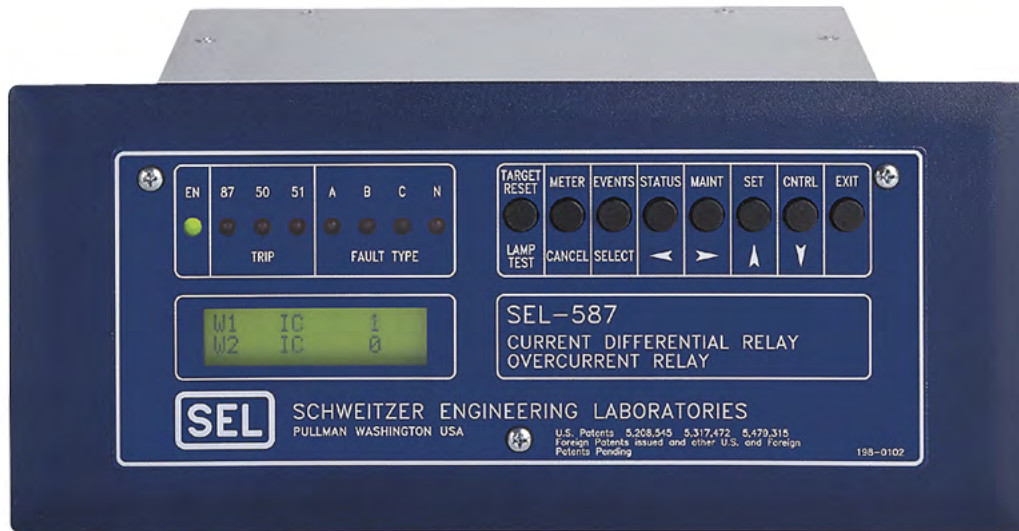




SEL-587 Current Differential Relay

Economical Differential Protection for Power Apparatus



Major Features and Benefits

The SEL-587 Current Differential Relay combines overcurrent and differential elements in an easy-to-apply power apparatus differential protection package. Relay security is achieved by an optimized set of user-selectable restraining and blocking elements. Dual-slope percentage, harmonic *restraint* and *blocking*, plus dc blocking are included. Zero-sequence currents are filtered out from the differential element for any combination of power and transformer CT connections. SELOGIC[®] control equations provide application flexibility when conditions warrant.

- **Protection.** Protect two-terminal transformers, generators, reactors, and other power apparatus using a combination of differential, instantaneous, definite-, and inverse-time overcurrent elements. Differential scheme security is achieved by the following:
 - Dual-slope percentage restraint
 - Second- and fourth-harmonic blocking or restraint plus dc blocking for magnetizing inrush
 - Fifth-harmonic blocking for transformer overexcitation
 - CT and transformer connection compensation
- **Monitoring.** Metering quantities are available for phase, ground, negative-sequence, differential, and harmonic currents. Post-fault analysis is simplified by information recorded in event reports having 15-cycle duration times. As many as 10 event reports are stored in nonvolatile memory. Self-test and alarm functions are standard.
- **Relay and Logic Settings Software.** ACCELERATOR QuickSet[®] SEL-5030 Software reduces engineering costs for relay settings and logic programming. The built-in HMI provides phasor diagrams that help support commissioning and troubleshooting.

Functional Overview

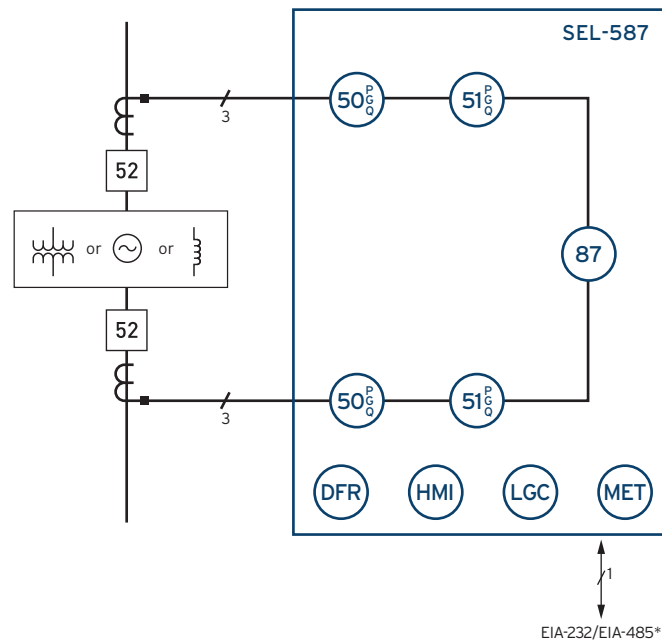


Figure 1 Functional Diagram

Model Variations

SEL-587-0 Relay

The SEL-587-0 has provided sophisticated and reliable service for many years. However, we recommend using the SEL-587-1 Relay for new designs because of the additional features it provides.

SEL-587-1 Relay

The following are the differences between the SEL-587-0 and the SEL-587-1.

- The SEL-587-0 trip logic can be set in one of two configurations, while the SEL-587-1 can be set in one of three configurations. The trip logic of each relay can be set to always latch the trip or to latch the trip if the current is above a certain threshold. The SEL-587-1 adds the ability to block trip latching.
- Each relay provides the ability to protect transformers with a variety of transformer and CT connections. Phase-angle shifts are compensated for and zero-sequence current is removed in most cases. The SEL-587-1 adds the ability to remove zero-sequence current in transformers with grounding banks within the differential zone or zigzag transformer applications.
- In addition to the harmonic blocking capabilities of the SEL-587-0, the SEL-587-1 provides second- and fourth-harmonic restraint and dc blocking capabilities.

