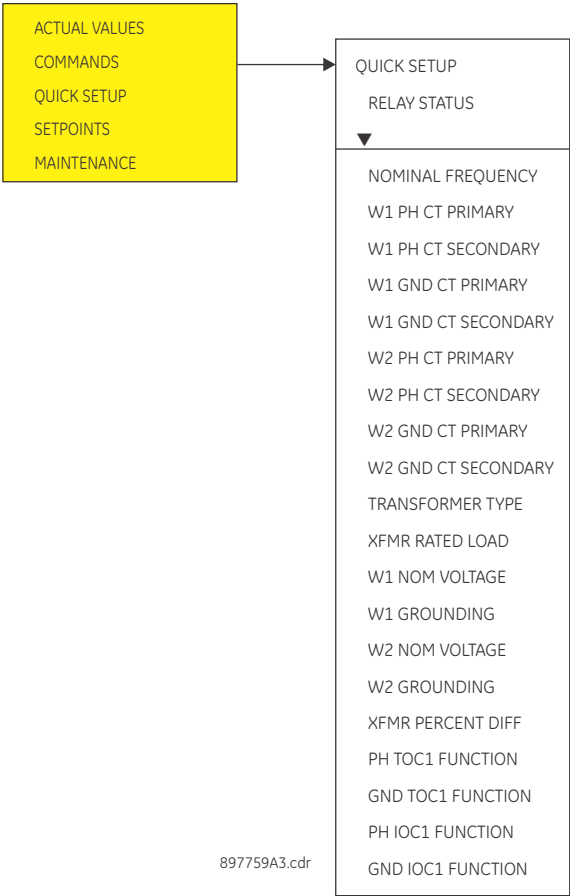
345 Transformer Protection System

Chapter 5: Quick setup - Front control panel

The “Quick Setup” utility is part of the 345 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.



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



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Figure 5-1: Quick Setup menu

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 >

RELAY STATUS

Range: Not Ready, Ready

Default: Not Ready

NOMINAL FREQUENCY

Range: 60 Hz, 50 Hz

Default: 60 Hz

W1 PH CT PRIMARY

Range: 1 A to 6000 A in steps of 1

Default: 5 A

W1 GND/SGND CT PRIMARY

Range: 1 A to 6000/600 A in steps of 1

Default: 5 A

W2 PH CT PRIMARY

Range: 1 A to 6000 A in steps of 1

Default: 5 A

W2 GND/SGND CT PRIMARY

Range: 1 A to 6000/600 A in steps of 1

Default: 5 A

TRANSFORMER TYPE

Range: Refer to above "Transformer Types" table

Default: Y/y0

XFMR RATED LOAD

Range: 0.00 to 200.00 MVA in steps of 0.01 MVA

Default: 5.0 MVA

W1 NOM VOLTAGE

Range: 0.01 to 250.00 kV in steps of 0.01 kV

Default: 13.8 kV

W1 GROUNDING

Range: Not Within Zone, Within Zone

Default: Not Within Zone

W2 NOM VOLTAGE

Range: 0.01 to 250.00 kV in steps of 0.01 kV

Default: 4.16 kV

W2 GROUNDING

Range: Not Within Zone, Within Zone

Default: Not Within Zone

XFMR PERCENT DIFF

Range: Disabled, Trip, Latched Alarm, Alarm

Default: Disabled

↳

PCNT DIFF FUNCTION*Range: Disabled, Trip, Latched Alarm, Alarm**Default: Disabled***MINIMUM PICKUP***Range: 0.05 to 1.00 x CT in steps of 0.01 x CT**Default: 0.10 x CT***SLOPE 1***Range: 15 to 100% in steps of 1%**Default: 30%***BREAKPOINT 1***Range: 0.50 to 4.00 x CT in steps of 0.01 x CT**Default: 1.50 x CT***BREAKPOINT 2***Range: 1.00 to 10.00 x CT in steps of 0.01 x CT**Default: 1.50 x CT***SLOPE 2***Range: 50 to 100% in steps of 1%**Default: 95%***PH TOC1 FUNCTION***Range: Disabled, Trip, Latched Alarm, Alarm**Default: Disabled*

↳

PHASE CT INPUT*Range: CT(W1), CT(W2)**Default: CT(W1)***PH TOC1 PICKUP***Range: 0.05 to 20.00 x CT in steps of 0.01 x CT**Default: 1.00 x CT***PH TOC1 CURVE***Range: ANSI Extremely/Very/Moderately/Normally Inverse, Definite Time, IEC Curve A/B/C and Short Inverse, IAC Extremely/Very/Inverse/Short**Default: Ext. Inverse***PH TOC1 TDM***Range: 0.05 to 50.00 in steps of 0.01**Default: 1.00***RLY1 TRIP W1 BKR***Range: Do Not Operate, Operate**Default: Do not operate***RLY2 TRIP W2 BKR***Range: Do Not Operate, Operate**Default: Do not operate***GND TOC1 FUNCTION***Range: Disabled, Trip, Latched Alarm, Alarm**Default: Disabled*

↳

GND CT INPUT*Range: CT(W1), CT(W2)**Default: CT(W1)***GND TOC1 PICKUP***Range: 0.05 to 20.00 × CT in steps of 0.01 × CT**Default: 1.00 × CT***GND TOC1 CURVE***Range: ANSI Extremely/Very/Moderately/Normally Inverse, Definite Time, IEC Curve A/B/C and Short Inverse, IAC Extremely/Very/Inverse/Short**Default: Ext. Inverse***GND TOC1 TDM***Range: 0.05 to 50.00 in steps of 0.01**Default: 1.00***RLY1 TRIP W1 BKR***Range: Do not operate, Operate**Default: Do not operate***RLY2 TRIP W2 BKR***Range: Do not operate, Operate**Default: Do not operate***PH IOC1 FUNCTION***Range: Disabled, Trip, Latched Alarm, Alarm**Default: Disabled*

↳

PH CT INPUT*Range: CT(W1), CT(W2)**Default: CT(W1)***PH IOC1 PICKUP***Range: 0.05 to 20.00 × CT in steps of 0.01 × CT**Default: 1.00 × CT***RLY1 TRIP W1 BKR***Range: Do not operate, Operate**Default: Do not operate***RLY2 TRIP W2 BKR***Range: Do not operate, Operate**Default: Do not operate***GND IOC FUNCTION***Range: Disabled, Trip, Latched Alarm, Alarm**Default: Disabled*

↳

GND CT INPUT*Range: CT(W1), CT(W2)**Default: CT(W1)***GND IOC1 PICKUP***Range: 0.05 to 20.00 × CT in steps of 0.01 × CT**Default: 1.00 × CT*

RLY1 TRIP W1 BKR

Range: Do not operate, Operate

Default: Do not operate

RLY2 TRIP W2 BKR

Range: Do not operate, Operate

Default: Do not operate



NOTE

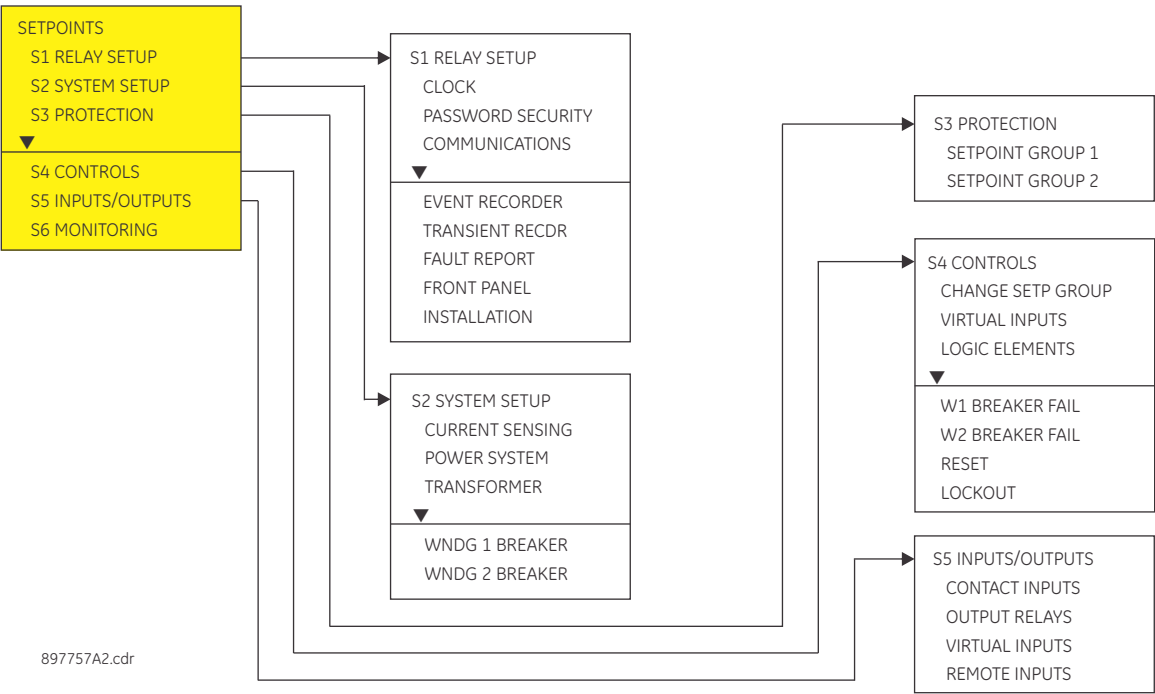
The settings changed using the Quick Setup menu, are available for review and modification by navigating through **S1 RELAY SETUP**, **S2 SYSTEM SETUP** and **S3 PROTECTION** in the **SETPOINTS** main menu.

345 Transformer Protection System

Chapter 6: Setpoints

Setpoints Main Menu

The 345 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.



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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.

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, and Logic Elements 1 to 16. 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.

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.

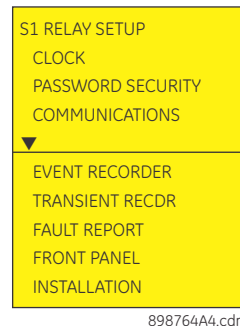
- **Setpoints:** Shown as a block with a heading labeled ‘**SETPOINT**’. The exact wording of the displayed setpoint message identifies the setpoint. Major functional setpoint selections are listed below the name and are incorporated in the logic.
- **Compensator Blocks:** Shown as a block with an inset 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



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Figure 6-2: Relay Setup menu

Clock

The 345 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.

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

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, 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 to 59

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 345 .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.

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 an 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:

SETPPOINT 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

- 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.

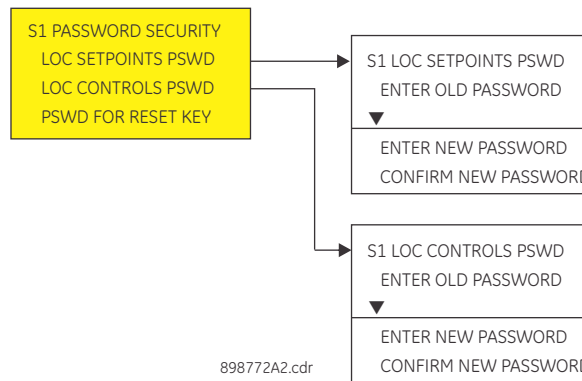


Figure 6-3: Menu for handling password security using keypad

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

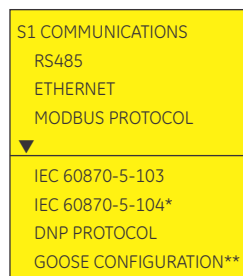
Range: Disabled, Enabled

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



* Available with comms Order Code 1

** Available with comms Order Code 2

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Figure 6-4: Main communications menu

RS485 interface

The 345 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.

Modbus

The Modicon Modbus protocol is supported by the 345 . Modbus is available via the RS485 serial link (Modbus RTU). The 345 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 345 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.

Save Restore Default Reset	
SETTING	PARAMETER
Modbus Slave Address	254

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

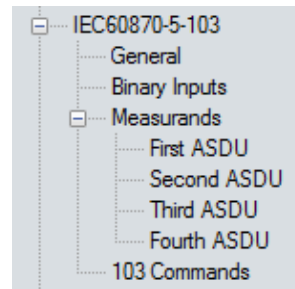


Figure 6-6: IEC 60870-5-103 serial communications settings

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

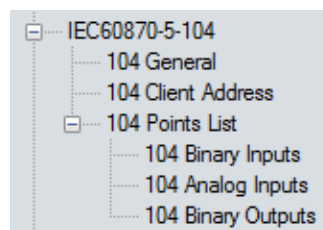


Figure 6-7: IEC 60870-5-104 protocol settings

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

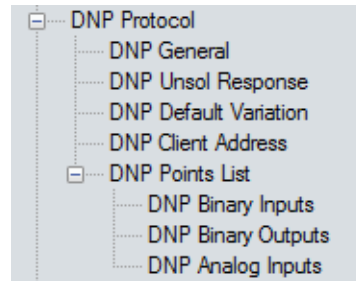


Figure 6-8: DNP communication settings

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 345 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 345 .

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 345 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 345 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.

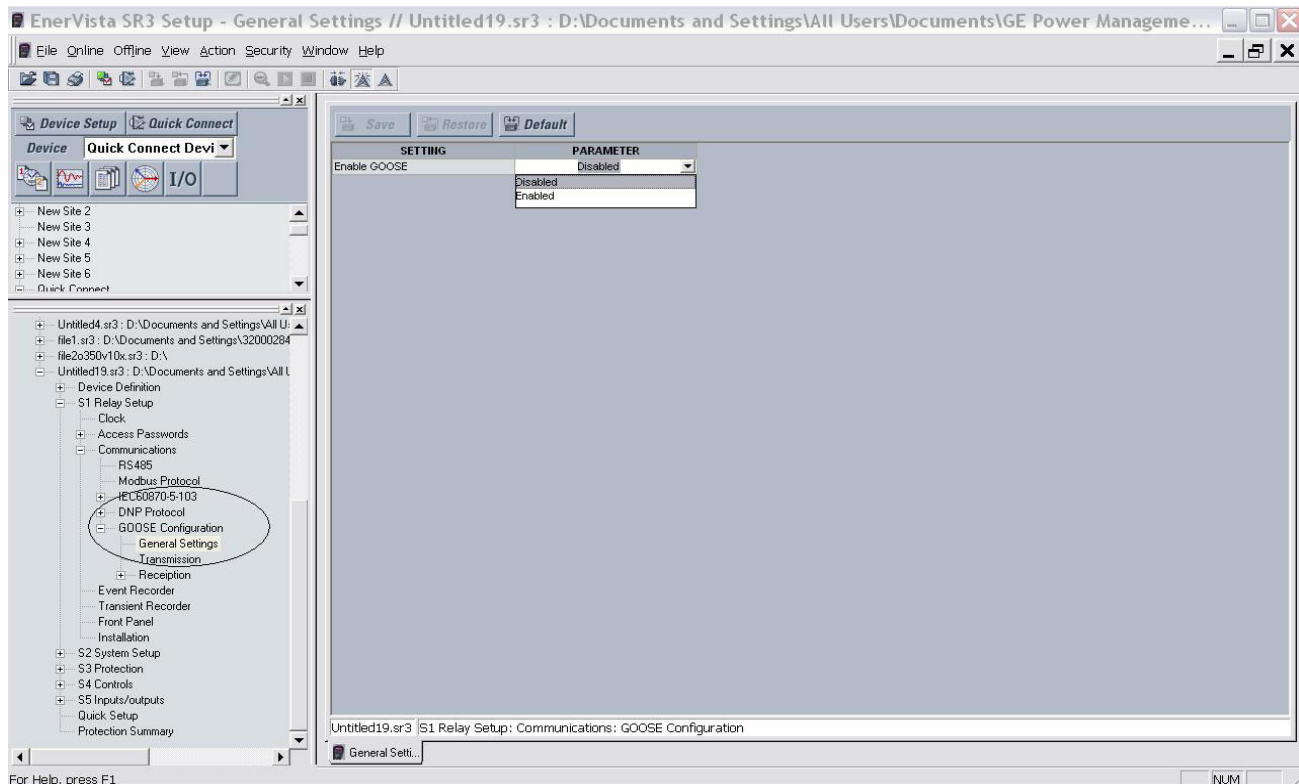


Figure 6-9: EnerVista 3 Series GOOSE General Settings

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, the Transient Recorder captures data for all analog currents: Winding 1 three-phase currents and ground, and Winding 2 three-phase currents and ground. 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".

Fault report

The 345 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.

W1 BKR OPEN COLOR

Range: Off, Red, Green, Orange

Default: Green

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

W1 BKR CLSD COLOR

Range: Off, Red, Green, Orange

Default: Green

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

W2 BKR OPEN COLOR

Range: Off, Red, Green, Orange

Default: Green

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

W2 BKR CLSD COLOR

Range: Off, Red, Green, Orange

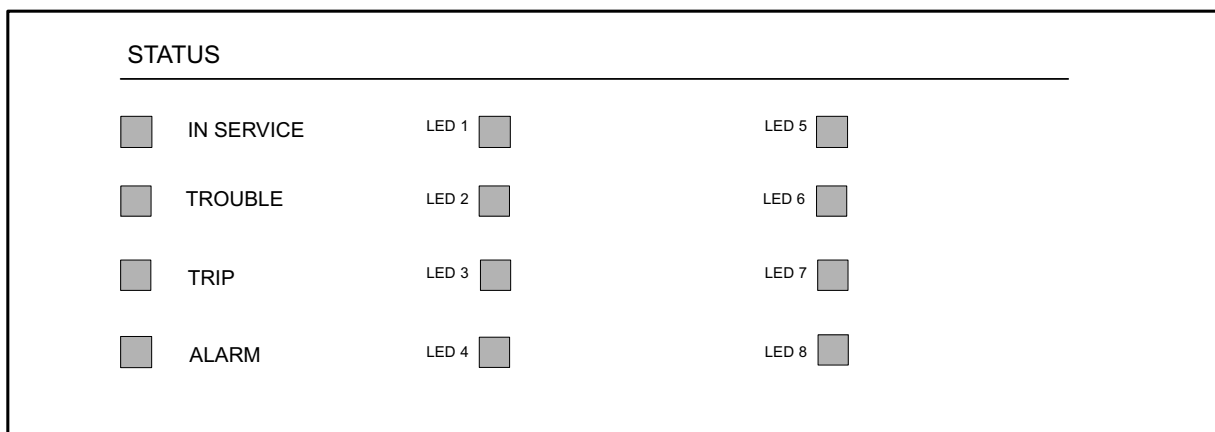
Default: Green

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

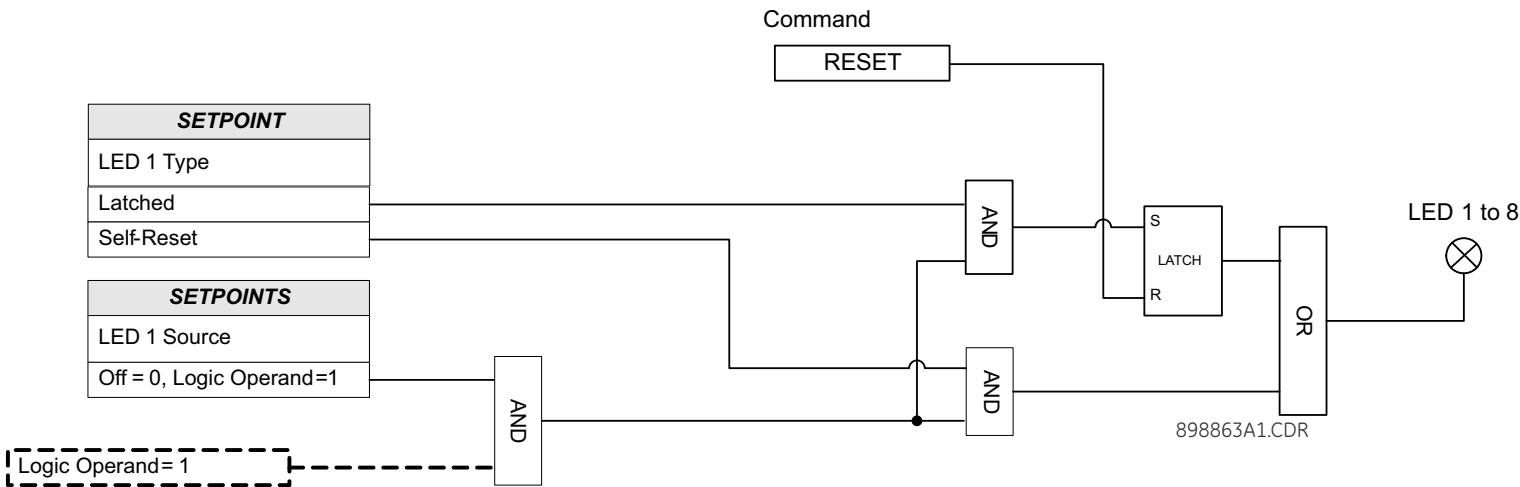


Figure 6-10: Programmable LED with Trigger SOURCE and Self-reset or Latched TYPE

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.

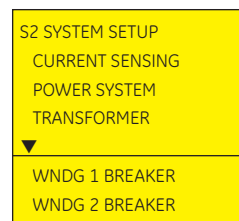
RELAY STATUS

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



897765A3.cdr

Figure 6-11: Main system setup menu

Current sensing

PATH: SETPOINTS > S2 SYSTEM SETUP > CURRENT SENSING

W1 PH CT PRIMARY

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

Default: 5 A

Enter the rated phase CT primary current of the three-phase current transformers associated with Winding 1.

W1 PH CT SECONDARY

Range: 1 A to 5 A in steps of 1 A

Default: 1 A

Configurable 1 A or 5 A secondary (must be specified with order code P0G0). Enter the rated phase CT secondary current of the three-phase current transformers associated with Winding 1.

W1 GND CT PRIMARY

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

Default: 5 A

Enter the rated ground CT primary current of the ground current transformers associated with Winding 1.

W1 GND CT SECONDARY

Range: 1 A to 5 A in steps of 1 A

Default: 1 A

Configurable 1 A or 5 A secondary (must be specified with order code P0G0). Enter the rated ground CT secondary current of the ground current transformers associated with Winding 1.

W2 PH CT PRIMARY

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

Default: 5 A

Enter the rated phase CT primary current of the three-phase current transformers associated with Winding 2.

W2 PH CT SECONDARY

Range: 1 A to 5 A in steps of 1 A

Default: 1 A

Configurable 1 A or 5 A secondary (must be specified with order code P0G0). Enter the rated phase CT secondary current of the three-phase current transformers associated with Winding 2.

W2 GND CT PRIMARY

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

Default: 5 A

Enter the rated ground CT primary current of the ground current transformers associated with Winding 2.

W2 GND CT SECONDARY

Range: 1 A to 5 A in steps of 1 A

Default: 1 A

Configurable 1 A or 5 A secondary (must be specified with order code P0G0). Enter the rated ground CT secondary current of the ground current transformers associated with Winding 2.

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.

Transformer

PATH: [SETPOINTS](#) > [S2 SYSTEM SETUP](#) > [TRANSFORMER](#)

XFMR RATED LOAD

Range: 0.00 to 200.00 MVA in steps of 0.01

Default: 5.00 MVA

Enter the self-cooled (100%) load rating for the power transformer.

TRANSFORMER TYPE

Range: Refer to above "Transformer Types" table

Default: y/y0

Select the transformer connection from a list of transformer types shown in table 6-1 "Transformer types".

PHASE COMPENSATION

Range: Internal (software), External (with CTs)

Default: Internal (software)

Select the type of phase compensation to be performed by the relay. If set to "Internal (software)", the transformer magnitude and phase shift compensations are performed internally by the relay algorithm. If set to "External (with CT's)", the transformer phase shift is externally compensated by the CT connections. The relay still performs magnitude compensation when the "External (with CTs)" option is selected.

W1 NOM VOLTAGE

Range: 0.01 to 250.00 KV in steps of 0.01

Default: 13.80 KV

Enter the nominal phase-to phase-voltage rating of Winding 1 of the transformer.

W1 GROUNDING

Range: Not Within Zone, Within Zone

Default: Not Within Zone

Select the setting "Within Zone", if there is a grounding path at Winding 1 side of the transformer such as grounded neutral, grounding transformer, or grounded corner of a delta winding. Select "Not Within Zone", if there is no grounding path for Winding 1 in the zone.

W2 NOM VOLTAGE

Range: 0.01 to 250.00 KV in steps of 0.01

Default: 4.16 KV

Enter the nominal phase-to phase-voltage rating of Winding 2 of the transformer.

W2 GROUNDING

Range: Not Within Zone, Within Zone

Default: Not Within Zone

Select the setting "Within Zone", if there is a grounding path at the Winding 2 side of the transformer, such as grounded neutral, grounding transformer, or grounded corner of a delta winding. Select "Not Within Zone", if there is no grounding path for Winding 2 in the zone.

The Delta connection of CTs inherently has the effect of removing the zero sequence components of the phase currents. If there were a grounding bank on the Delta winding of the power transformer within the zone of protection, a ground fault would result in differential (zero sequence) current and false trips. In such case, it would be necessary to insert a zero sequence current trap with the wye connected CTs on the Delta winding of the transformer.

In general, zero sequence removal is necessary if zero sequence can flow into and out of one transformer winding but not the other winding. Transformer windings that are grounded inside zone protection allow zero sequence current flow in that winding, and therefore it is from these windings that zero sequence removal is necessary.

Transformer setup phase & magnitude compensations

Percent (biased) differential protection is the main type of protection for power transformers with respect to detecting all types of transformer internal faults. This protection is based on Kirchhoff's Law where the algebraic sum of all currents flowing in and out of the protected equipment is equal to zero. However, when applying this law to transformer protection, one should keep in mind that direct summation of the measured per-phase transformer currents does not automatically result in a zero differential current. This is because:

1. The transformer voltage ratio results in different winding nominal currents.
2. The winding CTs are not rated to exactly match the winding nominal currents.
3. Physically, the transformer windings are connected in Delta, Wye, or Zig-Zag configuration, and each introduces a phase shift.

For correct performance of percent differential protection, it is necessary to adjust the magnitude and phase relationships of the CT secondary currents for each winding, in order to obtain near zero differential currents under normal transformer operating conditions. Traditionally, the phase shift between the currents from the transformer windings has been adjusted by connecting the CTs from the Wye winding in Delta connection, and the CTs from the Delta winding in Wye connection. The magnitude of this adjustment is accomplished using interposing CTs, or tapped relay windings. This, however, is not required when the 345 relay is installed.

The 345 relay simplifies the process by performing the magnitude and phase shift compensations automatically (internally). Upon receiving entered settings for the protected transformer and winding CT ratings, the relay automatically calculates and applies the correct magnitude of scaling to the winding currents, as well as the correct phase shift, in order to prepare the currents for summation. In order to performing the appropriate current compensation, all winding CTs must be connected in Wye (polarity markings pointing away from the transformer).

Magnitude Compensation Reference: Percent differential protection by the 345 relay uses the user-entered phase-to-phase voltage and the CT primary settings for Winding 1 as a reference for current magnitude compensation.

Phase Shift Compensation Reference: Percent differential protection by the 345 relay uses either the Delta or the Zig-Zag currents (depending on the transformer setup) as a phase shift reference to perform the phase shift compensation. When a Wye/Wye transformer is selected in the setup, the currents from the first Wye winding are used as a reference for the phase shift compensation.

EXAMPLE:

This section describes the process of automatic current magnitude and phase shift compensation using a specific example that shows how CT ratios, transformer voltage ratios, and transformer phase shifts are used to generate the correction factors. These correction factors are applied to the current signals to obtain extremely accurate differential currents. The menu paths in the example are shown graphically in the above figure.

Consider a typical Wye/Delta power transformer with the following data:

- Connection: Y/d30° (i.e. delta winding phase currents lag the corresponding wye winding phase currents by 30°)
- Transformer rated load: 5/7/9 MVA
- Winding 1: 13.8 kV nominal, 500/5 CT ratio
- Winding 2: 4.16 kV nominal, 1500/5 CT ratio.

The following sections will illustrate auto-configuration principles using in the example.

The current transformer ratings per each winding are entered as:

S2 SYSTEM SETUP > CURRENT SENSING > W1 PHASE CT PRIMARY: "500 A"

S2 SYSTEM SETUP > CURRENT SENSING > W2 PHASE CT PRIMARY: "1500 A"

The transformer type is entered as:

S2 SYSTEM SETUP > TRANSFORMER > TRANSFORMER TYPE: "Y/d30"

S2 SYSTEM SETUP > TRANSFORMER > XFMR RATED LOAD: "5 MVA"

S2 SYSTEM SETU > TRANSFORMER > W1 NOM F-F VOLTAGE: "13.8 kV"

S2 SYSTEM SETUP > TRANSFORMER > W1 GROUNDING: "Within Zone"

S2 SYSTEM SETUP > TRANSFORMER > W2 NOM F-F VOLTAGE: "4.16 kV"

S2 SYSTEM SETUP > TRANSFORMER > W2 GROUNDING: "Not Within Zone"

AUTOMATIC CT MISMATCH COMPENSATION

The 1500/5 CT on winding 2 does not perfectly match the 500/5 CT on Winding 1. The perfectly matched winding 2 CT primary at nominal winding 2 voltage is calculated as follows:

$$CT_2(ideal) = CT_1 \times \frac{V_1}{V_2} = 500 \times \frac{13.8kV}{4.16kV} = 1658.6 - \text{primary Amps} \quad \text{Eq. 1}$$

where:

CT_1 = Winding 1 CT primary rating

V_1 = Winding 1 nominal voltage

CT_2 = Winding 2 CT primary rating

V_2 = Winding 2 nominal voltage

Thus, for any load, the Winding 2 CT secondary current is higher (per unit) than the Winding 1 CT secondary current. The mismatch factor is $1658.6 / 1500 = 1.1057$.

The 345 relay calculates the magnitude correction factor for Winding 2 as follows:

$$M(w2) = \frac{kV(w2) \times CT(w2)}{kV(w1) \times CT(w1)} = \frac{4.16kV \times 1500}{13.8kV \times 500} = 0.904 \quad \text{Eq. 2}$$

The 345 calculates and automatically corrects the CT mismatch to a maximum mismatch factor of 16.

Hence, the measured currents from winding 2 will be automatically compensated by the relay applying the correction factor of 0.904. The currents from winding 1 are not multiplied by any correction factor, as they are always used by the relay as a magnitude reference.

Based on 100% transformer loading (5MVA), the measured winding currents are:

Winding 1 CT: measured

$$I_n(w1) = \frac{5MVA}{13.8kV \times \sqrt{3}} = 209A \quad \text{Eq. 3}$$

- winding 1 nominal current

Winding 2 CT: measured

$$I_n(w2) = \frac{5MVA}{4.16kV \times \sqrt{3}} = 694A \quad \text{Eq. 4}$$

- winding 2 nominal current

Based on 100% transformer loading, the compensated currents expressed in times CT (w1) as a reference and used by the percent differential protection will be as shown:

$$I_{comp.}(w1) \times CT = \frac{209A}{500} = 0.418 \times CT \quad \text{Eq. 5}$$

$$I_{comp.}(w2) \times CT = \frac{694A}{1500} \times 0.904 = 0.418 \times CT \quad \text{Eq. 6}$$

PHASE SHIFT COMPENSATION

The source phase sequence must be stated when describing the winding phase relationships since these relationships change when the phase sequence changes. The example below shows why this happens, using a transformer described in IEC nomenclature as “Yd1” or in GE Multilin nomenclature as “Y/d30.”

