SEL-387A Current Differential and Overcurrent Protection Relay

Versatile Solution for Power Apparatus Protection

Major Features and Benefits

The SEL-387A Relay offers restrained and unrestrained differential protection for two terminals. Second-, fourth-, and fifth-harmonic elements, augmented by the dc element, provide security during transformer energization and overexcitation conditions in a user-defined choice of either harmonic restraint or harmonic blocking. Overcurrent elements provide backup protection that contributes to the versatility of the SEL-387A.

Oscillographic event reports, Sequential Events Recorder (SER), circuit breaker contact wear monitor, and substation battery voltage monitor are all standard features. Four communications ports, local display panel, and extensive automation features are also standard. Expanded I/O is available as an option. Two optional restricted earth fault elements provide sensitive protection against earth faults for wye-connected transformers.

- **Protection.** Protect transformers, buses, generators, reactors, and other apparatus with a combination of differential and overcurrent protection. The differential element is set with either a single- or dual-slope percentage differential restraint characteristic for increased security during through-fault conditions.
- **Metering.** Interrogate the relay for instantaneous measurements of phase and demand current. The recorded peak demand, including the date and time of occurrence, is provided. Use accurate metering data for system EMS/SCADA applications.
- **Monitoring.** Schedule breaker maintenance when breaker monitor indicates. Notify personnel of substation battery voltage problems. Monitor critical operating temperatures using the SEL-2600 RTD Module. Use the SEL-387A through-fault event monitor for information on system through faults and resulting cumulative I^2t wear on transformer banks. Monitor critical operating temperatures through use of the SEL-2600.
- **Automation.** Take advantage of automation features that include 16 elements for each of the following: local control and local indication with front-panel LCD and pushbuttons, remote control, and latch control. Use the serial communications ports for efficient transmission of key information including metering data, protection elements and contact I/O status, SER reports, breaker contact wear monitor, relay summary event reports, and time synchronization. Select optional DNP3 Level 2 Slave protocol with virtual terminal support for SCADA system interface capability.
- **Relay and Logic Settings Software.** ACSELERATOR QuickSet® SEL-5030 Software reduces engineering costs for relay settings and logic programming. The built-in Human Machine Interface (HMI) provides phasor diagrams that help support commissioning and troubleshooting.

Functional Overview

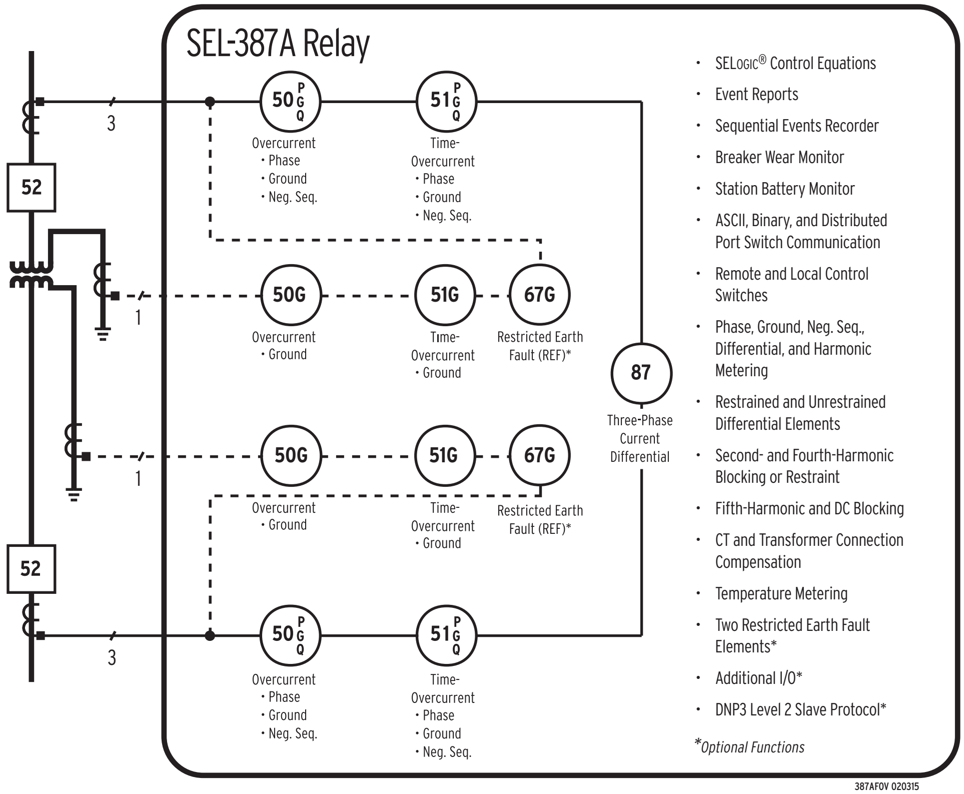


Figure 1 Functional Diagram

Protection Features

The SEL-387A contains a wide array of protective elements and control logic to protect two-winding power transformers, reactors, generators, and other apparatus. It includes current differential elements with percentage restraint and harmonic blocking elements, two optional sensitive restricted earth fault (REF) elements, and overcurrent elements. You can further tailor the relay to your particular application using advanced SELOGIC® control equations.

The relay has six independent setting groups. With this flexibility, the relay may be automatically configured for virtually any operating condition, for example, loading and source changes.

Current Differential Elements

The SEL-387A has three differential elements. These elements use operate and restraint quantities calculated from the two-winding input currents. The differential elements are set with either single- or dual-slope percentage differential characteristics. *Figure 2* illustrates an example of a dual-slope setting. Slope 1 takes care of differential currents resulting from CT errors and tap-changing. Slope 2 prevents undesired relay operation resulting from CT saturation for heavy external faults.

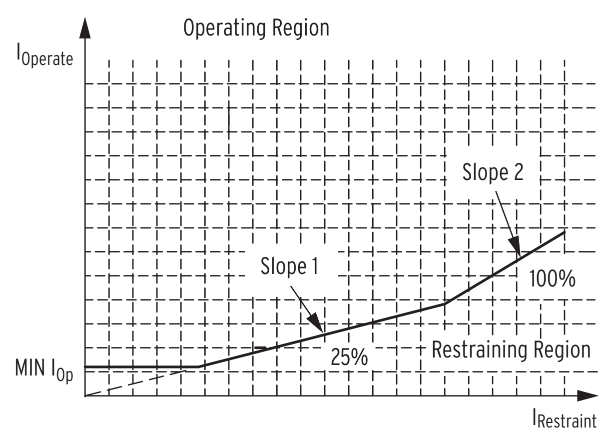


Figure 2 Dual-Slope Percentage Differential Restraint Characteristic

The SEL-387A provides security against conditions that may cause relay misoperation, resulting from both system and transformer events. Use the fifth-harmonic element to prevent relay misoperation during allowable overexcitation conditions. Even-harmonic elements (second and fourth harmonic) provide security against inrush currents during transformer energization, complemented by the dc element, which measures the dc offset. The even-harmonic element offers the choice between harmonic blocking and harmonic restraint. In the blocking mode, the user selects either blocking on an individual phase basis or on a common basis, as per application and philosophy. The second-, fourth-, and fifth-harmonic thresholds are set independently, and the dc blocking and harmonic restraint features are enabled independently.

An additional alarm function for the fifth-harmonic current employs a separate threshold and an adjustable timer to warn of overexcitation. This may be useful for transformer applications in or near generating stations.

There is also a set of unrestrained differential current elements. These elements simply compare the differential operating current quantity to a setting value, typically about 10 times the TAP setting.