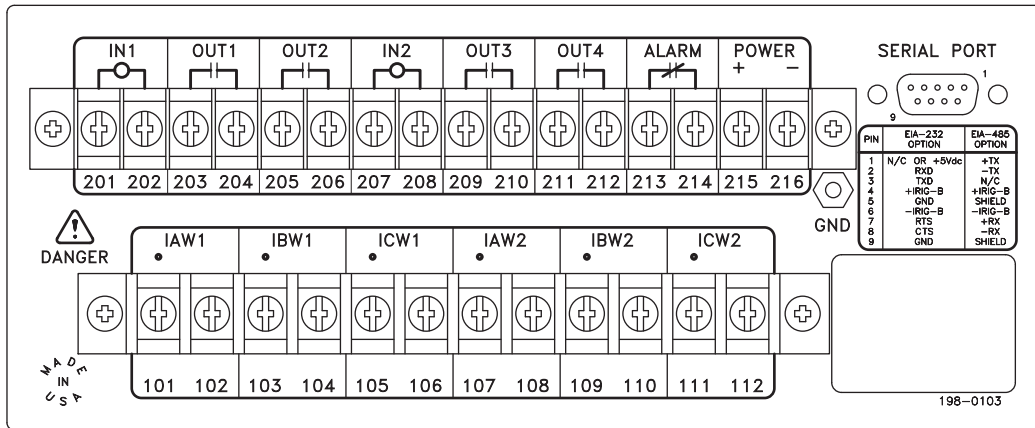
Two Rear-Panel Options

Conventional Terminal Blocks

This model includes hardware that supports six current inputs, two optoisolated inputs, four programmable output contacts, one alarm contact, one front EIA-232 port, one rear EIA-232 port, and IRIG-B time code. It uses terminal blocks that support #6 ring terminals. This robust package meets or exceeds numerous industry standard type tests.

Features of the conventional terminal block option are the following:

- Output contacts **OUT1-OUT4** and **ALARM** are not polarity-dependent.
- Optoisolator inputs **IN1** and **IN2** are not polarity-dependent.
- All screws are size #6-32.
- This relay is available in a 3.5" (2U) rack-mount package or a 4.9" panel-mount package.



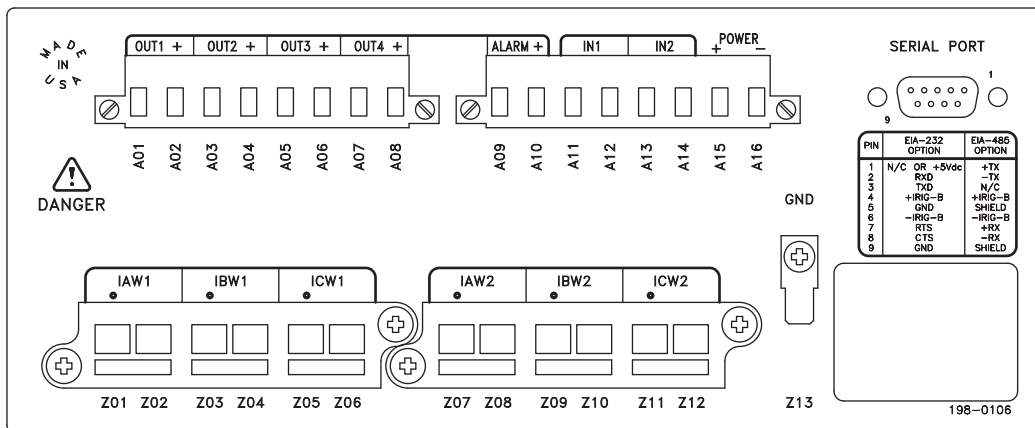
i3043a

Figure 2 Relay Rear Panel (Conventional Terminal Blocks Option)

Plug-In Connectors (Connectorized®)

This model includes hardware that supports all of the features of the conventional terminal block model. It differs in its use of plug-in connectors instead of terminal blocks. In addition, it provides:

- High-current interrupting output contacts.
- Quick connect/release hardware for rear-panel terminals.
- Level-sensitive optoisolated inputs.



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Figure 3 Relay Rear Panel (Plug-In Connectors Option)

This robust package meets or exceeds numerous industry standard type tests. It is available in a 3.5" (2U) rack-mount package or a 4.9" panel-mount package.

IMPORTANT: Improvements in Connectorized SEL-587 relays (Plug-In Connectors) result in part number changes.

The current transformer shorting connectors for current channel inputs IAW1, IBW1, ICW1, and IAW2, IBW2, and ICW2 have been made more robust. Thus, new Connectorized SEL-587 relays with this improved connector have a new part number (partial part number shown as follows):

Old	New
0587xJ	0587xW

The respective wiring harness part numbers for these old and new Connectorized SEL-587 relays are (partial part numbers shown as follows):

Old	New
WA0587xJ	WA0587xW

The other connectors on the SEL-587 rear panel (power input, output contacts, etc.) are the same for the old or new models. Only the current transformer shorting connectors have changed.

Figure 3 shows the rear panel for new model 0587xW. Because all terminal labeling/numbering remains the same between the new and old relays, these figures can also be used as a reference for old model 0587xJ. Only the connectors and part numbers have changed.

Connector terminals **A01–A08** and **ALARM** are polarity-dependent.

Current input connector (terminals **Z01–Z12**):

- Contains current transformer shorting mechanisms
- Accepts wire size AWG 16 to 10 (special tool required to attach wire to connector)
- Can be ordered prewired

Ground connection (terminal **Z13**): tab size 0.250" x 0.032", screw size #6-32.

Relay Elements

Table 1 Relay Elements

Restrained and Unrestrained Differential Element Settings	Setting	Setting Range
Operating-Current Pickup	O87P	(0.1–1.0), TAP
Restraint Slope 1 Percentage	SLP1	5%–100%
Restraint Slope 2 Percentage	SLP2	OFF, 50–200%
Restraint-Current Slope 1 Limit	IRS1	(1–16), TAP
Instantaneous-Unrestrained-Current Pickup	U87P	(1–16), TAP
Second-Harmonic Blocking Percentage	PCT2	OFF, 5%–100%
Fourth-Harmonic Blocking Percentage	PCT4	OFF, 5%–100%
Fifth-Harmonic Blocking Percentage	PCT5	OFF, 5%–100%

The relay automatically calculates TAP values from transformer ratings, CT ratios, and connections.

Table 2 Overcurrent Elements

Eight Overcurrent Elements for Winding 1	Instantaneous	Definite Time	Inverse Time
Phase	50P1H	50P1	51P1
Negative Sequence		50Q1	51Q1
Residual	50N1H	50N1	51N1
Eight Overcurrent Elements for Winding 2	Instantaneous	Definite Time	Inverse Time
Phase	50P2H	50P2	51P2
Negative Sequence		50Q2	51Q2
Residual	50N2H	50N2	51N2
Setting Ranges, 5 A Model, (A secondary)	OFF, (0.5–80)	OFF, (0.5–80)	OFF, (0.5–16)
Setting Ranges, 1 A Model, (A secondary)	OFF, (0.1–16) OFF Disables Element	OFF, (0.1–16)	OFF, (0.1–3.2) ANSI and IEC curves