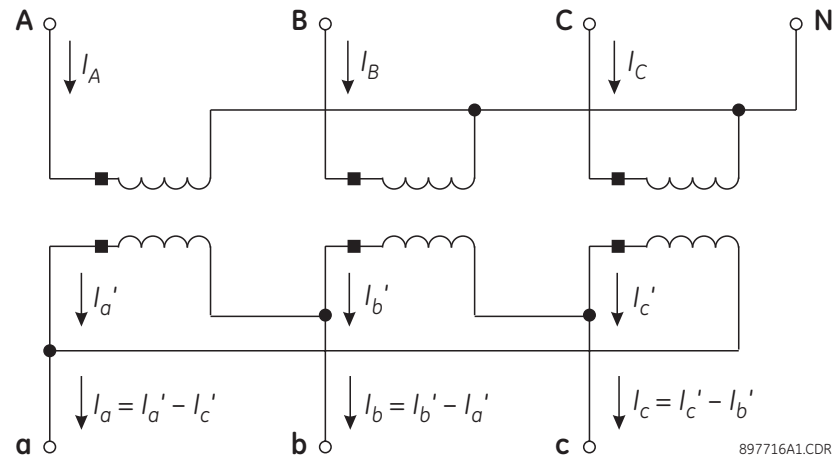


Figure 6-12: Example transformer

The above figure shows the physical connections within the transformer that produce a phase angle in the delta winding lagging the respective wye winding by 30°. The winding currents are also identified. Note that the total current out of the delta winding is described by an equation. Now assume that a source, with a sequence of ABC, is connected to transformer terminals ABC, respectively. The currents that would be present for a balanced load are shown below.

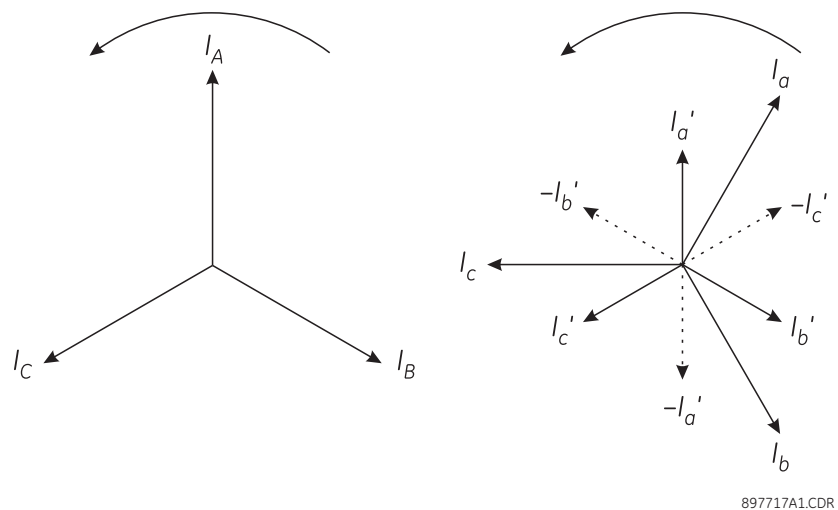


Figure 6-13: Phasors for ABC sequence

Note that the delta winding currents lag the wye winding currents by 30°, which is in agreement with the transformer nameplate.

Now assume that a source, with a sequence of ACB is connected to transformer terminals A, C, B respectively. The currents that would be present for a balanced load are shown below:

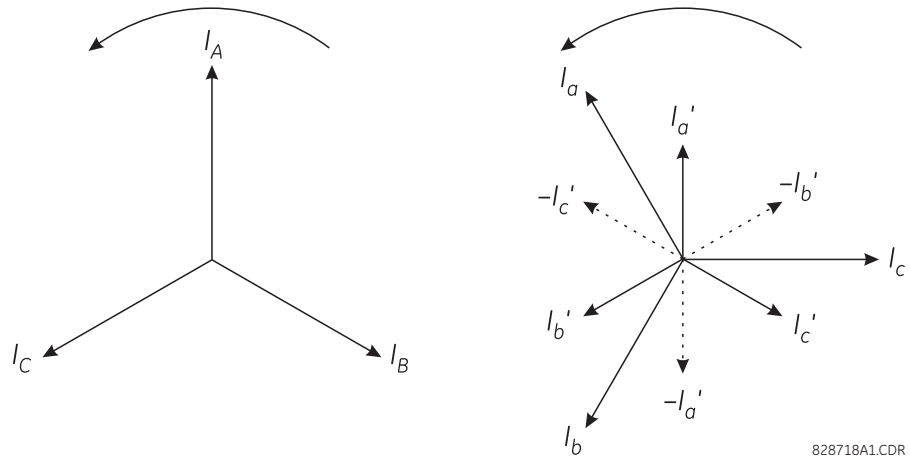


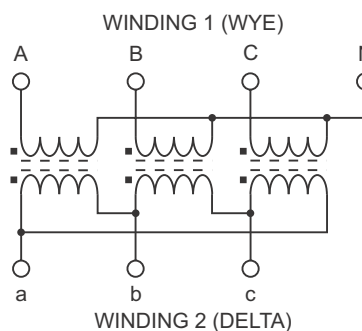
Figure 6-14: Phasors for ACB sequence

Note that the delta winding currents leads the wye winding currents by 30°, (which is a type Yd11 in IEC nomenclature and a type Y/d330 in GE Multilin nomenclature) which is in disagreement with the transformer nameplate. This is because the physical connections and hence the equations used to calculate current for the delta winding have not changed. The transformer nameplate phase relationship information is only correct for a stated phase sequence.

It may be suggested that for the ACB sequence the phase relationship can be returned to that shown on the transformer nameplate by connecting source phases A, B and C to transformer terminals A, C, and B respectively. This will restore the nameplate phase shifts but will cause incorrect identification of phases B and C within the relay, and is therefore not recommended.

All information presented in this manual is based on connecting the relay phase A, B and C terminals to the power system phases A, B and C respectively. The transformer types and phase relationships presented are for a system phase sequence of ABC, in accordance with the standards for power transformers. Users with a system phase sequence of ACB must determine the transformer type for this sequence.

The following diagram shows the internal connections of the Y/d30° transformer from our example:



The 345 performs this phase angle correction internally based on the following setpoint. Set **S2 SYSTEM SETUP > TRANSFORMER > TRANSFORMER TYPE** to "Y/d30°".

The 345 supports all standard two-winding transformer types. Each transformer type from the **Transformer Types** table below provides the following information:

transformer type notation as it appears on the display

winding connection (wye, delta, or zig-zag) and ground CT assignment

angle by which a winding lags winding 1

diagrams showing the phase relationships of voltage phasors, where (the arrow sign) indicates the reference phase

Transformer type	Wdg.	Connection	Voltage phasors	Phase shift
Y/d30°	1	WYE (gnd 1/2)		30° lag
	2	DELTA 30° Lag		0°

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phase angle correction (or phase shift) that is initially performed to calculate differential currents

As shown in the “Y/d30°” entry of the transformer types table, the 30° lag of the Delta results into 0° phase shift applied to its currents (Delta –phase reference), and 30° phase angle correction (phase shift) applied to the winding 1 currents (Wye winding). These angle corrections are described in the table as Phase shift.

In our example, the transformer has the Y-D connection. Traditionally, CTs on the Wye connected transformer winding (winding 1) would be connected in a delta arrangement, which compensates for the phase angle lag introduced in the Delta connected winding (winding 2), so that line currents from both windings can be compared at the relay. The Delta connection of CTs, however, inherently has the effect of removing the zero sequence components of the phase currents. If there were a grounding bank on the Delta winding of the power transformer within the zone of protection, a ground fault would result in differential (zero sequence) current and false trips. In such a case, it would be necessary to insert a zero sequence current trap with the Wye connected CTs on the Delta winding of the transformer.

In general, zero sequence removal is necessary if zero sequence can flow into and out of one transformer winding but not the other winding. Transformer windings that are grounded inside the zone of protection allow zero sequence current flow in that winding, and therefore it is from these windings that zero sequence removal is necessary.

The 345 performs this phase angle compensation and zero sequence removal automatically, based on the settings entered for the transformer. All CTs are connected Wye (polarity markings pointing away from the transformer). All currents are phase and zero sequence compensated internally before the calculation of differential and restraint quantities.

The phase reference winding (wf) is the winding which will have a phase shift of 0° applied to it. The phase reference winding is chosen to be the delta or zigzag (non-wye) winding with the lowest winding index, if one exists. For a transformer that has no delta or zigzag windings, the first winding is chosen.

The phase compensation angle Φ_{comp} is the angle by which a winding current is shifted to refer it to the phase reference winding, and is calculated by the 345 for each winding as follows:

$$\Phi_{comp}[w] = | \Phi[w_f] - \Phi[w] |$$

Eq. 7

where Rotation = "ABC"

$$\Phi_{comp}[W] = | \Phi[W] - \Phi[W_f] | \quad \text{Eq. 8}$$

where Rotation = "ACB"

In our example, the phase reference winding would be winding 2 (i.e. $w_f = 2$). The phase compensation angle for each winding would then be calculated as follows (assuming Rotation = "ABC"):

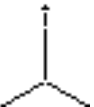
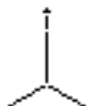
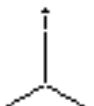
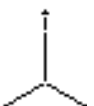
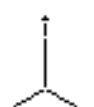
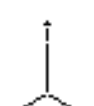
$$\Phi_{comp}[1] = -30^\circ - 0^\circ = -30^\circ = 30^\circ \text{ lag}$$

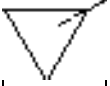
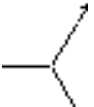
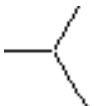
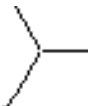
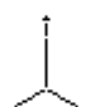
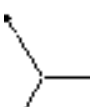
$$\Phi_{comp}[2] = -30^\circ - (-30^\circ) = 0^\circ \quad \text{Eq. 9}$$

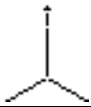
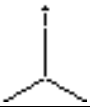
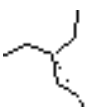
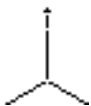
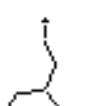
TRANSFORMER TYPES

A complete table of two-winding transformer types is shown below.

Table 6-1: Transformer types

Transformer Type	Wdg.	Connection	Voltage Phasors	Phase Shift (Φ_{comp})	Transformer Type	Wdg.	Connection	Voltage Phasors	Phase Shift (Φ_{comp})
2W External Correction	1	WYE (gnd 1/2)		0°	Y/y0°	1	WYE (gnd 1/2)		0°
	2	WYE (gnd 2/3) 0°		0°		2	WYE (gnd 2/3) 0°		0°
Y/y180°	1	WYE (gnd 1/2)		180° lag	Y/d30°	1	WYE (gnd 1/2)		30° lag
	2	WYE (gnd 2/3) 180° lag		0°		2	DELTA (gnd 2/3) 30° lag		0°
Y/d150°	1	WYE (gnd 1/2)		150° lag	Y/d210°	1	WYE (gnd 1/2)		210° lag
	2	DELTA (gnd 2/3) 150° lag		0°		2	DELTA (gnd 2/3) 210° lag		0°
Y/d330°	1	WYE (gnd 1/2)		330° lag	D/d0°	1	DELTA (gnd 1/2)		0°
	2	DELTA (gnd 2/3) 330° lag		0°		2	DELTA (gnd 2/3) 0°		0°

Transformer Type	Wdg.	Connection	Voltage Phasors	Phase Shift (Φ_{comp})	Transformer Type	Wdg.	Connection	Voltage Phasors	Phase Shift (Φ_{comp})
D/d60°	1	DELTA (gnd 1/2)		60° lag	D/d120°	1	DELTA (gnd 1/2)		120° lag
	2	DELTA (gnd 2/3) 60° lag		0°		2	DELTA (gnd 2/3) 120° lag		0°
D/d180°	1	DELTA (gnd 1/2)		180° lag	D/d240°	1	DELTA (gnd 1/2)		240° lag
	2	DELTA (gnd 2/3) 180° lag		0°		2	DELTA (gnd 2/3) 240° lag		0°
D/d300°	1	DELTA (gnd 1/2)		300° lag	D/y30°	1	DELTA (gnd 1/2)		0°
	2	DELTA (gnd 2/3) 300° lag		0°		2	WYE (gnd 2/3) 30° lag		330° lag
D/y150°	1	DELTA (gnd 1/2)		0°	D/y210°	1	DELTA (gnd 1/2)		0°
	2	WYE (gnd 2/3) 150° lag		210° lag		2	WYE (gnd 2/3) 210° lag		150° lag
D/y330°	1	DELTA (gnd 1/2)		0°	Y/z30°	1	WYE (gnd 1/2)		30° lag
	2	WYE (gnd 2/3) 330° lag		30° lag		2	ZIG-ZAG (gnd 2/3) 30° lag		0°

Transformer Type	Wdg.	Connection	Voltage Phasors	Phase Shift (Φ_{comp})	Transformer Type	Wdg.	Connection	Voltage Phasors	Phase Shift (Φ_{comp})
Y/z150°	1	WYE (gnd 1/2)		150° lag	Y/z210°	1	WYE (gnd 1/2)		210° lag
	2	ZIG-ZAG (gnd 2/3) 150° lag		0°		2	ZIG-ZAG (gnd 2/3) 210° lag		0°
Y/z330°	1	WYE (gnd 1/2)		330° lag	D/z0°	1	DELTA (gnd 1/2)		0°
	2	ZIG-ZAG (gnd 2/3) 330° lag		0°		2	ZIG-ZAG (gnd 2/3) 0° lag		0°
D/z60°	1	DELTA (gnd 1/2)		60° lag	D/z120°	1	DELTA (gnd 1/2)		120° lag
	2	ZIG-ZAG (gnd 2/3) 60° lag		0°		2	ZIG-ZAG (gnd 2/3) 120° lag		0°
D/z180°	1	DELTA (gnd 1/2)		180° lag	D/z240°	1	DELTA (gnd 1/2)		240° lag
	2	ZIG-ZAG (gnd 2/3) 180° lag		0°		2	ZIG-ZAG (gnd 2/3) 240° lag		0°
D/z300°	1	DELTA (gnd 1/2)		300° lag	3W External Correction	1	WYE		0°
	2	ZIG-ZAG (gnd 2/3) 300° lag		0°		23	WYE 0°		0°
							WYE 0°		0°

The following table shows the linear combination of phases of a transformer winding that achieves the phase shift and zero sequence removal for typical values of Φ_{comp} :

where:

$I_A[w]$ = uncompensated winding 'w' phase A current

$I_{Ap}[w]$ = phase and zero sequence compensated winding 'w' phase A current.

Table 6-2:

$\Phi_{\text{Comp}}[W]$	GROUNDING[W] = "NOT WITHIN ZONE"	GROUNDING[W] = "WITHIN ZONE"
0°	$I_A^P[W] = I_A[W]$ $I_B^P[W] = I_B[W]$ $I_C^P[W] = I_C[W]$	$I_A^P[W] = \frac{2}{3}I_A[W] - \frac{1}{3}I_B[W] - \frac{1}{3}I_C[W]$ $I_B^P[W] = \frac{2}{3}I_B[W] - \frac{1}{3}I_A[W] - \frac{1}{3}I_C[W]$ $I_C^P[W] = \frac{2}{3}I_C[W] - \frac{1}{3}I_A[W] - \frac{1}{3}I_B[W]$
30° lag	$I_A^P[W] = \frac{1}{\sqrt{3}}I_A[W] - \frac{1}{\sqrt{3}}I_C[W]$ $I_B^P[W] = \frac{1}{\sqrt{3}}I_B[W] - \frac{1}{\sqrt{3}}I_A[W]$ $I_C^P[W] = \frac{1}{\sqrt{3}}I_C[W] - \frac{1}{\sqrt{3}}I_B[W]$	$I_A^P[W] = \frac{1}{\sqrt{3}}I_A[W] - \frac{1}{\sqrt{3}}I_C[W]$ $I_B^P[W] = \frac{1}{\sqrt{3}}I_B[W] - \frac{1}{\sqrt{3}}I_A[W]$ $I_C^P[W] = \frac{1}{\sqrt{3}}I_C[W] - \frac{1}{\sqrt{3}}I_B[W]$
60° lag	$I_A^P[W] = -I_C[W],$ $I_B^P[W] = -I_A[W],$ $I_C^P[W] = -I_B[W]$	$I_A^P[W] = -\frac{2}{3}I_C[W] + \frac{1}{3}I_A[W] + \frac{1}{3}I_B[W]$ $I_B^P[W] = -\frac{2}{3}I_A[W] + \frac{1}{3}I_B[W] + \frac{1}{3}I_C[W]$ $I_C^P[W] = -\frac{2}{3}I_B[W] + \frac{1}{3}I_A[W] + \frac{1}{3}I_C[W]$
90° lag	$I_A^P[W] = \frac{1}{\sqrt{3}}I_B[W] - \frac{1}{\sqrt{3}}I_C[W]$ $I_B^P[W] = \frac{1}{\sqrt{3}}I_C[W] - \frac{1}{\sqrt{3}}I_A[W]$ $I_C^P[W] = \frac{1}{\sqrt{3}}I_A[W] - \frac{1}{\sqrt{3}}I_B[W]$	$I_A^P[W] = \frac{1}{\sqrt{3}}I_B[W] - \frac{1}{\sqrt{3}}I_C[W]$ $I_B^P[W] = \frac{1}{\sqrt{3}}I_C[W] - \frac{1}{\sqrt{3}}I_A[W]$ $I_C^P[W] = \frac{1}{\sqrt{3}}I_A[W] - \frac{1}{\sqrt{3}}I_B[W]$
120° lag	$I_A^P[W] = I_B[W]$ $I_B^P[W] = I_C[W]$ $I_C^P[W] = I_A[W]$	$I_A^P[W] = \frac{2}{3}I_B[W] - \frac{1}{3}I_A[W] - \frac{1}{3}I_C[W]$ $I_B^P[W] = \frac{2}{3}I_C[W] - \frac{1}{3}I_A[W] - \frac{1}{3}I_B[W]$ $I_C^P[W] = \frac{2}{3}I_A[W] - \frac{1}{3}I_B[W] - \frac{1}{3}I_C[W]$
150° lag	$I_A^P[W] = \frac{1}{\sqrt{3}}I_B[W] - \frac{1}{\sqrt{3}}I_A[W]$ $I_B^P[W] = \frac{1}{\sqrt{3}}I_C[W] - \frac{1}{\sqrt{3}}I_B[W]$ $I_C^P[W] = \frac{1}{\sqrt{3}}I_A[W] - \frac{1}{\sqrt{3}}I_C[W]$	$I_A^P[W] = \frac{1}{\sqrt{3}}I_B[W] - \frac{1}{\sqrt{3}}I_A[W]$ $I_B^P[W] = \frac{1}{\sqrt{3}}I_C[W] - \frac{1}{\sqrt{3}}I_B[W]$ $I_C^P[W] = \frac{1}{\sqrt{3}}I_A[W] - \frac{1}{\sqrt{3}}I_C[W]$
180° lag	$I_A^P[W] = -I_A[W]$ $I_B^P[W] = -I_B[W]$ $I_C^P[W] = -I_C[W]$	$I_A^P[W] = -\frac{2}{3}I_A[W] + \frac{1}{3}I_B[W] + \frac{1}{3}I_C[W]$ $I_B^P[W] = -\frac{2}{3}I_B[W] + \frac{1}{3}I_A[W] + \frac{1}{3}I_C[W]$ $I_C^P[W] = -\frac{2}{3}I_C[W] + \frac{1}{3}I_A[W] + \frac{1}{3}I_B[W]$
210° lag	$I_A^P[W] = \frac{1}{\sqrt{3}}I_C[W] - \frac{1}{\sqrt{3}}I_A[W]$ $I_B^P[W] = \frac{1}{\sqrt{3}}I_A[W] - \frac{1}{\sqrt{3}}I_B[W]$ $I_C^P[W] = \frac{1}{\sqrt{3}}I_B[W] - \frac{1}{\sqrt{3}}I_C[W]$	$I_A^P[W] = \frac{1}{\sqrt{3}}I_C[W] - \frac{1}{\sqrt{3}}I_A[W]$ $I_B^P[W] = \frac{1}{\sqrt{3}}I_A[W] - \frac{1}{\sqrt{3}}I_B[W]$ $I_C^P[W] = \frac{1}{\sqrt{3}}I_B[W] - \frac{1}{\sqrt{3}}I_C[W]$

$\Phi_{\text{COMP}}[W]$	GROUNDING[W] = "NOT WITHIN ZONE"	GROUNDING[W] = "WITHIN ZONE"
240° lag	$I_A^P[W] = I_C[W]$ $I_B^P[W] = I_A[W]$ $I_C^P[W] = I_B[W]$	$I_A^P[W] = \frac{2}{3}I_C[W] - \frac{1}{3}I_A[W] - \frac{1}{3}I_B[W]$ $I_B^P[W] = \frac{2}{3}I_A[W] - \frac{1}{3}I_B[W] - \frac{1}{3}I_C[W]$ $I_C^P[W] = \frac{2}{3}I_B[W] - \frac{1}{3}I_A[W] - \frac{1}{3}I_C[W]$
270° lag	$I_A^P[W] = \frac{1}{\sqrt{3}}I_C[W] - \frac{1}{\sqrt{3}}I_B[W]$ $I_B^P[W] = \frac{1}{\sqrt{3}}I_A[W] - \frac{1}{\sqrt{3}}I_C[W]$ $I_C^P[W] = \frac{1}{\sqrt{3}}I_B[W] - \frac{1}{\sqrt{3}}I_A[W]$	$I_A^P[W] = \frac{1}{\sqrt{3}}I_C[W] - \frac{1}{\sqrt{3}}I_B[W]$ $I_B^P[W] = \frac{1}{\sqrt{3}}I_A[W] - \frac{1}{\sqrt{3}}I_C[W]$ $I_C^P[W] = \frac{1}{\sqrt{3}}I_B[W] - \frac{1}{\sqrt{3}}I_A[W]$
300° lag	$I_A^P[W] = -I_B[W]$ $I_B^P[W] = -I_C[W]$ $I_C^P[W] = -I_A[W]$	$I_A^P[W] = -\frac{2}{3}I_B[W] + \frac{1}{3}I_A[W] + \frac{1}{3}I_C[W]$ $I_B^P[W] = -\frac{2}{3}I_C[W] + \frac{1}{3}I_A[W] + \frac{1}{3}I_B[W]$ $I_C^P[W] = -\frac{2}{3}I_A[W] + \frac{1}{3}I_B[W] + \frac{1}{3}I_C[W]$
330° lag	$I_A^P[W] = \frac{1}{\sqrt{3}}I_A[W] - \frac{1}{\sqrt{3}}I_B[W]$ $I_B^P[W] = \frac{1}{\sqrt{3}}I_B[W] - \frac{1}{\sqrt{3}}I_C[W]$ $I_C^P[W] = \frac{1}{\sqrt{3}}I_C[W] - \frac{1}{\sqrt{3}}I_A[W]$	$I_A^P[W] = \frac{1}{\sqrt{3}}I_A[W] - \frac{1}{\sqrt{3}}I_B[W]$ $I_B^P[W] = \frac{1}{\sqrt{3}}I_B[W] - \frac{1}{\sqrt{3}}I_C[W]$ $I_C^P[W] = \frac{1}{\sqrt{3}}I_C[W] - \frac{1}{\sqrt{3}}I_A[W]$

MAGNITUDE, PHASE ANGLE, AND ZERO SEQUENCE COMPENSATION

Transformer magnitude, phase angle, and zero-sequence compensation calculations

Complete magnitude, phase angle, and zero sequence compensation is as follows:

Winding 1 compensated currents:

$$I_A^C[w1] = I_A^P[w1]$$

$$I_B^C[w1] = I_B^P[w1]$$

$$I_C^C[w1] = I_C^P[w1]$$

Winding 2 compensated currents:

$$I_A^C[w2] = M[w2] \cdot I_A^P[w2]$$

$$I_B^C[w2] = M[w2] \cdot I_B^P[w2]$$

$$I_C^C[w2] = M[w2] \cdot I_C^P[w2]$$

where:

$$I_A^C[w], I_B^C[w], \text{ and } I_C^C[w]$$

- magnitude, phase and zero sequence compensated winding w phase currents

$$M[w2]$$

- magnitude compensation factor for winding 2 (see previous sections)

$$I_A^P[w], I_B^P[w], \text{ and } I_C^P[w]$$

- phase and zero sequence compensated winding phase currents (see earlier).

In our example, the following phase and zero-sequence compensation equations would be used:

For Winding 1 (Wye – grounded neutral):

$$I_A^P[w] = \frac{1}{\sqrt{3}} I_A[w] - \frac{1}{\sqrt{3}} I_C[w]$$

$$I_B^P[w] = \frac{1}{\sqrt{3}} I_B[w] - \frac{1}{\sqrt{3}} I_A[w]$$

$$I_C^P[w] = \frac{1}{\sqrt{3}} I_C[w] - \frac{1}{\sqrt{3}} I_B[w]$$

For Winding 2 (Delta):

$$I_A^P[w] = I_A[w]$$

$$I_B^P[w] = I_B[w]$$

$$I_C^P[w] = I_C[w]$$

The complete compensated winding 1 and winding 2 currents would be as follows:

Winding 1

$$I_A^C[w1] = 0.418xCT\angle 0^\circ$$

$$I_B^C[w1] = 0.418xCT\angle 120^\circ lag$$

$$I_C^C[w1] = 0.418xCT\angle 240^\circ lag$$

Winding 2

$$I_A^C[w2] = 0.418xCT\angle 180^\circ lag$$

$$I_B^C[w2] = 0.418xCT\angle 300^\circ lag$$

$$I_C^C[w2] = 0.418xCT\angle 60^\circ lag$$

DIFFERENTIAL AND RESTRAINT CURRENT CALCULATIONS

Differential currents are calculated as follows:

$$Id_A = I_A^C[w1] + I_A^C[w2]$$

$$Id_B = I_B^C[w1] + I_B^C[w2]$$

$$Id_C = I_C^C[w1] + I_C^C[w2]$$

Restraint currents are calculated as follows:

$$Ir_A = \max\{|I_A^C[w1]|, |I_A^C[w2]|\}$$

$$Ir_B = \max\{|I_B^C[w1]|, |I_B^C[w2]|\}$$

$$Ir_C = \max\{|I_C^C[w1]|, |I_C^C[w2]|\}$$

where,

$$Id_A, Id_B \text{ and } Id_C$$

are the phase differential currents, and

I_{r_A} , I_{r_B} , and I_{r_C}

are the phase restraint currents.

Per the example, the per-phase differential and restraint currents would be as follows:

Differential currents

$$Id_A = 0 \times CT$$

$$Id_B = 0 \times CT$$

$$Id_C = 0 \times CT$$

Restraint currents

$$Ir_A = 0.418 \times CT$$

$$Ir_B = 0.418 \times CT$$

$$Ir_C = 0.418 \times CT$$

Winding breakers

The status of the Winding 1 breaker is monitored by the 345 relay using the status of either one or two contact inputs, 52a (CI#1) and 52b (CI#2), wired to the Winding 1 breaker auxiliary contacts 52a and 52b, and the status of the Winding 2 breaker 52a (CI#3) and 52b (CI#4) wired to Winding 2 breaker aux 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 > WNDG 1 BREAKER

52a CONTACT

Range: Disabled, Contact Input 1

Default: Disabled

Select Contact Input 1 [52a (CI#1)] if connected to breaker auxiliary contact 52a.

52b CONTACT

Range: Disabled, Contact Input 2

Default: Disabled

Select Contact Input 2 [52b (CI#2)] if connected to breaker auxiliary contact 52b.

BKR CONNECTED

Range: Contact Input 5 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.

PATH: SETPOINTS > S2 SYSTEM SETUP > WNDG 2 BREAKER

52a CONTACT

Range: Disabled, Contact Input 3

Default: Disabled

Select Contact Input 3 [52a (CI#3)] if connected to Winding 2 breaker auxiliary contact 52a.

52b CONTACT

Range: Disabled, Contact Input 4

Default: Disabled

Select Contact Input 4 [52b (CI#4)] if connected to Winding 2 breaker auxiliary contact 52b.

BKR CONNECTED

Range: Contact Input 5 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.



It is highly recommended to monitor the status of the Winding 1 and Winding 2 breakers using both breaker auxiliary contacts 52a, and 52b; however using only one of them is also acceptable.

The 345 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 6-3: 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	

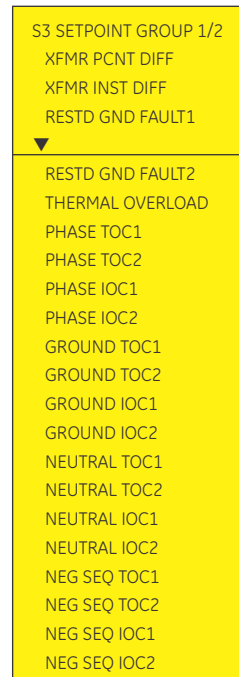
If the contact input selected under BKR CONNECTED setting is asserted, the breaker is considered connected to the primary system. When the breaker is determined disconnected, the breaker state is shown to be neither open, nor closed.

Table 6-4: 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

S3 Protection

The 345 protection elements are organized in two identical setpoint groups: Setpoint Group 1 and Setpoint Group 2.



897798A2.cdr

Figure 6-15: Main Protection menu

Breaker tripping

Tripping the winding breakers in the 345 relay is performed by energizing Output Relay 1 (RLY1 W1 BKR TRIP) and Output Relay 2 (RLY2 W2 BKR TRIP). Most of the 345 protection, control, and monitoring elements can be configured to trip one of the two winding breakers, or both breakers together. In these cases, selecting to trip only one specific breaker, or both together, can be configured in the menu of the element as follows:

1. Set the main function setpoint in the element menu (for example, PH TOC1 FUNCTION) to Trip.
This adds the setpoints RLY1 TRIP W1 BKR and RLY2 TRIP W2 BKR used for tripping the Winding 1 and Winding 2 breakers respectively. These setpoints are only visible when the FUNCTION setpoint is set to Trip, and supports tripping individual breakers.
2. Set one or both of the setpoints RLY1 TRIP W1 BKR and RLY2 TRIP W2 BKR to Operate to enable triggering the corresponding output relay or relays upon operation of the element.



NOTE

A few 345 elements, such as Percent Differential, Instantaneous Differential, Restricted Ground Fault, and Thermal Overload, can only trip both breakers together. Elements that only trip both breakers specify this behavior in the main FUNCTION setpoint description.

For example, the following screenshot shows the EnerVista 3 Series Setup software menu for Phase Timed Overcurrent (51P), with the function setpoint Phase TOC1 Function set to Disabled.

SaveRestoreDefault

SETTING [GROUP 1]	PARAMETER
Phase TOC1 Function	Disabled
Phase TOC1 CT Input	CT (W1)
Phase TOC1 Pickup	1.00 x CT
Phase TOC1 Curve	Extremely Inverse
Phase TOC1 Multiplier	1.00
Phase TOC1 Reset	Instantaneous
Phase TOC1 Relays	Relay : Disabled
Phase TOC1 Block 1	Off
Phase TOC1 Block 2	Off
Phase TOC1 Block 3	Off

When the function setpoint is changed to Trip, additional setpoints can be configured as shown.

SaveRestoreDefault

SETTING [GROUP 1]	PARAMETER
Phase TOC1 Function	Trip
Phase TOC1 CT Input	CT (W2)
Phase TOC1 Pickup	1.00 x CT
Phase TOC1 Curve	Extremely Inverse
Phase TOC1 Multiplier	1.00
Phase TOC1 Reset	Instantaneous
Phase TOC1 Relay 1 Trip W1 Breaker	Operate
Phase TOC1 Relay 2 Trip W2 Breaker	Do Not Operate
Phase TOC1 Relays	Relay : Disabled
Phase TOC1 Block 1	Off
Phase TOC1 Block 2	Off
Phase TOC1 Block 3	Off

Setting Phase TOC1 Relay 1 Trip W1 Breaker to Operate results in output relay 1 (W1 breaker) tripping when the Phase TOC1 element operates.