Restricted Earth Fault Protection

Order the two optional REF elements to complement the differential elements. The two REF elements are independent, providing an element on each side of wye-wye or wye-delta (with grounding bank) transformers. Apply the REF protection feature to achieve sensitive detection of internal ground faults. The REF function compares the directions of neutral current and winding residual current. Operating current is derived from the residual current calculated for the protected winding. A directional element determines whether the fault is internal or external. Zero-sequence current thresholds and selectable CT saturation logic supervise tripping.

Overcurrent Protection

The SEL-387A has 11 overcurrent elements for each set of 3-phase current input windings, 22 elements total. Nine of the 11 overcurrent elements are torque-controlled elements comprised of one instantaneous, one definite-time, and one inverse-time element for phase, negative-sequence, and residual currents. The phase elements operate on the maximum of the phase currents. Two additional phase overcurrent elements (not torque controlled) assist in phase identification for targeting and level-sensing functions.

The REF option includes 3 sets of 5 neutral overcurrent elements, 15 elements total. These provide torque-controlled, definite-time (1 element), torque-controlled instantaneous (1 element), non-torque-controlled instantaneous (2 elements), and inverse-time (1 element) protection. Although 2 current inputs are used for the REF elements, the overcurrent elements on all 3 windings are still available for measuring neutral current.

The time-overcurrent curves listed in *Table 1* have two reset characteristic choices for each time-overcurrent element. One choice resets the elements if current drops below pickup for at least one cycle. The other choice emulates the reset characteristic of an electromechanical induction disk relay.

Table 1 Time-Overcurrent Curves

US	IEC
Moderately Inverse	Standard Inverse
Inverse	Very Inverse
Very Inverse	Extremely Inverse
Extremely Inverse	Long-Time Inverse
Short-Time Inverse	Short-Time Inverse

Temperature Measurement

The SEL-387A accepts up to 12 RTD inputs from the SEL-2600 RTD Module at any one of the ports using an SEL-2800M Fiber-Optic Transceiver. Connecting a second SEL-2600 to a second relay port doubles the number of RTD inputs for a total of 24 RTD inputs. Set two thresholds per RTD input to alarm for unacceptably high temperature levels.

Metering and Monitoring

Table 2 Metering Capabilities

Quantities	Description
Current $I_{A,B,C}$, $3I_1$, $3I_2$, $I_{Residual}$	Phase and sequence currents for each winding.
Demand Current $I_{A,B,C}$, $3I_2$, $I_{Residual}$	Phase and sequence demand currents for each winding.
Peak Demand $I_{A,B,C}$, $3I_2$, $I_{Residual}$	Phase and sequence peak demand currents for each winding.
Phasors $I_{A,B,C,}$ $3I_{1,}$ $3I_{2,}$ $I_{Residual}$	Phase and sequence current phasors for each winding (magnitudes and angles).
Differential Currents I_{OP}, I_{RT}, InF2, InF5	Operate, restraint, second-harmonic, and fifth-harmonic currents.
Harmonics $I_{A,B,C}$	Phase currents–fundamental to the 15th harmonic–for each winding.
RTD Temperatures	As many as 24 individual temperatures from two SEL-2600 RTD modules. Each SEL-2600 RTD module provides 12 RTD inputs.

Metering Capabilities

The SEL-387A provides three types of fundamental frequency metering functions: instantaneous, demand (thermal), and peak demand. Metered quantities shown in *Table 2* include phase currents for both winding inputs; positive-, negative-, and zero-sequence (residual) currents for both winding inputs; and operate, restraint, second-harmonic, and fifth-harmonic currents for the three differential elements.

Harmonic metering provides a snapshot of harmonic current magnitudes in the phase currents, including the fundamental and harmonic components through the 15th.

Event Reporting and Sequential Events Recorder (SER)

Event report and SER features simplify post-fault analysis and improve understanding of simple and complex protective scheme operations. They also aid in testing and troubleshooting relay settings and protection schemes.

Event Reports

In response to a user-selected trigger, the present element status information contained in each event report confirms relay, scheme, and system performance for every fault. Decide how much detail is necessary when you request an event report: 1/4- or 1/8-cycle resolution for filtered data; 1/4-, 1/8-, 1/16-, 1/32-, or 1/64-cycle resolution for raw analog data. For each report the relay stores the most recent 15, 30, or 60 cycles of data in nonvolatile memory. The length of pre-event information can be specified through a setting. The relay stores a total of 7 seconds of event report data. Relay settings are appended to the bottom of each event report.

Available reports include:

- **Winding event reports**, using filtered data and showing up to 9 currents at 4 or 8 samples per cycle, as well as the status of digital inputs and outputs.
- **Digital event reports**, showing pickup of overcurrent and demand elements at 4 or 8 samples per cycle, as well as the status of digital inputs and outputs.
- **Differential event reports**, showing differential quantities, element pickup, SELOGIC control equation set variables, and digital inputs and outputs at 4 or 8 samples per cycle.
- **Raw event reports**, using unfiltered data at 4, 8, 16, 32, or 64 samples per cycle, as well as the status of digital inputs and outputs.

Event report information can be used in conjunction with the ACSELERATOR Analytic Assistant® SEL-5601 Software to produce oscillographic type reports suitable for inclusion in analysis documents and reports. An example of event report data showing transformer inrush current is presented in *Figure 3*.

Sequential Events Recorder (SER)

The relay SER stores the latest 512 entries using as many as 96 programmable relay elements. Use this feature to gain a broad perspective of relay element operation. Events that trigger an SER entry include: input/output change of state and element pickup/dropout. Each entry includes time data derived from an IRIG-B source, if used.

The demodulated IRIG-B time-code input synchronizes the SEL-387A Relay time to within ±5 ms of the time-source input. A convenient source for this time code is the SEL-2032, the SEL-2030, or the SEL-2020 Communications Processor.

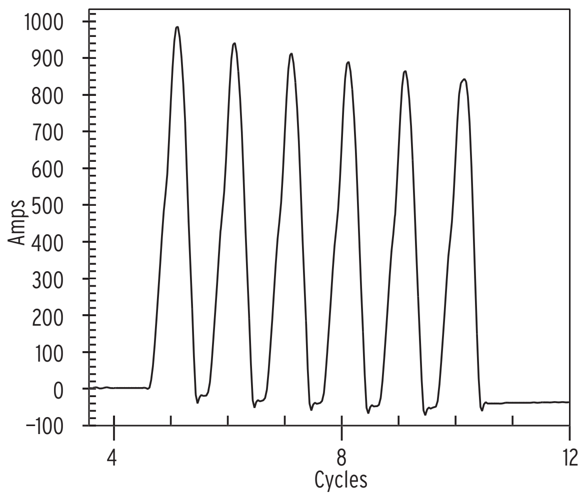


Figure 3 Transformer Energizing Inrush Current Plotted From Event Report

Substation Battery Monitor for DC Quality Assurance

The SEL-387A measures and reports the substation battery voltage presented to its power supply terminals. The relay includes four programmable threshold comparators and associated logic for alarm and control. For example, if the battery charger fails and the measured dc voltage falls below a programmable threshold, operations personnel are notified before the substation battery voltage falls to unacceptable levels. Monitor these comparator outputs with the communications processor and trigger messages, telephone calls, or other actions.

The measured dc voltage is reported in the METER display via serial port communications, on the LCD front-panel display, and in the event report. Use event report data to see an oscillographic display of the battery voltage. This report illustrates how the magnitude of the substation battery voltage varies during trip, close, and other control operations.

Breaker Contact Wear Monitor

Circuit breakers experience mechanical and electrical wear every time they operate. Effective scheduling of breaker maintenance compares manufacturer's published breaker wear data, interruption levels, and operation count with actual field data. The SEL-387A breaker monitoring function captures the total interrupted current and number of operations for up to two breakers.