Percentage Differential Element

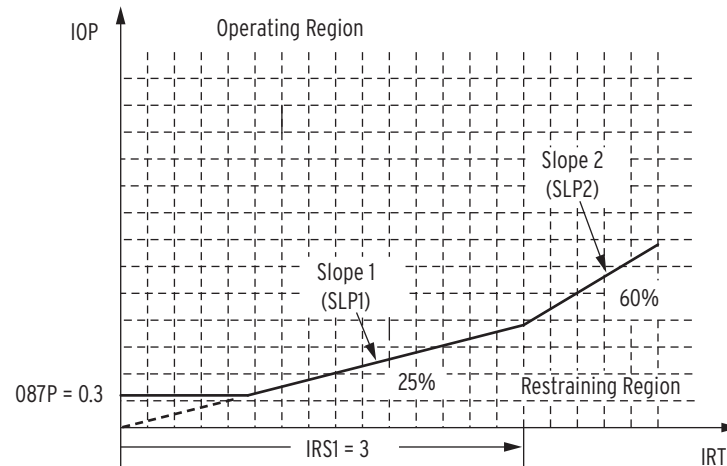


Figure 4 Percentage Differential Element

Operation, Metering, Control, and Reporting

Apply This Relay to Protect

- Any two-winding power transformer
- Three-winding power transformers where the tertiary winding is not connected
- Reactors, generators, large motors, and other two-terminal power apparatus

Smart Relay Settings Simplify Current Connections

- Relay accepts delta- or wye-connected CT secondary circuits
- Enter transformer ratings and connections, CT ratios and connections
- Relay calculates TAP values, corrects CT ratios and transformer ratios
- CT secondary circuits are isolated, allowing them to be connected to other protection

High-Side and Low-Side Overcurrent Elements Provide Additional Protection

- Use high-side overcurrent elements for built-in transformer backup protection
- Negative-sequence overcurrent elements detect ground faults through delta-wye transformer banks
- Use low-side overcurrent elements for backup distribution bus or feeder protection
- Negative-sequence overcurrent elements provide sensitive phase-to-phase protection independent of load current

Externally Torque-Controlled Overcurrent Elements

- Optionally, select relay control inputs to supervise overcurrent elements
- Select torque-controlled overcurrent elements individually
- Implement a reverse interlocking scheme for fast-bus tripping on radial systems
- Provide external directional supervision

Operator Controls and Serial Communications

- Front-panel pushbuttons and display
- Complete operation from front-panel EIA-232 or rear-panel EIA-232 serial communications port
- Full access to event history, relay status, and meter information
- Passcode-protected settings and controls

Current Meter Functions

- Provides instantaneous, demand, and peak demand current magnitudes for both windings
- Calculates operate, restraint, second-, and fifth-harmonic current magnitudes
- Records peak demand and peak harmonic current magnitudes

Breaker Monitor and Control

- Saves trip counters and accumulated, interrupt current in nonvolatile memory
- Controls each breaker with separate **OPEN** and **CLOSE** commands

SELOGIC Control Equations

- Assign input functions
- Create application-specific output functions
- Design unique trip and control schemes
- Minimize external timers, auxiliary relays, wiring, and panel space
- Obtain event reporting for all relay elements, inputs, and outputs

Event Reporting

- Relay stores 10 reports in nonvolatile memory
- Reports have 15-cycle duration
- Each event report has two parts:
 - Part 1 shows input currents, overcurrent elements, general differential elements, inputs, and outputs.
 - Part 2 shows operating restraint currents, maximum second- and fifth-harmonic currents, more detailed information of the differential elements, and the remaining elements.

Relay and Logic Setting Software

The QuickSet software uses the Microsoft Windows operating system to simplify settings and provide analysis support for the SEL-587.

One can, for instance, open an QuickSet HMI screen and obtain phasor information similar to that shown in *Figure 5*.

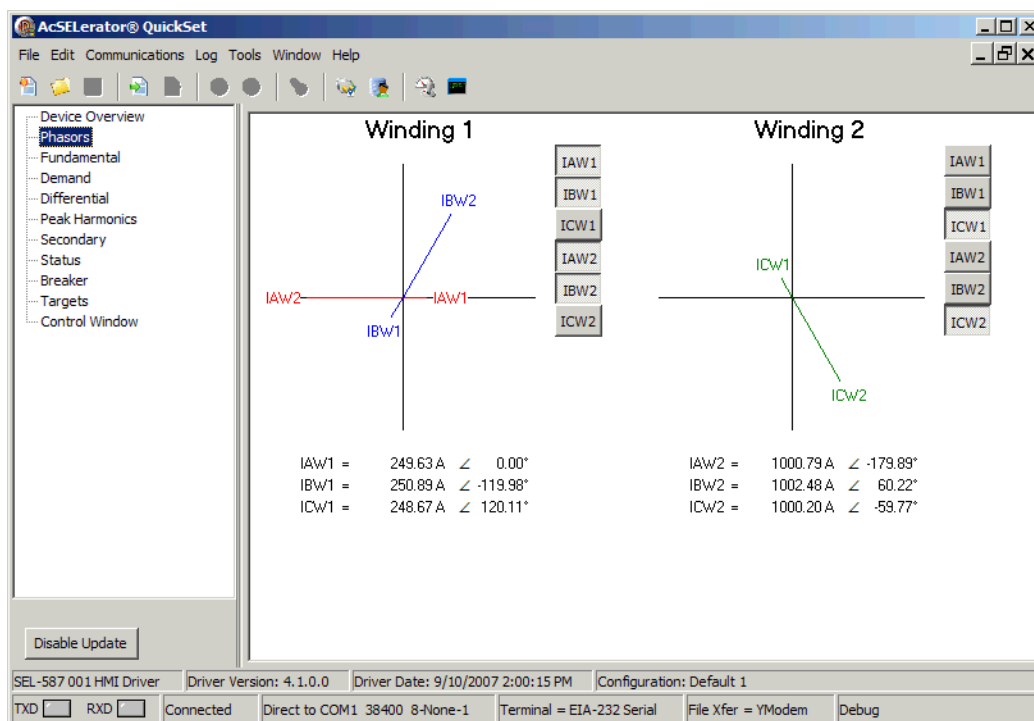


Figure 5 QuickSet HMI Screen Showing SEL-587 Phasor Information

Use the QuickSet software to create and manage relay settings:

- Develop settings offline with an intelligent settings editor that only allows valid settings.
- Use online help to assist with configuration of proper settings.
- Organize settings with the relay database manager.
- Load and retrieve settings through use of a simple PC communications link.

Use the QuickSet software to verify settings and analyze events:

- Analyze power system events with integrated waveform and harmonic analysis tools.

Use the QuickSet software to aid with monitoring, commissioning, and testing the SEL-587:

- Use the HMI to monitor current phasor information during testing.
- Use the PC interface to remotely obtain power system data.