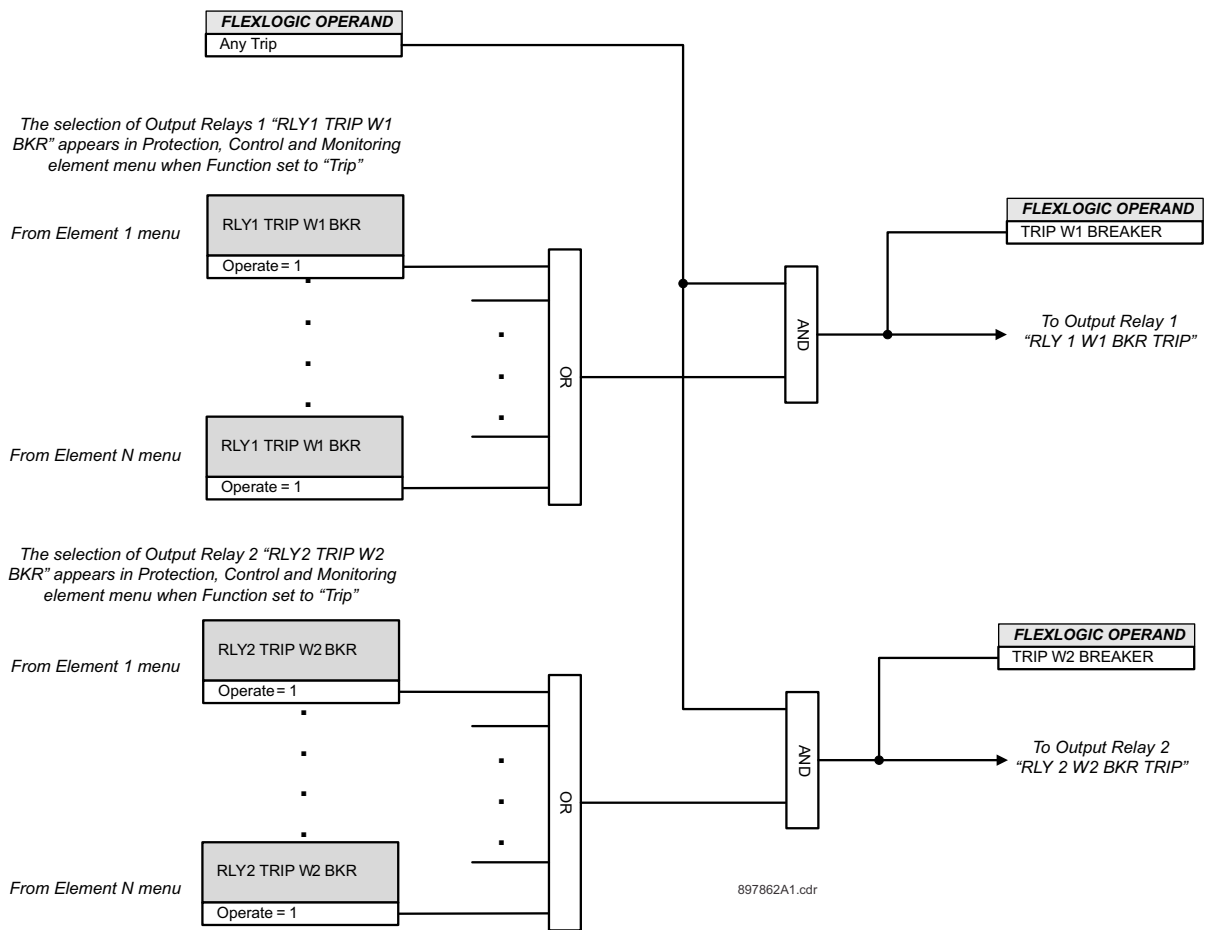


Figure 6-16: Breaker tripping logic diagram

Transformer percent differential (87T)

The 345 provides one percent differential element per setpoint group. The settings menu of the percent differential element defines a dual slope, dual breakpoint differential/restraint characteristic. The calculation of differential and restraint currents are as shown on the figure below.

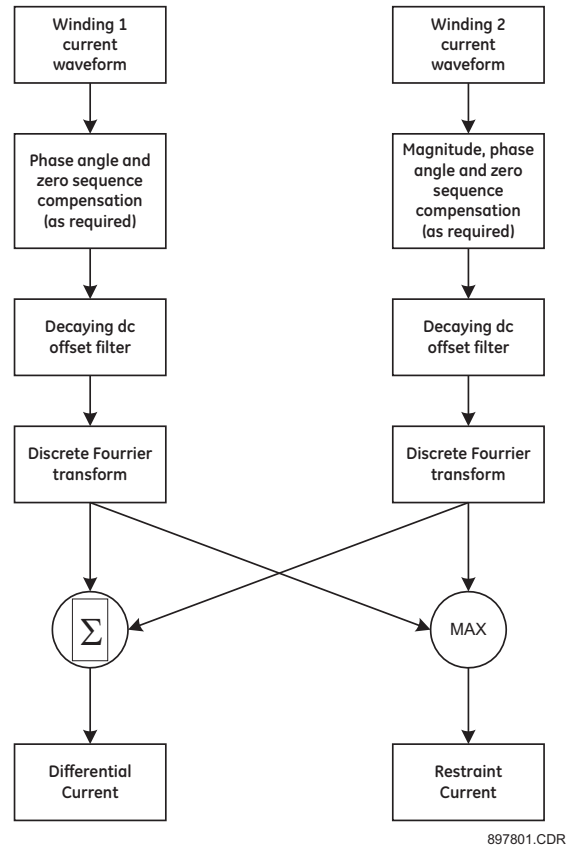


Figure 6-17: Calculation of transformer differential (Id) and restraint (Ir) currents

The 345 continuously calculates per-phase differential and restraint currents, and compares their ratio with the user pre-defined differential/restraint characteristic. The purpose of this characteristic is to provide a zone for differential protection operation, and a zone for no operation, where the user can define protection sensitivity and dependability during internal faults, and security during external faults.

The differential current is calculated per-phase as a vector sum of currents from both windings after magnitude and angle compensation.

$$Id = \bar{I}_{1comp} + \bar{I}_{2comp} \quad \text{Eq. 10}$$

The restraint current is calculated as a maximum of the same internally compensated currents:

$$Ir = \max(|\bar{I}_{1comp}|, |\bar{I}_{2comp}|) \quad \text{Eq. 11}$$

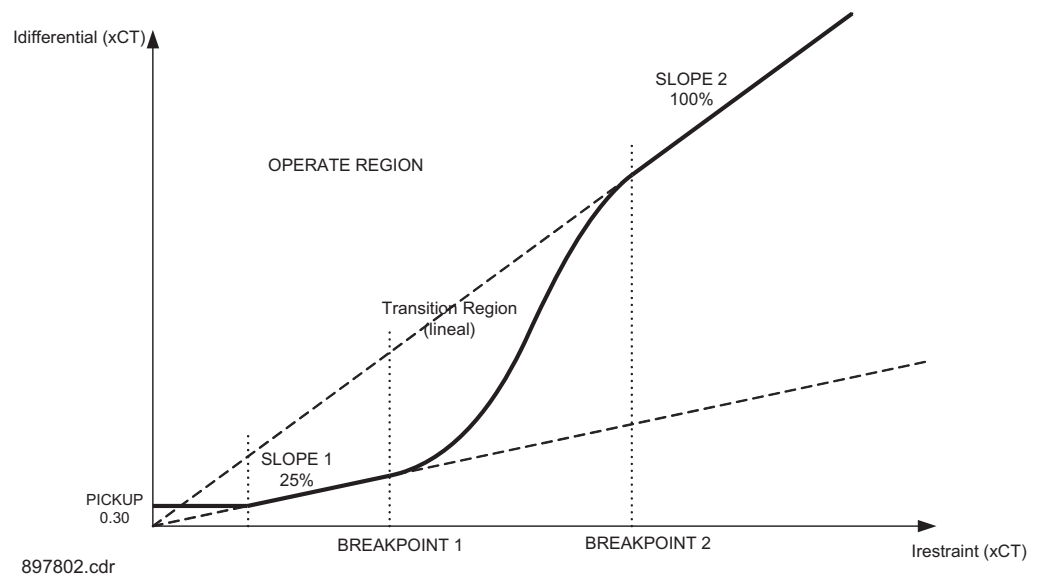


Figure 6-18: Differential / Restraint characteristic

The figure above shows the differential/restraint characteristic of the main transformer percent differential protection.

PATH: [SETPOINTS > S3 PROTECTION > S3 SETPOINT GROUP1 > XFMR PCNT DIFF](#)

XFMR DIFF FUNCTION

Range: Disabled, Latched Alarm, Alarm, Trip

Default: Disabled

For details see [Common setpoints](#).

Output relays #1 "R1 TRIP" and #2 "R2 TRIP" will operate when the **Trip** setting is selected and the Percent Differential protection is in operation.

MINIMUM PICKUP

Range: 0.05 to 1.00 x CT in steps of 0.01

Default: 0.10 x CT

This setting defines the minimum differential current required for operation. The setting is selected based on the amount of differential current that might be seen under normal conditions. This differential current is a result of the transformer magnetizing current, CT inaccuracies, and a transformer ratio that may change as a result of the transformer on-load tap changer.

SLOPE 1

Range: 15 to 100% in steps of 1

Default: 30%

This setting is applicable for restraint (through) currents of zero to kneepoint 1, and defines the ratio of differential/restraint currents, above which the element will operate. The slope is set to ensure sensitivity of internal faults at normal transformer loading.

BREAK 1

Range: 0.50 to 4.00xCT in steps of 0.01xCT

Default: 1.50xCT

The setting for Breakpoint 1 defines the limit of linear operation of Winding 1 CT, accounting for up to 80% of residual flux that effectively reduces the capability of the CT by a factor of 5. Breakpoint 1 should be set below the current that would cause CT saturation due to DC components and/or residual magnetism. Very often the Breakpoint

1 setting is based on the transformer Winding 1 nominal current (100% transformer loading). In such cases, one should check whether or not this setting complies with the above recommendation regarding the CT linear performance. This breakpoint marks the end of slope 1, where no CT saturation is expected to restrain (through) currents smaller than that breakpoint.

BREAK 2

Range: 1.00 to 10.00×CT in steps of 0.01×CT

Default: 1.5×CT

Breakpoint 2 should be set below the fault current that is most likely to saturate any of the transformer CTs due to an AC component alone. The setting is expressed in times CT primary of Winding 1. For example if 10 kA is the maximum AC through fault current before Winding 2 CT (1000:5) starts to saturate, on a 5 MVA transformer with a ratio of 13.8kV/4.16kV, and a Winding1 CT (500:5) rating, the Breakpoint 2 setting will be 6.02 × CT.

In this example:

$$\text{Fault current (W2)} = 10\text{kA}$$

$$\text{CT primary (W2)} = 1000 \text{ A} / (1 \times \text{CT})$$

$$M(W2) = \frac{kV(w2) \times CT(w2)}{kV(w1) \times CT(w1)} = \frac{4.16 \text{ kV} \times (1000:5)}{13.8 \text{ kV} \times 500:5} = 0.602$$

$$\text{Breakpoint 2} = \frac{\text{fault current (W2)} \times M(W2)}{\text{CT primary (W2)}} = \frac{10 \text{ kA} \times 0.602}{1000 \text{ A} / (1 \times \text{CT})} = 6.02 \text{ CT}$$

SLOPE 2

Range: 50 to 100% in steps of 1

Default: 95%

The Slope 2 setting ensures stability during fault conditions of the type that produce CT saturation and spurious high differential current. Slope 2 should be set high to cater for the worst case scenario where one set of CTs saturates, but the other set does not. In such cases the differential/restraint ratio can go as high as 95% to 98%.

INRUSH INHBT FUNCT

Range: Disabled, 2nd Harm Block

Default: 2nd Harm Block

This setting enables or disables the inrush inhibit function. None of the settings for inrush inhibit are active when the function is set to "Disabled".

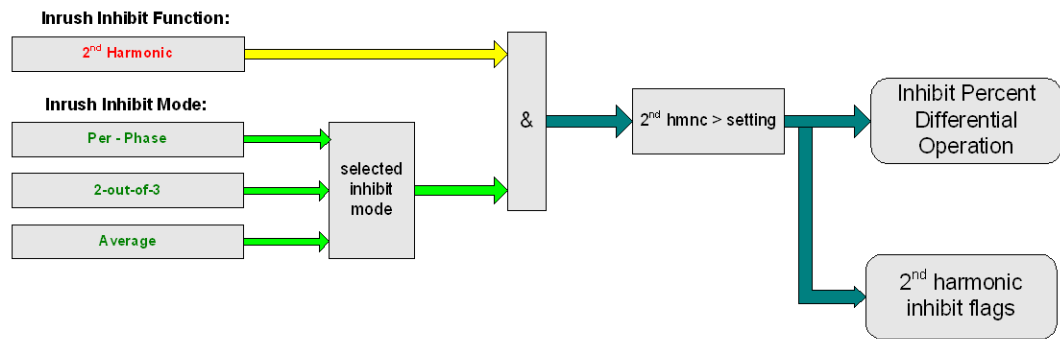


Figure 6-19: Transformer Inrush inhibiting

INRUSH INHBT LEVEL

Range: 0.1 to 40.0% in steps of 0.1

Default: 10%

This setting specifies the ratio of 2nd harmonic differential current to the fundamental frequency differential current for the selected mode of 2nd harmonic inhibit. The percent differential protection will be blocked from operation if the actual ratio of the differential 2nd harmonic current to the fundamental frequency differential current is above this threshold.

INRUSH INHBT MODE

Range: "Per Phase", "1-out-of-3", "2-out-of-3", "Average"

Default: Per Phase

This setting specifies the mode of blocking during transformer magnetizing (inrush) conditions.

If set to "Per phase," the function performs inrush inhibit for each phase individually.

If set to "1-out-of-3," the relay checks the 2nd harmonic level per-phase differential current, and blocks the differential protection for all three phases, if the 2nd harmonic on any one of the three phases is higher than the setting for inrush inhibit level.

If set to "2-out-of-3," the relay checks the 2nd harmonic level on the per-phase differential current, and blocks the differential protection for all three phases if the 2nd harmonic on any two of these three phases is higher than the setting for the inrush inhibit level.

If set to "Average," the relay calculates the average 2nd harmonic level and compares this level against the setting for the inrush inhibit level. Averaging of the 2nd harmonics is adaptive and depends on the magnitude of the differential current per-phase. If the differential current on any of the three phases goes below the differential current cut-off level of $0.04 \times CT$, the 2nd harmonic current from that phase gets dropped (zeroed) from the equation for averaging, and the dividing number (divisor) is decreased from 3 to 2. The same happens if the magnitude of the differential current on one of the two remaining phases drops below the cutoff level during energization. In this case the 2nd harmonic on this phase will be dropped from summation, and the dividing number (divisor) will be decreased to 1.

OVEREXCIT INHIBIT

Range: Disabled, 5th Harm

Default: Disabled

This setting provides 5th harmonic differential protection blocking during an overexcitation condition that results from an increased V/Hz ratio.

Such an overexcitation condition from an increased V/Hz ratio, poses a danger to the protected transformer. A given transformer can tolerate an overfluxing condition for a limited time, as the danger is associated with thermal processes in the core. So instantaneous tripping of the transformer by the differential protection is not desirable.

The relay uses a traditional 5th harmonic ratio for inhibiting the differential function during overexcitation conditions.

OVEREX INHT LEVEL

Range: 1.0 to 40.0% in steps of 0.1

Default: 10.0%

This setting specifies the level of 5th harmonic during overexcitation (overfluxing) transformer conditions. When the 5th harmonic level exceeds the specified OVEREX INHT LEVEL setting (5th harmonic ratio) the differential element is blocked. The overexcitation inhibit works on a per-phase basis.

OUTPUT RELAY X

For details see [Common setpoints](#).

BLOCK 1/2/3

For details see [Common setpoints](#).

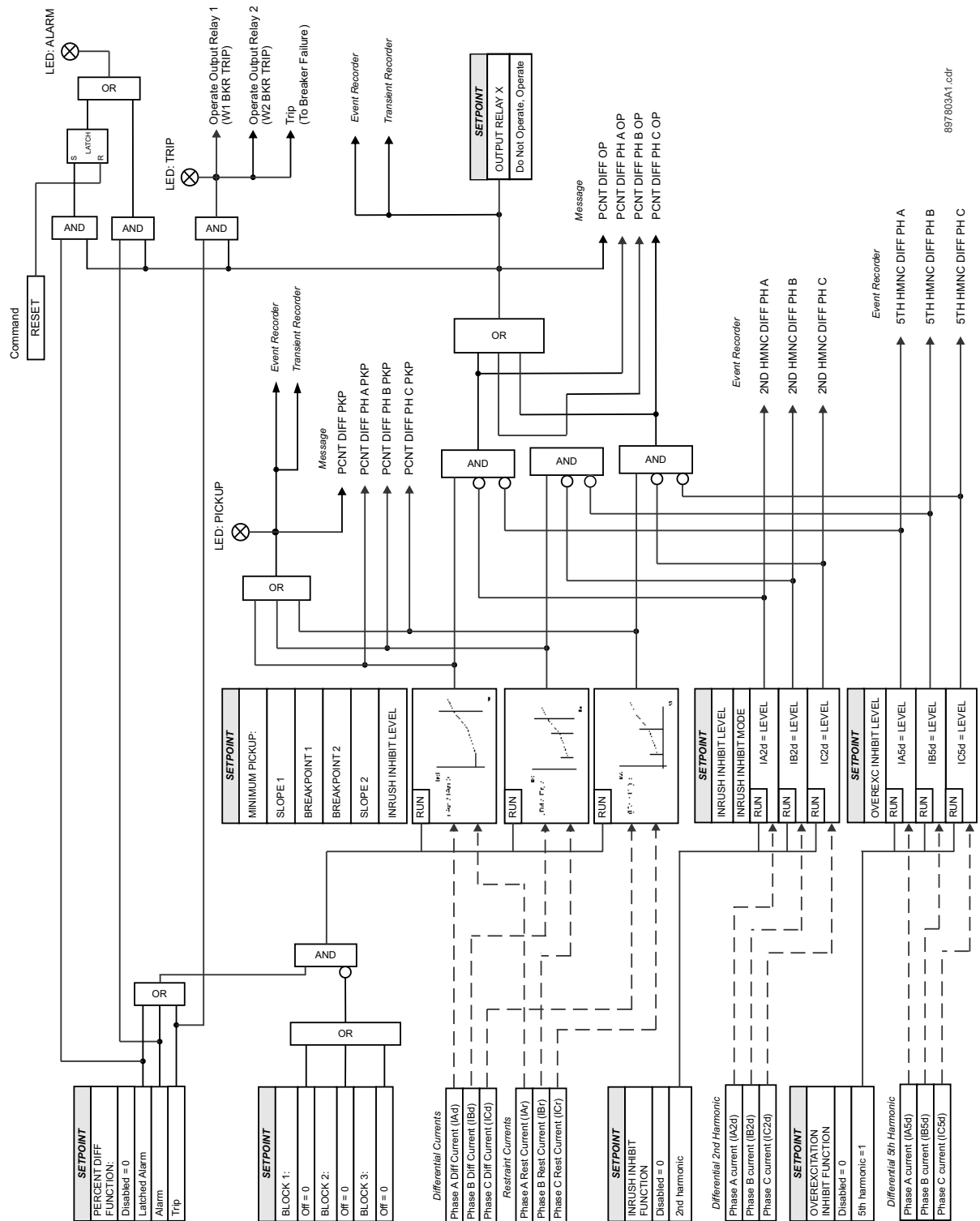


Figure 6-20: Percent Differential Protection logic diagram

Transformer instantaneous differential (50/87)

The 345 relay provides one Instantaneous Differential element per setpoint group. Instantaneous Differential protection is not biased protection and operates in a fashion similar to instantaneous overcurrent protection. Inputs to this protection are computed on the basis of the relay per-phase differential currents. Operation occurs if the value of any of the computed phase differential currents is above the instantaneous differential pickup setting.

Instantaneous Differential protection is usually set to operate during high-fault current situations, and if used, its pickup is set according to the following criteria:

- The pickup setting ($\times CT$) is selected to be higher than the maximum inrush current during transformer energization
- The pickup setting is set higher than the fault current for faults occurring outside the zone of protection
- The pickup setting is selected to be lower than the maximum fault current during internal fault conditions.

PATH: [SETPOINTS > S3 PROTECTION > S3 PROTECTION GROUP 1\(2\) > XFMR INST DIFF](#)

INST DIFF FUNCTION

Range: Disabled, Latched Alarm, Alarm, Trip

Default: Disabled

For details see [Common setpoints](#).

The output relays #1 "R1 TRIP" and #2 "R2 TRIP" will operate, when the **Trip** setting is selected, and the Instantaneous Differential protection is operational.

INST DIFF PICKUP

Range: 3.00 – 20.00 $\times CT$ in steps of 0.01 $\times CT$

Default: 8.00 $\times CT$

This setting defines the pickup level of the differential current required for operation.

OUTPUT RELAY X

For details see [Common setpoints](#).

INST DIFF BLOCK1/2/3

For details see [Common setpoints](#).

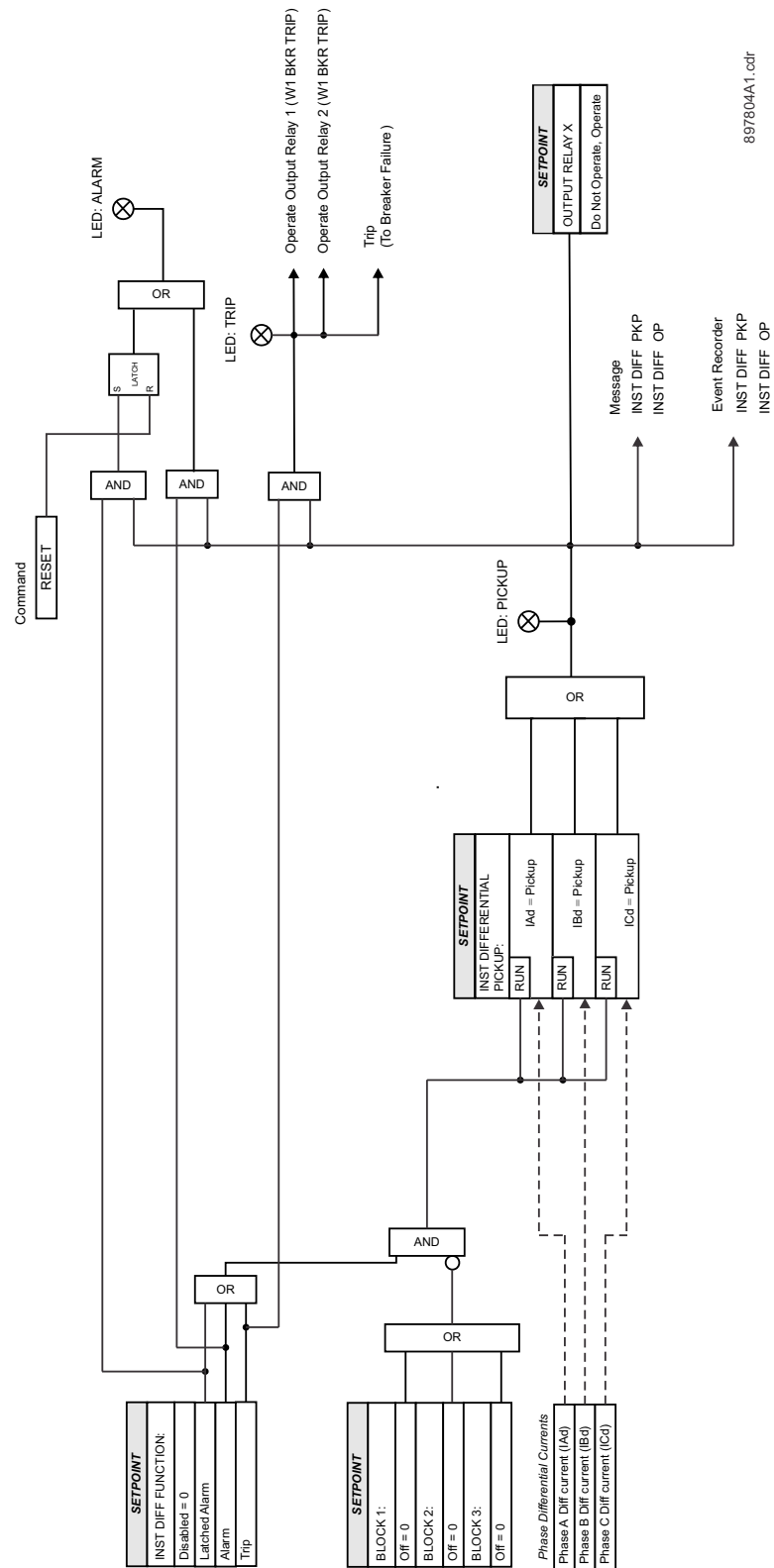


Figure 6-21: Instantaneous Differential Protection logic diagram

Restricted ground fault (87G or RGF)

Depending on the SR345 order code, the relay provides up to two Restricted Ground Fault elements per setpoint group; one per winding.

The Restricted Ground Fault (RGF) protection provides ground fault detection for low-magnitude ground fault currents primarily for ground faults closed to the neutral point of the wye connected winding. An internal ground fault on an impedance grounded wye winding will produce a low magnitude ground fault current depending on position of the fault with respect of the winding neutral point. See the diagrams below, expressing the dependence of the fault current with respect to the fault distance from the neutral point.

The resultant primary current can be negligible for ground winding faults within 30% distance from the neutral point since the fault voltage is not the system voltage, but rather the result of the transformation ratio between the primary windings and the percentage of shorted turns. Therefore, the resultant differential currents may be below the pickup and/or the slope setting of the main differential element, where the fault will go undetected. Application of the restricted ground fault protection extends the fault coverage towards the neutral point.

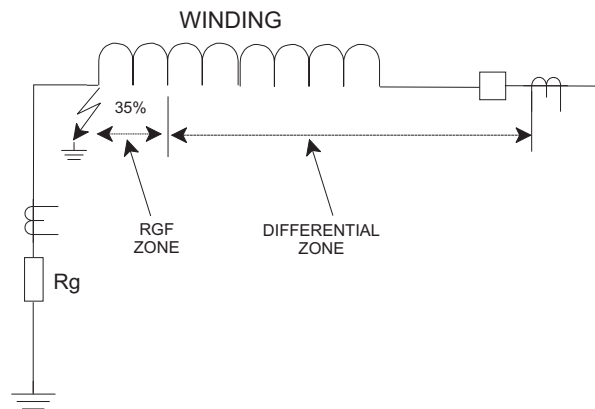


Figure 6-22: RGF and percent differential zones of protection

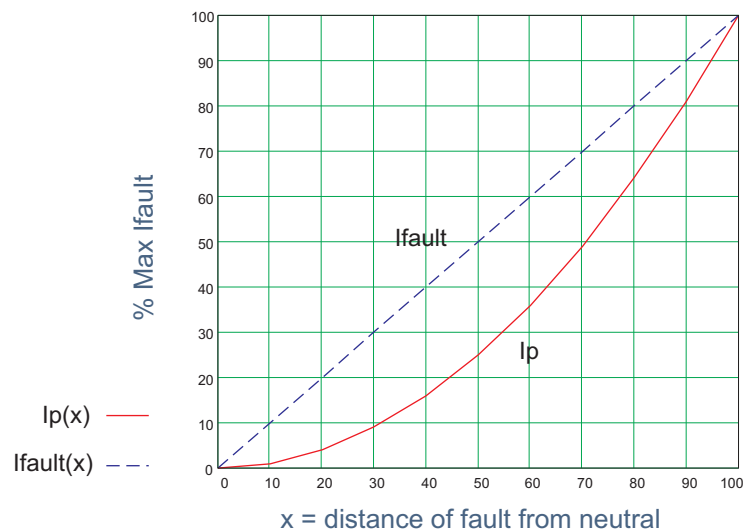
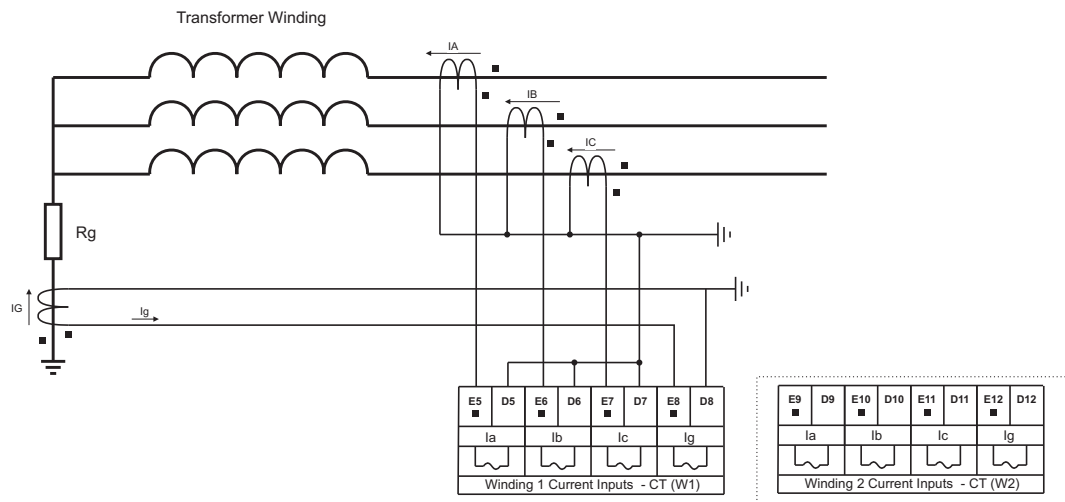


Figure 6-23: Fault currents vs points from neutral

The SR345 implementation of the restricted ground fault protection is a low impedance current differential scheme. The 345 calculates the magnitude of the ground differential current as a difference between the vectors of the computed residual current, and the measured ground current (i.e. $3I_0 - I_g$), and applies a restraining current defined as the maximum measured line current (I_{max}) to produce a percent slope value. The slope setting allows the user to determine the sensitivity of the element based on the class and quality of the CTs used.

The figure below shows the typical wiring between the winding CTs and the 345 CT terminals to assure the correct performance of the protection. The restricted earth fault protection is also available for delta windings with in-zone grounding transformer, or for Delta corner grounded windings.



The 345 RGF protection includes ground current supervision mechanism to provide more security during external non-ground faults associated with CT saturation, that may result into spurious neutral current, and may jeopardize the security of the RGF protection. When the GND CURRENT SUPERVISION setting is selected as "Enabled", the algorithm checks if the ground current measured by the relay satisfies the selected GND CURRENT SUPERVISION LEVEL, before making operation decision. The ground current supervision is not active if the GND CURRENT SUPERVISION is selected as "Disabled". The RGF protection works without the supervision as well.

PATH: SETPOINTS > S3 PROTECTION > S3 PROTECTION GROUP 1(2) > RESTRICTED GROUND FAULT 1(2)

RGF FUNCTION

Range: Disabled, Latched Alarm, Alarm, Trip

Default: Disabled

For details see [Common setpoints](#).

Output relays #1 "R1 TRIP" (and #2 "R2 TRIP") will operate only when the **Trip** setting is selected, and the Restricted Ground Fault protection is operational.

CT INPUTS

Range: CT (W1), CT(W2)

Default: CT (W1)

This setting defines the winding three-phase and ground currents used by the RGF function.

RGF PICKUP

Range: 0.02 to 20 × CT (W1) in steps of 0.01

Default: 0.10 × CT (W1)

This setting defines the minimum pickup level of the ground differential current required for operation. The pickup value is expressed in times phase CT primary rating.

RGF SLOPE

Range: 0 to 100% in steps of 1%

Default: 0%

This setting defines the slope as the ratio between the ground differential current and the maximum line current (ground restraining current) in percentages. The RGF element will operate if the actual ground differential/restraint ratio is greater than the slope and the ground differential current is greater than the RGF pickup setting. See the RGF Logic diagram.

RGF DELAY

Range: 0.00 to 600.00 S in steps of 0.01

Default: 0.30 s

The RGF pickup time delay setting defines the time required for the RGF element to operate after it has picked up. This time delay will override the spurious ground differential current condition caused by CT saturation due to external non-ground faults, or during transformer energization. Since RGF protection is intended to detect small ground fault currents, delayed clearance of such a fault is not a high concern. On the other hand delayed RGF operation due to a spurious ground differential current caused by an out-of-zone fault can be used as a backup for downstream protections should they fail to clear the fault.