Each time a monitored breaker trips, the relay integrates the interrupted current with previously stored current values. When the results exceed the threshold set by the breaker wear curve (*Figure 4*), the relay initiates an alarm via an output contact or the front-panel display. The typical settings shown in *Figure 4* are Set Point 1, Set Point 2, and Set Point 3. Set Point 1 approximates the continuous load current rating of the breaker. Set Point 3 is the maximum rated interrupting current for the particular breaker. Set Point 2 is some intermediate current value that provides the closest visual "fit" to the manufacturer's curve.

The wear for each pole of each monitored breaker is calculated separately since the breaker monitor accumulates current by phase. When first applying the relay, preload any previous estimated breaker wear. The incremental wear for the next interruption, and all subsequent interruptions, is added to the prestored value for a total wear value. Reset the breaker monitor operation counters, cumulative interrupted currents by pole, and percent wear by pole after breaker maintenance or installing a new breaker.

The breaker monitor report lists all breakers, the number of internal and external trips for each breaker, the total accumulated rms current by phase, and the percent wear by pole.

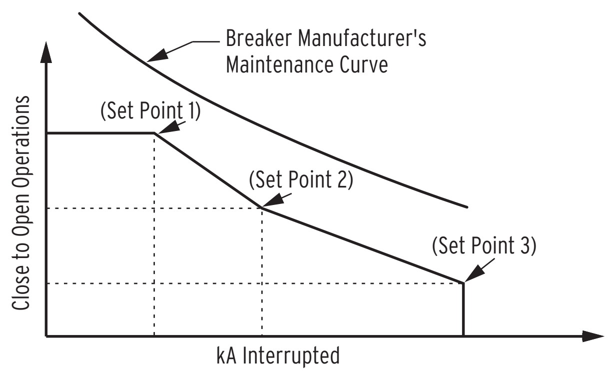


Figure 4 Breaker Contact Wear Curve and Settings

Through-Fault Event Monitor

A through fault is an overcurrent event external to the differential protection zone. Though a through fault is not an in-zone event, the currents required to feed this external fault can cause great stress on the apparatus inside the differential protection zone. Through-fault currents can cause transformer winding displacement leading to mechanical damage and increased transformer thermal wear. An SEL-387A through-fault event monitor gathers current level, duration, and date/time for each through fault. The monitor also calculates a simple I^2t and cumulatively stores these data per phase. Use through-fault event data to schedule proactive transformer bank maintenance and help justify through-fault mitigation efforts. Apply the accumulated I^2t alarm capability of the relay to indicate excess through-fault current over time.

Relay and Logic Setting Software

The ACSELERATOR QuickSet software uses the Microsoft® Windows® operating system to simplify settings and provide analysis support for the SEL-387A.

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

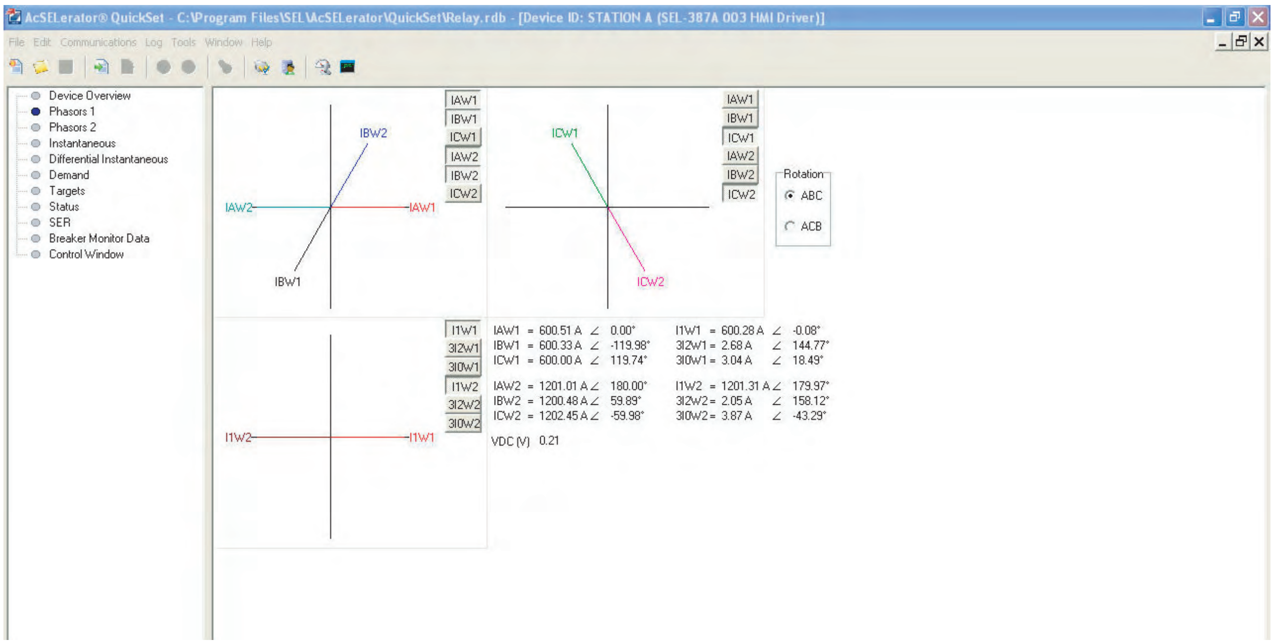


Figure 5 ACSELERATOR SEL-5030 HMI Screen Showing SEL-387 Phasor Information

Use the ACSELERATOR QuickSet software to create and manage relay settings:

- ➤ Develop settings off-line with an intelligent settings editor that only allows valid settings.
- ➤ Use on-line 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 ACSELERATOR QuickSet software to verify settings and analyze events:

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

Use the ACSELERATOR QuickSet software to aid with monitoring, commissioning, and testing the SEL-387A:

- ➤ Use the HMI to monitor current phasor information during testing.
- ➤ Use the PC interface to remotely retrieve breaker wear, monitor accumulated through-fault levels, and obtain other power system data.

Note: To use ACSELERATOR QuickSet software in the SEL-387A Relay, one must have relay Firmware Version R606.

Automation

Serial Communications

The SEL-387A is equipped with four independently operated serial ports: one EIA-232 port on the front and two EIA-232 ports and one EIA-485 port on the rear. The relay does not require special communications software. Use any system that emulates a standard terminal system. Establish communication by connecting computers, modems, protocol converters, printers, a communications processor, SCADA serial port, and/or RTU for local or remote communication.

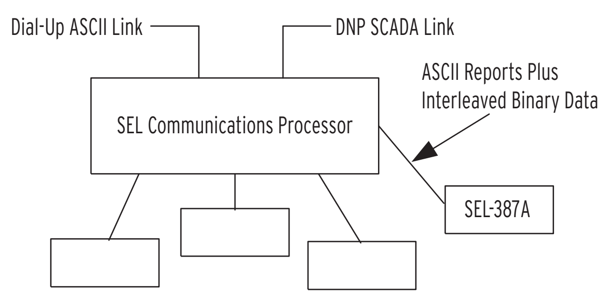


Figure 6 Example Communication System

SEL communications processors are often applied as the hub of a star network, with point-to-point fiber or copper connection between the hub and the SEL-387A. The communications processor supports external communications links including the public switched telephone network for engineering access to dial out alerts and private line connections to your SCADA system.

SEL manufactures a variety of standard cables for connecting this and other relays to a variety of external devices. Consult your SEL representative for more information on cable availability.