Note: To use QuickSet software in the SEL-587 Relay, the relay must have firmware version R702 or later.

Wiring Diagrams

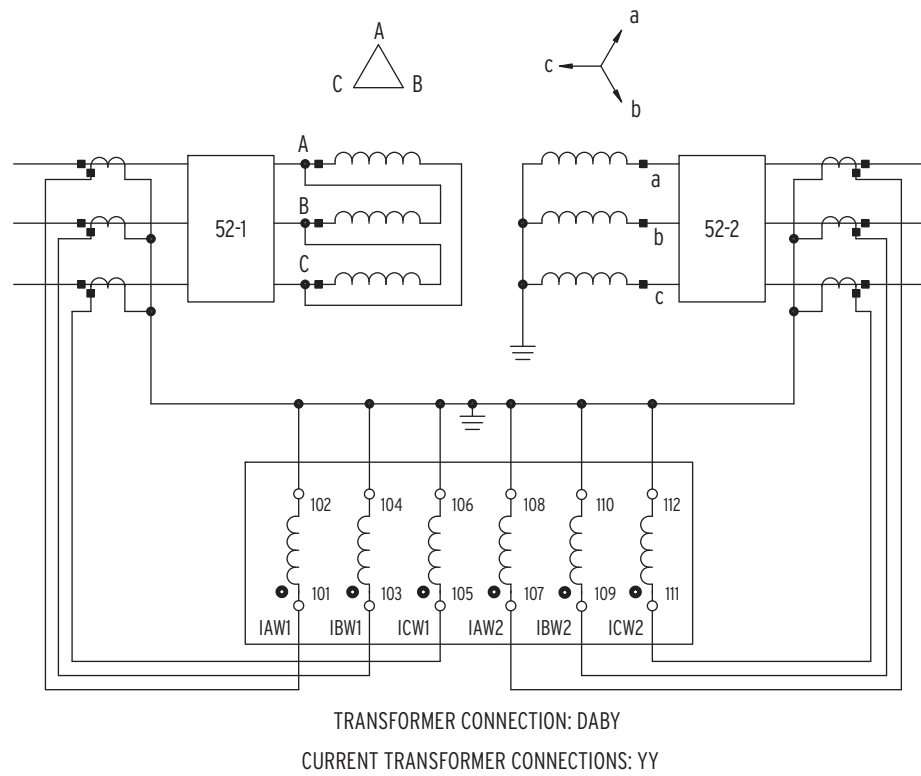


Figure 6 Typical AC Connection Diagram, Three-Winding Autotransformer Application

- ▶ Relay automatically compensates for power transformer phase shift and ratio scaling.
- ▶ Protects delta-wye, wye-delta, delta-delta, and wye-wye transformers.
- ▶ Accepts delta- or wye-connected CTs on either side of the transformer.

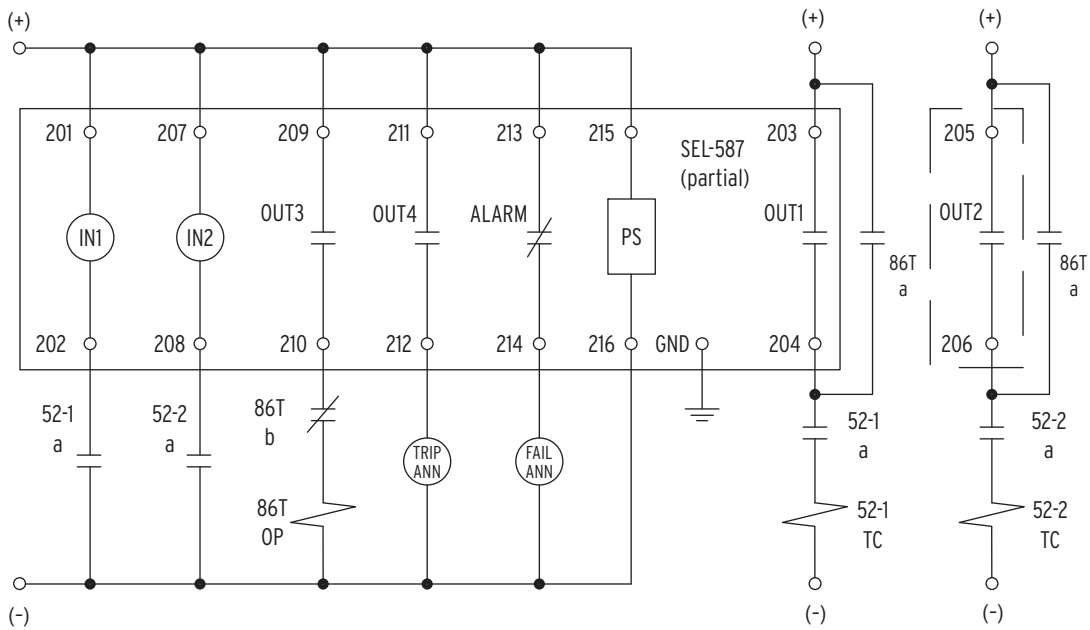
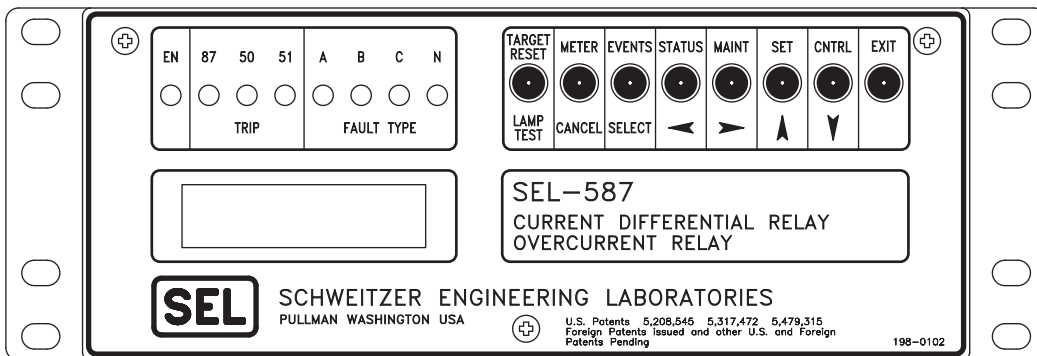