GND CURRENT SPVSN

Range: Disabled, Enabled

Default: Disabled

This setting enables or disables the ground current supervision of the RGF function. If set to “Disabled”, the RGF function will work without ground current supervision. The ground current level is monitored if the setting is set to “Enabled”.

GND SUPV LEVEL

Range: 0.02 to 10.00 × CT_g (W1) in steps of 0.01

Default: 0.10 × CT_g (W1)

This setting defines the level of measured ground current above which operation of the RGF protection is allowed. The setting is presented in times ground CT primary. The measured ground current is compared to the setting only if the GND CURRENT SUPERVISION setting is set to “Enabled”.

OUTPUT RELAY 3 to 6

For details see [Common setpoints](#).

BLOCK 1/2/3

For details see [Common setpoints](#).

Example: Transformer: 5MVA, 13.8kV/4.16kV, D/Yg1 type

$R_g = 10$ ohms

Phase CTs: 800:5

Ground CT: 300:5

$I_{f_{gnd(max)}} = 4.16kV / (10 \text{ ohms} \times \sqrt{3}) = 240A$ - maximum ground fault current

To detect a ground fault on the Wye winding at 15% distance from the neutral point, the relay shall detect ground differential current of:

$I_{gd} = (15 \times 240) / 100 = 36 A / 800 = 0.045 \times CT$ – PKP setting for the RGF protection

The transformer loading will be almost unaffected for ground faults close to the winding neutral, so that the winding rated load can be used as a reference in defining the RGF slope setting. The rated load for 4.16kV Wye winding is:

$$I_{\text{rated}} = 5\text{MVA} / (4.16\text{kV} \cdot \sqrt{3}) = 693 \text{ A}$$

Slope setting, % = $(36 \text{ A} / 693\text{A}) \cdot 100 = 5.1 \%$. Select 5% if the transformer is expected to run most of the time at full load. If most of the time the transformer runs at lower than the nominal loads, the slope setting can be set to higher value:

@ 70% load the slope setting would be: $(36 / 485 \text{ A}) \cdot 100 = 7\%$

@ 50% load the slope setting would be: $(36 / 346 \text{ A}) \cdot 100 = 10\%$ \

@ 30% load the slope setting would be: $(36 / 208 \text{ A}) \cdot 100 = 17\%$

The ground current supervision feature and/or the RGF pickup time delay can be used if CT saturation due to heavy external faults, is a concern.

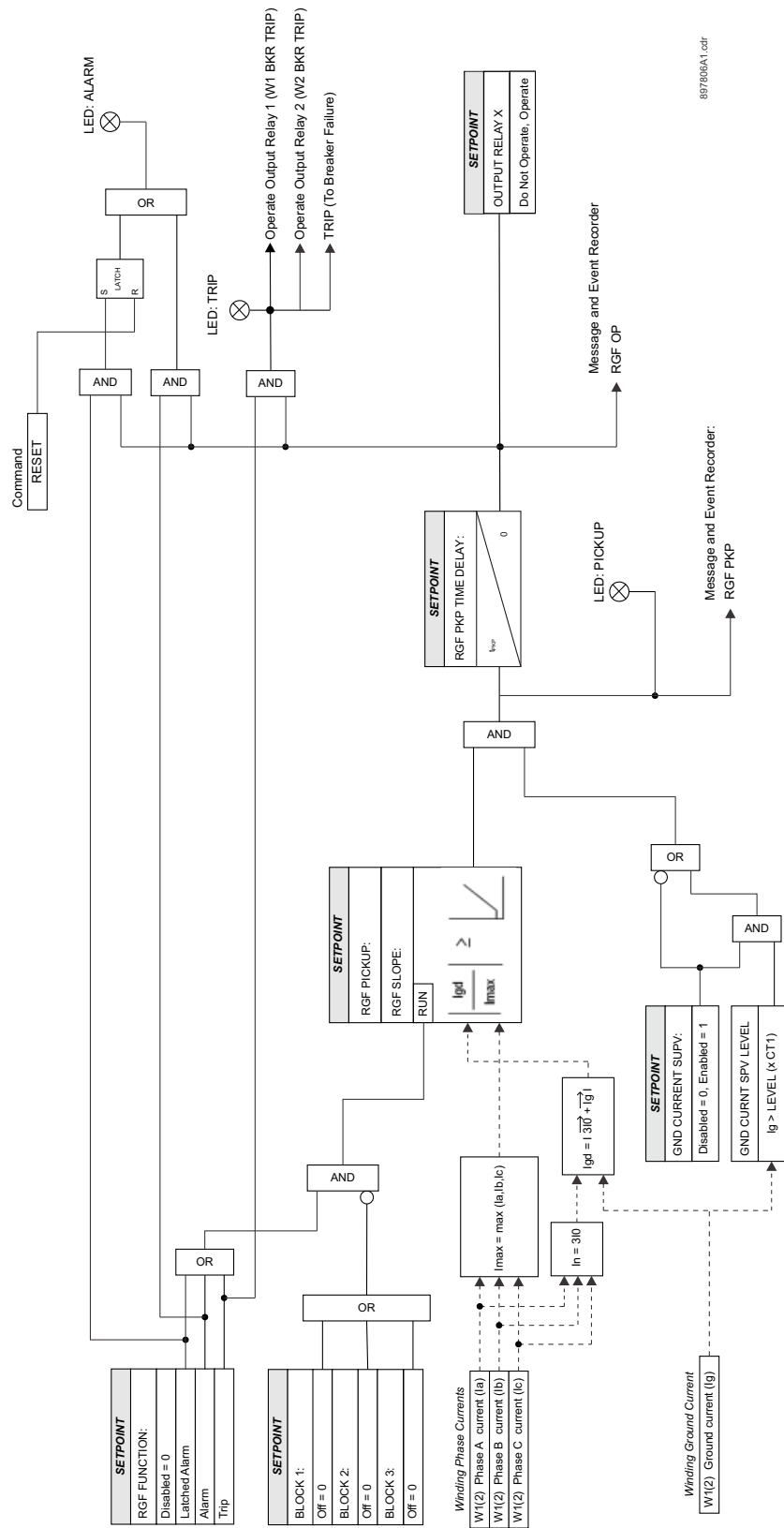


Figure 6-24: Restricted Ground Fault Protection logic diagram

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. 12

$$\theta(t) = \theta(t-1) + \frac{\Delta t}{\tau} \left(\left(\frac{I_{phase}}{I_{pickup}} \right)^2 - \theta(t-1) \right)$$

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. 13

$$T_{TRIP} = \tau \times \ln \left(\frac{\left(\frac{I_{phase}}{I_{pickup}} \right)^2 - \theta_0}{\left(\frac{I_{phase}}{I_{pickup}} \right)^2 - \theta} \right)$$

Where:

T_{TRIP} = Time to trip in seconds

θ_0 = Initial thermal capacity

$\theta = 1$ = Thermal capacity state 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. 14

$$T_{TRIP} = \tau \times \ln \left(\frac{(I_{phase} / I_{pickup})^2}{(I_{phase} / I_{pickup})^2 - \theta} \right)$$

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. 15

$$I_{pickup} = K * I_{base}$$

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, Trip, Latched Alarm, Alarm

Default: Disabled

The output relays #1 "TRIP W1 BKR" and #2 "TRIP W2 BKR" will operate only if the **Trip** function is selected, and the accumulated thermal capacity for any of the phases is over 100%. The "ALARM" LED will turn on if the thermal capacity for any phase is over the THERMAL OVLD ALARM setting, regardless of whether **Alarm**, **Latched Alarm** or **Trip** is selected as the function. The "ALARM" 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 the function, the "ALARM" LED will flash when the thermal capacity on any phase is over the THERMAL OVLD ALARM setting, and will stay on even after the thermal capacity for all phases drops below 97% of the THERMAL OVLD ALARM setting. The LED can be reset upon initiation of the "Reset" command.

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 $6.00 \times \tau_H$ in steps of $0.01 \times \tau_H$

Default: $2.00 \times \tau_H$

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".

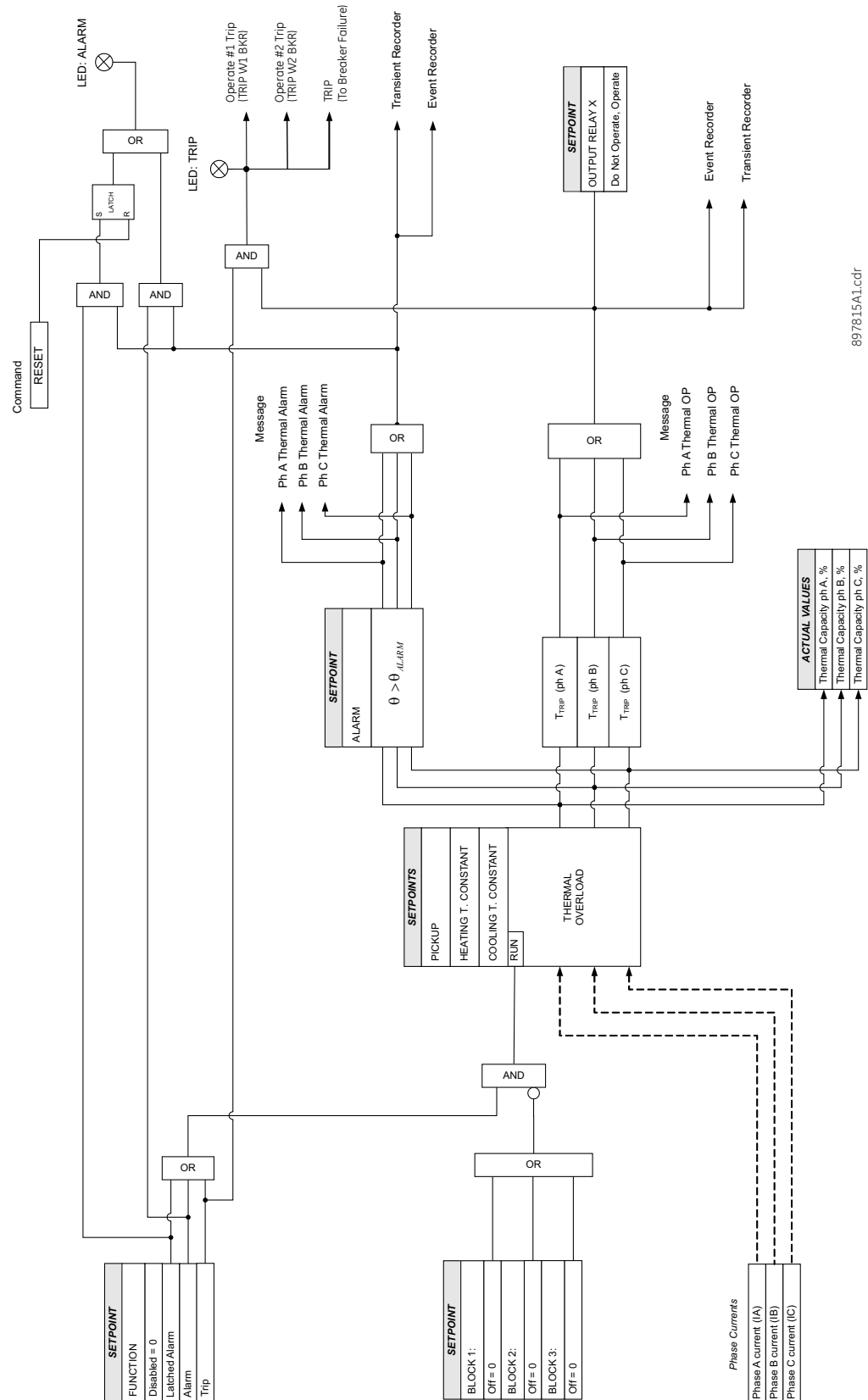


Figure 6-25: Thermal Overload protection logic diagram

Time overcurrent curves

The 345 relay has two setpoint groups. When ordering the relay the user can select each group to have two phase time overcurrent 51P(2), two ground time overcurrent 51G(2), two neutral time overcurrent 51N(2), and two negative sequence time overcurrent 51_2(2) elements. The programming of these elements is identical: PKP, Inverse Curve selection, and Time Dial Multiplier (TDM). The curve shape can be either a standard curve selected from a range of standard ANSI, IEC, IAC curves or Definite time.

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.



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 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)	
Normally Inverse	Inverse	Curve C (BS142)	
Moderately Inverse	Short Inverse	IEC Short Inverse	

- **<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 Time Overcurrent 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; C_R = characteristic constant (5 for ANSI, IAC, and Definite Time; 8 for IEC curves)

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:

$$T = M \times \left(A + \frac{B}{(I/I_{pu}) - C} + \frac{D}{((I/I_{pu}) - C)^2} + \frac{E}{((I/I_{pu}) - C)^3} \right) \quad \text{Eq. 16}$$

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

Table 6-5: 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 6-6: ANSI Curve Trip Times (in seconds)

Multiplier (TDM)	Current (I/I _{pickup})									
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
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

Multiplier (TDM)	Current (I/I _{pickup})									
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
4.0	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:

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

Eq. 17

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

Table 6-7: 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 6-8: IEC Curve Trip Times (in seconds)

Multiplier (TDM)	Current (I/I _{pickup})									
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
IEC Curve A										
0.05	0.860	0.501	0.315	0.249	0.214	0.192	0.176	0.165	0.156	0.149
0.10	1.719	1.003	0.630	0.498	0.428	0.384	0.353	0.330	0.312	0.297
0.20	3.439	2.006	1.260	0.996	0.856	0.767	0.706	0.659	0.623	0.594
0.40	6.878	4.012	2.521	1.992	1.712	1.535	1.411	1.319	1.247	1.188
0.60	10.317	6.017	3.781	2.988	2.568	2.302	2.117	1.978	1.870	1.782
0.80	13.755	8.023	5.042	3.984	3.424	3.070	2.822	2.637	2.493	2.376
1.00	17.194	10.029	6.302	4.980	4.280	3.837	3.528	3.297	3.116	2.971
IEC Curve B										
0.05	1.350	0.675	0.338	0.225	0.169	0.135	0.113	0.096	0.084	0.075
0.10	2.700	1.350	0.675	0.450	0.338	0.270	0.225	0.193	0.169	0.150
0.20	5.400	2.700	1.350	0.900	0.675	0.540	0.450	0.386	0.338	0.300
0.40	10.800	5.400	2.700	1.800	1.350	1.080	0.900	0.771	0.675	0.600
0.60	16.200	8.100	4.050	2.700	2.025	1.620	1.350	1.157	1.013	0.900
0.80	21.600	10.800	5.400	3.600	2.700	2.160	1.800	1.543	1.350	1.200
1.00	27.000	13.500	6.750	4.500	3.375	2.700	2.250	1.929	1.688	1.500
IEC Curve C										
0.05	3.200	1.333	0.500	0.267	0.167	0.114	0.083	0.063	0.050	0.040
0.10	6.400	2.667	1.000	0.533	0.333	0.229	0.167	0.127	0.100	0.081
0.20	12.800	5.333	2.000	1.067	0.667	0.457	0.333	0.254	0.200	0.162
0.40	25.600	10.667	4.000	2.133	1.333	0.914	0.667	0.508	0.400	0.323

Multiplier (TDM)	Current (I/I _{pickup})									
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
0.60	38.400	16.000	6.000	3.200	2.000	1.371	1.000	0.762	0.600	0.485
0.80	51.200	21.333	8.000	4.267	2.667	1.829	1.333	1.016	0.800	0.646
1.00	64.000	26.667	10.000	5.333	3.333	2.286	1.667	1.270	1.000	0.808
IEC Short Time										
0.05	0.153	0.089	0.056	0.044	0.038	0.034	0.031	0.029	0.027	0.026
0.10	0.306	0.178	0.111	0.088	0.075	0.067	0.062	0.058	0.054	0.052
0.20	0.612	0.356	0.223	0.175	0.150	0.135	0.124	0.115	0.109	0.104
0.40	1.223	0.711	0.445	0.351	0.301	0.269	0.247	0.231	0.218	0.207
0.60	1.835	1.067	0.668	0.526	0.451	0.404	0.371	0.346	0.327	0.311
0.80	2.446	1.423	0.890	0.702	0.602	0.538	0.494	0.461	0.435	0.415
1.00	3.058	1.778	1.113	0.877	0.752	0.673	0.618	0.576	0.544	0.518

IAC Curves

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

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

Eq. 18

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

Table 6-9: 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 6-10: 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

Multiplier (TDM)										
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
IAC Inverse										
0.5	0.578	0.375	0.266	0.221	0.196	0.180	0.168	0.160	0.154	0.148
1.0	1.155	0.749	0.532	0.443	0.392	0.360	0.337	0.320	0.307	0.297
2.0	2.310	1.499	1.064	0.885	0.784	0.719	0.674	0.640	0.614	0.594
4.0	4.621	2.997	2.128	1.770	1.569	1.439	1.348	1.280	1.229	1.188
6.0	6.931	4.496	3.192	2.656	2.353	2.158	2.022	1.921	1.843	1.781
8.0	9.242	5.995	4.256	3.541	3.138	2.878	2.695	2.561	2.457	2.375
10.0	11.552	7.494	5.320	4.426	3.922	3.597	3.369	3.201	3.072	2.969
IAC Short Inverse										
0.5	0.072	0.047	0.035	0.031	0.028	0.027	0.026	0.026	0.025	0.025
1.0	0.143	0.095	0.070	0.061	0.057	0.054	0.052	0.051	0.050	0.049
2.0	0.286	0.190	0.140	0.123	0.114	0.108	0.105	0.102	0.100	0.099
4.0	0.573	0.379	0.279	0.245	0.228	0.217	0.210	0.204	0.200	0.197
6.0	0.859	0.569	0.419	0.368	0.341	0.325	0.314	0.307	0.301	0.296
8.0	1.145	0.759	0.559	0.490	0.455	0.434	0.419	0.409	0.401	0.394
10.0	1.431	0.948	0.699	0.613	0.569	0.542	0.524	0.511	0.501	0.493

Phase timed overcurrent (51P)

The relay has two Phase Time Overcurrent elements per protection group. The settings of this function are applied to each of the three phases to produce phase overcurrent trip or pickup. There is no intentional “dead band” where the current is above the pickup level. However the pickup accuracy is guaranteed within the current input accuracy of 3% above the set PKP value. The TOC pickup flag is asserted when the current on any phase is above the PKP value. The TOC trip flag is asserted if the element stays picked up for the time defined by the selected inverse curve and the magnitude of the current. The element drops from pickup without operating if the measured current drops below 97-99% of the pickup value before the time for operation is reached. When Definite Time is selected, the time for TOC operation is defined only by the TDM setting. The selection of 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 $5 \times 0.1 = 0.5$ s applying the time delay accuracy outlined under the Technical Specification, and adding approximately 8 to 10 ms output relay time.

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 1\(2\)](#)

PH TOC1(2) FUNCTION

Range: Disabled, Latched Alarm, Alarm, Trip

Default: Disabled

For details see [Common setpoints](#).

The output relays #1 “R1 TRIP” (and #2 “R2 TRIP”) will operate when the **Trip** setting is selected, and the Phase TOC operates.

PHASE CT INPUTS*Range: CT(W1), CT(W2)**Default: CT(W1)*

The Phase Timed Overcurrent menu provides the selection of either CT(W1) input currents or CT(W2) currents. If CT(W1) is selected, the PH TOC element will use the ratings of the Winding 1 CTs entered on the relay under SYSTEM SETUP/S2 CURRENT SENSING. If the CT(W2) setting is selected, the relay will use the CT ratings associated with transformer Winding 2.

PH TOC1(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 time overcurrent pickup level, specified as times CT. For example, a PKP setting of 0.9 x CT with 300:5 CT translates into 270A primary current.

PH TOC1(2) CURVE*Range: ANSI Extremely/Very/Moderately/Normally Inverse, Definite Time, IEC Curve A/B/C and Short Inverse, IAC Extremely/Very/Inverse/Short**Default: Extremely Inverse*

This setting sets the shape of the selected inverse curve.

PHASE TOC1(2) TDM*Range: 0.50 to 50.00 in steps of 0.01**Default: 1.00*

This setting provides the 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 after pickup, of 2.59 seconds.

PH TOC 1(2) 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.

RLY1 TRIP W1 BKR and RLY2 TRIP W2 BKR*Range: Do not operate, Operate**Default: Do not operate*

The menu for the two trip output relays - RLY1 TRIP W1 BKR and RLY2 TRIP W2 BKR - is available only if the **Trip** setting is selected as the function for the Phase Timed Overcurrent element. One or both trip output relays can be selected to operate upon Phase TOC operation.



The "RLY1 TRIP W1 BKR" and "RLY2 TRIP W2 BKR" setpoints will be displayed on the OC menu regardless of the selected OC function. These output relays will not operate if either **Alarm** or **Latched Alarm** is selected as an OC function, regardless of the Operate/Do Not Operate value selected. The output relays are operational only if the OC function is selected as **Trip**.

OUTPUT RELAY X

For details see [Common setpoints](#).

BLOCK 1/2/3

For details see [Common setpoints](#).

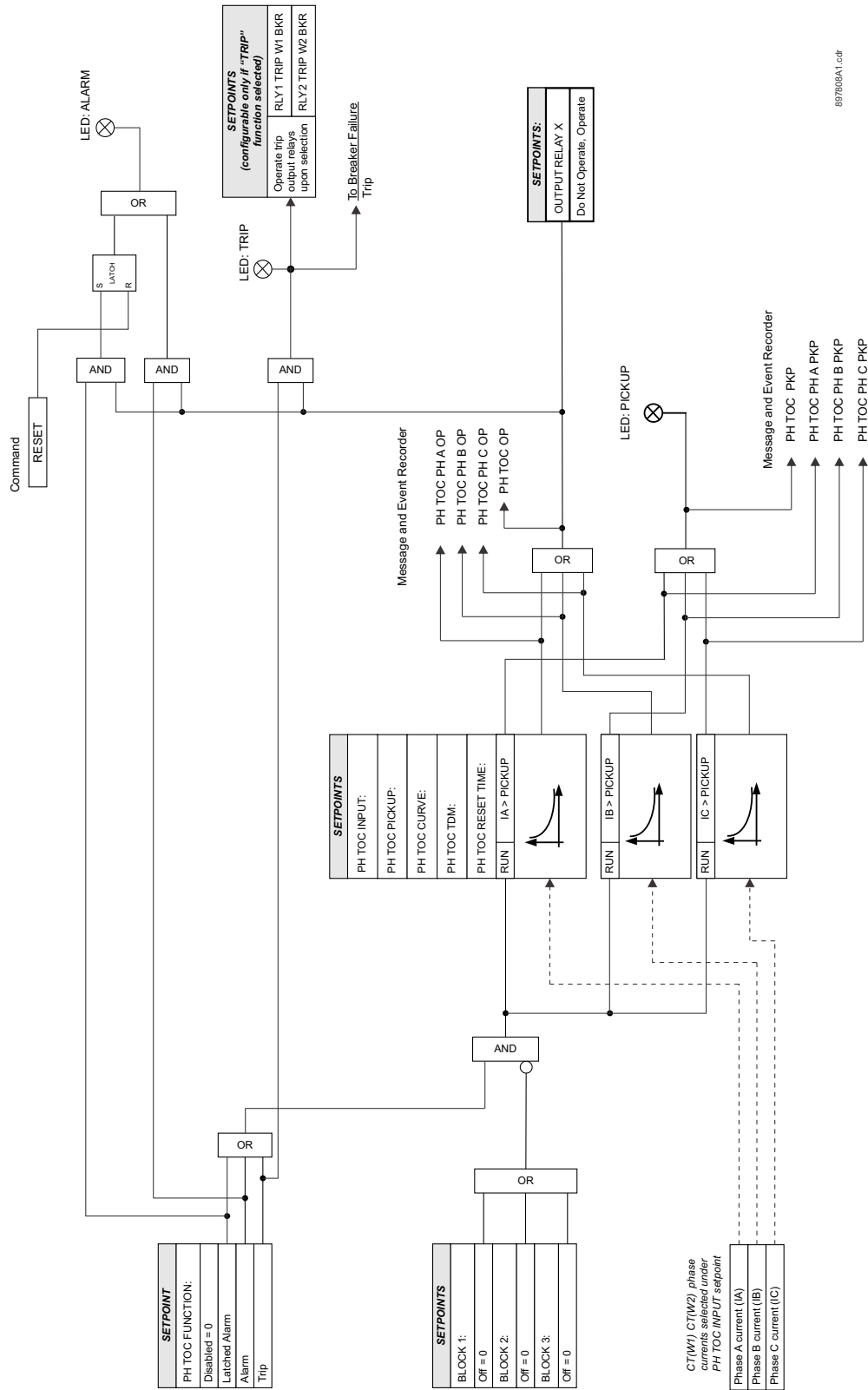


Figure 6-26: Phase time overcurrent protection logic diagram

Phase instantaneous overcurrent (50P)

The 345 relay has two identical instantaneous overcurrent protections - Phase IOC1, and Phase IOC2 per protection group. Each of them consists of three separate instantaneous overcurrent relays; 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 > S3 SETPOINT GROUP 1\(2\) > S3 PHASE IOC1\(2\)](#)

PH IOC1(2) FUNCTION

Range: Disabled, Latched Alarm, Alarm, Trip

Default: Disabled

For details see [Common setpoints](#).

PH CT INPUTS

Range: CT(W1), CT(W2)

Default: CT(W1)

The Phase Instantaneous Overcurrent menu provides a selection for either CT(W1) input currents or CT(W2) currents. If CT(W1) is selected, the PH IOC element will use the ratings of the Winding 1 CTs entered on the relay under SYSTEM SETUP/S2 CURRENT SENSING. If the CT(W2) setting is selected, the relay will use the CT ratings associated with transformer Winding 2.

PH IOC1(2) PKP

Range: 0.05 to 20.00 $\times$ CT in steps of 0.01 $\times$ CT

Default: 1.00 $\times$ CT

This setting sets the instantaneous overcurrent pickup level. For example, a PKP setting of 0.9 $\times$ 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 delay used to delay the protection operation.

RLY1 TRIP W1 BKR and RLY2 TRIP W2 BKR

Range: Do not operate, Operate

Default: Do not operate

The menu for the two trip output relays - RLY1 TRIP W1 BKR and RLY2 TRIP W2 BKR - is available only if the **Trip** setting is selected as the function for the Phase Instantaneous Overcurrent element. One or both trip output relays can be selected to operate upon Phase IOC operation.



The "RLY1 TRIP W1 BKR" and "RLY2 TRIP W2 BKR" setpoints will be displayed on the OC menu regardless of the selected OC function. These output relays will not operate if either **Alarm** or **Latched Alarm** is selected as an OC function, regardless of the Operate/Do Not Operate value selected. The output relays are operational only if the OC function is selected as **Trip**.

OUTPUT RELAY X

For details see [Common setpoints](#).

BLOCK 1/2/3

For details see [Common setpoints](#).

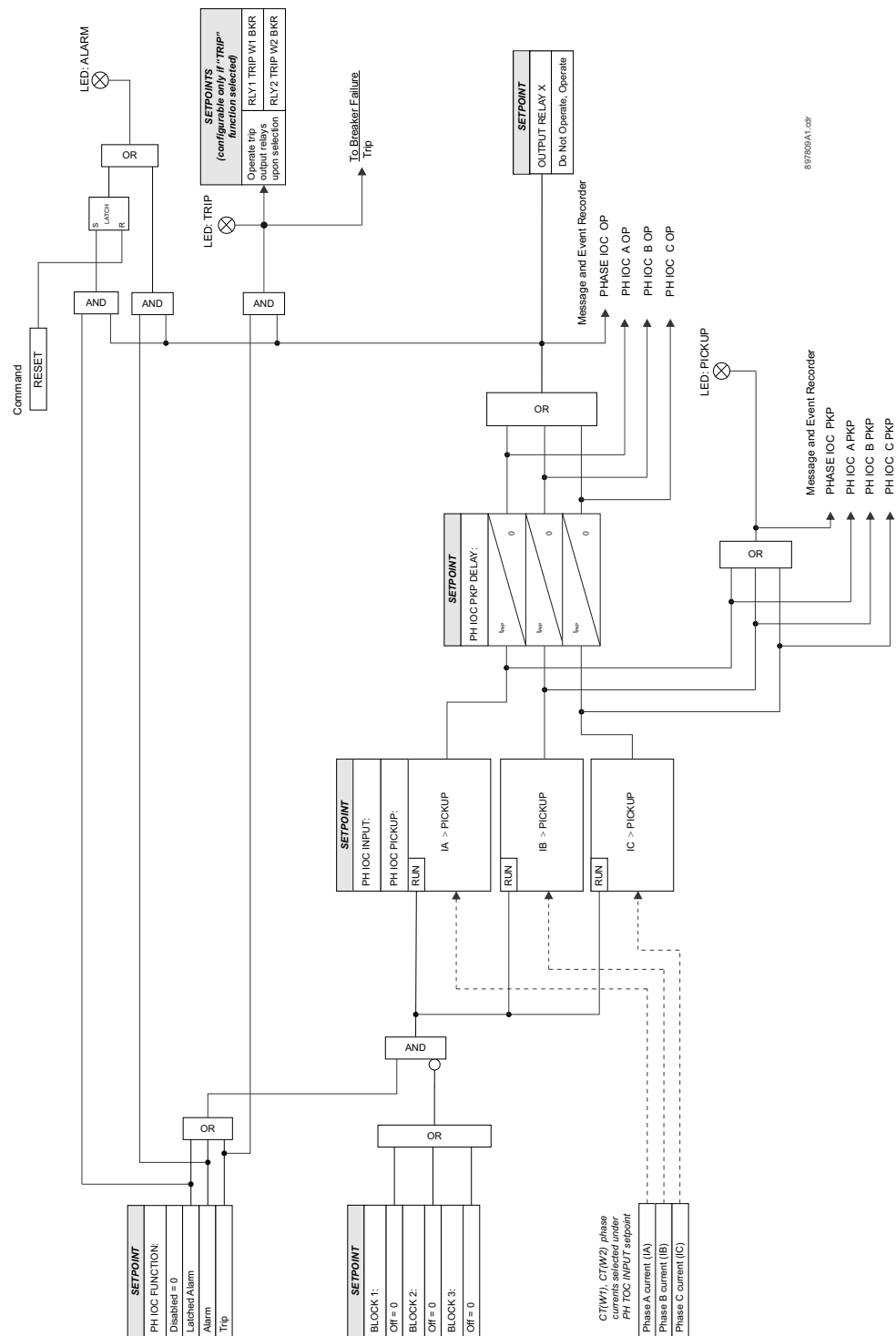


Figure 6-27: Phase Instantaneous Overcurrent Protection logic diagram

Ground timed overcurrent (51G/SG)

The relay has two Ground Time Overcurrent elements per setpoint group. The settings of the function are applied to the measured winding ground input current to produce pickup and trip flags. The Ground TOC pickup flag is asserted, when the ground current is above the PKP value. The Ground TOC trip flag is asserted if the element stays picked-up for the time defined by the selected inverse curve and the magnitude of the current. The element drops from pickup without operation if the measured current drops below 97-99% of the pickup value, before the time for operation is reached. When Definite Time is selected, the time for Ground TOC operation is defined only by the TDM setting. The Definite Time selection has a default time of 0.1s.

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



The settings from the menu for Sensitive Ground TOC, will appear only when the relay is ordered with the sensitive ground CT. Otherwise, the relay displays the menu for Ground TOC protection.

GND TOC1(2) FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm

Default: Disabled

For details see [Common setpoints](#).

If the **Trip** setting is selected, the TOC menu allows the user to select the operation of either RLY1 TRIP W1 BKR, "RLY2 TRIP W2 BKR", or both trip output relays.