Table 3 Open Communications Protocols

Type	Description
Simple ASCII	Plain language commands for human and simple machine communications. Use for metering, setting, self-test status, event reporting, and other functions.
Compressed ASCII	Comma-delimited ASCII data reports. Allows external devices to obtain relay data in an appropriate format for direct import into spreadsheets and database programs. Data are checksum protected.
Extended Fast Meter and Fast Operate	Binary protocol for machine-to-machine communications. Quickly updates SEL-2032/SEL-2030/SEL-2020 Communications Processors, RTUs, and other substation devices with metering information, relay element, I/O status, time-tags, open and close commands, and summary event reports. Data are checksum protected. Binary and ASCII protocols operate simultaneously over the same communications lines so control operator metering information is not lost while a technician is transferring an event report.
Distributed Port Switch Protocol	Enables multiple SEL devices to share a common communications bus (two-character address setting range is 01–99). Use this protocol for low-cost, port-switching applications.
DNP3 Level 2 Slave	Certified Distributed Network Protocol. Includes automatic dial-out capability for settings-based DNP events, full-point remapping, individual scaling and dead-band thresholds for analog inputs, and virtual terminal support with full ASCII capability.

Control Logic and Integration

The SEL-387A control logic:

- **Replaces traditional panel control switches.** Eliminate traditional panel control switches with 16 local control switches. Set, clear, or pulse local control switches with the front-panel pushbuttons and display. Program the local control switches into your control scheme via SELOGIC control equations. Use the local control switches to perform functions such as a trip test or a breaker trip/close.
- **Eliminates RTU-to-relay wiring.** Eliminate RTU-to-relay wiring with 16 remote control switches. Set, clear, or pulse remote control switches via serial port commands. Program the remote control switches into your control scheme via SELOGIC control equations. Use remote control switches for SCADA-type control operations such as trip, close, and settings group selection.
- **Replaces traditional latching relays.** Replace up to 16 traditional latching relays for such functions as “remote control enable” with latch control switches. Program latch set and latch reset conditions with SELOGIC control equations. Set or reset the nonvolatile latch control switches via optoisolated inputs, remote control switches, local control switches, or any programmable logic condition. The latch control switches retain their state when the relay loses power.
- **Replaces traditional indicating panel lights.** Replace traditional indicating panel lights with 16 programmable displays. Define custom messages (e.g., Breaker Open, Breaker Closed) to report power system or relay conditions on the front-panel display. Control which messages are displayed via SELOGIC control equations.

Unique Capabilities

Advanced SELOGIC Control Equations

Advanced SELOGIC control equations allow the engineer to assign relay outputs to any logical combination of relay elements or inputs.

Program SELOGIC control equations by combining relay elements, inputs, and outputs with SELOGIC control equation operators. The state of all logical elements in the relay is reflected by bits of a table called the “Relay Word.” These logical elements include all current (50/51) and directional level detecting elements, timer elements, SELOGIC control equation variables, inputs, outputs, and remote, local, and latched bits. Any element in the Relay Word can be used in these equations.

SELOGIC control equation operators include OR, AND, invert, parentheses, and rising and falling edges of element state changes.

The basic building blocks of SELOGIC control equations are the Relay Word bits. The Relay Word bits are simple digital quantities having a logical value of either 0 or 1. The terms “assert” or “asserted” refer to a Relay Word bit that has a value of 1 or is changing from 0 to 1. The terms “deassert” or “deasserted” refer to a Relay Word bit that has a value of 0 or is changing from 1 to 0. Relay Word bits are asserted or deasserted by various elements within the relay and are used in the fixed internal logic of the relay to make decisions, to interpret inputs, or to drive outputs. These same bits are made available to the user so that the user can exercise flexibility in defining inputs or outputs, specifying control variables for internal logic, or for creating special customized logic through the use of SELOGIC control equations.

In addition to Boolean logic, 16 general purpose SELOGIC control equation timers eliminate external timers for custom protection or control schemes. Each timer has independent time-delay pickup and dropout settings. Program each timer input with any desired element (e.g., time qualify a current element). Assign the timer output to trip logic, transfer trip communications, or other control scheme logic.

Figure 7 depicts an example breaker failure circuit, configured with relay elements and stored in nonvolatile memory.

The following four lines show the SELOGIC control equations to create the breaker fail circuit.

S1V1	=	50P11 * TRIP1
S1V2	=	50P11 * TRIP1
OUT104	=	S1V1T (retrip)
OUT105	=	S1V2T (breaker failure trip)

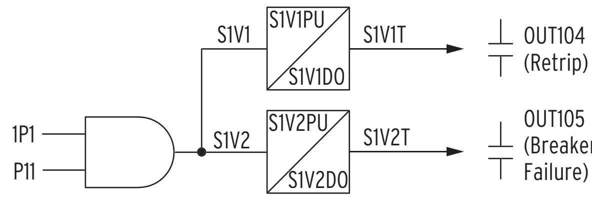


Figure 7 Dedicated Breaker Fail Scheme Created With SELOGIC Control Equation Variables/Timers

Six Independent Setting Groups Increase Operation Flexibility

The relay stores six setting groups. Selectable setting groups make the SEL-387A ideal for applications requiring frequent setting changes and for adapting the protection to changing system conditions. Select the active setting group by contact input, command, or other programmable conditions. Use these setting groups to cover a wide range of protection and control contingencies.

Selecting a group also selects logic settings. Program group selection logic to adjust settings for different operating conditions, such as station maintenance, seasonal operations, emergency contingencies, loading, source changes, and adjacent relay setting changes.

Additional Features

Front-Panel User Interface

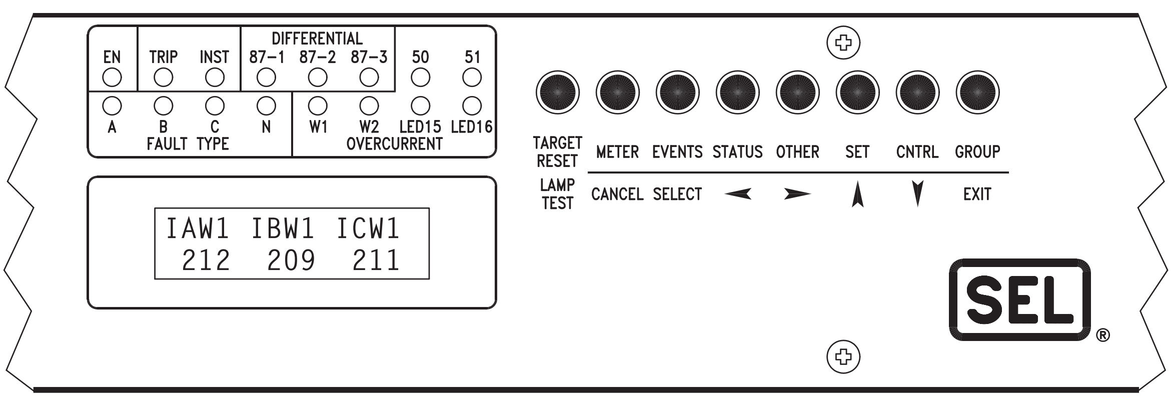


Figure 8 Status and Trip Target LEDs, Front-Panel Display, and Pushbuttons

A close-up view of the user interface portion of the SEL-387A front panel is shown in *Figure 8*. It includes a 2-line, 16-character LCD, 16 LED target indicators, and 8 pushbuttons for local communication.

Front-Panel Display

The LCD shows event, metering, setting, and relay self-test status information. The display is controlled with the eight multifunction pushbuttons. The target LEDs display relay target information as described in *Table 4*.