Figure 7 Typical DC Connection Diagram, Three-Winding Transformer Application

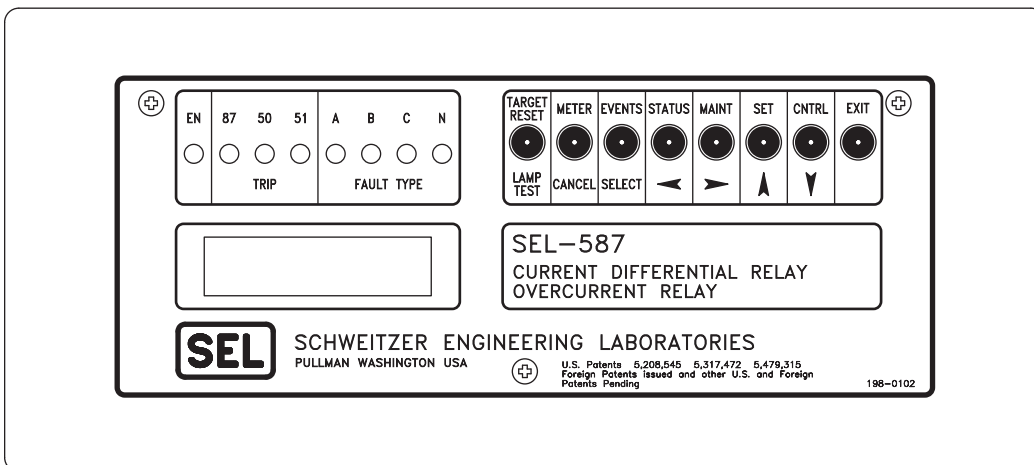
- Relay outputs are programmable to support a variety of applications.
- In this example, **OUT1** and **OUT2** provide high-side and low-side overcurrent tripping. **OUT3** operates the transformer lockout auxiliary for differential element operations.

Front- and Rear-Panel Diagrams



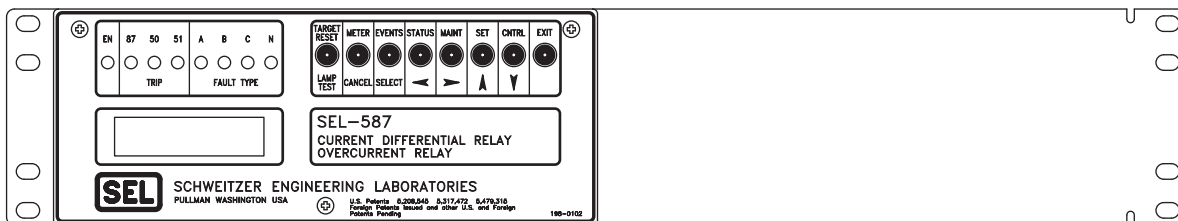
Relay Front Panel, Rack-Mount Version (Half Rack Width)

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Relay Front Panel, Panel-Mount Version

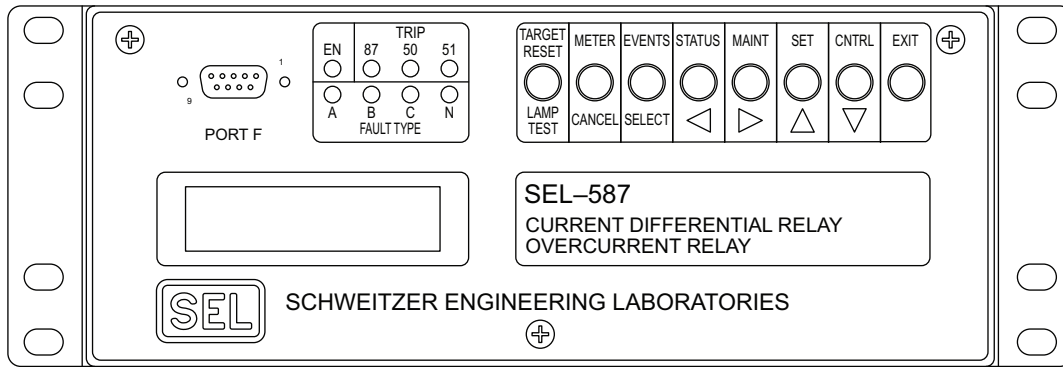
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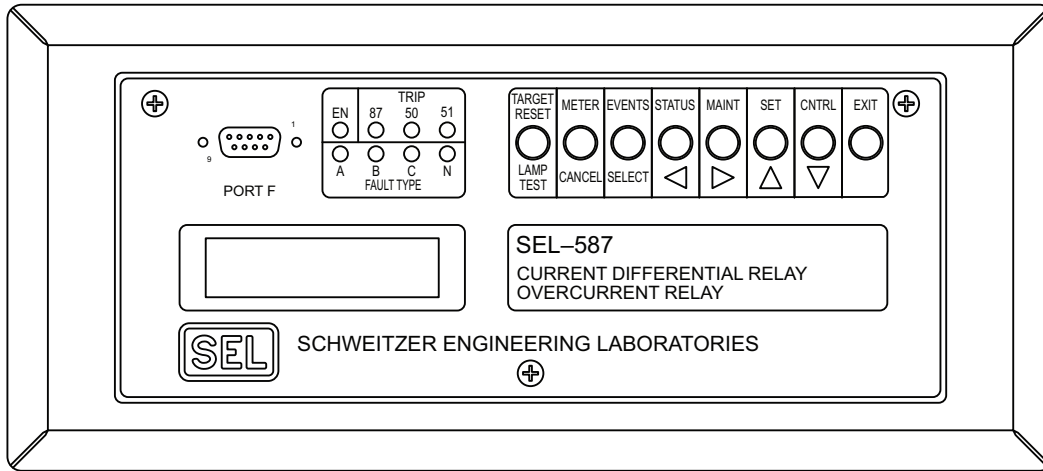
Relay Fitted With Mounting Bracket (SEL P/N 9100) for Mounting in 19-Inch Rack

i3045a

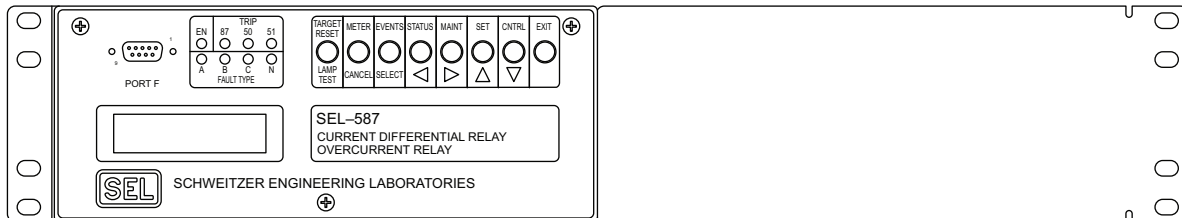
Figure 8 SEL-587 Front Panels Without Serial Front Port