GND CT INPUTS

Range: CT(W1), CT(W2)

Default: CT(W1)

The Ground Timed Over-Current menu provides for the selection for either ground CT of winding 1 - CT(W1), or ground CT of winding 2 - CT(W2), input. If CT(W1) is selected, the GND TOC element will use the ground CT rating of Winding 1 entered on the relay under SYSTEM SETUP/S2 CURRENT SENSING. If CT(W2) setting is selected, the relay will use the ground CT rating associated with transformer Winding 2.

GND TOC1(2) PKP

Range: 0.05 to 20.00 x CT in steps of 0.01 x CT

Default: 1.00 x CT

SENS.GND TOC1(2) PKP

Range: 0.05 to 20.00 x CT in steps of 0.001 x CT

Default: 1.000 x CT

This setting sets the Time Overcurrent pickup level specified in times CT. For example, a PKP setting of 0.9 x CT with 300:5 CT translates into 270A primary current. If the relay is ordered with a Sensitive Ground CT, the range for this setting is 0.005 to 3.000 x CT, with a step of 0.001xCT, and a default value of 1.000 x CT.

GND TOC1(2) CURVE

Range: ANSI Extremely/Very/Moderately/Normally Inverse, Definite Time IEC Curve A/B/C and Short Inverse IAC

Default: Extremely Inverse

This setting sets the shape of the selected overcurrent inverse curve.

GND TOC1(2) TDM*Range: 0.05 to 50.00 in steps of 0.01**Default: 1.00*

This setting provides the selection of the Time Dial Multiplier, using 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 greater than the PKP level, the operation of the element will not occur before 2.59s has elapsed from the time of pickup.

GND TOC1(2) RESET*Range: Instantaneous, Linear**Default: Instantaneous*

This setting provides for the selection of either an Instantaneous or a Linear reset time. If Instantaneous reset is selected, the ground TOC element will reset instantaneously providing the current drops below 97-98% below the Ground 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:

$$T_{RESET} = E.M.C_R \quad \text{Eq. 19}$$

where:

T_{RESET} - reset time in seconds;

E - energy capacity reached (per unit);

M - curve multiplier;

C_R - characteristic constant (5 for ANSI, IAC, and Definite Time; 8 for IEC curves).

RLY1 TRIP W1 BKR and RLY2 TRIP W2 BKR*Range: Do not operate, Operate**Default: Do not operate*

The menu for the two trip output relays - RLY1 TRIP W1 BKR and RLY2 TRIP W2 BKR - is only available if the **Trip** setting is selected as a function for the Ground TOC element. Either one, or both trip output relays can be selected to operate upon Ground TOC operation.

**NOTE**

The "RLY1 TRIP W1 BKR" and "RLY2 TRIP W2 BKR" setpoints will be displayed on the OC menu regardless of the selected OC function. These output relays will not operate if either **Alarm** or **Latched Alarm** is selected as an OC function, regardless of the Operate/Do Not Operate value selected. The output relays are operational only if the OC function is selected as **Trip**.

OUTPUT RELAY X

For details see [Common setpoints](#).

BLOCK 1/2/3

For details see [Common setpoints](#).

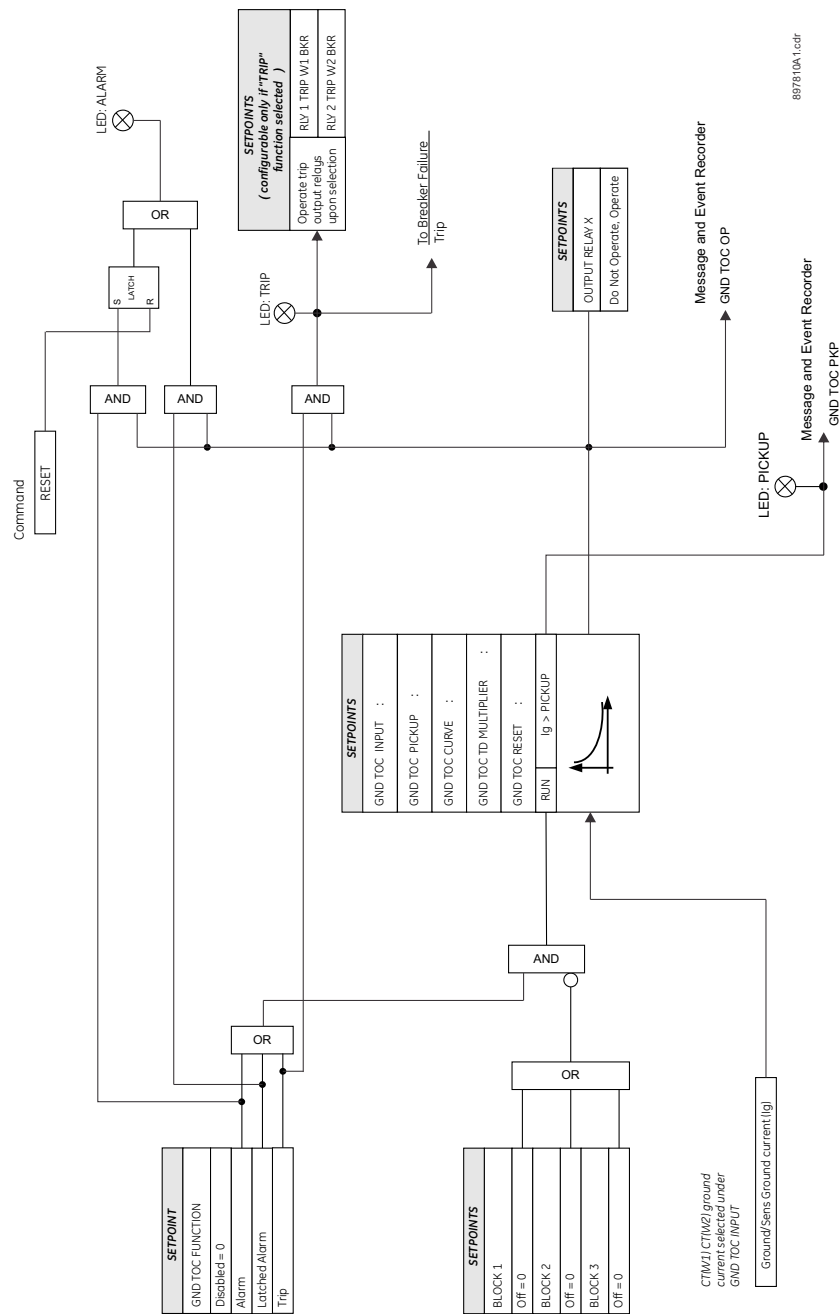


Figure 6-28: Ground/Sensitive Ground Timed Overcurrent Protection logic diagram

Ground instantaneous overcurrent (50G/SG)

The relay has two Ground/Sensitive Ground Instantaneous Overcurrent protections per setpoint group. The settings of these functions are applied to the measured ground, or sensitive ground current for producing pickup and trip flags. The Ground IOC pickup flag is asserted when the ground current is above the PKP value. The Ground IOC operate flag is asserted if the element stays picked up for the time defined by the Ground IOC PKP Delay setting. If the pickup time delay is set to 0.00 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 to 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 IOC1(2) FUNCTION

Range: Disabled, Trip, Alarm, Latched Alarm

Default: Disabled

For details see [Common setpoints](#).

If the **Trip** setting is selected, the IOC menu allows the user to select the operation of either one of the two trip output relays "RLY1 TRIP W1 BKR", "RLY2 TRIP W2 BKR", or both.

GND CT INPUTS

Range: CT(W1), CT(W2)

Default: CT(W1)

The Ground Instantaneous Overcurrent menu provides for selection of either the ground CT of Winding 1-CT(W1), or the ground CT of Winding 2- CT(W2) input. If CT(W1) is selected, the GND IOC element will use the ground CT rating of Winding 1 entered on the relay under SYSTEM SETUP/S2 CURRENT SENSING. If CT(W2) setting is selected, the relay will use the ground CT rating associated with transformer Winding 2.

GND IOC1(2) PKP

Range: 0.05 to 20.00 x CT in steps of 0.01 x CT

Default: 1.00 x CT

SENS.GND IOC1(2) PKP

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

Default: 1.000 x CT

This setting sets the ground overcurrent pickup level specified as times CT. For example, a PKP setting of 0.9 x CT with 300:5 CT translates into 270A primary current. For Sens. Ground CT, the range of the setting is from 0.005 to 3.000 x CT, with a step of 0.001 x CT, and a default value of 1.000 x CT.

GND IOC1(2) DELAY

Range: 0.00 to 300.00 sec in steps of 0.01 sec

Default: 0.00 sec

This setting provides the selection of the pickup time delay used to delay operation of the protection.

RLY1 TRIP W1 BKR and RLY2 TRIP W2 BKR

Range: Do Not Operate, Operate

Default: Do Not Operate

The menu for the two trip output relays - RLY1 TRIP W1 BKR and RLY2 TRIP W2 BKR - is available only if the **Trip** setting is selected as a function for the Ground IOC element. One or both trip output relays can be selected to operate under the operating condition.



The "RLY1 TRIP W1 BKR" and "RLY2 TRIP W2 BKR" setpoints will be displayed on the OC menu regardless of the selected OC function. These output relays will not operate if either **Alarm** or **Latched Alarm** is selected as an OC function, regardless of the Operate/Do Not Operate value selected. The output relays are operational only if the OC function is selected as **Trip**.

OUTPUT RELAY X

For details see [Common setpoints](#).

BLOCK 1/2/3

For details see [Common setpoints](#).

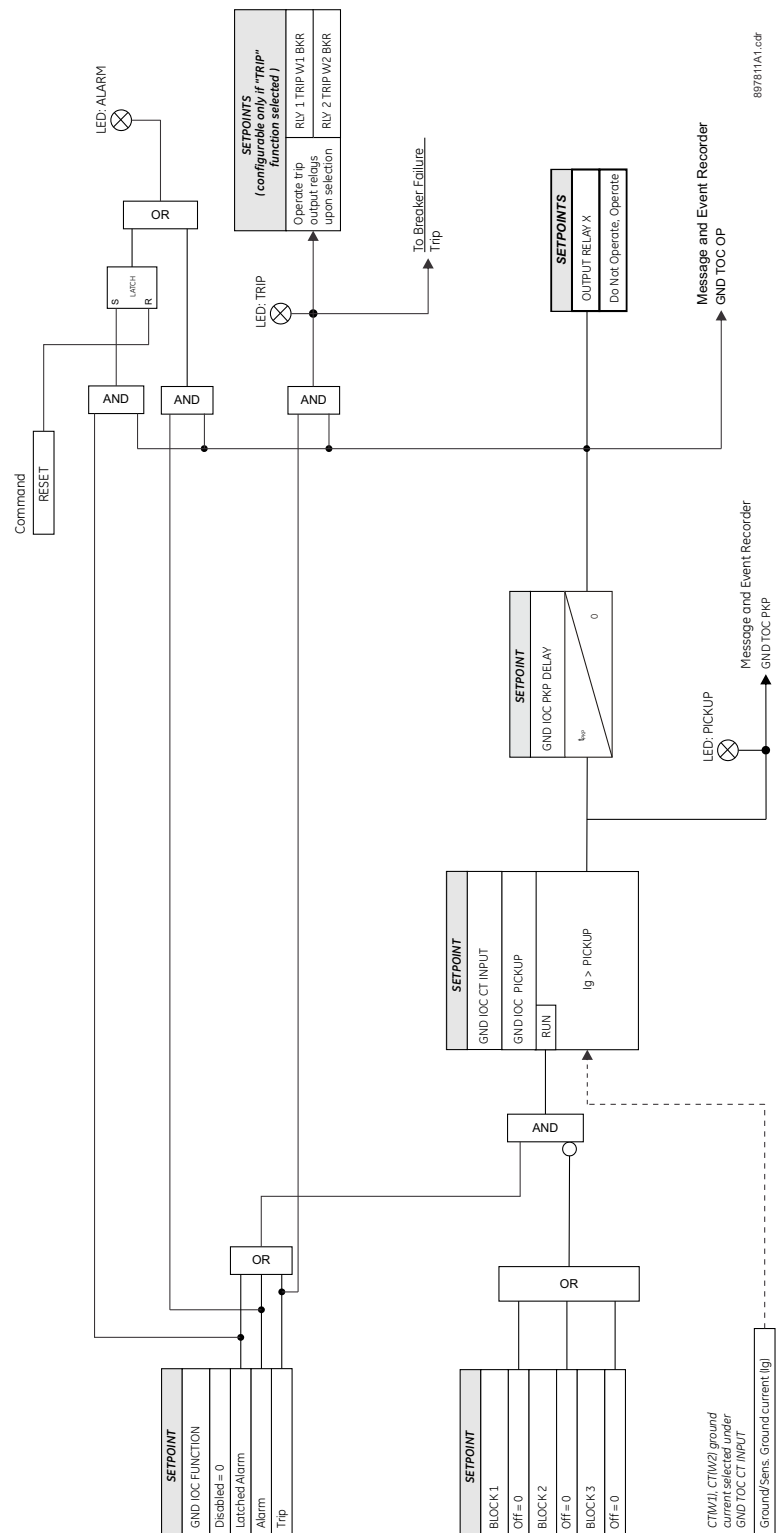


Figure 6-29: Ground/Sensitive Ground Instantaneous Overcurrent Protection logic diagram

Neutral timed overcurrent (51N)

The relay has two Neutral Time Overcurrent elements 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 trip flag is asserted if the element stays picked up for the time defined by the selected inverse curve and the magnitude of the current. The element drops from pickup without operating if the neutral current drops below 97-99% of the pickup value, before the time for operation is reached. When Definite Time is selected, the time for Neutral TOC operation is defined only by the TDM setting.

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) > S3 NEUTRAL TOC1(2)

NTRL TOC1(2) FUNCTION

Range: Disabled, Latched Alarm, Alarm, Trip

Default: Disabled

For details see [Common setpoints](#).

If the **Trip** setting is selected, the IOC menu allows the user to select the operation of either one of the two trip output relays "RLY1 TRIP W1 BKR", "RLY2 TRIP W2 BKR", or both.

NTRL CT INPUTS

Range: CT(W1), CT(W2)

Default: CT(W1)

The menu of the Neutral Time OverCurrent element provides for selection of either CT (W1), or CT(W2) input currents. If CT(W1) is selected, the NTRL TOC element will use the neutral current computed by the relay based on Winding 1 phase currents and the Winding 1 CT ratings. If CT(W2) setting is selected, the NTRL TOC element will use the computed neutral current from Winding 2 phase currents and Winding 2 CT ratings.

NTRL TOC1(2) PKP

Range: 0.05 to 20.00 $\times$ CT in steps of 0.01 $\times$ CT

Default: 1.00 $\times$ CT

This setting sets the time overcurrent pickup level specified as times CT. For example, a PKP setting of 0.9 $\times$ CT(W1) with CT(W1) rating of 300:5 translates into 270A primary current.

NTRL TOC1(2) CURVE

Range: ANSI Extremely/Very/Moderately/Normally Inverse Definite Time IEC Curve A/B/C and Short Inverse IAC Extremely/Very/Inverse/Short

Default: Extremely Inverse

This setting sets the shape of the selected overcurrent inverse curve.

NTRL TOC1(2) TDM

Range: 0.05 to 50.00 in steps of 0.01

Default: 1.00

This setting provides for selection of the 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 2.59s have elapsed from pickup.

NTRL TOC1(2) 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.

RLY1 TRIP W1 BKR and RLY2 TRIP W2 BKR

Range: Do Not Operate, Operate

Default: Do Not Operate

The menu for the two trip output relays - RLY1 TRIP W1 BKR and RLY2 TRIP W2 BKR - is available only if the **Trip** setting is selected as a function for the Neutral Timed Overcurrent element. One or both trip output relays can be selected to operate upon Neutral TOC operation.



The "RLY1 TRIP W1 BKR" and "RLY2 TRIP W2 BKR" setpoints will be displayed on the OC menu regardless of the selected OC function. These output relays will not operate if either **Alarm** or **Latched Alarm** is selected as an OC function, regardless of the Operate/Do Not Operate value selected. The output relays are operational only if the OC function is selected as **Trip**.

OUTPUT RELAY X

For details see [Common setpoints](#).

BLOCK 1/2/3

For details see [Common setpoints](#).

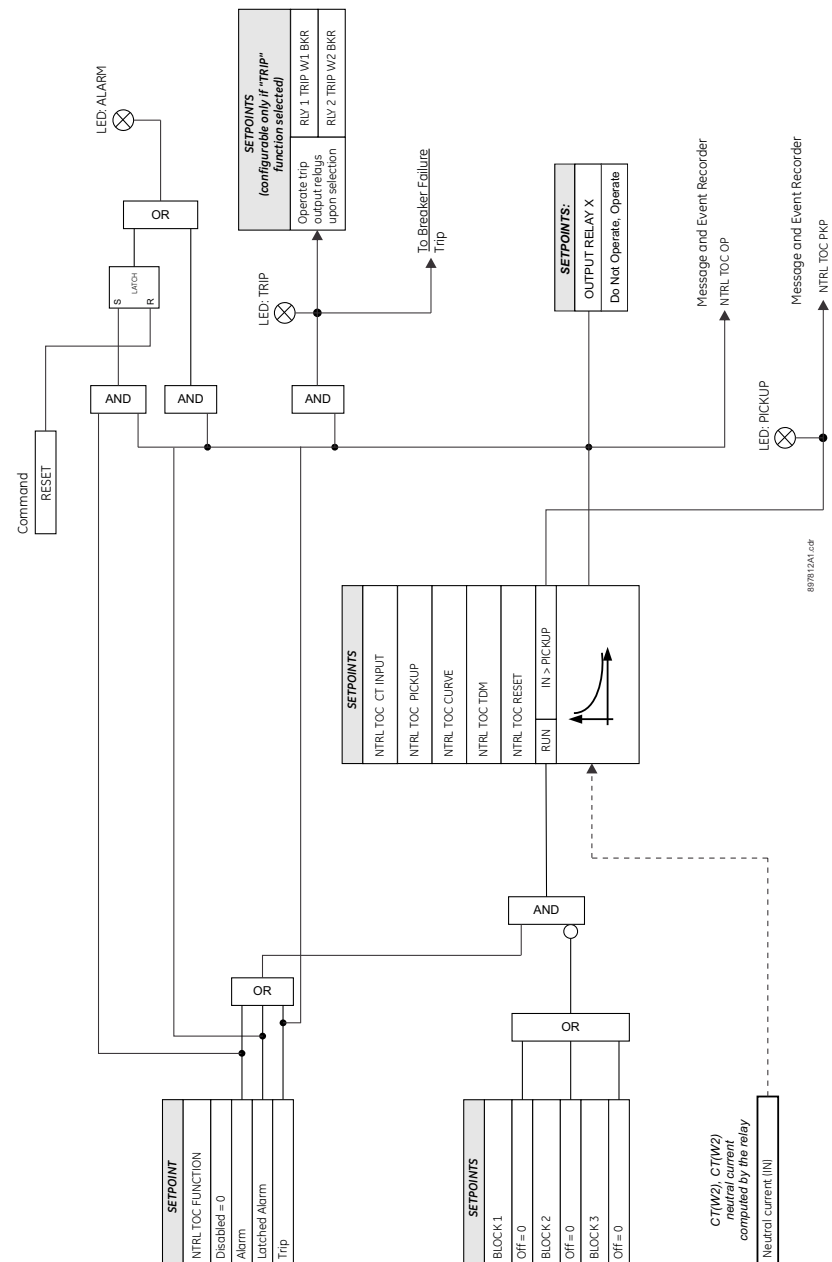


Figure 6-30: Neutral Timed Overcurrent Protection logic diagram

Neutral instantaneous overcurrent (50N)

The relay has two Instantaneous Overcurrent elements per setpoint group. The settings of this function are applied to the calculated neutral current to produce pickup and trip flags. The Neutral IOC pickup flag is asserted when the neutral current is above the PKP value. The Neutral IOC operate flag is asserted if the element stays picked up for the time defined by the Neutral IOC 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. 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 \(2\) > S3 NEUTRAL IOC1\(2\)](#)

NTRL IOC1(2) FUNCTION

Range: Disabled, Latched Alarm, Alarm, Trip

Default: Disabled

For details see [Common setpoints](#).

If the **Trip** setting is selected, the IOC menu allows the user to select the operation of either one of the two trip output relays "RLY1 TRIP W1 BKR", "RLY2 TRIP W2 BKR", or both.

NTRL CT INPUTS

Range: CT(W1), CT(W2)

Default: CT(W1)

The Neutral Overcurrent menu provides selection for either CT (W1), or CT(W2) phase inputs. If CT(W1) is selected, the NTRL IOC element will use the neutral current computed by the relay based on Winding 1 phase currents and the Winding 1 CT ratings. If CT(W2) setting is selected, the relay will use the computed neutral current based on Winding 2 phase currents and Winding 2 CT ratings.

NTRL 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 neutral instantaneous overcurrent pickup level specified in times CT.

NTRL IOC1(2) DELAY

Range: 0.00 to 300.00 sec in steps of 0.01 sec

Default: 0.00 sec

This setting provides for selection of the pickup time delay used to delay the operation of the protection.

RLY1 TRIP W1 BKR and RLY2 TRIP W2 BKR

Range: Do Not Operate, Operate

Default: Do Not Operate

The menu for the two trip output relays - RLY1 TRIP W1 BKR and RLY2 TRIP W2 BKR - is available only if the **Trip** setting is selected as a function for the Neutral IOC element. One or both trip output relays can be selected to operate upon Neutral IOC operation.



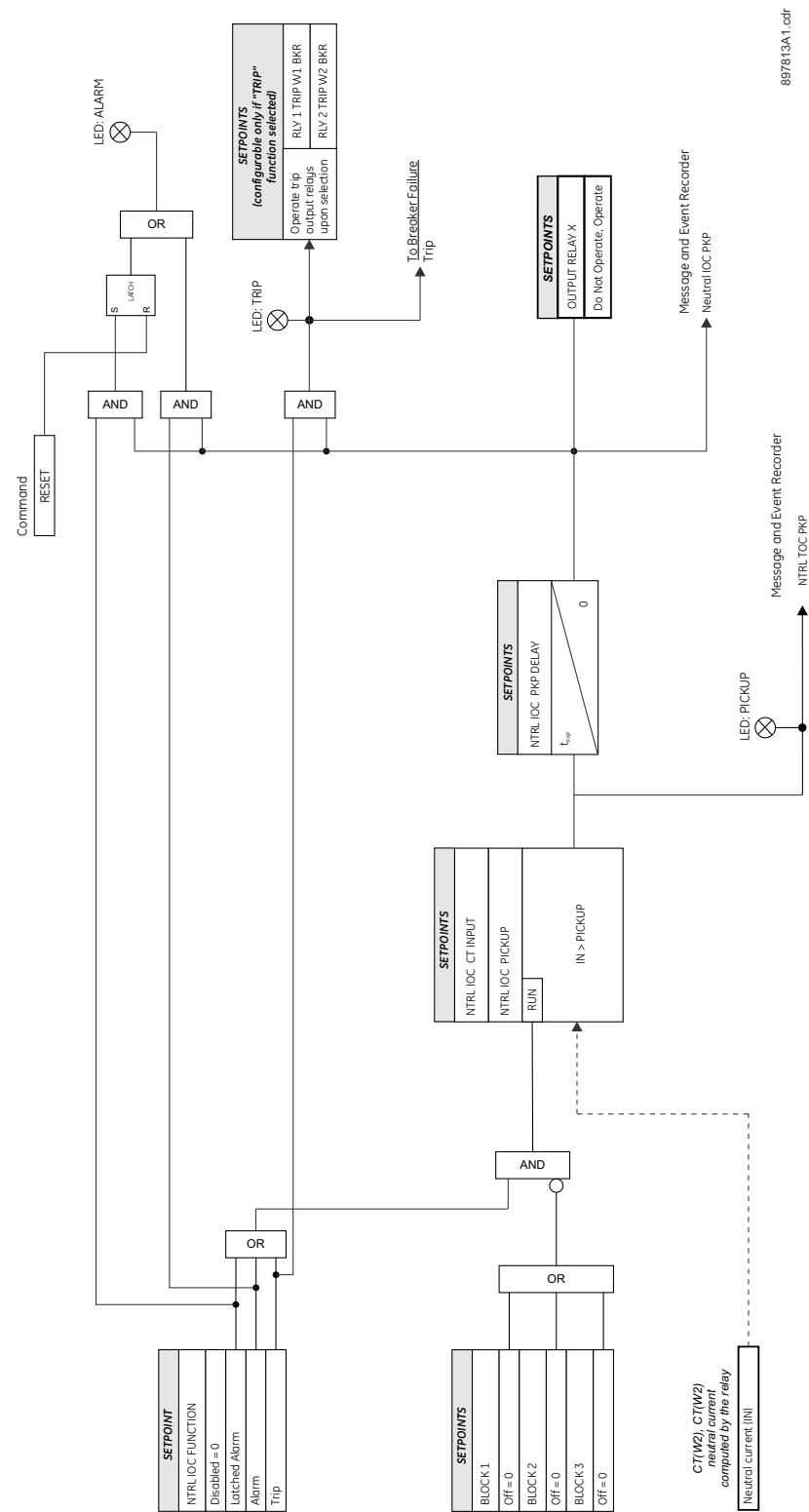
The "RLY1 TRIP W1 BKR" and "RLY2 TRIP W2 BKR" setpoints will be displayed on the OC menu regardless of the selected OC function. These output relays will not operate if either **Alarm** or **Latched Alarm** is selected as an OC function, regardless of the Operate/Do Not Operate value selected. The output relays are operational only if the OC function is selected as **Trip**.

OUTPUT RELAY X

For details see [Common setpoints](#).

BLOCK 1/2/3

For details see [Common setpoints](#).



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Figure 6-31: Neutral Instantaneous Overcurrent Protection logic diagram

Negative sequence timed overcurrent (51_2)

The SR3 relay has two Negative Sequence Overcurrent elements per setpoint group. The negative sequence overcurrent protection responds to negative sequence $|I_2|$ current, where it is calculated as .

$$|I_2| = \frac{1}{3} \cdot |I_A + I_B \cdot (1\angle 240) + I_C \cdot (1\angle 120)|$$

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 $5 \times 0.1 = 0.5s$.

PATH: [SETPOINTS > S3 PROTECTION > SETPOINT GROUP 1\(2\) > NEG SEQ TOC1\(2\)](#)

NEG SEQ TOC1(2) FUNC

Range: Disabled, Latched Alarm, Alarm, Trip

Default: Disabled

For details see [Common setpoints](#).

If the Trip setting is selected, the IOC menu allows the user to select the operation of either one of the two trip output relays "RLY1 TRIP W1 BKR", "RLY2 TRIP W2 BKR", or both.

PHASE CT INPUTS

Range: CT(W1), CT(W2)

Default: CT(W1)

The Negative Sequence TOC menu provides selection for either CT(W1) input currents or CT(W2) currents. If CT(W1) is selected, the NEG SEQ TOC element will use CT ratings associated with transformer winding 1. If the CT(W2) setting is selected, the relay will use the CT ratings associated with transformer winding 2.

NEG SEQ TOC1(2) PKP

Range: 0.05 to $20.00 \times CT$ in steps of $0.01 \times CT$

Default: $1.00 \times CT$

This setting defines the negative sequence TOC pickup level associated with the ratings of the CTs selected under NEG SEQ CT INPUT.

For example if $CT(W1) = 100:5$, and the $CT(W2) = 500:5$, a pickup of $0.5 \times CT$ with NEG SEQ CT INPUT = CT(W1) will be equivalent to a pickup of $0.5 \times 100 = 50$ Amps negative sequence current. The same pickup setting with NEG SEQ CT INPUT selected as CT(W2) will lead to a pickup threshold of 250 Amps neg. sequence current

NEG SEQ TOC1(2) CURVE

Range: - ANSI Extremely/Very/Moderately/Normally Inverse- Definite Time- IEC Curve A/ B/C and Short Inverse- IAC Extremely/Very/Inverse/Short

Default: Ext Inverse

This setting defines the shape of the selected overcurrent inverse curve.

NEG SEQ TOC1(2) 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 TOC1(2) 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:

$$T_{RESET} = E.M.C_R \quad \text{Eq. 20}$$

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

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.

RLY1 TRIP W1 BKR and RLY2 TRIP W2 BKR

Range: Do not operate, Operate

Default: Do not operate

The menu for the two trip output relays - RLY1 TRIP W1 BKR and RLY2 TRIP W2 BKR - is available only if the **Trip** setting is selected as a function for the Negative Sequence TOC element. One, or both, trip output relays can be selected to operate under the Negative Sequence TOC operating condition.



NOTE

The "RLY1 TRIP W1 BKR" and "RLY2 TRIP W2 BKR" setpoints will be displayed on the OC menu regardless of the selected OC function. These output relays will not operate if either **Alarm** or **Latched Alarm** is selected as an OC function, regardless of the Operate/Do Not Operate value selected. The output relays are operational only if the OC function is selected as **Trip**.

OUTPUT RELAY X

For details see [Common setpoints](#).

BLOCK 1/2/3

For details see [Common setpoints](#).

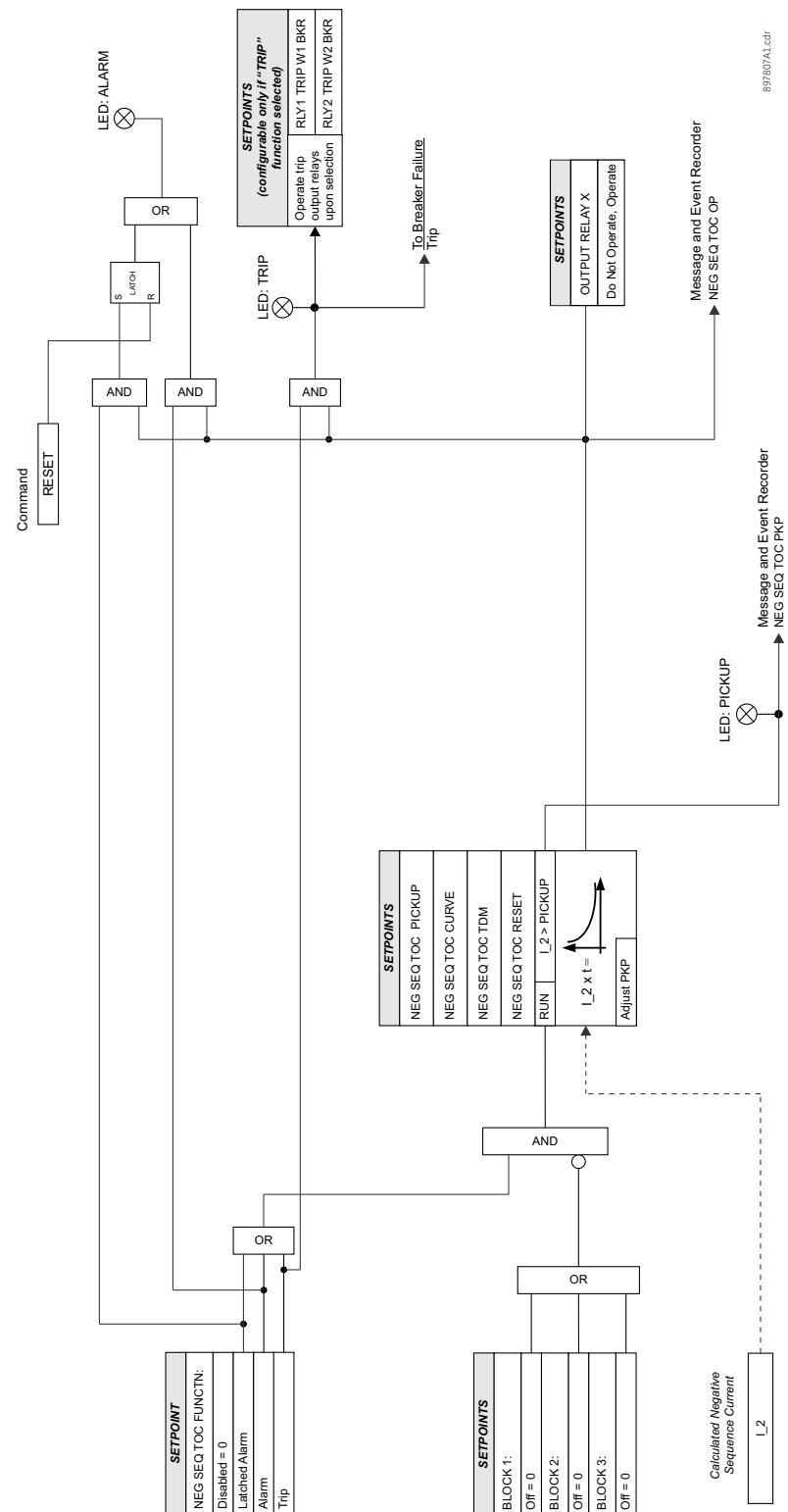


Figure 6-32: Negative Sequence Timed Overcurrent logic diagram

Negative sequence instantaneous overcurrent (50_2)

The 345 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 .

$$|I_2| = \frac{1}{3} \cdot |I_A + I_B \cdot (1\angle 240) + I_C \cdot (1\angle 120)|$$

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](#).