The LCD is controlled by the pushbuttons, automatic messages the relay generates, and user-programmed Display Points. The default display scrolls through any active, nonblank Display Points. Next, the relay scrolls through primary phase and neutral currents (if active). Each display remains for two seconds, before scrolling continues. Any message generated by the relay due to an alarm condition takes precedence over the normal default display. The {EXIT} pushbutton returns the display to the default display, if some other front-panel function is being performed.

Error messages such as self-test failures are displayed on the LCD in place of the default display when they occur.

During power up, the LCD displays: Initializing. When the EN LED indicates the relay is enabled, the active Display Points will be scrolled.

Status and Trip Target LEDs

The SEL-387A includes 16 status and trip target LEDs on the front panel. These targets are shown in *Figure 8* and explained in *Table 4*.

The target LEDs are an indication of what the relay has detected on the power system and how the relay has reacted.

The states of the 10 dedicated LEDs (all but EN, A, B, C, LED15, and LED16) are stored in nonvolatile memory. If power to the relay is lost, these 10 targets will be restored to their last state when power is restored.

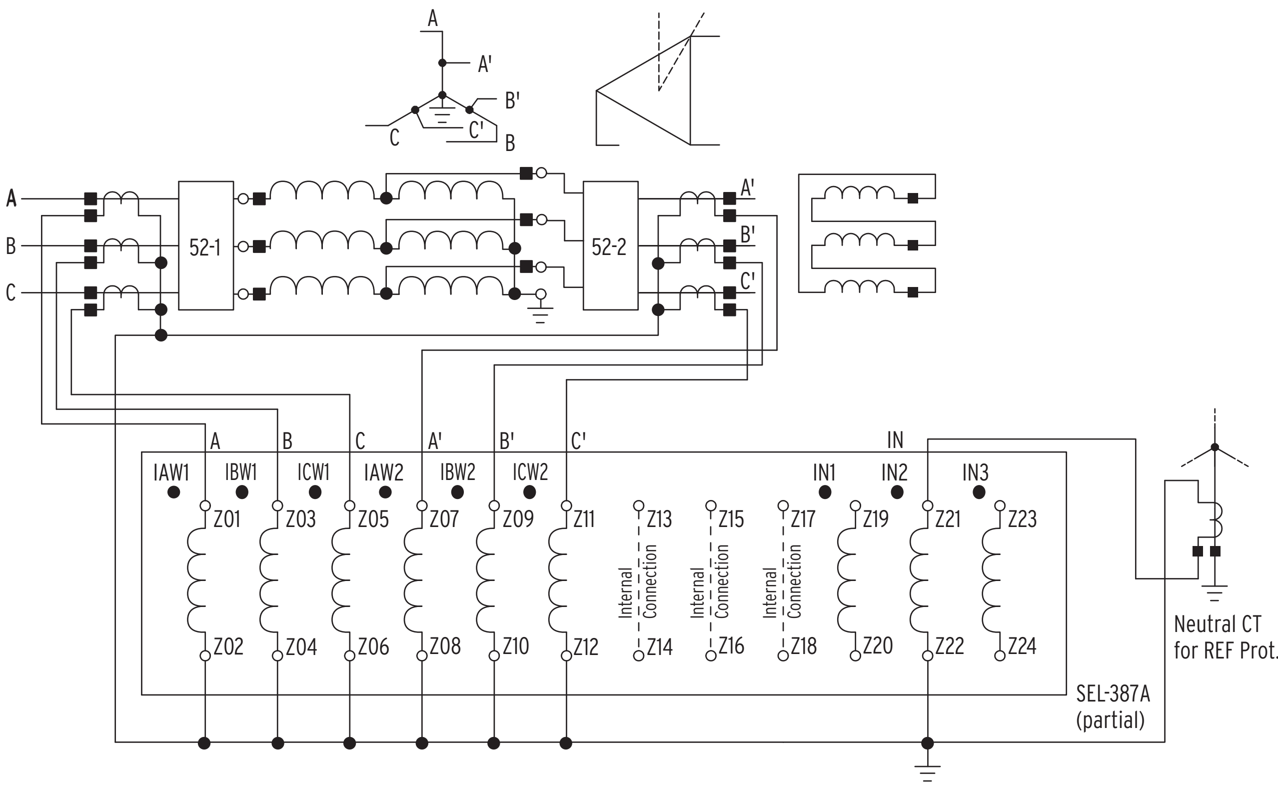
Table 4 Description of Target LEDs

Target LED	Function
EN	Relay powered properly, self-tests okay.
TRIP	A trip occurred.
INST	Trip due to an instantaneous overcurrent, definite-time overcurrent, or current differential element operation.
DIFFERENTIAL	
87-1, 87-2, 87-3	A current differential element operated.
50	Trip due to an instantaneous or definite-time overcurrent element.
51	Trip due to an inverse-time-overcurrent element.
FAULT TYPE	Programmable; defaults to:
A, B, C	Phases involved in the fault.
N	Ground involved in the fault.
OVERCURRENT	
W1, W2	Windings involved in the fault.
LED15, LED16	Programmable.

Model Options

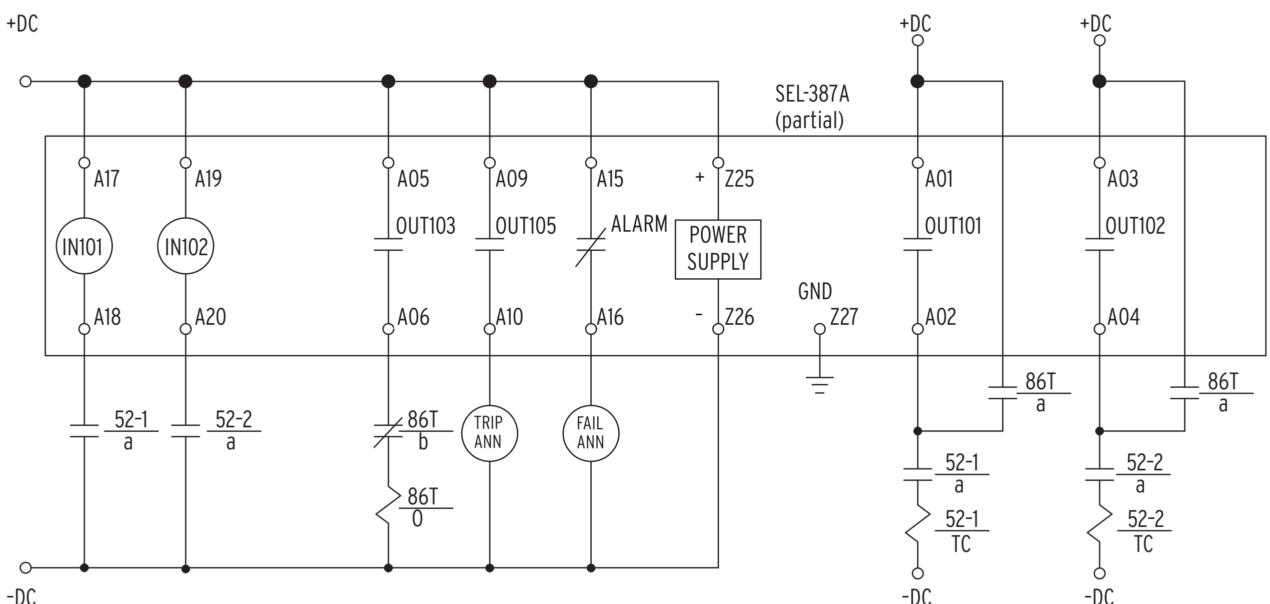
The base model SEL-387A has 8 output contacts and 6 optoisolated inputs. All SEL-387A models include the option of an additional 12 outputs and 8 inputs or an additional 4 outputs and 16 inputs. Assign the inputs for control functions, monitoring logic, and general indication. Except for a dedicated alarm output, each output contact is programmable using SELogic control equations.