Relay Front Panel, Rack-Mount Version (Half Rack Width)

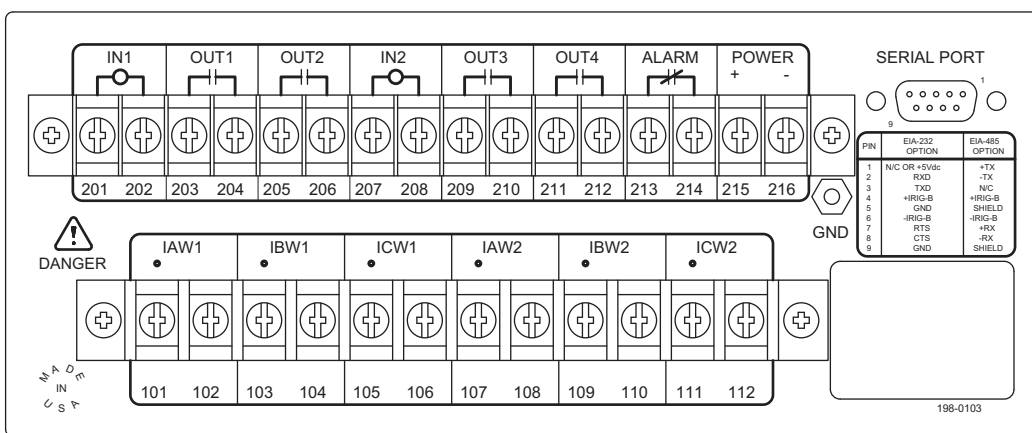


Relay Front Panel, Panel-Mount Version

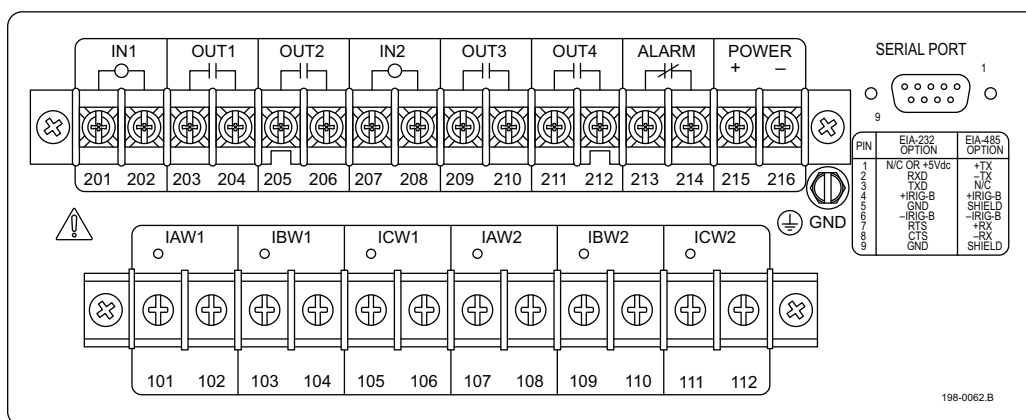


Relay Fitted With Mounting Bracket (SEL P/N 9100) for Mounting in 19-Inch Rack

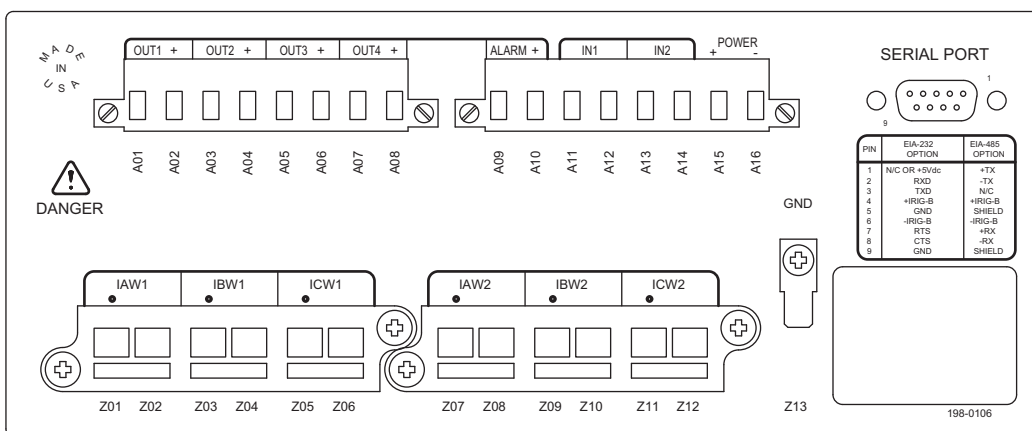
Figure 9 SEL-587 Front Panels With Serial Front Port



Relay Rear Panel Without Serial Front Port, Conventional Terminal Blocks Version



Relay Rear Panel With Serial Front Port, Conventional Terminal Blocks Version

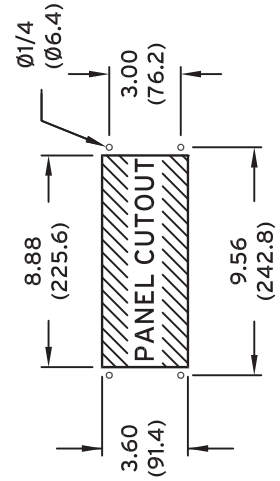
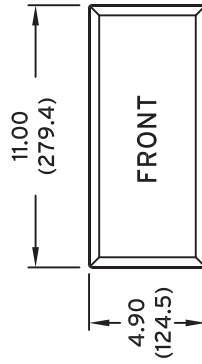
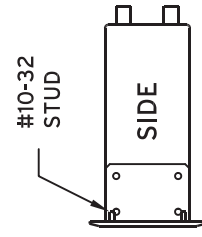
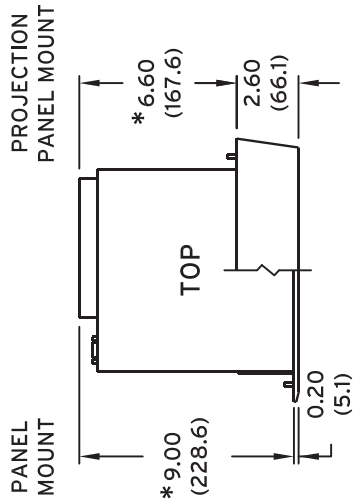