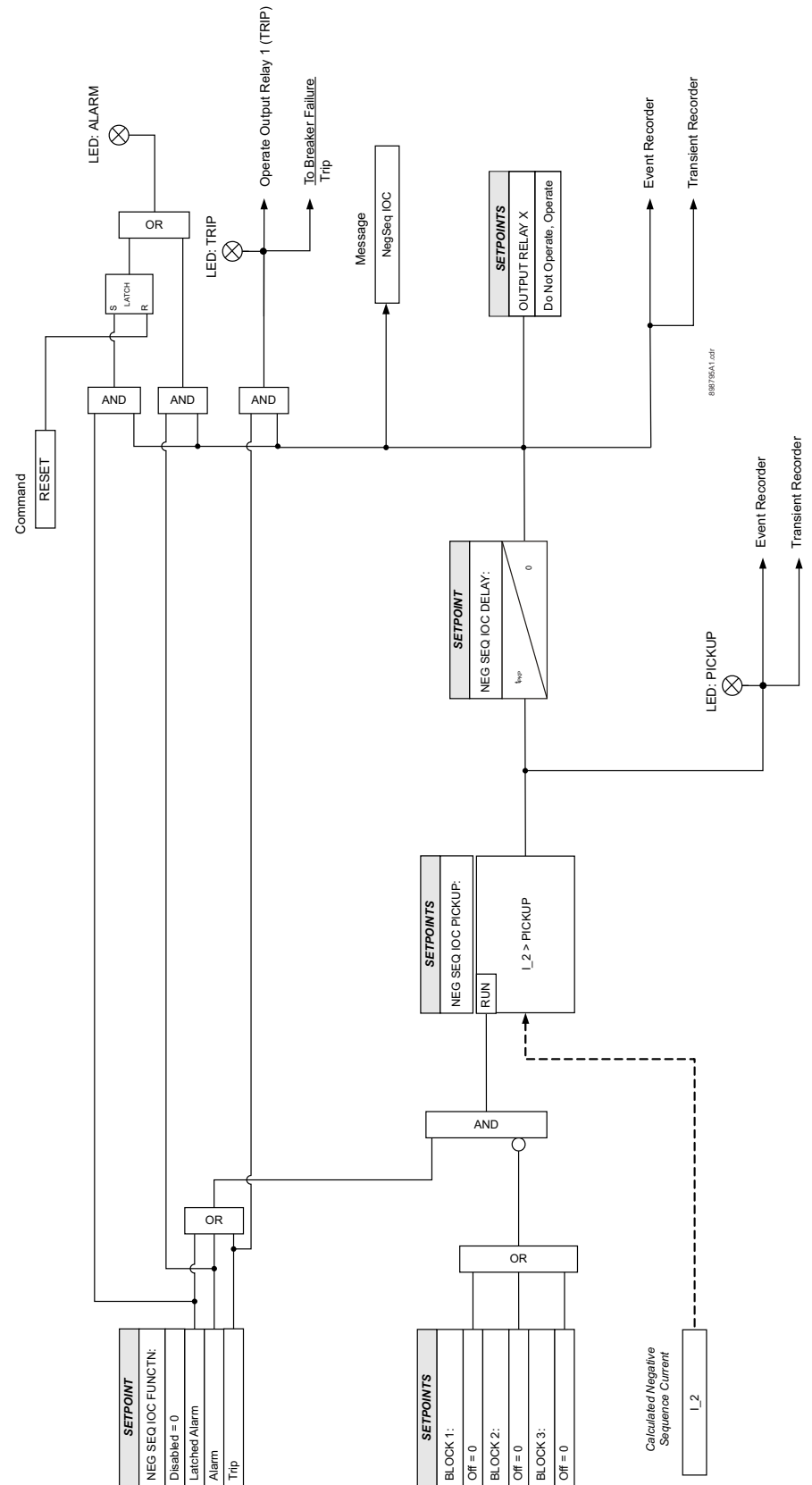
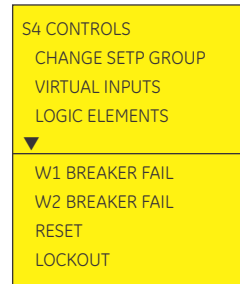


Figure 6-33: Negative sequence instantaneous overcurrent protection logic diagram

S4 Controls



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Figure 6-34: Main controls menu

Change setpoint group

The 345 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.

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

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.

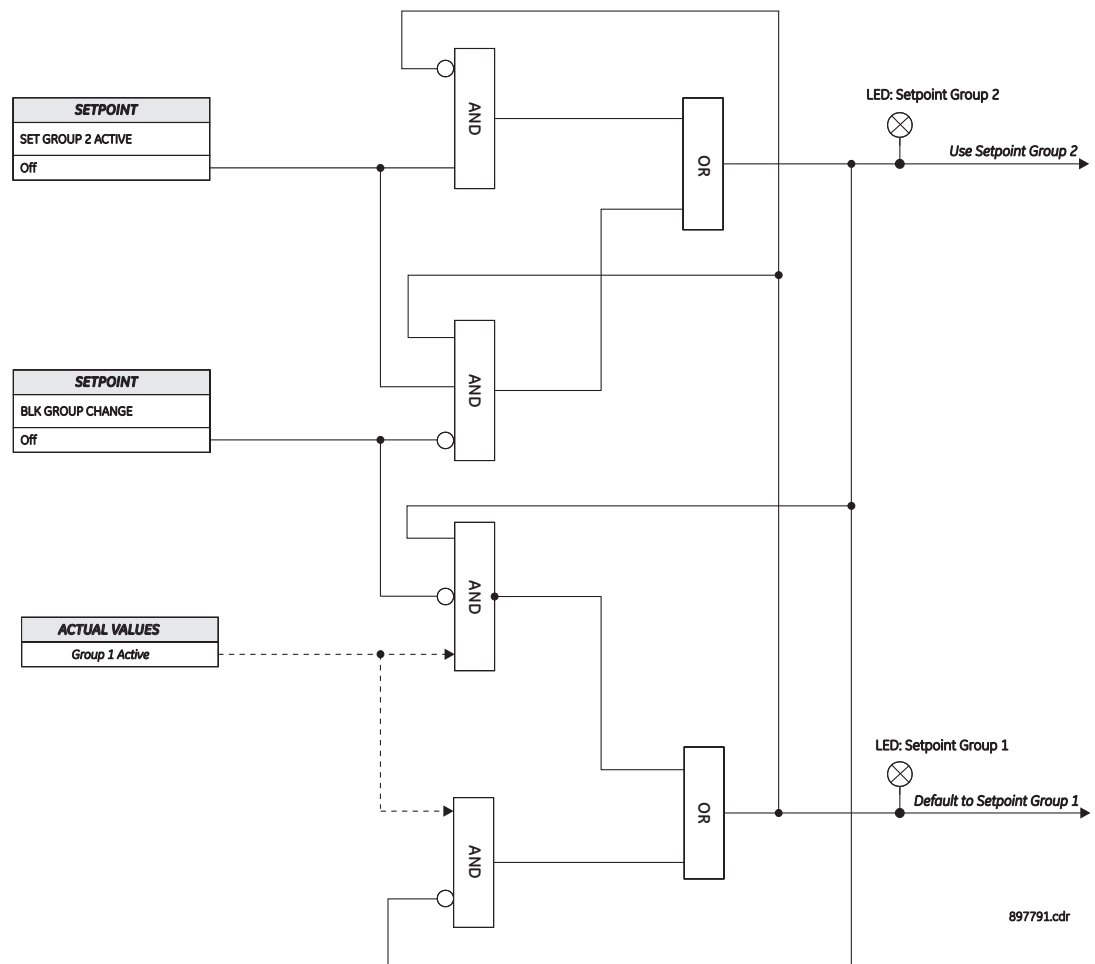


Figure 6-35: Switching setpoint groups - Logic diagram

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 345 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 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

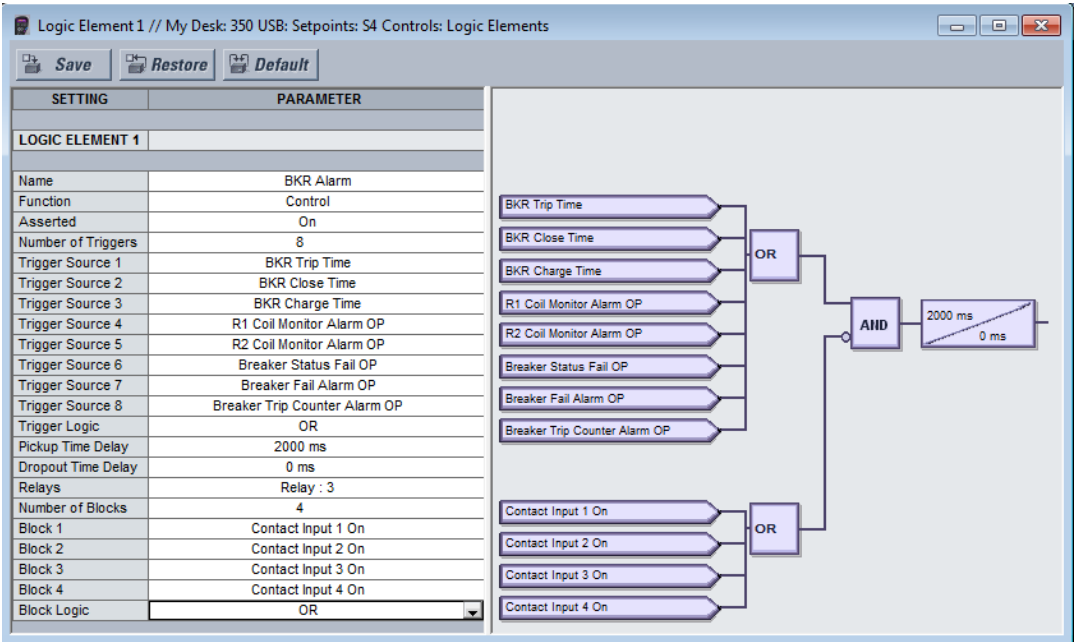


Figure 6-36: Example of an overall breaker alarm from EnerVista

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.

The same logic using Logic Element 2 can be built for Breaker #2.

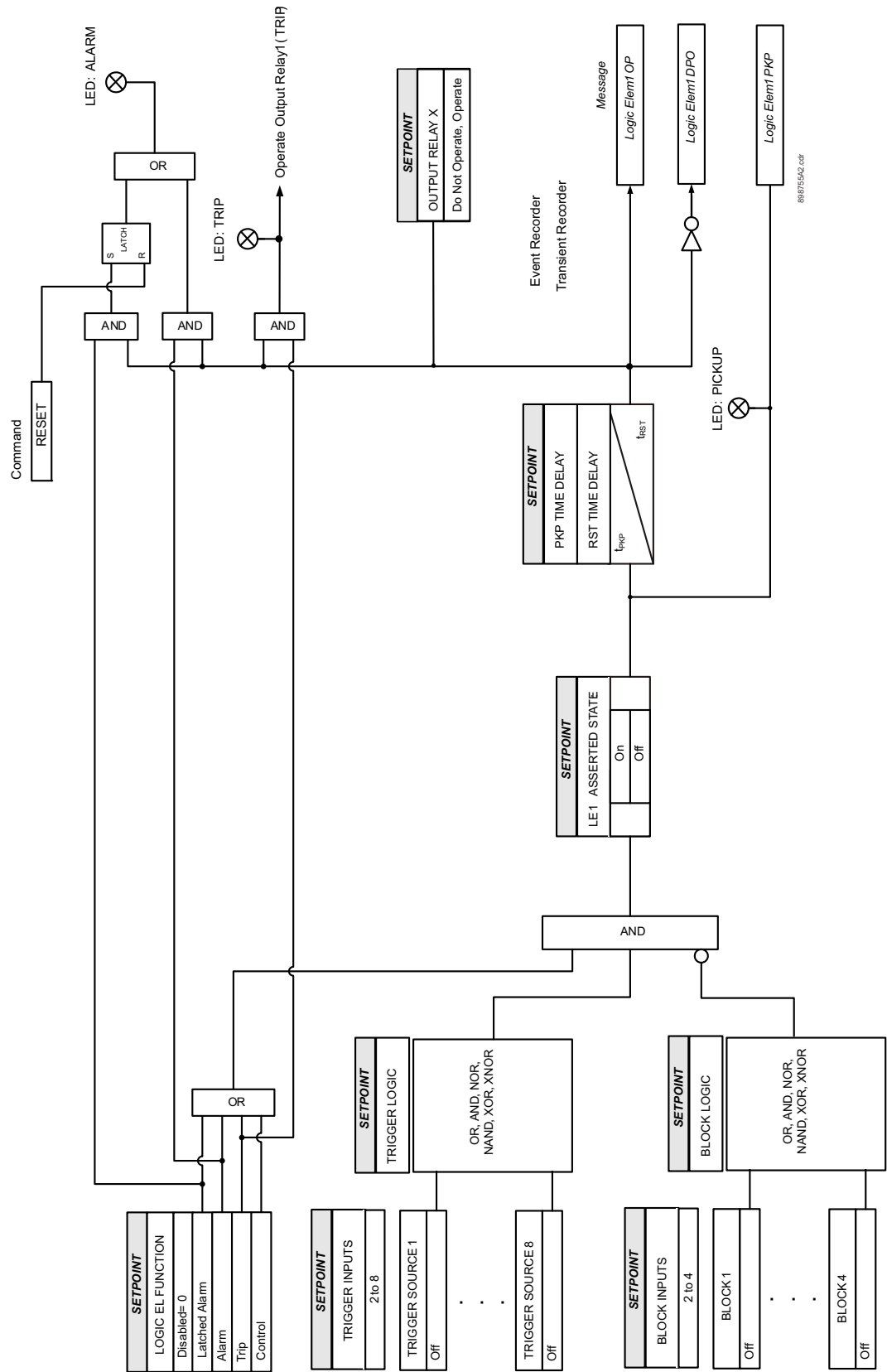


Figure 6-37: Logic Element logic diagram

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	
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 the breaker is racked in the system
	BKR2 Connected	Defines the status of breaker 2 in the power system. BKR2 Connected means breaker 2 is racked in the system
	Setpoint Group2 On	Setpoint Group 2 is active
	Open Breaker	Defines a command to open the breaker

Element	Operands	Event Description
	Close Breaker	Defines a command to close the breaker
	Maint. Req.	
	52a Contact OP	
	52b Contact OP	
	BKR2 52a Cont OP	
	52b Contact OP	
	Reset OK	Reset command has been executed
	BKR Stat Open	Breaker status open detected
	BKR2 Stat Open	Breaker 2 status open detected
	BKR2 Stat Open DPO	
	BKR Stat Clsd	Breaker status closed detected
	BKR2 Stat Clsd	Breaker 2 status closed detected
	BKR2 Stat Clsd DPO	
	Setpoint Group1 On	Setpoint Group 1 is active
	Setpoint Group2 On	Setpoint Group 2 is active
	Group Change Blk	Changing of Setpoint Groups is blocked
	Trip BKR1 Blk	
	Trip BKR 1 OP	
	Trip BKR 2 OP	
	Trip BKR2 Blk	
	Trip BKR 1 DPO	
	Trip BKR 2 DPO	
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		
2nd Harmonic Differential	2nd Hmnc Diff OP	2nd Hmnc Diff Ph B	
	2nd Hmnc Diff Ph A	2nd Hmnc Diff Ph C	
5th Harmonic Differential	5th Hmnc Diff OP	5th Hmnc Diff Ph B	
	5th Hmnc Diff Ph A	5th Hmnc Diff Ph C	
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
Breaker Failure	BKR1 Fail Alrm PKP	BKR2 Stat Fail OP	BKR Stat Fail OP
	BKR1 Fail Alrm OP	BKR2 Fail Alrm PKP	BKR2 Fail Alrm DPO
	BKR1 Fail Alrm DPO	BKR2 Fail Alrm OP	
Demand	Curr Dmd1 Alrm OP	C Dmd2 PhA Alrm OP	Curr Dmd1 Block
	Curr Dmd2 Alrm OP	C Dmd2 PhB Alrm OP	Curr Dmd2 Block
		C Dmd2 PhC Alrm OP	
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	

Element	Operands		
Ground Timed Overcurrent	Gnd TOC1 Trip PKP	Gnd TOC1 Alarm PKP	Gnd TOC2 Trip DPO
	Gnd TOC1 Trip OP	Gnd TOC1 Alarm OP	Gnd TOC2 Block
	Gnd TOC1 Trip DPO	Gnd TOC1 Alarm DPO	Gnd TOC2 Alarm OP
	Gnd TOC2 Trip PKP	Gnd TOC1 Block	Gnd TOC2 Alarm DPO
	Gnd TOC2 Trip OP	Gnd TOC2 Alarm PKP	
Instantaneous Differential	Inst Diff Trip PKP	Inst Diff Alrm PKP	Inst Diff Block
	Inst Diff Trip OP	Inst Diff Alrm OP	
	Inst Diff Trip DPO	Inst Diff Alrm 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 2 Trp OP
	NSeq IOC Trp OP	NSeq IOC Alrm DPO	NSeq IOC 2 Trp DPO
	NSeq IOC Trp DPO	NSeq IOC Block	NSeq IOC 2 AlrmDPO
	NSeq IOC Alrm PKP	NSeq IOC 2 AlrmPKP	NSeq IOC 2 Block
	NSeq IOC 2 Trp PKP	NSeq IOC 2 Alrm OP	
Negative Sequence Timed Overcurrent	NSeq TOC1 Trip PKP	NSeq TOC1 Alrm OP	NSeq TOC2 Trip OP
	NSeq TOC1 Trip OP	NSeq TOC1 Alrm DPO	NSeq TOC2 Trip DPO
	NSeq TOC1 Trip DPO	NSeq TOC1 Blk	NSeq TOC2 Alrm DPO
	NSeq TOC1 Alrm PKP	NSeq TOC2 Alrm PKP	NSeq TOC2 Blk
	NSeq TOC2 Trip PKP	NSeq TOC2 Alrm OP	
Neutral Instantaneous Overcurrent	Ntrl IOC1 Trip PKP	Ntrl IOC1 Alrm PKP	Ntrl IOC2 Trip DPO
	Ntrl IOC1 Trip OP	Ntrl IOC1 Alrm OP	Ntrl IOC2 Block
	Ntrl IOC1 Trip DPO	Ntrl IOC1 Alrm DPO	Ntrl IOC2 Alrm OP
	Ntrl IOC2 Trip PKP	Ntrl IOC1 Block	Ntrl IOC2 Alrm DPO
	Ntrl IOC2 Trip OP	Ntrl IOC2 Alrm PKP	
Neutral Timed Overcurrent	Ntrl TOC1 Trip PKP	Ntrl TOC1 Alrm OP	Ntrl TOC2 Trip OP
	Ntrl TOC1 Trip OP	Ntrl TOC1 Alrm DPO	Ntrl TOC2 Trip DPO
	Ntrl TOC1 Trip DPO	Ntrl TOC1 Block	Ntrl TOC2 Alrm DPO
	Ntrl TOC1 Alrm PKP	Ntrl TOC2 Alrm PKP	Ntrl TOC2 Block
	Ntrl TOC2 Trip PKP	Ntrl TOC2 Alrm OP	
Percent Differential	Pcnt Diff Trip PKP	Pcnt Diff Alrm PKP	Pcnt Diff Block
	Pcnt Diff Trip OP	Pcnt Diff Alrm OP	
	Pcnt Diff Trip DPO	Pcnt Diff Alrm DPO	
	Ph Dif A Alarm PKP	Ph Dif C Alarm PKP	Ph Diff B Trip PKP
	Ph Dif A Alarm OP	Ph Dif C Alarm OP	Ph Diff B Trip OP
	Ph Dif A Alarm DPO	Ph Dif C Alarm DPO	Ph Diff B Trip DPO
	Ph Dif B Alarm PKP	Ph Diff A Trip PKP	Ph Diff C Trip PKP
	Ph Dif B Alarm OP	Ph Diff A Trip OP	Ph Diff C Trip OP
	Ph Dif B Alarm DPO	Ph Diff A Trip DPO	Ph Diff C Trip 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 IOC2 Alrm PKP	Ph A IOC1 Trip PKP
	Ph A IOC1 Alrm OP	Ph A IOC2 Alrm OP	Ph A IOC1 Trip OP
	Ph A IOC1 Alrm DPO	Ph A IOC2 Alrm DPO	Ph A IOC1 Trip DPO
	Ph B IOC1 Alrm PKP	Ph B IOC2 Alrm PKP	Ph B IOC1 Trip PKP
	Ph B IOC1 Alrm OP	Ph B IOC2 Alrm OP	Ph B IOC1 Trip OP
	Ph B IOC1 Alrm DPO	Ph B IOC2 Alrm DPO	Ph B IOC1 Trip DPO
	Ph C IOC1 Alrm PKP	Ph C IOC2 Alrm PKP	Ph C IOC1 Trip PKP
	Ph C IOC1 Alrm OP	Ph C IOC2 Alrm OP	Ph C IOC1 Trip OP
	Ph C IOC1 Alrm DPO	Ph C IOC2 Alrm DPO	Ph C IOC1 Trip 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
Phase Timed Overcurrent	Ph TOC1 Trip PKP	Ph TOC1 Alarm PKP	Ph TOC2 Alrm OP
	Ph TOC1 Trip OP	Ph TOC1 Alarm OP	Ph TOC2 Alrm DPO
	Ph TOC1 Trip DPO	Ph TOC1 Alarm DPO	Ph TOC2 Trip OP
	Ph TOC1 Block	Ph TOC2 Block	Ph TOC2 Trip DPO
	Ph TOC2 Alrm PKP	Ph TOC2 Trip PKP	
	Ph A TOC1 Alrm PKP	Ph A TOC2 Alrm PKP	Ph A TOC1 Trip PKP
	Ph A TOC1 Alrm OP	Ph A TOC2 Alrm OP	Ph A TOC1 Trip OP
	Ph A TOC1 Alrm DPO	Ph A TOC2 Alrm DPO	Ph A TOC1 Trip DPO
	Ph B TOC1 Alrm PKP	Ph B TOC2 Alrm PKP	Ph B TOC1 Trip PKP
	Ph B TOC1 Alrm OP	Ph B TOC2 Alrm OP	Ph B TOC1 Trip OP
	Ph B TOC1 Alrm DPO	Ph B TOC2 Alrm DPO	Ph B TOC1 Trip DPO
	Ph C TOC1 Alrm PKP	Ph C TOC2 Alrm PKP	Ph C TOC1 Trip PKP
	Ph C TOC1 Alrm OP	Ph C TOC2 Alrm OP	Ph C TOC1 Trip OP
	Ph C TOC1 Alrm DPO	Ph C TOC2 Alrm DPO	Ph C TOC1 Trip DPO
	Ph A TOC2 Trip PKP	Ph B TOC2 Trip PKP	Ph C TOC2 Trip PKP
	Ph A TOC2 Trip OP	Ph B TOC2 Trip OP	Ph C TOC2 Trip OP
	Ph A TOC2 Trip DPO	Ph B TOC2 Trip DPO	Ph C TOC2 Trip DPO
Restricted Ground Fault	RGF1 Trip PKP	RGF2 Trip PKP	RGF1 Alarm DPO
	RGF1 Trip OP	RGF2 Trip OP	RGF1 Block
	RGF1 Trip DPO	RGF2 Trip DPO	RGF2 Alarm DPO
	RGF1 Alarm PKP	RGF2 Alarm PKP	RGF2 Block
	RGF1 Alarm OP	RGF2 Alarm OP	
RTD	RTD 1..12 Trip PKP	RTDTrouble BLK	Hot RTD PKP
	RTD 1..12 Trip OP	RTD Trouble Alr OP	Hot RTD OP
	RTD1..12 BLK	RTD 1..12 Alarm PKP	Hot RTD DPO
		RTD 1..12 Alarm OP	
Self-Test Error	Self-Test Rly 7 On	Self Test Alarm OP	

Element	Operands		
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 TOC2 Trip OP
	SGnd TOC1 Trip OP	SGnd TOC1 Alrm OP	SGnd TOC2 Trip DPO
	SGnd TOC1 Trip DPO	SGnd TOC1 Alrm DPO	SGnd TOC2 Alrm DPO
	SGnd TOC1 Block	SGnd TOC2 Alrm PKP	SGnd TOC2 Block
	SGnd TOC2 Trip PKP	SGnd TOC2 Alrm OP	
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 PhC Alrm OP	Therm PhB Trip OP
	Therm PhA Alrm DPO	Therm PhC Alrm DPO	Therm PhB Trip DPO
	Therm PhB Alrm OP	Therm PhA Trip OP	Therm PhC Trip OP
	Therm PhB Alrm DPO	Therm PhA Trip DPO	Therm PhC Trip DPO
Trip Counter	BKRTripCntrAlrm OP	W2BKRTripCntrAlrm OP	
Trip Coil Monitoring	R1 CoilMonAlrm PKP	R2 CoilMonAlrm PKP	R1 CoilMonAlrm DPO
	R1 CoilMonAlrm OP	R2 CoilMonAlrm OP	R2 CoilMonAlrm DPO

Winding breaker failure

There are two Breaker Failure functions, one per winding breaker. The BF function monitors the phase currents after a trip command from a protection element is initiated. If any phase current is above the set current level after the BF DELAY timer/timers expire, a Breaker Failure will be declared, and will operate the selected output relays. The Breaker Failure scheme also provides the setup for BF initiate from the external input via Contact Input, Virtual Input, Remote Input, or Logic Element.

The operation of the filter that reduces the overreaching effect of the asymmetrical offset currents will cause the measured current to ramp down to zero after the breaker trips. It is strongly recommended that a margin of 1.5 power cycle time is added to the expected breaker time-to-trip time for the BF DELAY1 and BF DELAY 2 timers.



W1 BREAKER FAIL logic is triggered only upon operation of a protection element with a function set to **Trip**, and the CT INPUT associated with Winding 1 CT - i.e. CT(W1). Similarly, the W2 BREAKER FAIL logic will be triggered only upon operation of a protection element with the function set to **Trip**, and the CT INPUT set to CT(W2).

When the 345 relay allows the configuration of only one breaker failure function, this function is always associated with the Winding 1 breaker, and will be triggered upon operation of any protection element with a FUNCTION setting set to **Trip**, and the CT INPUT set to CT(W1).

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](#) > [W1\(W2\) 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 x CT

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

Default: Off

This setting selects the external initiate signal to launch the **Breaker Failure** function.

BF TIME DELAY 1

Range: 0.03 to 1.00 s in steps of 0.01 s

Default: 0.1 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 before a trip condition is recognized, BF TIMER DELAY 1 has expired, and at least one of the phase currents is above the BF CURRENT setpoint.

OUTPUT RELAY X

For details see [Common setpoints](#).

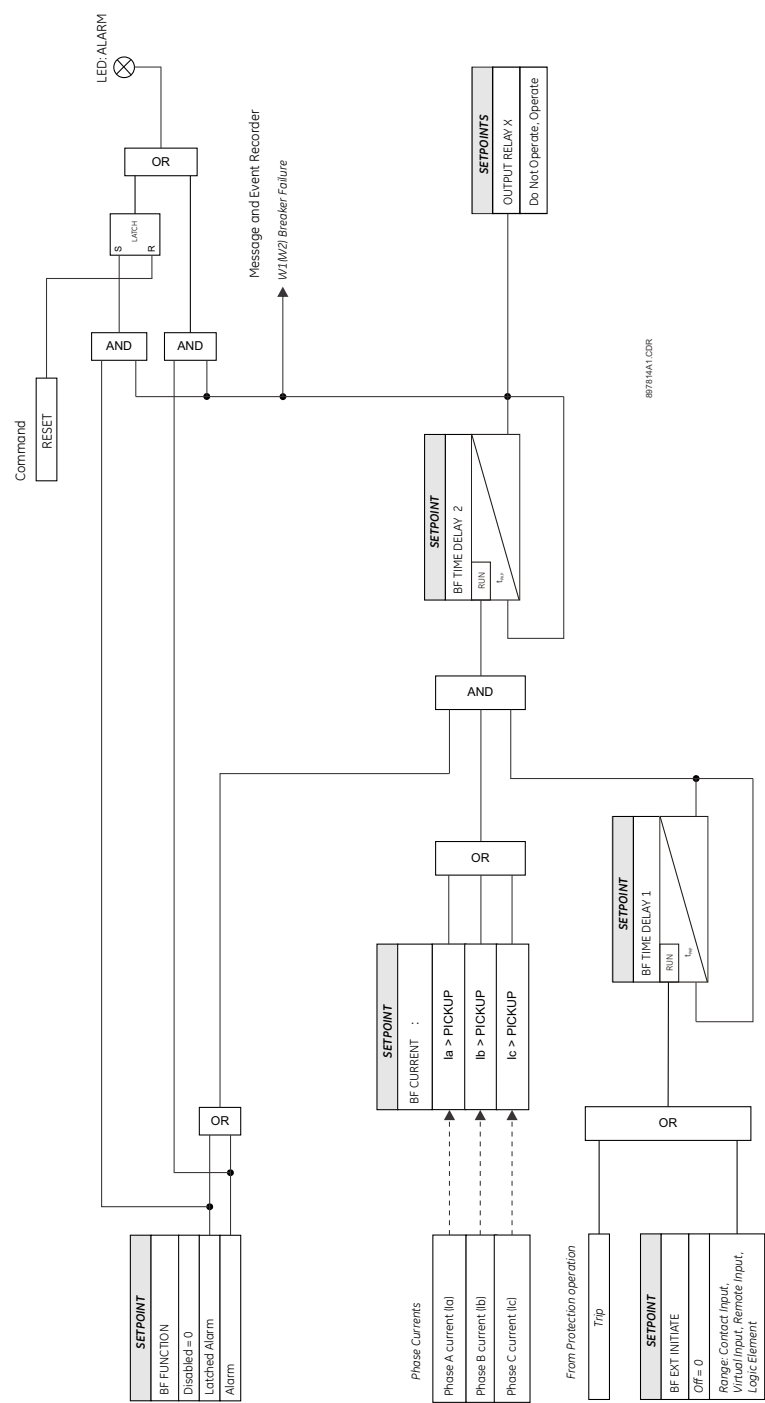


Figure 6-38: Breaker Failure logic diagram

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. To use the Lockout feature from a 345 relay, first program a Logic Element using the "Lockout OP" operand. The Logic Element shall be then set to drive an output relay with an NC contact connected in series with an outside output relay normally used for closing the breaker. The full lockout sequence is then the following: a protection operates, sends trip command to the breaker and the breaker opens. The same protection is set to trigger Lockout. The programmed Logic Element operates and drives an output relay with an NC contact connected in series with a relay used for breaker closing. The NC contact opens and blocks the closing to the breaker, until the lockout is reset.

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.

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.



The lockout state can be applied to both output relays W1 BKR TRIP and W2 BKR TRIP used for tripping the transformer breakers. 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 two TRIP outputs,) the breaker may not close, as the trip signal would have priority over the close signal.