Wiring Diagrams



Transformer Connections: YY (Yy0)
Current Transformer Connection: YY

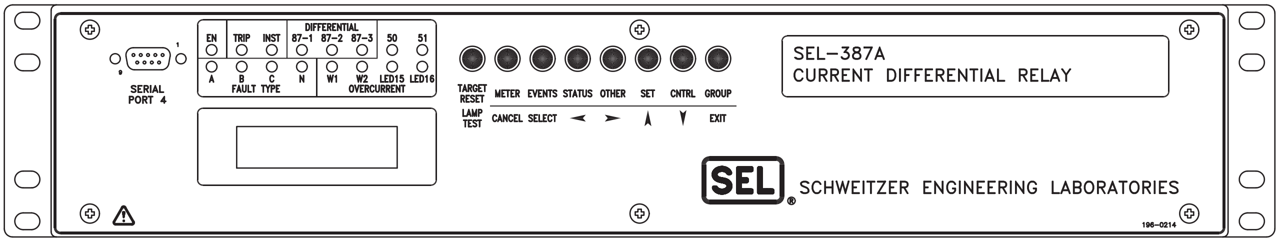
Figure 9 Typical AC Connection Diagram, Buried-Delta Autotransformer Application



Remaining: 4 Inputs (IN103–IN106)
3 Outputs (OUT104, OUT106, OUT107)

Figure 10 Typical DC Connection Diagram, Two-Winding Transformer Application

Front- and Rear-Panel Diagrams



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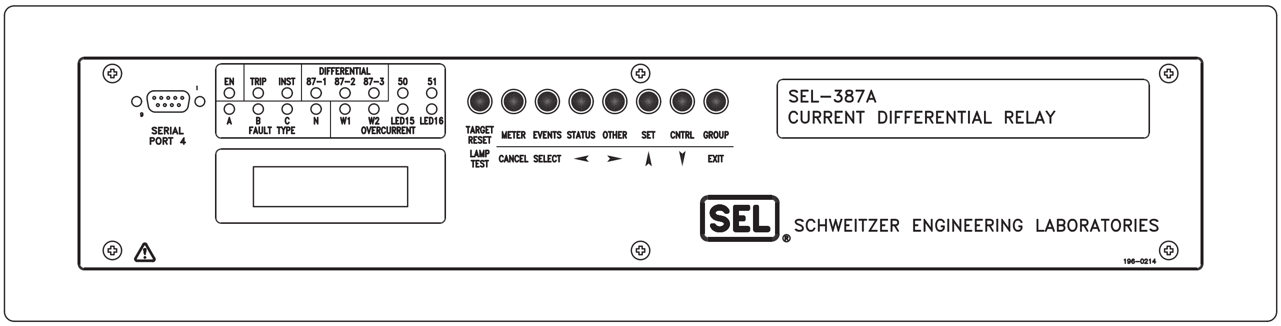
2U Rack-Mount Front Panel



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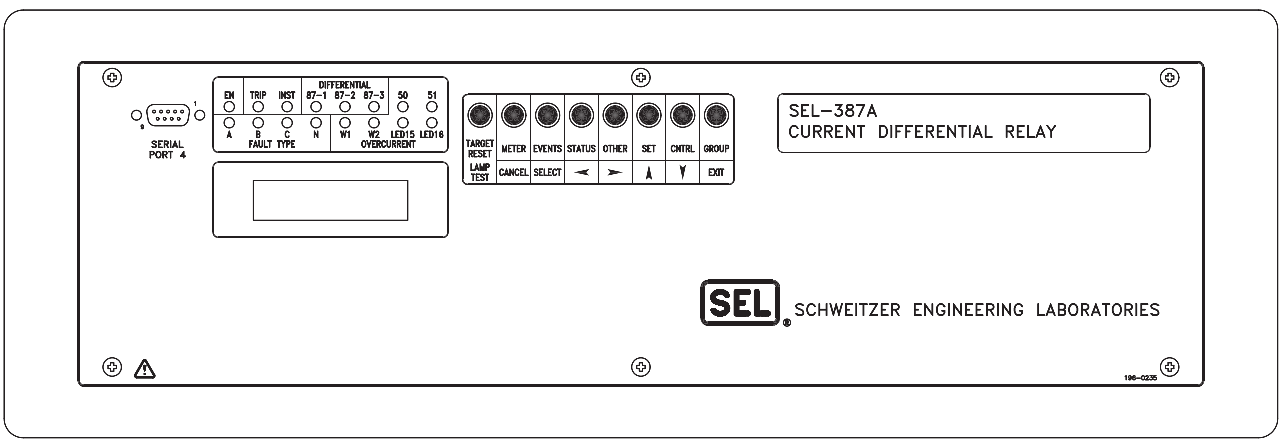
2U Panel-Mount Front Panel



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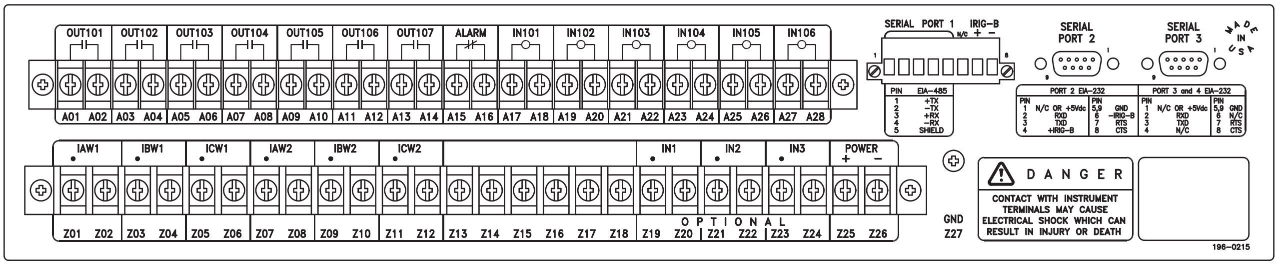
3U Panel-Mount Front Panel

Figure 11 SEL-387A Front-Panel Diagrams



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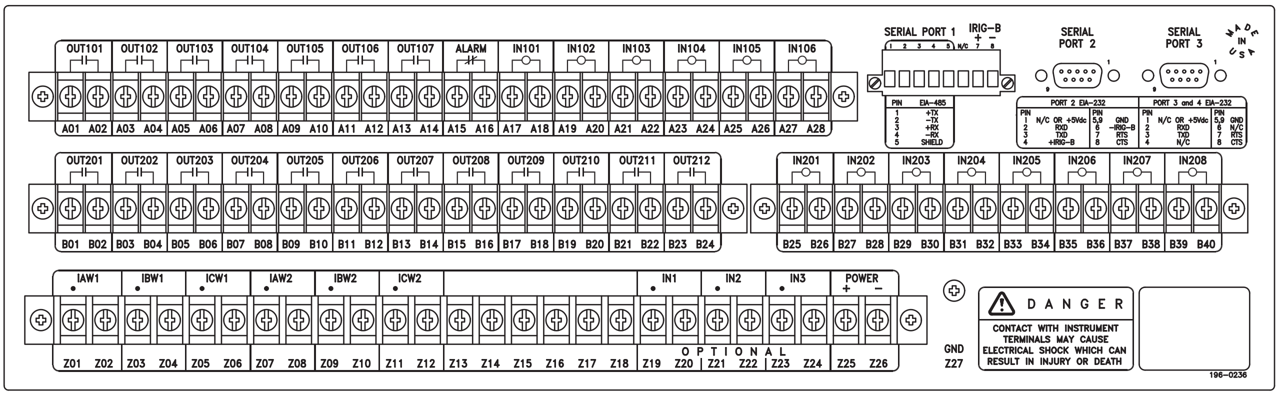