Relay Rear Panel, Plug-In Connectors Version

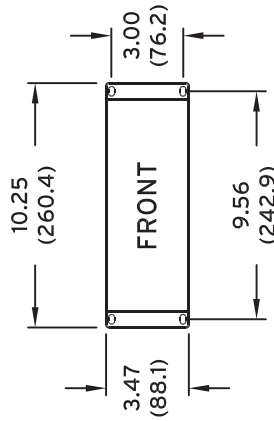
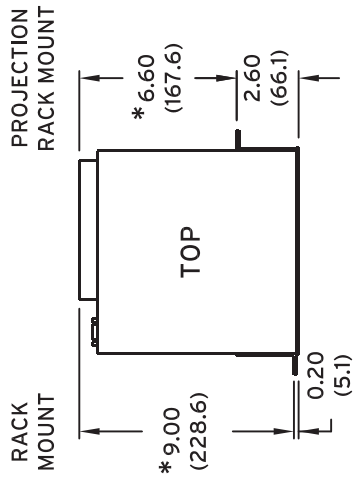
Figure 10 SEL-587 Rear-Panel Diagrams

Relay Dimensions

PANEL-MOUNT CHASSIS



RACK-MOUNT CHASSIS



* ADD 0.80 (20.3) FOR CONNECTORIZED RELAYS

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Specifications

Compliance

Designed and manufactured under an ISO 9001 certified quality management system

UL Listed to U.S. and Canadian safety standards (File E212775; NRGU, NRGU7)

CE Mark

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

General

Tightening Torque

Terminal Block:

Minimum: 9 in-lb (1.1 Nm)

Maximum: 12 in-lb (1.3 Nm)

Connectorized:

Minimum: 5 in-lb (0.6 Nm)

Maximum: 7 in-lb (0.8 Nm)

Terminal Connections

Terminals or stranded copper wire. Ring terminals are recommended. Minimum temperature rating of 105°C.

AC Current Inputs

5 A nominal:	15 A continuous, 500 A for 1 s, linear to 100 A symmetrical 625 A for 1 cycle (sinusoidal waveform)
Burden:	0.16 VA @ 5 A, 1.15 VA @ 15 A
1 A nominal:	3 A continuous, 100 A for 1 s, linear to 20 A symmetrical 250 A for 1 cycle (sinusoidal waveform)
Burden:	0.06 VA @ 1 A, 0.18 VA @ 3 A

Power Supply

Rated:	125/250 V
Range:	85–350 Vdc or 85–264 Vac
Interruption:	100 ms @ 250 Vdc
Ripple:	5%
Burden:	<5.5 W
Rated:	48/125 Vdc or 125 Vac
Range:	36–200 Vdc or 85–140 Vac
Interruption:	100 ms @ 125 Vdc
Ripple:	5%
Burden:	<5.5 W

Rated:	24 Vdc
Range:	16–36 Vdc polarity-dependent
Interruption:	25 ms @ 36 Vdc
Ripple:	5%
Burden:	<5.5 W

Note: Interruption and Ripple per IEC 60255-11:1979.

Output Contacts

Conventional Terminal Blocks Option (Standard Outputs):

Make:	30 A
Carry:	6 A
1 s Rating:	100 A
MOV Protection:	270 Vac, 360 Vdc, 40 J
Pickup/Dropout Time:	< 5 ms

Breaking Capacity (10000 operations):

24 V	0.75 A	L/R = 40 ms
48 V	0.50 A	L/R = 40 ms
125 V	0.30 A	L/R = 40 ms
250 V	0.20 A	L/R = 40 ms

Cyclic Capacity (2.5 cycles/second):

24 V	0.75 A	L/R = 40 ms
48 V	0.50 A	L/R = 40 ms
125 V	0.30 A	L/R = 40 ms
250 V	0.20 A	L/R = 40 ms

Plug-In Connectors Option (High Current Interrupting Outputs):

Make:	30 A
Carry:	6 A
MOV Protection:	330 Vdc, 40 J
Pickup/Dropout Time:	< 5 ms
Dropout Time:	< 8 ms, typical

Breaking Capacity (10000 operations):

24 V	10 A	L/R = 40 ms
48 V	10 A	L/R = 40 ms
125 V	10 A	L/R = 40 ms
250 V	10 A	L/R = 20 ms

Cyclic Capacity (4 cycles in 1 second followed by 2 minutes idle for thermal dissipation):

24 V	10.0 A	L/R = 40 ms
48 V	10.0 A	L/R = 40 ms
125 V	10.0 A	L/R = 40 ms
250 V	10.0 A	L/R = 20 ms

Note: Do not use high current interrupting output contacts to switch ac control signals. These outputs are polarity-dependent.

Note: Make per IEEE C37.90-1989; Breaking and Cyclic Capacity per IEC 60255-0-20:1974.

Optoisolated Inputs

Conventional Terminal Blocks Option:

Jumper-Selectable:	
24 Vdc:	15–30 Vdc
48 Vdc:	30–60 Vdc
125 Vdc:	80–150 Vdc
250 Vdc:	150–300 Vdc

Level-Sensitive:

48 Vdc:	Pickup 38.4–60 Vdc; Dropout 28.8 Vdc
110 Vdc:	Pickup 88–132 Vdc; Dropout 66 Vdc
125 Vdc:	Pickup 105–150 Vdc; Dropout 75 Vdc
220 Vdc:	Pickup 176–264 Vdc; Dropout 132 Vdc
250 Vdc:	Pickup 200–300 Vdc; Dropout 150 Vdc

Plug-In Connectors Option:

Standard (Non-Level-Sensitive):

24 Vdc:	Pickup 15–30 Vdc
---------	------------------

Level-Sensitive:

48 Vdc:	Pickup 38.4–60 Vdc; Dropout 28.8 Vdc
110 Vdc:	Pickup 88–132 Vdc; Dropout 66 Vdc
125 Vdc:	Pickup 105–150 Vdc; Dropout 75 Vdc
250 Vdc:	Pickup 200–300 Vdc; Dropout 150 Vdc

Note: Optoisolated inputs draw approximately 4 mA of current. All current ratings are at nominal input voltages.

Routine Dielectric Strength Tests

AC Current Inputs,:	2500 Vac for 10 s
---------------------	-------------------

Power Supply, Optoisolated Inputs, and Output Contacts:	3100 Vdc for 10 s
---	-------------------

Frequency and Rotation

System Frequency:	60 or 50 Hz
Phase Rotation:	ABC or ACB

Communications Port Options

Front-Panel Port:	EIA-232
Rear-Panel Port:	EIA-232 or EIA-485
Baud:	300–38400 bps

Time-Code Input

Relay accepts demodulated IRIG-B time-code input at Port 1.

Dimensions

See *Figure 2.1* through *Figure 2.3*.