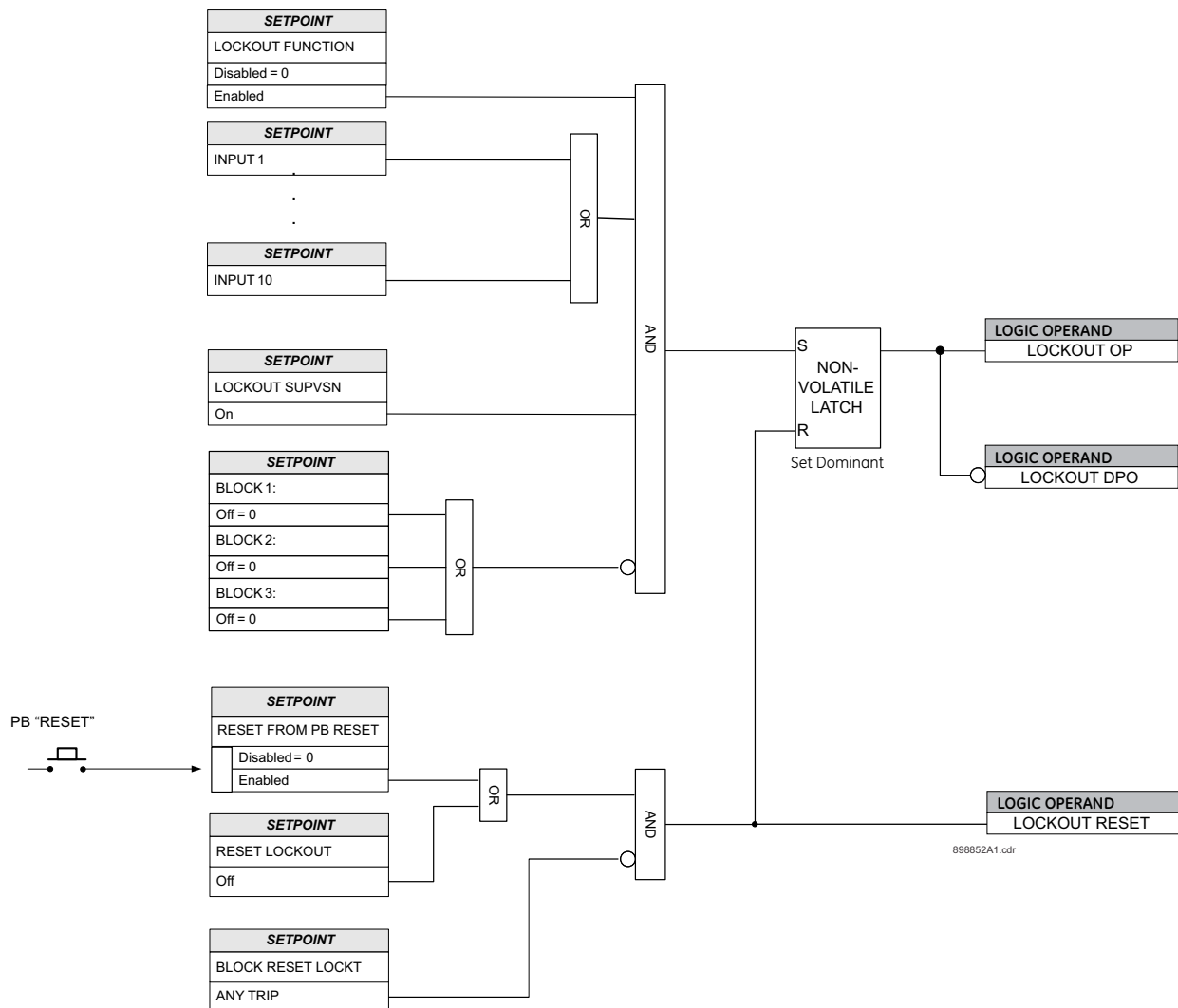


Figure 6-39: Lockout logic diagram

S5 Inputs/Outputs

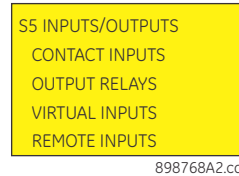


Figure 6-40: Main inputs/outputs menu

Contact inputs

The 345 relay is equipped with ten (10) 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 345 typical wiring diagram) that require an external DC voltage source. The voltage threshold (17V, 33V, 84V, 166V) is selectable, and it applies for all ten 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

CONTACT INPUT 1

Range: 14 characters

Default: Bkr1 52a (CI#1)

CONTACT INPUT 2

Range: 14 characters

Default: Bkr1 52b (CI#2)

CONTACT INPUT 3

Range: 14 characters

Default: Bkr2 52a (CI#3)

CONTACT INPUT 4

Range: 14 characters

Default: Bkr2 52b (CI#4)

CONTACT INPUT X [5 to 10]

Range: 14 characters

Default: Input X

DEBOUNCE TIME

↳

CONTACT INPUT X [1 TO 10]

Range: 1 to 64 ms

Default: 2 ms

Each of the contact inputs 5 to 10, can be named to reflect the function it represents within the application. Up to 14 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.

Contact Input 1 and Contact Input 2 are named by the factory as 52a and 52b respectively and are used for monitoring the Winding1 breaker open/close state when wired to the Winding 1 breaker auxiliary contacts 52a and 52b.

Contact Input 3 and Contact Input 4 are named by the factory as 52a and 52b respectively and are used for monitoring the Winding2 breaker open/close state when wired to the Winding 2 breaker auxiliary contacts 52a and 52b.

Output relays

The 345 relay is equipped with seven electromechanical relays: two special relays designed for Winding 1 Breaker trip and Winding 2 Breaker trip, 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 two Trip output relays is designed to be controlled by the state of the circuit breaker as monitored by a 52a or 52b contact.

- The Trip 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.
- If a delay is programmed for the Trip 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.
Yes	No	Trip Relay remains operational until 52a indicates an open breaker.
No	Yes	Trip Relay remains operational until 52b indicates an open 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.

Output Relay 1 - W1 breaker "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 > RLY 1 W1 BKRTRIP

RLY1 SEAL-IN

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.

Output Relay 2 - W2 breaker "Trip"

PATH: SETPOINTS > S5 INPUTS/OUTPUTS > OUTPUT RELAYS > RLY 2 W2 BKRTRIP

RLY2 SEAL-IN

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 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 2 TRIP

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.

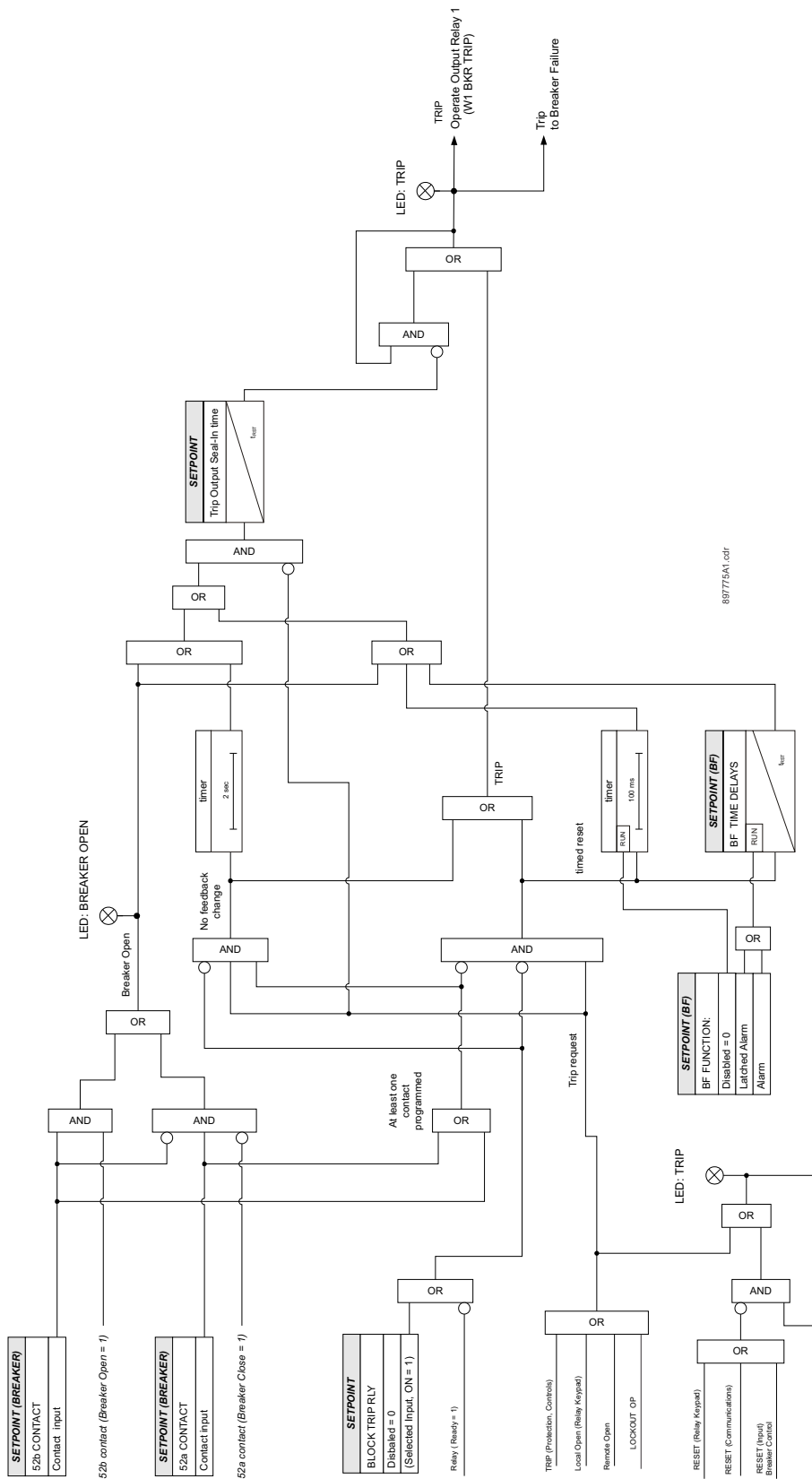


Figure 6-41: Relay 1 "TRIP" and Relay #2 "TRIP" logic diagram

Auxiliary Output Relays 3 to 6

The 345 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

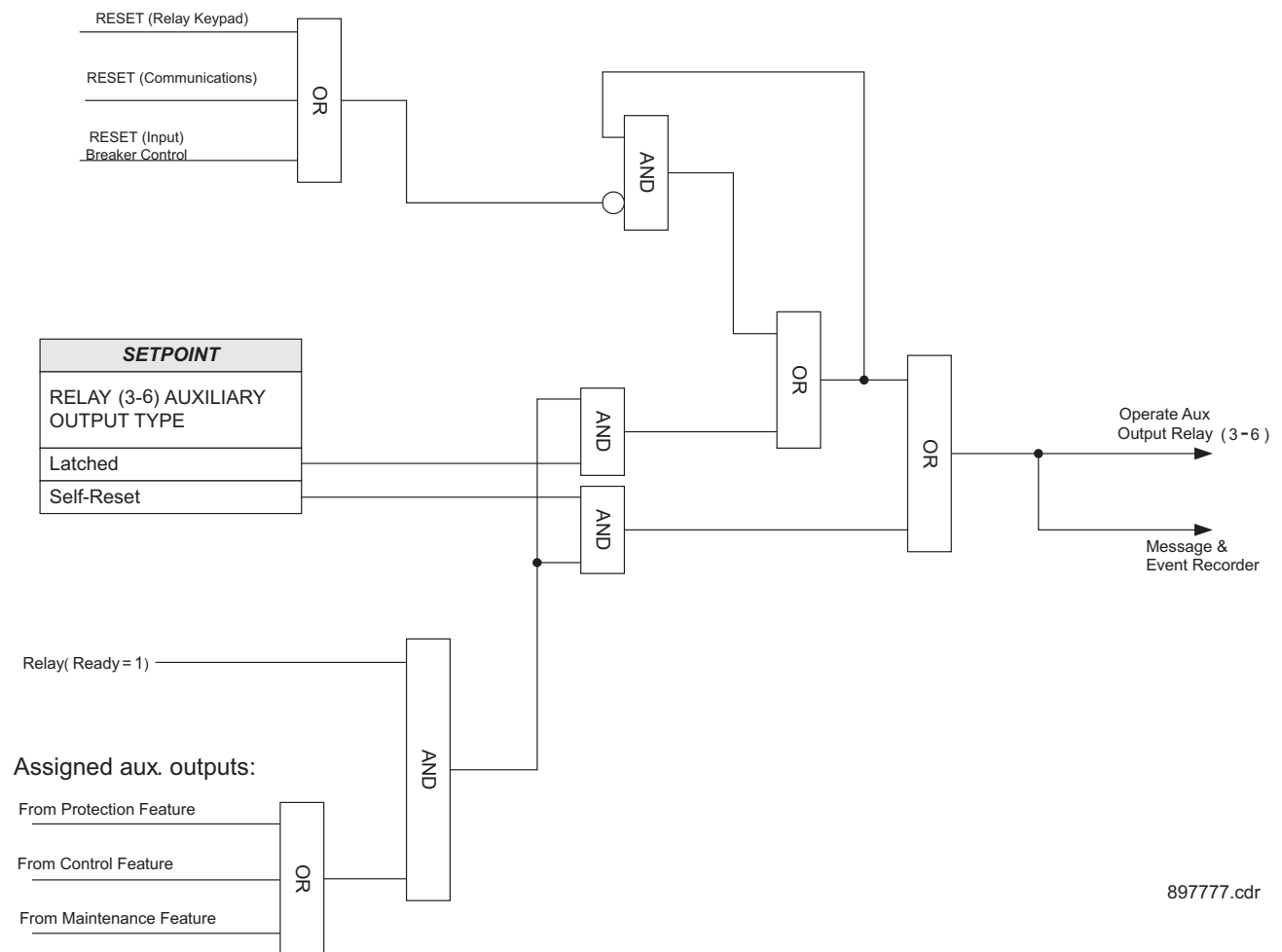


Figure 6-42: Auxiliary relays

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.

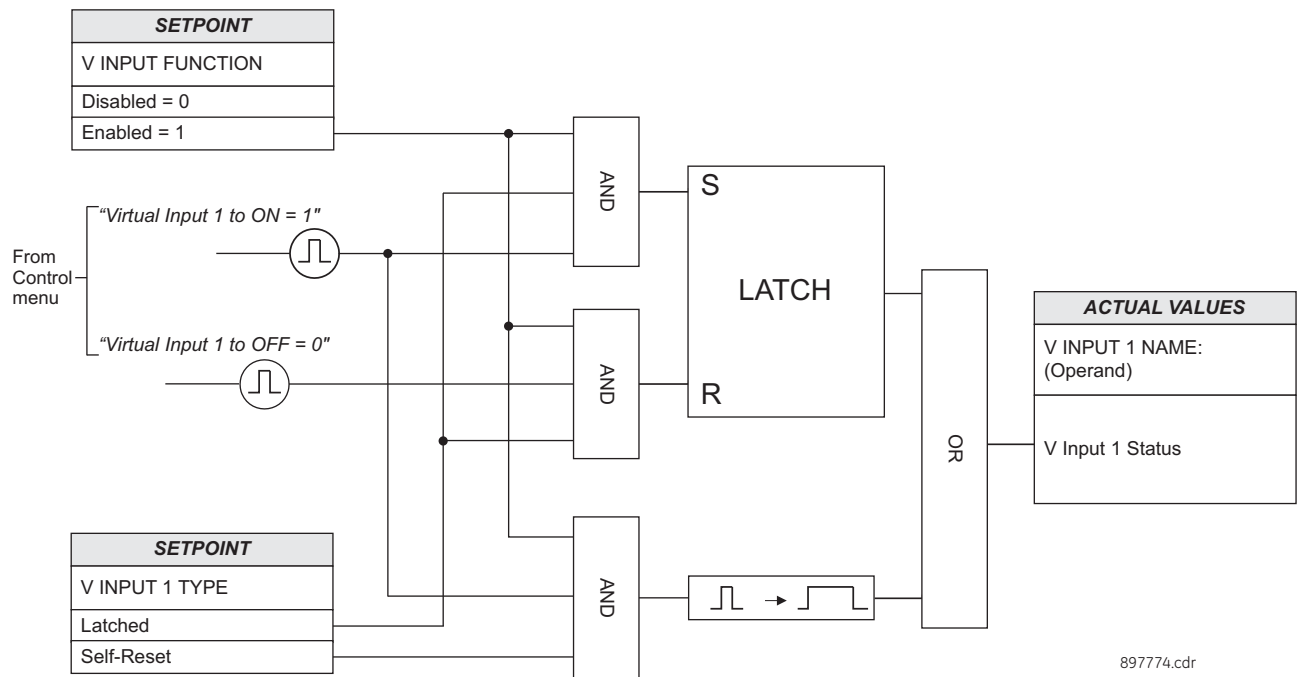


Figure 6-43: Virtual inputs scheme logic

Remote inputs

Remote Inputs are available for programming under the EnerVista 3 Series Setup software. Refer to the *3 Series Communications Guide* for details.

Remote outputs

Remote Inputs are available for programming under the EnerVista 3 Series Setup software. Refer to the *3 Series Communications Guide* for details.

S6 Monitoring

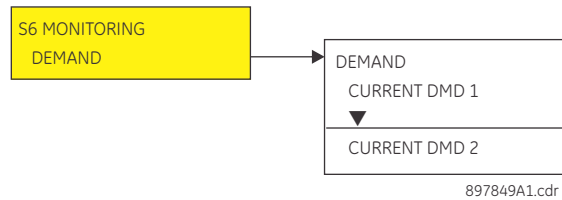


Figure 6-44: Main monitoring menu

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.

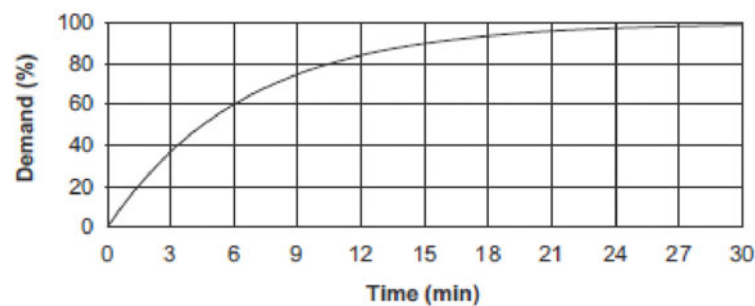


Figure 6-45: Thermal Demand Characteristic (15 min response)

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

Path: S6 MONITORING > DEMAND > CURRENT DEMAND 2

FUNCTION

Range: Disabled, Alarm, Latched Alarm

Default: Disabled

For details see [Common setpoints](#).

CT INPUT

Range: CT (W1), CT (W2)

Default: CT (W1)

Select the current inputs from W1 CT, or W2 CT.

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](#).

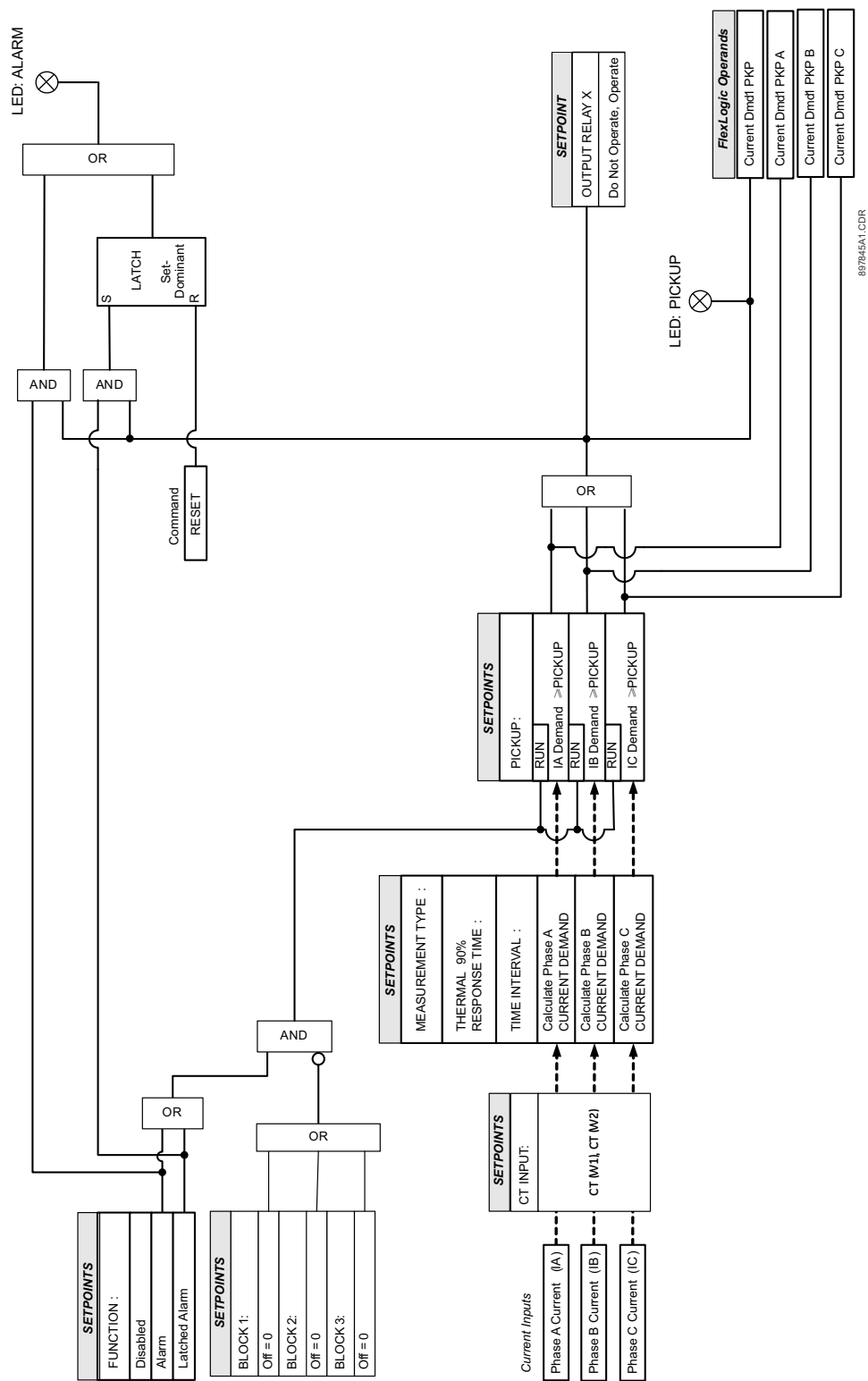


Figure 6-46: Current Demand logic diagram

RTD temperature monitoring (49T)

The 345 supports up to 12 RTD inputs from Remote Module Inputs/Outputs (RMIO).

As an option, a CANBUS-based RMIO module can be installed on the 345, which can monitor up to 12 RTDs. The RTD protection setpoints can be seen only if the 345 has the RMIO module installed and validated. If, for some reason, communication with the RMIO module is lost or interrupted, the 345 will issue an RMIO MISMATCH self-test error indicating the failure. This feature is useful as it ensures that the remote RTDs are being continuously monitored.

The RTD type supported is 100 Ohm Platinum. Each of these may be configured to have a trip temperature as well as an alarm temperature. The alarm temperature is normally set slightly above the normal running temperature. The trip temperature is normally set at the insulation rating. Trip Voting has been added for extra security in the event of RTD malfunction. If enabled, a second RTD must also exceed the trip temperature of the RTD being checked before a trip will be issued. If the RTD is chosen to vote with itself, the voting feature is disabled.

Each RTD may also be configured as being of application type Ambient, Top-Oil, Bottom-Oil, or Other. The table below - *RTD Temperature vs Resistance* - lists RTD resistance versus temperature.

PATH: [SETPOINTS](#) > [S6 MONITORING](#) > [RTD TEMPERATURE](#) > [RTD #1\(12\)](#)

RTD #1 to 12 APPLICATION

Range: None, Top-oil, Bottom-oil, Ambient, Other

Default: None

Sets the application type.

RTD #1 to 12 NAME

Range: 1 to 18 characters

Default: RTD 1(12)

Sets the RTD programmable name.

RTD #1 to 12 ALARM

Range: Disabled, Enabled

Default: Disabled

This setting enables the RTD #1 to 12 Alarm functionality.

RTD #1 to 12 ALARM TEMP

Range: 1°C to 250°C in steps of 1°C

Default: 130°C

Sets the Alarm temperature.

RTD #1 to 12 ALARM PKP DELAY

Range: 0.00 to 600.00 s in steps of 0.01 s

Default: 2.00 s

Sets the Alarm pickup delay time.

RTD #1 to 12 ALARM DPO DELAY

Range: 0.00 to 600.00 s in steps of 0.01 s

Default: 2.00 s

Sets the Alarm dropout delay time.

RTD #1 to 12 TRIP

Range: Disabled, Enabled

Default: Disabled

This setting enables the RTD #1 to 12 Trip functionality.

RTD #1 to 12 TRIP TEMP

Range: 1°C to 250°C in steps of 1°C

Default: 155°C

Sets the Trip temperature.

RTD #1 to 12 TRIP PKP DELAY

Range: 0.00 to 600.00 s in steps of 0.01 s

Default: 2.00 s

Sets the Trip pickup delay time.

RTD #1 to 12 TRIP DPO DELAY

Range: 0.00 to 600.00 s in steps of 0.01 s

Default: 0.00 s

Sets the Trip dropout delay time.

RTD #1 to 12 TRIP VOTING

Range: Off, RTD #1 to 12

Default: Off

Sets the redundant RTD that must also exceed this RTD's trip temperature for a trip to occur.

OUTPUT RELAY X

For details see [Common setpoints](#).

BLOCK 1 to 3

For details see [Common setpoints](#).

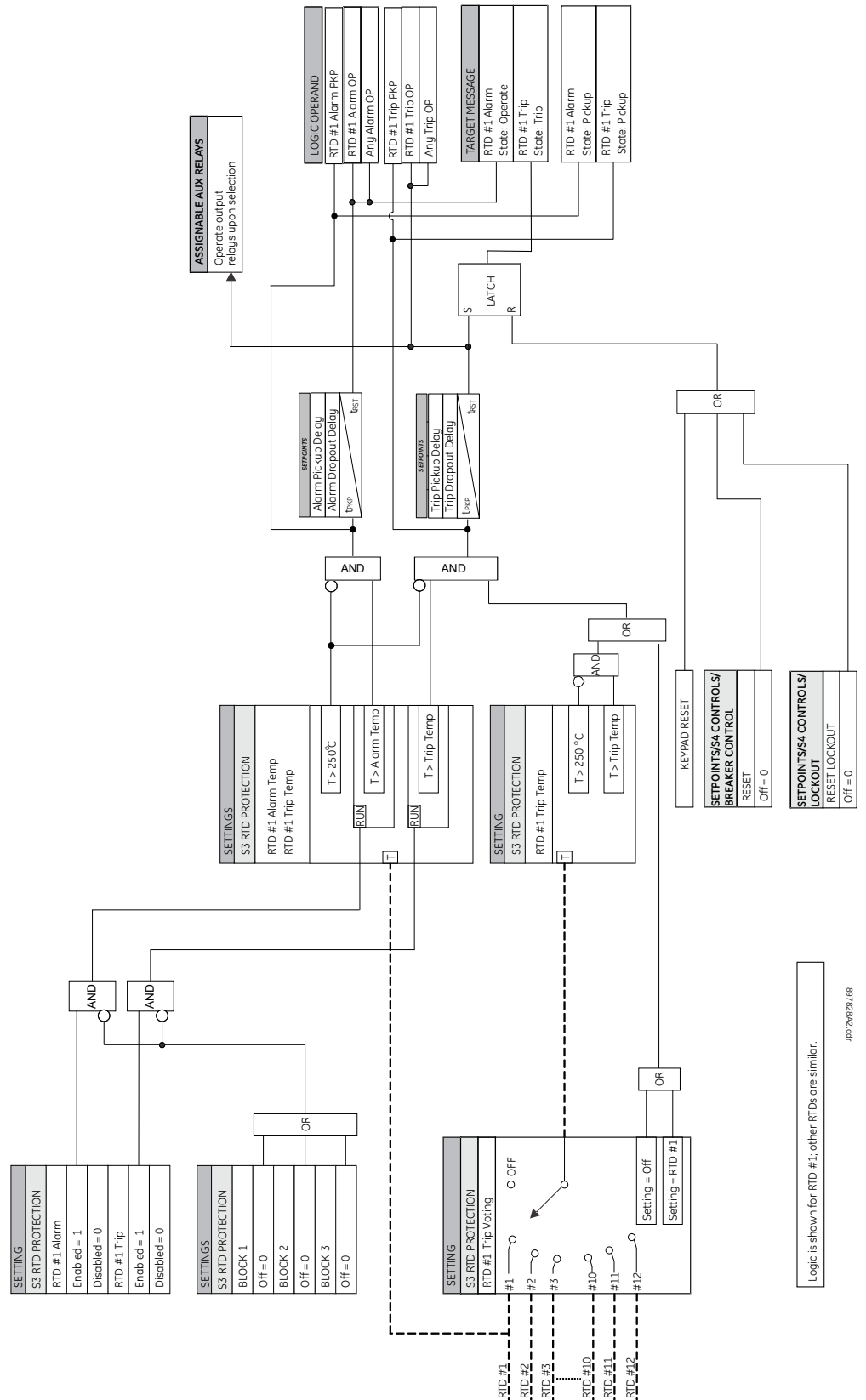


Figure 6-47: RTD Protection logic diagram

THE RTD TROUBLE ALARM

All RTDs that are programmed with either an alarm or a trip are monitored for sensor failure. When the measured temperature is greater than 250°C or less than -50°C, the RTD is declared failed and a common RTD trouble alarm is issued.

RTD TROUBLE ALARM

Range: Disable, Enable

Default: Disable

This setting enables the RTD Trouble Alarm functionality.

OUTPUT RELAY X

For details see [Common setpoints](#).

BLOCK 1 to 3

For details see [Common setpoints](#).