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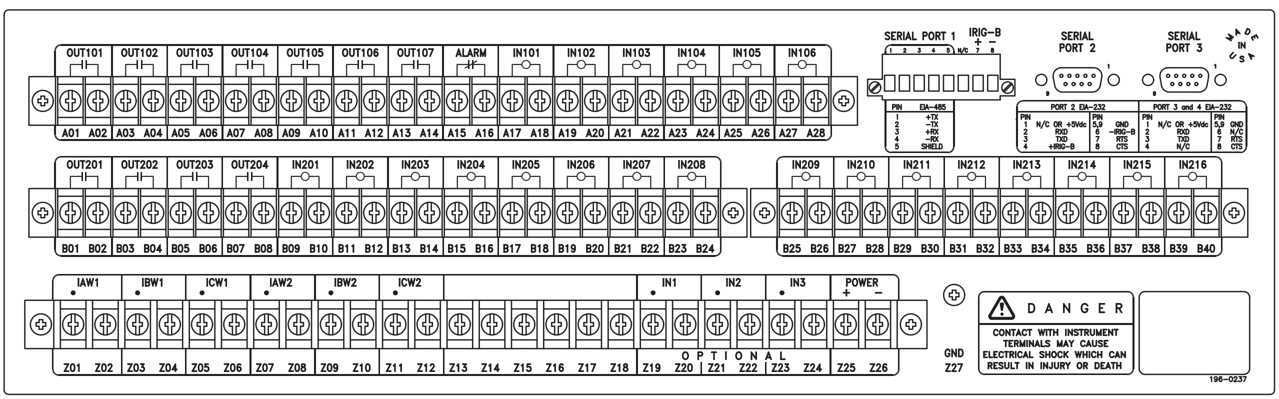

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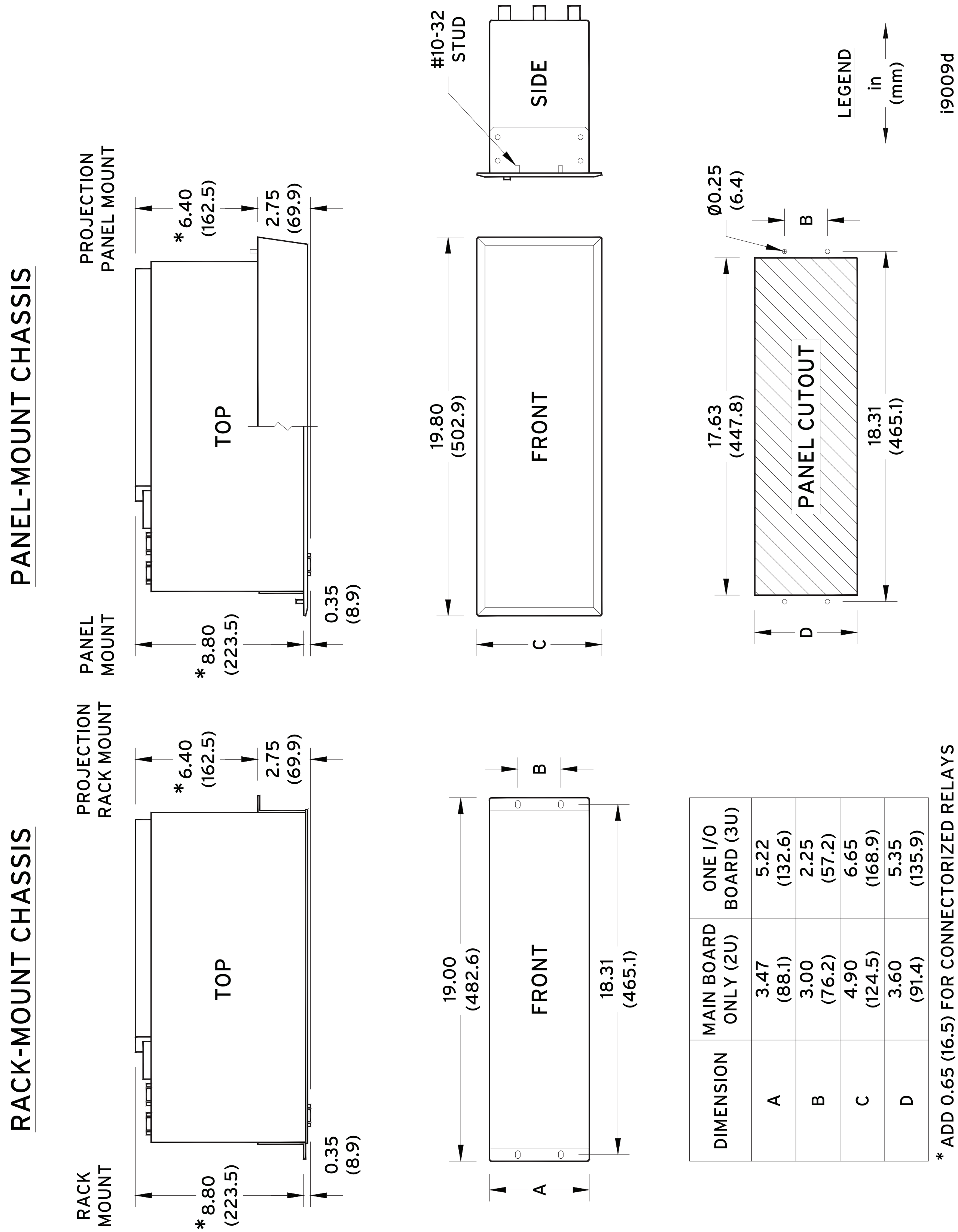
Figure 12 SEL-387A Rear-Panel Diagrams

Relay Dimensions



DIMENSION	MAIN BOARD ONLY (2U)	ONE I/O BOARD (3U)
A	3.47 (88.1)	5.22 (132.6)
B	3.00 (76.2)	2.25 (57.2)
C	4.90 (124.5)	6.65 (168.9)
D	3.60 (91.4)	5.35 (135.9)

* ADD 0.65 (16.5) FOR CONNECTORIZED RELAYS

Figure 13 SEL-387A Dimensions for Rack- and Panel-Mount Models

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
RCM Mark

General

Terminal Connections

Rear Screw-Terminal Tightening Torque

Terminal Block

Minimum:	9 in-lb (1.1 Nm)
Maximum:	12 in-lb (1.3 Nm)

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, 1250 A for 1 cycle
Burden:	0.27 VA at 5 A 2.51 VA at 15 A
1 A nominal:	3 A continuous, 100 A for 1 s, linear to 20 A symmetrical, 250 A for 1 cycle
Burden:	0.13 VA at 1 A 1.31 VA at 3 A

Power Supply

Rated:	125/250 Vdc or Vac
Range:	85–350 Vdc or 85–264 Vac
Burden:	<25 W
Interruption:	45 ms at 125 Vdc
Ripple:	100%
Rated:	48/125 Vdc or 125 Vac
Range:	38–200 Vdc or 85–140 Vac
Burden:	<25 W
Interruption:	160 ms at 125 Vdc
Ripple:	100%
Rated:	24/48 Vdc
Range:	18–60 Vdc polarity dependent
Burden:	<25 W
Interruption:	110 ms at 48 Vdc
Ripple:	100%

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

Output Contacts

Standard

Make:	30 A
Carry:	6 A continuous carry at 70°C 4 A continuous carry at 85°C
1 s Rating:	50 A
MOV Protection:	270 Vac/360 Vdc; 40 J
Pickup Time:	<5 ms
Dropout Time:	<5 ms, typical

Breaking Capacity (10,000 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

High-Current Interrupting Option

Make:	30 A
Carry:	6 A continuous carry at 70°C 4 A continuous carry at 85°C
1 s Rating:	50 A
MOV Protection:	330 Vdc; 130 J
Pickup Time:	<5 ms
Dropout Time:	<8 ms, typical

Breaking Capacity (10,000 Operations):

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

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 60255-23:1994.