Operating Temperature

–40° to +85°C (–40° to +185°F)

Weight

2.6 kg (5 lb, 12 oz)

Relay Shipping Weight

4 kg (9 lb)

Type Tests

Emissions

Electromagnetic Emissions for Relays:	EIC 60255-25:2000 [BS EN 60255-25:2000]
*Generic Emissions, Heavy Industrial:	EN 50081-2:1993, Class A
*Generic Immunity, Heavy Industrial:	EN 50082-2:1995, Class A
*Radiated and Conducted Emissions:	EN 55011:1998, +A1:1999 +A2:2002

Environmental Tests

Cold:	IEC 60068-2-1:1990 +A1:1993 +A2:1994 [BS EN 60068-2-1:1993 +REAF:2005] Test Ad; 16 hr at –40°C
Dry Heat:	IEC 60068-2-2:1974 +A1:1993 +A2:1994 [BS EN 60068-2-2:1993 +REAF:2005] Test Bd; 16 hr at +85 C
Damp Heat, Cyclic:	IEC 60068-2-30:1980, Test Db; 55°C, 6 cycles, 95% humidity

Dielectric Strength and Impulse Tests

Dielectric Strength:	IEC 60255-5:1977 2500 Vac on analogs, contact inputs, and contact outputs; 3100 Vdc on power supply
Impulse:	IEC 60255-5:1977 0.5 J, 5 kV

Electromagnetic Compatibility Immunity

Magnetic Field:	IEC 61000-4-8:1993 [BS EN 61000-4-8:1994] 1000 A/m for 3 seconds, 100 A/m for 1 minute
Radiated Radio Frequency:	ENV 50140:1993 10 V/m
Electrostatic Discharge:	IEC 60255-22-2:1996 [BS EN 60255-22-2:1997], Level 2, 4, 6, 8 kV
1 MHz Burst Disturbance	IEC 60255-22-1:1988 Class 3 (2500 V common and differential mode)
Fast Transient Disturbance:	IEEE C37.90.2-1987 10 V/m IEC 60255-22-4:1992, Level 4 (4 kv @ 2.5 kHz on power supply; 2 kV @ 5 kHz on input/output, signal, data, and control lines)
*Conducted Radio Frequency:	IEC 61000-4-6:1996 ENV 50141:1993, 10 Vrms
Radiated Radio Frequency (900 MHz With Modulation):	ENV 50204:1995 10 V/m
Surge Withstand:	IEEE C37.90.1-1989 3.0 kV oscillatory; 5.0 kV transient

Vibration and Shock Testing

Vibration:	IEC 60255-21-1:1988 [BS EN 60255-21-1:1996 +A1:1996] Class 1 Endurance, Class 2 Response
Shock and Bump:	IEC 60255-21-2:1988 [BS EN 60255-21-2:1996 +A1:1996], Class 1 Shock Withstand, Bump; Class 2 Shock Response
Seismic:	IEC 60255-21-3:1993 [BS EN 60255-21-3:1995 +A1:1995], Class 2 (Conventional Terminal Block only)

Object Penetration

Object Penetration:	IEC 60529:1989 IP30
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Note: * = terminal block version only.

Sampling

16 samples per power system cycle

Processing

Differential elements, optoisolated inputs, and contact outputs are processed at 1/8 cycle.
Overcurrent elements are processed at 1/8 cycle.

Metering Accuracy

Instantaneous Currents:

5 A Model: $\pm 2\% \pm 0.10$ A

1 A Model: $\pm 2\% \pm 0.02$ A

Demand Currents:

5 A Model: $\pm 2\% \pm 0.10$ A

1 A Model: $\pm 2\% \pm 0.02$ A

Differential Element

Unrestrained Pickup

Range: 1–16 in per unit of TAP

Restrained Pickup

Range: 0.1–1.0 in per unit of TAP

Pickup Accuracy (A secondary):

5 A Model: $\pm 5\% \pm 0.10$ A

1 A Model: $\pm 5\% \pm 0.02$ A

Unrestrained Element Pickup Time

Min/Typ/Max: 0.8/1.1/2.0 cycles

Restrained Element (with harmonic blocking) Pickup Time

Min/Typ/Max: 1.6/1.7/2.3 cycles

Restrained Element (with harmonic restraint) Pickup Time (SEL-587-1)

Min/Typ/Max: 2.2/2.6/2.8 cycles

Harmonic Blocking Element

Pickup Range (% of fundamental):

5%–100%

Pickup Accuracy (A secondary):

5 A Model: $\pm 5\% \pm 0.10$ A

1 A Model: $\pm 5\% \pm 0.02$ A

Time Delay Accuracy: $\pm 0.1\% \pm 0.25$ cycle

Instantaneous/Definite-Time Overcurrent Elements (Winding)

Pickup Range (A secondary):

5 A Model: 0.5–80.0 A

1 A Model: 0.1–16.0 A

Pickup Accuracy (A secondary):

5 A Model: $\pm 5\% \pm 0.10$ A

1 A Model: $\pm 5\% \pm 0.02$ A

Pickup Time (Typ/Max): 0.75/1.20 cycles

Time Delay Range: 0–16,000 cycles

Time Delay Accuracy: $\pm 0.1\% \pm 0.25$ cycle

Transient Overreach: <5% of pickup

Time-Overcurrent Elements (Winding and Combined Current)

Pickup Range (A secondary):

5 A Model: 0.50–16.00 A

1 A Model: 0.10–3.20 A

Pickup Accuracy (A secondary):

5 A Model: $\pm 5\% \pm 0.10$ A

1 A Model: $\pm 5\% \pm 0.02$ A

Pickup Time (Typ/Max): 0.75/1.20 cycles

Curves:

U1 = U.S. Moderately Inverse

U2 = U.S. Inverse

U3 = U.S. Very Inverse

U4 = U.S. Extremely Inverse

C1 = IEC Class A (Standard Inverse)

C2 = IEC Class B (Very Inverse)

C3 = IEC Class C (Extremely Inverse)

C4 = IEC Long-Time Inverse

Time-Dial Range

U.S. Curves: 0.50–15.00, 0.01 step

IEC Curves: 0.05–1.00, 0.01 step

Timing Accuracy:

$\pm 4\% \pm 2\% (I_{NOM}/I_{SEC}) \pm 1.5$ cycles for current between 2 and 30 multiples of pickup. Curves operate on definite-time for current greater than 30 multiples of pickup or 16 times nominal.

Reset Characteristic:

Induction-disk reset emulation or 1-cycle linear reset

Technical Support

We appreciate your interest in SEL products and services. If you have questions or comments, please contact us at:

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