Table 6-11: RTD Temperature vs Resistance

Temperature		100 Ω Pt (DIN 43760)
°C	°F	
-50	-58	80.31
-40	-40	84.27
-30	-22	88.22
-20	-4	92.16
-10	14	96.09
0	32	100.00
10	50	103.90
20	68	107.79
30	86	111.67
40	104	115.54
50	122	119.39
60	140	123.24
70	158	127.07
80	176	130.89
90	194	134.70
100	212	138.50
110	230	142.29
120	248	146.06
130	266	149.82
140	284	153.58
150	302	157.32
160	320	161.04
170	338	164.76
180	356	168.47
190	374	172.46
200	392	175.84
210	410	179.51
220	428	183.17
230	446	186.82
240	464	190.45
250	482	194.08

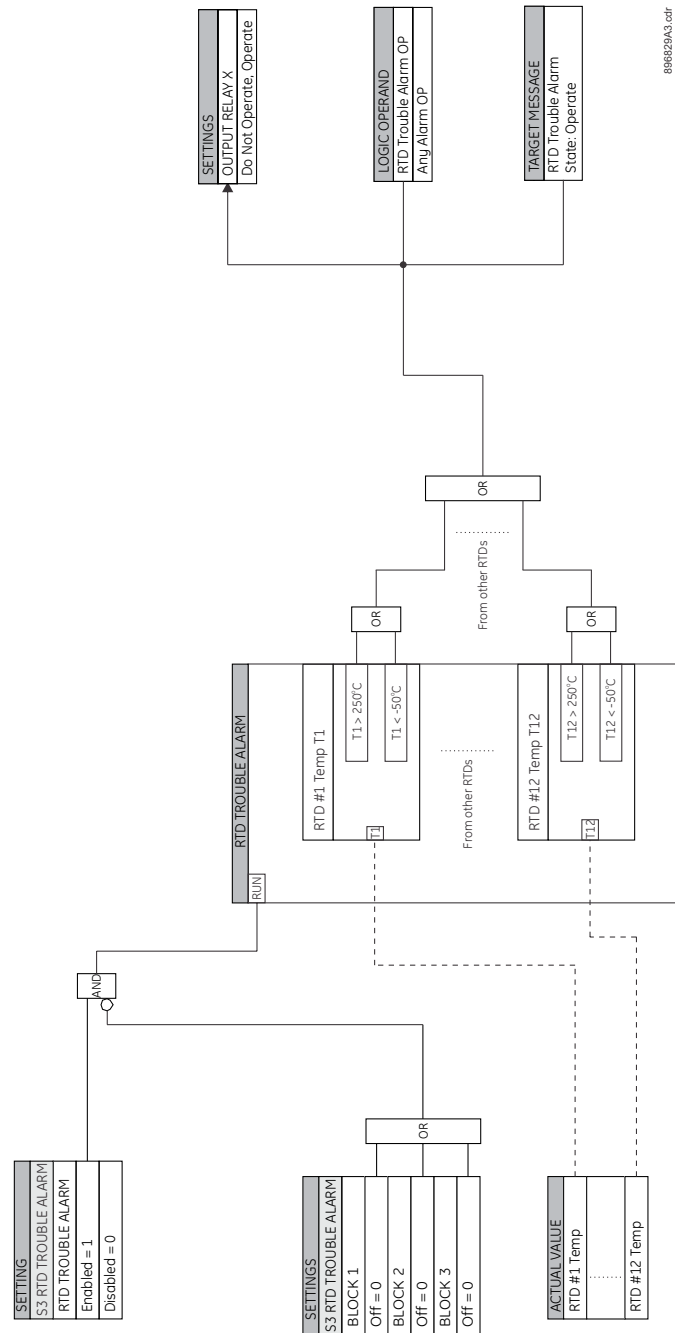
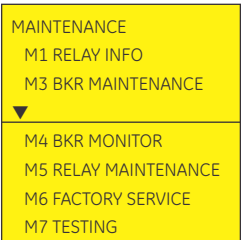


Figure 6-48: RTD Trouble Alarm logic diagram

345 Transformer Protection System

Chapter 7: Maintenance

Information about the relay and the breaker can be obtained through the features included in the Maintenance page.



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Figure 7-1: Main maintenance menu

M1 Relay information

PATH: MAINTENANCE > M1 RELAY INFO

RELAY NAME

Range: alpha-numeric name of up to 14 characters
Default: Transformer Name

ORDER CODE

345-EP5G5HEMNN3EDN

This screen shows the relay order code.

RMIO

Range: G, GG, GGG, GGGG

Displays the validated RMIO. This value will be seen only if the RMIO module is installed.

MAIN FIRMWARE REV

1.41

This screen shows the relay firmware revision.

MAIN BUILD DATE**Aug 16 2015**

This screen shows the relay firmware build date.

MAIN BUILD TIME**16:12:32**

This screen shows the relay firmware build time.

MAIN BOOT REVISION**1.20**

This screen shows the relay boot code revision.

MAIN BOOT DATE**Dec 11 2015**

This screen shows the relay boot code date.

MAIN BOOT TIME**10:44:54**

This screen shows the relay boot code time.

COMM FIRMWARE REV**1.40**

This screen shows the relay communication firmware revision.

COMM BUILD TIME**16:59:27**

This screen shows the relay communication firmware build time.

COMM BOOT REVISION**1.30**

This screen shows the relay communication boot code revision.

COMM BOOT DATE**Apr 7 2015**

This screen shows the relay communication boot code date.

COMM BOOT TIME**16:22:41**

This screen shows the relay communication boot code time.

SERIAL NUMBER**ML0T09000001**

Each 345 relay has a unique Serial Number.

ETHERNET MAC ADR**00.A0.F4.08.A0.E9**

Each 345 relay has a unique Mac Address.

FPGA VERSION**1.00**

M3 Breaker maintenance

M3 BKR MAINTENANCE
W1 BKRTRIP COIL
W2 BKRTRIP COIL

897860A1.cdr

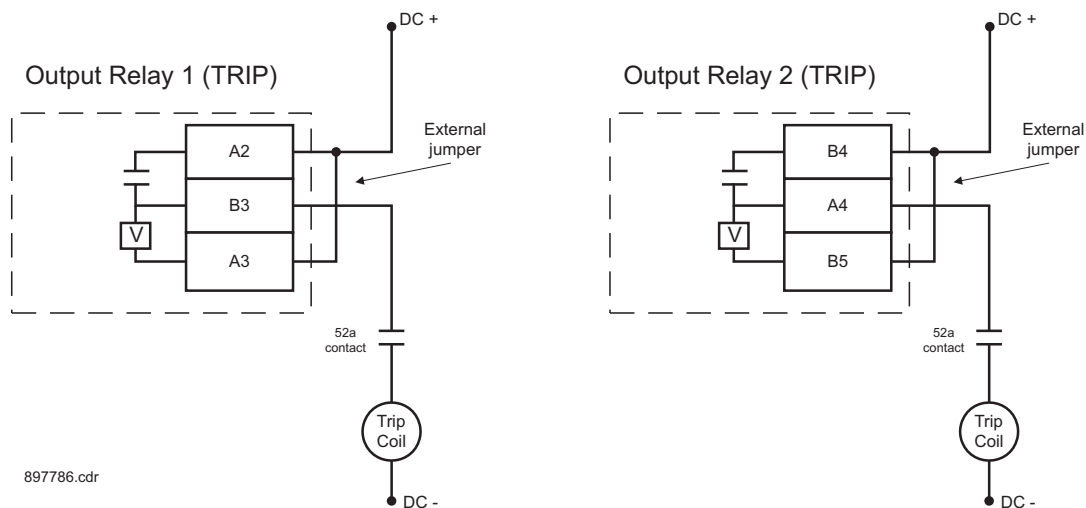
Figure 7-2: Breaker maintenance menu

Trip coil

The Trip coil monitoring is performed by a built-in voltage monitor on the Form A output relays: RLY1 W1 BKR TRIP and RLY2 W2 BKR TRIP. The voltage monitor is connected across the Form A contact, and effectively the relay detects healthy current through the circuit. An external jumper must be made between terminals "A2" and "A3" for Output Relay 1 (RLY1 W1 BKR TRIP) coil monitoring and "B4" and "B5" for Output Relay 2 (RLY2 W2 BKR 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.



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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.

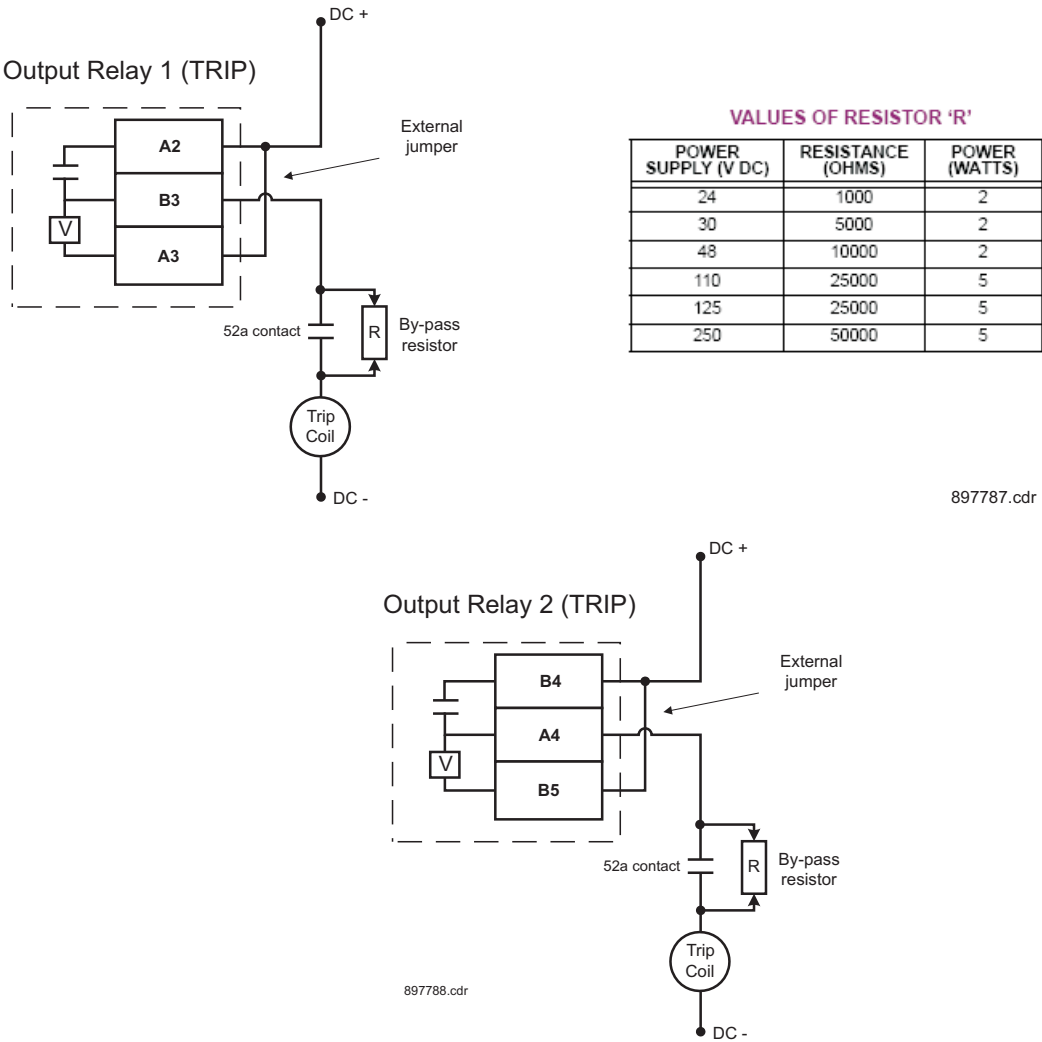


Figure 7-4: Trip circuits with continuous monitoring

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 > W1(W2) BKR TRIP

RLY1(2) 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 RLY1(2) coil circuitry problem.

RLY1(2) COIL DELAY

Range: 1 to 10 sec in steps of 1 sec

Default: 5 s

This setting defines the RLY1(2) 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 RLY1(2) circuit integrity monitoring. The circuits will be monitored regardless of breaker position. When “BYPASS BKR STATE” is set to Disabled, monitoring of the RLY1(2) 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](#).

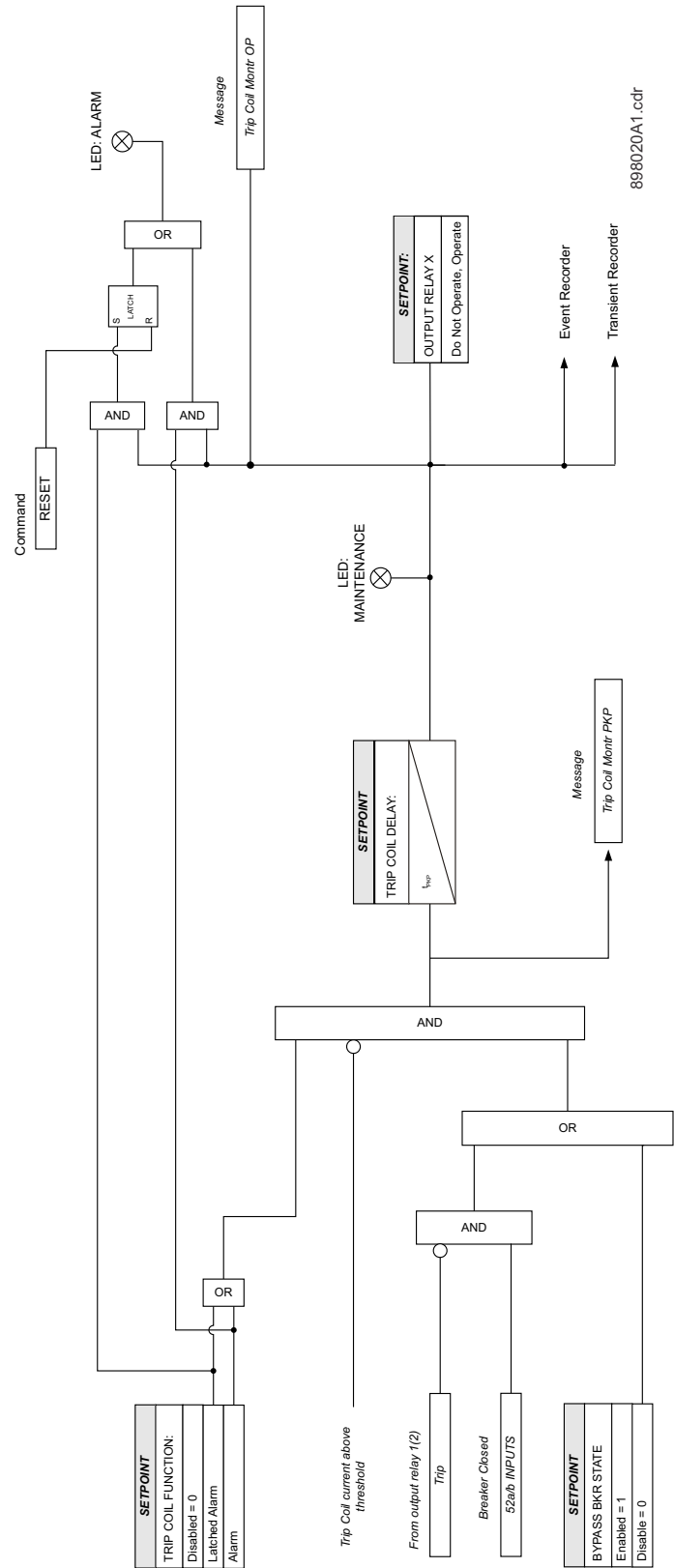


Figure 7-5: Trip coil monitoring logic diagram

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 > W1 (W2) 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](#).

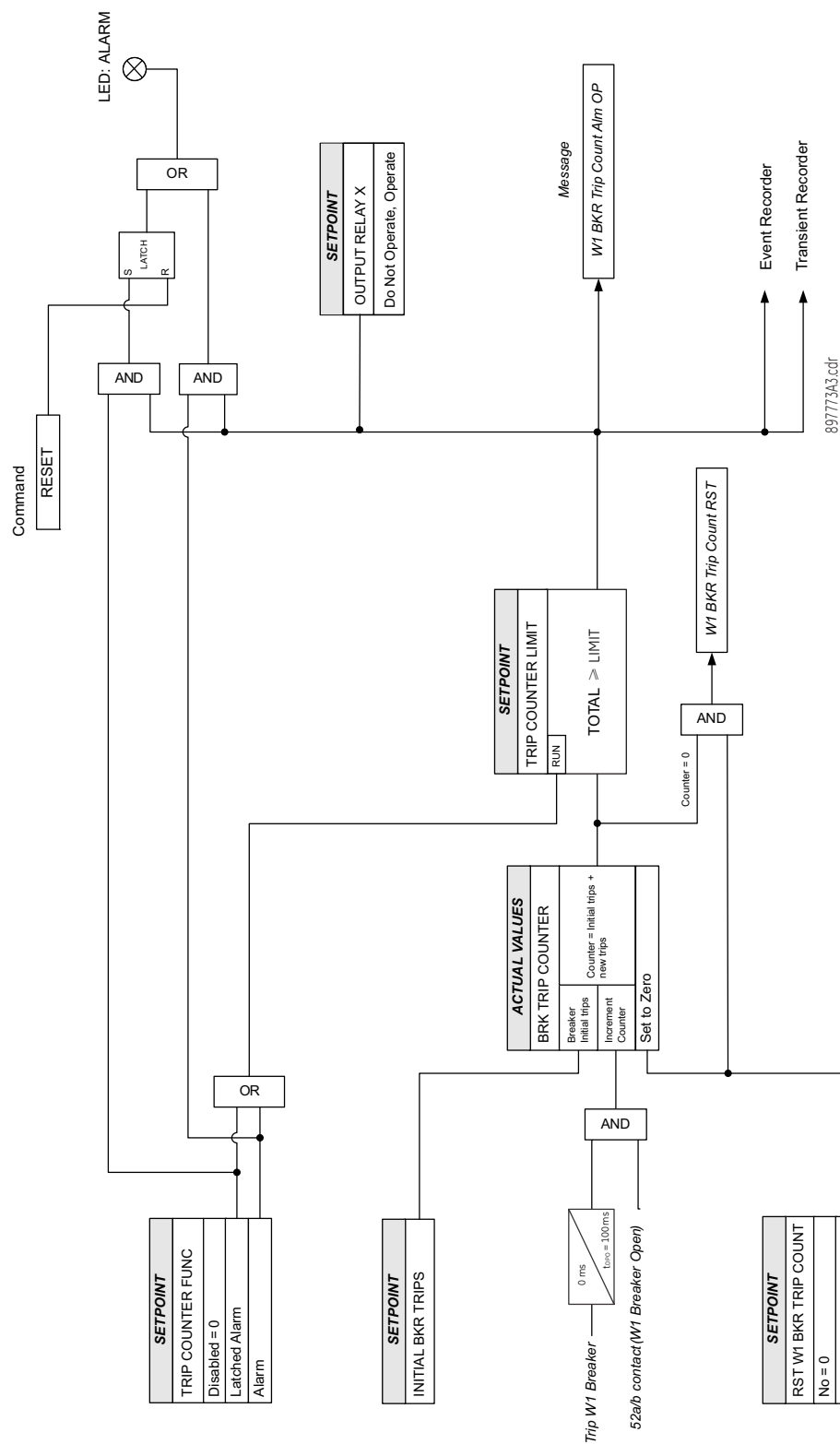


Figure 7-6: W1 (W2) BKR trip counter logic diagram

Breaker health

The 345 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 > W1 (W2) 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 CMND INPUT

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

Default: Off

This setting selects an operand (in most cases a contact input wired from the breaker control switch) to indicate a close command has been sent to the breaker externally. The "high" state of the operand is used to start the Close timer.

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

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](#).

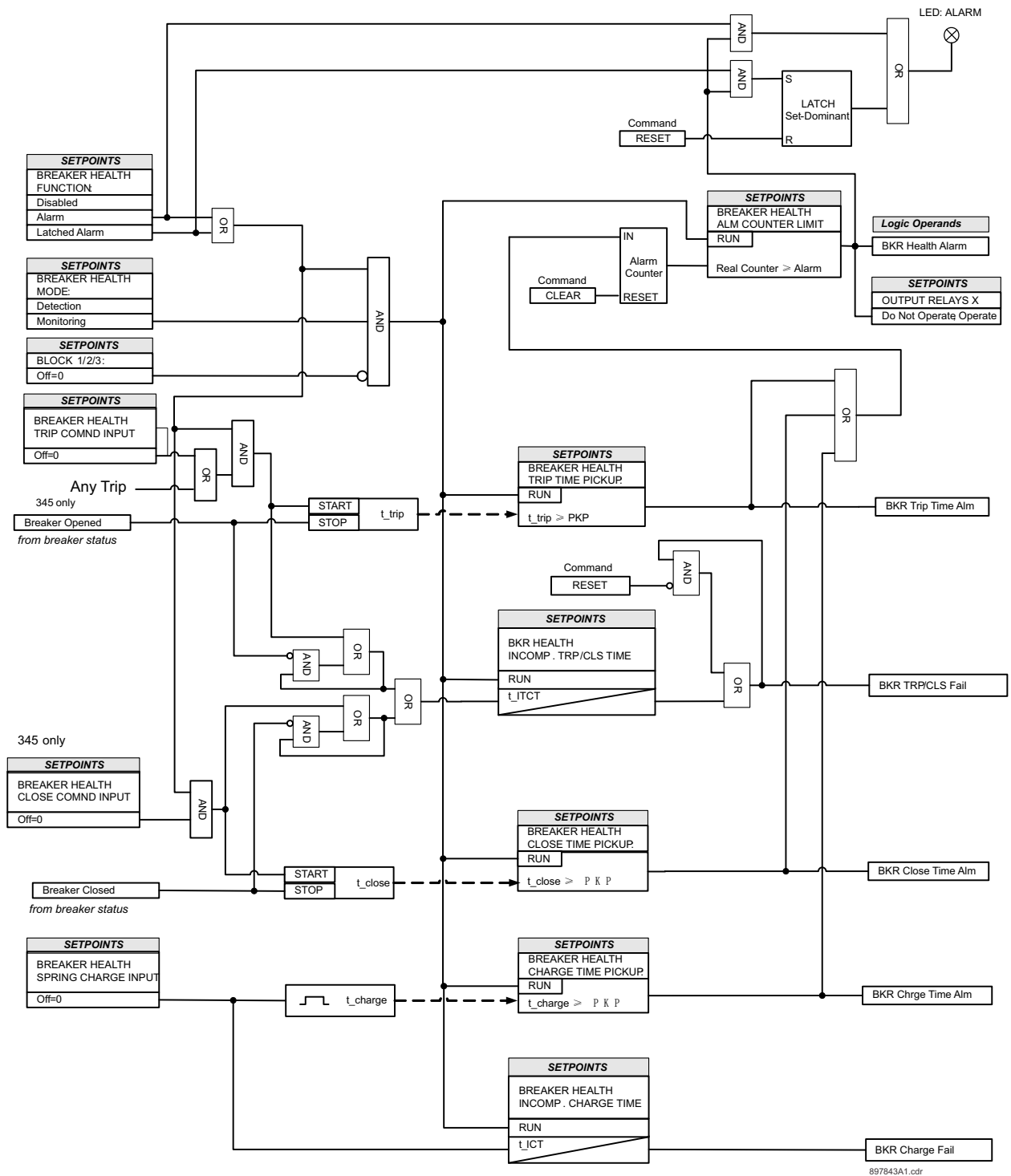


Figure 7-7: Breaker health logic diagram

Reset counters

Reset counter commands clear various counters.

PATH: [MAINTENANCE > M3 RESET COUNTERS](#)

RST W1 (W2) 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 W1 (W2) 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 W1 (W2) BKR TRIP TIMES

Range: No, Yes

Default: No

Entering a "Yes" command will clear the Trip Time Counters, and an event - "Reset Trip Time Counter" - will be recorded

RST W1 (W2) 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 W1 (W2) 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 W1 (W2) 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 345 stores the number of trips. The counter can be reset under **M3 RESET COUNTERS > RST BKR TRIP COUNT** set to "Yes".

PATH: **MAINTENANCE > M4 W1 (W2) BKR MONITOR**

W1 (W2) BKR TRIP COIL

Healthy

Range: Healthy, Unhealthy

W1 (W2) BKR TRIP COUNTER

5

Range: 0 to 10000 trips

W1 (W2) BKR ALARM COUNTER

5

Range: 0 to 10000 trips

W1 (W2) LAST TRIP TIME

5

Range: 0 to 10000 ms

W1 (W2) AVG TRIP TIME

5

Range: 0 to 10000 ms

W1 (W2) LAST CLOSE TIME

5

Range: 0 to 10000 ms

W1 (W2) AVG CLOSE TIME

5

Range: 0 to 10000 ms

W1 (W2) LAST CHARGE TIME

5

Range: 0 to 60000 ms

W1 (W2) 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](#).

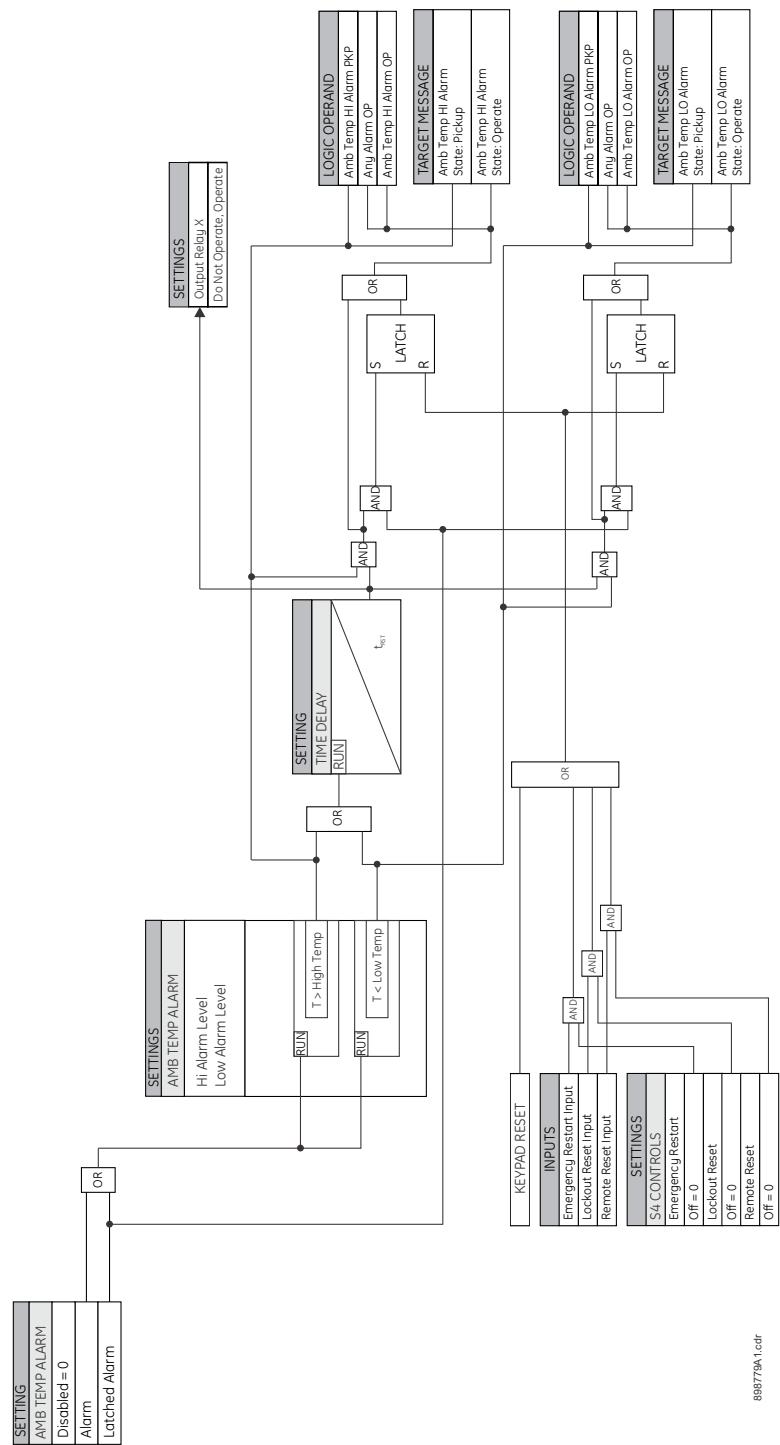


Figure 7-8: Ambient Temperature Alarm logic diagram

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".



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 345 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 345 requires minimal maintenance. As a microprocessor-based relay, its characteristics do not change over time. The expected service life of a 345 is 20 years when the environment and electrical conditions are within stated specifications.

While the 345 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.

345 Transformer 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 VERNOVA 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 VERNOVA service department. Use the detailed return procedure outlined at

https://www.gevernova.com/grid-solutions/multilin/support/ret_proc.htm

The current warranty and return information are outlined at

<https://www.gevernova.com/grid-solutions/multilin/warranty.htm>

Change Notes

Manual Revision history

Table 1: Revision History

MANUAL P/N	RELEASE DATE
1601-9098-A1	12 February 2010
1601-9098-A2	6 December 2010
1601-9098-A5	9 December 2011
1601-9098-A6	29 February 2012
1601-9098-A7	14 September 2012
1601-9098-A8	13 June 2013
1601-9098-A9	12 July 2013
1601-9098-AA	21 October 2013
1601-9098-AB	26 August 2014
1601-9098-AC	17 December 2015
1601-9098-AD	15 July 2016
1601-9098-AE	10 March 2017
1601-9098-AF	30 September 2017
1601-9098-AG	July 2019

Table 2: Major Updates to SR345-AG

Page Number	CHANGES
	Changed manual revision number to AG
Chapter 1	Order codes updated
Chapter 2	Wire Range section updated
Chapter 4	Event Records note added re. configuring number of events shown
General	Minor Corrections

Table 3: Major Updates to SR345-AF

Page Number	CHANGES
	Changed manual revision number to AF
Chapter 1	Updated Table 1-2 Correction to order codes: Current Protection option M Updated notes at the beginning of the Specifications section Updated voltage and current input accuracy to be at nominal frequency Updated power supply power consumption
Chapter 6	S4 Controls Logic Elements: note added
General	Minor Corrections

Table 4: Major Updates to SR345-AE

Page Number	CHANGES
	Changed manual revision number to AE Changed 345 revision to 2.3x
General	Changed features for 2.3x: RTD logic diagram updated Programmable LEDs setpoint added to configure LEDs as self-reset or latched Event Recorder Lockout setpoint descriptions updated Password and Security setpoint added and description updated Trip Counter logic diagram updated
General	New features for 2.3x: RTD (S6 Monitoring)
Chapter 1	Updated Order Codes Updated Line Diagram and Table 1-1 Protection Elements
Chapter 6	Breaker Tripping section adding under S3 Protection
Chapter 7	Breaker Health section adding under M3 Breaker Maintenance
General	Minor Corrections

Table 5: Major Updates to SR345-AD

Page Number	CHANGES
	Changed manual revision number to AD Changed 345 revision to 2.2x
General	Changed features for 2.2x: Logic Elements, Thermal Overload, Transient Recorder.
General	New features for 2.2x: Programmable LEDs, Trip Counter, Fault Reports, Lockout, Demand, Testing.
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	Minor Corrections

Table 6: Major Updates to SR345-AC

Page Number	CHANGES
	Changed manual revision number to AC Changed branding to Grid Solutions Updated logos
Chapter 1	Order codes: Added Accessories list Specifications, Data capture, updated Clock Accuracy Specifications, Power Supply: - Changed High Range Power Supply Range to 250 VDC - Added Fuse rating Specifications, Controls, Breaker Failure: added Reset Time Specifications, Testing and certification: - Added EAC certification - Added Country of origin, Date of manufacture, Declaration of Conformity - Updated Dielectric voltage withstand test levels Specifications: added Physical and Environmental (from QSG)
Chapter 2	Added IP20 cover (optional)
Chapter 3	Added Upgrading the software Updated Downloading and saving setpoint files Added Uninstalling files and clearing data Updated Loading new relay firmware
Chapter 5	Updated Quick Setup Menu ranges and default values
Chapter 6	Removed Direction setpoints from Common Setpoints section Added SNTP settings to Clock section Updated Subnet IP Mask default setting Updated Buffer Setup default setting Updated Trigger Position default settings Updated Transformer type default setting Updated Transformer percent differential: Slope 1 default setting Updated Transformer thermal protection: Cool time constant default setting Updated Phased TOC protection: PH TOC1 (2) PKP range Updated Ground TOC protection range values Updated Neutral TOC protection: NTRL TOC1 (2) PKP range
Chapter 7	Added General maintenance
Appendix	Added Repairs
n/a	Minor corrections throughout manual.

Table 7: Major Updates to SR345-AB

Page Number	CHANGES
	Changed manual revision number to AB and 345 revision number to 1.5x
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 8: Major Updates to SR345-AA

Page Number	CHANGES
	Change manual revision number to AA
Chapter 6	Transformer percent differential, BREAK 2 description

Table 9: Major Updates to SR345-A9

Page Number	CHANGES
	Change manual revision number to A9
Chapter 6	Clarify SR3 IEC 61850 GOOSE Details

Table 10: Major Updates to SR345-A8

Page Number	CHANGES
	Change manual revision number to A8
Chapter 1	Updated Testing and Certification table
General	Minor Corrections

Table 11: Major Updates to SR345-A7

Page Number	CHANGES
	Change manual revision number to A7
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 12: Major Updates to SR345-A6

Page Number	CHANGES
	Change manual revision number to A6
Chapter 2	Revise Control Power parameters

Table 13: Major Updates to SR345-A5

Page Number	CHANGES
	Change manual revision number to A5
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
General	Add support for additional safety/protection elements

Table 14: Major Updates for SR345-A3 and A4

Page Number	CHANGES
	Minor changes