Optoisolated Inputs

250 Vdc:	Pickup 200–300 Vdc; Dropout 150 Vdc
220 Vdc:	Pickup 176–264 Vdc; Dropout 132 Vdc
125 Vdc:	Pickup 105–150 Vdc; Dropout 75 Vdc
110 Vdc:	Pickup 88–132 Vdc; Dropout 66 Vdc
48 Vdc:	Pickup 38.4–60 Vdc; Dropout 28.8 Vdc
24 Vdc:	Pickup 15.0–30 Vdc

Note: 24, 48, and 125 Vdc optoisolated inputs draw approximately 4 mA of current; 110 Vdc inputs draw approximately 8 mA of current; and 220 and 250 Vdc inputs draw approximately 5 mA of current. All current ratings are at nominal input voltage.

Routine Dielectric Strength

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:	50 or 60 Hz
Phase Rotation:	ABC or ACB

Communications Ports

EIA-232:	1 front and 2 rear
EIA-485:	1 rear, 2100 Vdc isolation
Baud Rate:	300–19200 baud

Operating Temperature

–40° to +85°C (–40° to +185°F)

Time-Code Input

Relay accepts demodulated IRIG-B time-code input at Port 1 or 2. Relay is time synchronized to within ±5 ms of time source input.

Weight

2U rack unit height:	6.8 kg (15 lb)
3U rack unit height:	8 kg (17.75 lb)

Type Tests

Emissions

Generic Emissions, Heavy Industrial:	EN 50081-2:1993, Class A
Generic Immunity, Heavy Industrial:	EN 50082-2:1995
Radiated and Conducted Emissions:	EN 55011:1998, Class A
Conducted Radio Frequency:	EN 61000-4-6:1996, ENV 50141:1993, 10 Vrms
Radiated Radio Frequency (900 MHz with modulation):	ENV 50204:1995, 10 V/m

Environmental Tests

Cold:	IEC 60068-2-1:1990 [EN 60068-2-1:1993] Test Ad; 16 hr at –40°C
Damp Heat Cyclic:	IEC 60068-2-30:1980 Test Db; 25° to 55°C, 6 cycles, 95% humidity
Dry Heat:	IEC 60068-2-2:1974 [EN 60068-2-2:1993] Test Bd: 16 hr at +85°C

Dielectric Strength and Impulse Tests

Dielectric:	IEC 60255-5:1977 IEEE C37.90-1989 2500 Vac on analogs, contact inputs, and contact outputs 3100 Vdc on power supply 2200 Vdc on EIA-485 communications port
Impulse:	IEC 60255-5:1977 0.5 J, 5000 V

Electrostatic Discharge Test

ESD:	IEC 60255-22-2:1996 IEC 61000-4-2:1995 Level 4

RFI and Interference Tests

1 MHz Burst Disturbance:	IEC 60255-22-1:1988 Class 3
Fast Transient Disturbance:	IEC 60255-22-4:1992 IEC 61000-4-4:1995 Level 4
Radiated EMI:	IEC 60255-22-3:1989 ENV 50140:1993 IEEE C37.90.2-1995, 35 V/m no keying test
Surge Withstand:	IEEE C37.90.1-1989 3.0 kV oscillatory; 5.0 kV fast transient

Vibration and Shock Tests

Shock and Bump:	IEC 60255-21-2:1988 Class 1 IEC 60255-21-3:1993 Class 2
Sinusoidal Vibration:	IEC 60255-21-1:1988 Class 1

Object Penetration

Object Penetration:	IEC 60529:1989 IP 30, IP 54 from the front panel using the SEL-9103 front-cover dust and splash protection

Processing Specifications

64 samples per power system cycle

Metering Accuracy

5 A Model	
Phase Currents:	±1.5% ±0.10 A and ±1.5°
Sequence Currents:	±3.0% ±0.10 A and ±2.0°
Differential Quantities:	±5.0% ±0.10 A
2nd and 5th Harmonic:	±5.0% ±0.10 A
Current Harmonics:	±5.0% ±0.10 A
1 A Model	
Phase Currents:	±1.5% ±0.02 A and ±1.5°
Sequence Currents:	±3.0% ±0.02 A and ±2.0°
Differential Quantities:	±5.0% ±0.02 A
2nd and 5th Harmonic:	±5.0% ±0.02 A
Current Harmonics:	±5.0% ±0.02 A

Substation Battery Voltage Monitor

Pickup Range:	20–300 Vdc, 1 Vdc steps
Pickup Accuracy:	±2% ±2 Vdc

Relay Elements

Differential Element

Unrestrained Pickup Range:	1–20 in per unit of tap
Restrained Pickup Range:	0.1–1.0 in per unit of tap
Pickup Accuracy (A secondary)	
5 A Model:	±5% ±0.10 A
1 A Model:	±5% ±0.02 A
Unrestrained Element Pickup Time:	0.8/1.0/1.9 cycles (Min/Typ/Max)
Restrained Element (with harmonic blocking) Pickup Time:	1.5/1.6/2.2 cycles (Min/Typ/Max)
Restrained Element (with harmonic restraint) Pickup Time:	2.62/2.72/2.86 cycles (Min/Typ/Max)

Harmonic Element

Pickup Range (% of fundamental):	5–100%
Pickup Accuracy (A secondary)	
5 A Model:	±5% ±0.10 A
1 A Model:	±5% ±0.02 A
Time Delay Accuracy:	±0.1% ±0.25 cycle

Winding Instantaneous/Definite-Time Overcurrent Elements

Pickup Ranges (A secondary)	
5 A Model:	0.25–100.00 A
1 A Model:	0.05–20.00 A
Pickup Accuracies (A secondary)	
5 A Model	
Steady State:	±3% ±0.10 A
Transient:	±5% ±0.10 A
1 A Model	
Steady State:	±3% ±0.02 A
Transient:	±5% ±0.02 A

Note: For transient, ±6% for negative-sequence elements.

Pickup Time:	0.75/1.20 cycles (Typ/Max)
Time Delay Range:	0–16000 cycles
Time Delay Accuracy:	±0.1% ±0.25 cycle

Winding Time Overcurrent Elements

Pickup Ranges (A secondary)	
5 A Model:	0.5–16.0 A
1 A Model:	0.1–3.2 A
Pickup Accuracies (A secondary)	
5 A Model	
Steady State:	±3% ±0.10 A
Transient:	±5% ±0.10 A
1 A Model	
Steady State:	±3% ±0.02 A
Transient:	±5% ±0.02 A

Note: For transient, ±6% for negative-sequence elements.

Curve	
U1 =	U.S. Moderately Inverse
U2 =	U.S. Inverse
U3 =	U.S. Very Inverse
U4 =	U.S. Extremely Inverse
U5 =	U.S. Short-Time Inverse
C1 =	IEC Class A (Standard Inverse)
C2 =	IEC Class B (Very Inverse)
C3 =	IEC Class C (Extremely Inverse)
C4 =	IEC Long-Time Inverse
C5 =	IEC Short-Time Inverse
Time-Dial Range	
US Curves:	0.50–15.00
IEC Curves:	0.05–1.00
Timing Accuracy:	±4% ±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.
Reset Characteristic:	Induction-disk reset emulation or 1 cycle linear reset

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